Proposed Course Structure and Syllabus

for

B.Tech. Chemical Technology

BIOPROCESS TECHNOLOGY

DEPARTMENT OF CHEMICAL ENGINEERING

Visvesvaraya National Institute of Technology

Nagpur 440 010 (India)

2026

Institute Vision Statement

To contribute effectively to the National and International endeavor of producing quality human resource of world class standard by developing a sustainable technical education system to meet the changing technological needs of the Country and the World incorporating relevant social concerns and to build an environment to create and propagate innovative technologies for the economic development of the Nation.

Institute Mission Statement

The mission of VNIT is to achieve high standards of excellence in generating and propagating knowledge in engineering and allied disciplines. VNIT is committed to providing an education that combines rigorous academics with joy of discovery. The Institute encourages its community to engage in a dialogue with society to be able to effectively contribute for the betterment of humankind.

List of faculty Members

Sr No	Faculty Name	Areas of specialization
1	Dr. K. L. Wasewar	Separation Processes, Ionic liquids
2	Dr. Sachin. A. Mandavagane	Bio-fertilizer, adsorption, bio-adsorbent
3	Dr. M. N. Varma	Reaction Engineering, Bio-fuel, Supercritical fluids
4	Dr. S. S. Sonawane	Nanotechnology, nano-fluids, polymer composite
5	Dr. A. S. Chaurasia	Pyrolysis, gasification , CFD
6	Dr. Diwakar Z. Shende	Separation processes, mass transfer
7	Dr. Ajit Rathod	Membrane separation, catalysis, heat transfer
8	Dr. Pradip Dhamole	Bio-fuel, Biological wastewater treatment, Bio-separation processes
9	Dr. R. Methekar	Process control, Fuel cell, batteries
10	Dr. Vijayakumar R. P.	Polymer nano-composite, carbon nano-tube
11	Dr. C. Ravikumar	Bio-nanotechnology, hydrodynamics
12	Dr. A. P. Gaikwad	Bio-fuel, Catalysis
13	Dr. Shyam M. Kodape	Membrane Bioreactor, Industrial Waste Treatment, Waste Valorization, Green Synthesis
14	Dr. S. P. Tajane	Bio-fertilizer, mechanical operations
15	Dr. P. Wanjari	Nano-technology, molecular dynamic simulation
16	Dr. A. Kannan	Bio-nano film, separation processes
17	Dr Arijit Das	Separation processes, extraction, ceramic membrane

The department offers following undergraduate program

	Program	Description
UG	B.Tech. Chemical Technology (Bioprocess Technology)	Intake: 30

Credit System at VNIT:

Education at the Institute is organized around the semester-based credit system of study. The prominent features of the credit system are a process of continuous evaluation of a student's performance / progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation. A student's performance/progress is measured by the number of credits he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum number of credits and a minimum grade point average must be acquired by a student in order to qualify for the degree.

Course credits assignment

Each course, except a few special courses, has certain number of credits assigned to it depending on lecture, tutorial and laboratory contact hours in a week.

For Lectures and Tutorials: One lecture hour per week per semester is assigned one credit and

For Practical/ Laboratory/ Studio: One hour per week per semester is assigned half credit.

Example: Course XXXXXX with (3-0-2) as (L-T-P) structure, i.e. 3 hr Lectures + 0 hr Tutorial + 2 hr Practical per week, will have (3x1 + 0x1 + 2x0.5 =) 4 credits.

Grading System

The grading reflects a student's own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is based on fitting performance of the class to some statistical distribution. The course coordinator and associated faculty members for a course formulate appropriate procedure to award grades. These grades are reflective of the student's performance vis-à-vis instructor's expectation. If a student is declared pass in a subject, then he/she gets the credits associated with that subject.

Depending on marks scored in a subject, a student is given a Grade. Each grade has got certain grade points as follows:

Grade	Grade points	Description
AA	10	Outstanding
AB	9	Excellent
BB	8	Very good
BC	7	Good
CC	6	Average
CD	5	Below average
DD	4	Marginal (Pass Grade)
FF	0	Poor (Fail) /Unsatisfactory / Absence from end-sem exam
NP	-	Audit pass
NF	-	Audit fail
SS	-	Satisfactory performance in zero credit core course
ZZ	-	Unsatisfactory performance in zero credit core course
W	-	Insufficient attendance

Performance Evaluation

The performance of a student is evaluated in terms of two indices, viz, the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester and Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time. CGPA is rounded up to second decimal.

The Earned Credits (ECR) are defined as the sum of course credits for courses in which students have been awarded grades between AA to DD. Grades obtained in the audit courses are not counted for computation of grade point average.

Earned Grade Points in a semester (EGP) = **Σ** (Course credits x Grade point) for courses in which AA- DD grade has been obtained

SGPA = EGP / Σ (Course credits) for courses registered in a semester in which AA- FF grades are awarded

CGPA= EGP / Σ(Course credits) for courses passed in all completed semesters in which AA- DD grades are awarded

Attendance Rules

1. All students must attend every class and 100% attendance is expected from the students. However, in consideration of the constraints/ unavoidable circumstances, the attendance can be relaxed by course coordinator only to the extent of not more than 25%. Every student must attend minimum of 75% of the classes actually held for that course.
2. A student with less than 75% attendance in a course during the semester, will be awarded W grade. Such a student will not be eligible to appear for the end semester and re-examination of that course. Even if such a student happens to appear for these examinations, then, answer books of such students will not be evaluated.
3. A student with W grade is not eligible to appear for end semester examination, reexamination & summer term.

Name of UG Program: B.Tech. Chemical Technology (Bioprocess Technology)

Sr. No.	Category of Course - PC	Symbol	Earned Credit Requirement
1.	Basic Sciences	BS	12
2.	Engineering Sciences	ES	16
3.	Institute Core	IC	2
4.	Humanities	HU	3
5	Departmental Core	DC	76
6	Mandatory Non-Credit	MNC	0
Sr. No.	**Category of Course - PE**	**Symbol**	**Earned Credit Requirement**
7.	Institute Elective	IE	6
8.	Departmental Elective	DE	42
9.	Open Course / Humanities & Management	OC / HM	3
	Total		160

	PC						PE			
Sem	**BS**	**ES**	**IC**	**HU**	**DC**	**MNC**	**IE**	**OC/HM**	**DE**	**Total**
I	8	9	0	3	0	0	0	0	0	**20**
II	4	7	2	0	3	0	3	3	0	**22**
III	0	0	0	0	20	0	3	0	3	**26**
IV	0	0	0	0	21	0	0	0	3	**24**
V	0	0	0	0	21	0	0	0	3	**24**
VI	0	0	0	0	8	0	0	0	15	**23**
VII	0	0	0	0	3	0	0	0	12	**15**
VIII	0	0	0	0	0	0	0	0	6	**6**
Total	**12**	**16**	**2**	**3**	**76**	**0**	**6**	**3**	**42**	**160**

NEP Implementation at VNIT

Proposed Credit Structure for B. Tech Chemical Technology (Bioprocess Technology)

S.N.	Category	Symbol	%	Credit Req.	Proposed	I	II	III	IV	V	VI	VII	VIII
1	Basic Sciences	BS	10%	12–16	**12**	**8**	**4**	**0**	**0**	**0**	**0**	**0**	**0**
2	Engineering Sciences	ES	10%	12–16	**16**	**9**	**7**	**0**	**0**	**0**	**0**	**0**	**0**
3	Institute Core	IC	1%	2	**2**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0**
4	Humanities	HU	2%	3	**3**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
5	Departmental Core	DC	41%	66–78	**76**	**0**	**3**	**20**	**21**	**21**	**8**	**3**	**0**
6	Mandatory Non-Credit	MNC	List of Courses	At least 4 courses	**--**								
7	Institute Elective	IE	4%	06	**6**	**0**	**3**	**3**	**0**	**0**	**0**	**0**	**0**
8	Departmental Elective	DE	Min26 %	Min.42	**42**	**0**	**0**	**3**	**3**	**3**	**15**	**12**	**6**
9	Humanities & Magt	HM**	0–4%	0-6	**3**	**0**	**3**	**0**	**0**	**0**	**0**	**0**	**0**
10	Open Course	OC**	0-4%	0-6		**0**		**0**	**0**	**0**	**0**	**0**	**0**
	Total			**Min.160**	**Min.160**	**20**	**22**	**26**	**24**	**24**	**23**	**15**	**6**
						42		**50**		**47**		**21**	

Total 160

B. Tech. 160 credits

B. Tech. with Honors: 160 + 15 credits (five department electives from any one basket of electives)

B. Tech Chemical Technology (Bioprocess Technology) Semester I

Code	Course	Type	L-T-P	Credits	Pre-requisites
CHLxxx	Chemical Science for Materials and Energy Systems	BS	3-0-0	3	None
CHP1**	Chemistry	BS	0-0-2	1	None
AML1**	Engineering Mechanics	ES	3-0-0	3	None
AMP1**	Engineering Mechanics	ES	0-0-2	1	None
EEL1**	Electrical Engineering	ES	3-0-0	3	None
EEP1**	Electrical Engineering	ES	0-0-2	1	None
MAL1**	Mathematics	BS	3-1-0	4	None
MELxxx	Basic Engineering Graphics	ES	2-0-2	3	None
MEP1xx	Engineering Workshop	ES	0-0-2	1	None
SAA101	Health Information and Sports–Part I	MNC	0-0-2	0	None
	Total Credits			**20**	

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
1st Sem	8	9	0	3	0	0	0	0	20
Cumulative	8	9	0	3	0	0	0	0	20

L-T-P=3-1-0 Means, Three Theory Hrs + One Tutorial hrs + Zero Laboratory or Practical Hrs per Week.

L-T-P=0-0-2 Means, Two Hrs of Laboratory Practical per Week

B. Tech Chemical Technology (Bioprocess Technology) Semester II

Code	Course	Type	L-T-P	Credits	Pre-requisites
CSL1**	Computer Programming	ES	3-0-2	4	None
ICLA101	Environmental Studies	IC	2-0-0	2	None
******	OC/HM	OC /HM	3-0-0	3	None
HULxxx	English and Corporate Communication	HU	2-0-2	3	None
PHL1**	Physics	BS	3-0-0	3	None
PHP1**	Physics	BS	0-0-2	1	None
IELxxx	Institute Elective-I	IE	3-0-0	3	None
CML1xx	General Biology	DC	3-0-0	3	None
SAA102	Health Information and Sports–Part II	MNC	0-0-2	0	None
	Total Credits			22	
Certificate Exit Additional Course					
CMP3xx	Bioprocess Technology	DC	0-0-2	1	None

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
2^{nd} Sem	4	7	2	0	3	6	0	0	22
Cumulative	12	16	2	3	3	6	0	0	42

Summer internship of minimum 6 weeks – 1 Credit

B. Tech Chemical Technology (Bioprocess Technology) Semester III

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CML2**	Microbiology for Engineers	DC	3-0-0	3	None
CML2**	Biochemistry	DC	3-0-0	3	None
CML201	Chemical Process Calculations	DC	3-0-0	3	None
CML202	Fluid Mechanics	DC	3-0-0	3	None
CML203	Mechanical Operations	DC	3-0-0	3	None
CML204	Chemical Engineering Thermodynamics I	DC	3-0-0	3	None
CMP2**	Microbiology for Engineers Laboratory	DC	0-0-2	1	None
CMP2**	Biochemistry Laboratory	DC	0-0-2	1	None
IELxxx	Institute Elective -II	IE	3-0-0	3	None
AULxxx	Mandatory Non-Credit Category – I	MNC	0-0-2	0	None
	Electives				
CMLxxx	Elective 1	DE	3-0-0	3	None
			Total Credits (DC +DE+ IE = 20+3+3=26)	**26**	

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
3rd Sem	0	0	0	0	20	6	3	3	32
Cumulative	12	16	2	3	23	12	3	3	74

B. Tech Chemical Technology (Bioprocess Technology) Semester IV

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CML2**	Fermentation Technology	DC	3-0-0	3	None
CML2**	Cell Biology for Engineers	DC	3-0-0	3	None
CML221	Mass Transfer I	DC	3-0-0	3	None
CML222	Heat Transfer	DC	3-0-0	3	None
CML223	Chemical Reaction Engineering I	DC	3-0-0	3	None
CML225	Chemical Engineering Thermodynamics II	DC	3-0-0	3	None
CMP2**	Fermentation Technology Laboratory	DC	0-0-2	1	None
CMP202	Fluid Mechanics Laboratory	DC	0-0-2	1	None
CMP322	Heat Transfer Laboratory	DC	0-0-2	1	None
AULxxx	Mandatory Non-Credit Category -II	MNC	0-0-2	0	None
	Electives				
CMLxxx	Elective 2	DE	3-0-0	3	None
Total Credits (DC + DE = 21+3=24)				**24**	
Diploma Exit Additional Course					
CMD4xx	Mini Project	DC	0-0-4	2	None

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
4th Sem	0	0	0	0	21	3	3	3	30
Cumulative	12	16	2	3	44	15	6	6	104

Summer internship of minimum 6 weeks – 1 Credit

B. Tech Chemical Technology (Bioprocess Technology) Semester V

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CML3**	Downstream Processing	DC	3-0-0	3	None
CML3**	Computational Techniques and Biostatics	DC	3-0-0	3	None
CML3**	Molecular Biology and Genetic Engineering	DC	3-0-0	3	None
CML301	Mass Transfer II	DC	3-0-0	3	None
CML304	Chemical Reaction Engineering II	DC	3-0-0	3	None
CML302	Chem. Process Modeling & Simulation	DC	3-0-0	3	None
CMP3**	Molecular Biology & Genetic Engg. Laboratory	DC	0-0-2	1	None
CMP304	Chemical Reaction Engg. Laboratory	DC	0-0-2	1	None
CMP321	Mass Transfer Laboratory	DC	0-0-2	1	None
	Electives				
CMLxxx	Elective 3 / MOOC*	DE	3-0-0	3	None
Total Credits (DC + DE = 21+3=24)				**24**	

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
5th Sem	0	0	0	0	21	3	3	3	30
Cumulative	12	16	2	3	65	18	9	9	134

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.
MOOC/NPTEL/SWAYAM courses approved for UG Chemical Engineering are applicable for B.Tech. Chemical Technology (Bioprocess Technology)

B. Tech Chemical Technology (Bioprocess Technology) Semester VI

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CMD401	Project Phase-I	DC	0-0-6	3	None
CML352	Transport Phenomena	DC	3-0-0	3	None
CM3***	Downstream Processing Laboratory	DC	0-0-2	1	None
CMP302	Chem. Process Modelling and Simulation Laboratory	DC	0-0-2	1	None
	Electives				
CMLxxx	Elective - 4 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 5 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 6	DE	3-0-0	3	None
CMLxxx	Elective – 7	DE	3-0-0	3	None
CMLxxx	Elective – 8	DE	3-0-0	3	None
Total Credits (DC + DE = 8+15=23)				**23**	
Advanced Diploma Exit is permitted without additional course					

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
6th Sem	0	0	0	0	8	15	6	6	35
Cumulative	12	16	2	3	73	33	15	15	169

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.
MOOC/NPTEL/SWAYAM courses approved for UG Chemical Engineering are applicable for B.Tech. Chemical Technology (Bioprocess Technology)
Summer internship of minimum 6 weeks – 1 Credit

B. Tech Chemical Technology (Bioprocess Technology) Semester VII#

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CMD402	Project Phase-II	DC	0-0-6	3	None
	Electives				
CMLxxx	Elective - 9 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 10 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 11	DE	3-0-0	3	None
CMLxxx	Elective – 12	DE	3-0-0	3	None
Total Credits (DC + DE = 3+12=15)				**15**	

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
7th Sem	0	0	0	0	3	12	0	0	15
Cumulative	12	16	2	3	76	45	15	15	184

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.
MOOC/NPTEL/SWAYAM courses approved for UG Chemical Engineering are applicable for B.Tech. Chemical Technology (Bioprocess Technology)
VII and VIII semester will be interchanged if student opt for internship in VII semester.

B. Tech Chemical Technology (Bioprocess Technology) Semester VIII#

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
	Electives (Elective 13 + Elective 14 OR Internship)				
CMLxxx	Elective - 13 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 14 / MOOC*	DE	3-0-0	3	None
CMP4**	Internship	DE	6-0-0	6	
Total Credits (DC + DE = 0+6=6)				**6**	

Credits	BS	ES	IC	HU	DC	IE/DE/HM/OC	Minor	Honor	Total
8th Sem	0	0	0	0	0	6	0	0	6
Cumulative	12	16	2	3	76	51	15	15	190

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.
MOOC/NPTEL/SWAYAM courses approved for UG Chemical Engineering are applicable for B.Tech. Chemical Technology (Bioprocess Technology)
VII and VIII semester will be interchanged if student opt for internship in VII semester.

List of Electives for B.Tech. Chemical Technology (Bioprocess Technology)

CML3**	Biopharmaceutical Technology	3-0-0	3
CML3**	Industrial Biotechnology and Bioprocess Applications	3-0-0	3
CML3**	Nanotechnology for Bioprocess Technology	3-0-0	3
CML3**	Membrane Applications in Bioprocess Technology	3-0-0	3
CML4**	Bioreactor Design and Scale up	3-0-0	3
CML4**	Bioinformatics and Computational Biology	3-0-0	3
CML4**	Good Manufacturing Practices	3-0-0	3
CML4**	Systems Biology	3-0-0	3
CML4**	Biorefinery Engineering	3-0-0	3

$$ - In addition to above electives students can opt for other electives from different baskets

LIST OF PROPOSED HONORS PROGRAM IN B.TECH. CHEMICAL TECHNOLOGY (BIOPROCESS TECHNOLOGY)

Sr. No.	**PROPOSED HONORS PROGRAM IN CHEMICAL TECHNOLOGY (BPT)**
1.	Computation & Design
2.	Advanced Chemical Technology
3.	Advanced Chemical Engineering
4.	Sustainability & Management

ELECTIVES*

(* This is tentative list, few courses may be overlapped in other baskets also. The courses with syllabus overlapping more than 10% will not be allowed. Faculty advisor will check for the same.)

S. No.	Course Code	Computation & Design	L-T-P	Credits
1.	MAL208	Probability Theory and Statistical Methods	3-0-0	3
2	MLA205	Numerical Methods and Probability Theory	3-0-0	3
3	CML232	Introduction To Computing Software For Chemical Engineers	3-0-0	3
4	CML389	Chemical Informatics	3-0-0	3
5	CML401	Data Analytics For Chemical Engineers	3-0-0	3
6	CML402	Molecular Simulation And Informatics	3-0-0	3
7	CML415	Computational Methods In Chemical Engineering	3-0-0	3
8	CML428	CFD For Chemical Engineers	3-0-0	3
9	CML432	Computational Transport Processes	3-0-0	3
10	CML435	Computer Aided Design In Chemical Engineering	3-0-0	3
11	CML504	Mathematical Methods In Chemical Engineering	3-0-0	3
12	CML506	Process Analysis, Simulation And Design	3-0-0	3
13	CML521	Chemical Engg. Computational Fluid Dynamics	3-0-0	3
14	CML529	Optimization Techniques In Process Design	3-0-0	3
15	CML536	Analysis And Design Of Experiments	3-0-0	3

S. no.	Course Code	Advanced Chemical Technology	L-T-P	Credits
1.	CML336	Polymer Engg.	3-0-0	3
2.	CML388	Pulp And Paper Technology	3-0-0	3
3.	CML390	Technology Of Paints Pigments And Powder Coating	3-0-0	3
4.	CML391	Surface Coating Engineering	3-0-0	3
5.	CML392	Corrosion Engineering	3-0-0	3
6.	CML424	Petroleum Refinery Engineering	3-0-0	3
7.	CML425	Membrane Technology	3-0-0	3
8.	CML426	Polymer Processing	3-0-0	3
9.	CML429	Nanotechnology	3-0-0	3
10.	CML468	Ore And Mineral Processing	3-0-0	3
11.	CML522	Membrane Separation Processes	3-0-0	3
12.	CML524	Polymer Science And Engineering	3-0-0	3
13.	CML527	Mineral Beneficiation	3-0-0	3
14.	CML535	Advanced Nanotechnology	3-0-0	3
15.	CML***	Space Technology for Chemical Engineers	3-0-0	3

S. no.	Course Code	Advanced Chemical Engineering	L-T-P	Credits
1.	CML383	Advance Heat Transfer	3-0-0	3
2.	CML394	Introduction To Measuring Instruments	3-0-0	3
3.	CML427	Advanced Separation Process	3-0-0	3
4.	CML436	Advanced Separation Technology	3-0-0	3
5.	CML440	Chemical Reactor Analysis	3-0-0	3
6.	CML481	Instrumental Analytical Techniques	3-0-0	3
7.	CML501	Thermodynamics Of Phase And Chemical Equilibria	3-0-0	3
8.	CML502	Chemical And Catalytic Reaction Engineering	3-0-0	3
9.	CML503	Momentum Mass And Heat Transfer	3-0-0	3
10.	CML505	Industrial Process Control	3-0-0	3
11.	CML507	Novel Separation Processes	3-0-0	3
12.	CML525	Catalysis: Theory And Practice	3-0-0	3
13.	CML528	Interfacial Science And Engineering	3-0-0	3
14.	CML533	Mass Transfer With Chemical Reaction	3-0-0	3

S. no.	Course Code	Sustainability & Management	L-T-P	Credits
1.	CML233	Environmental Engineering	3-0-0	3
2.	CML231	Material Science And Engineering	3-0-0	3
3.	CML422	Plant Utility	3-0-0	3
4.	CML234	Industrial Waste Treatment	3-0-0	3
5.	CML342	Safety And Risk Analysis	3-0-0	3
6.	CML393	Innovative Design	3-0-0	3
7.	CML364	Green Chemistry & Engg.	3-0-0	3
8.	CML303	Process Control and Instrumentation	3-0-0	3
9.	CML439	Energy Management	3-0-0	3
10.	CML442	Reliability Engineering	3-0-0	3
11.	CML475	New And Renewable Energy Engineering	3-0-0	3
12.	CML479	Entrepreneurship Development	3-0-0	3
13.	CML491	Project Planning And Management	3-0-0	3
14.	CML526	Total Quality Management	3-0-0	3
15.	CML530	Process Intensification	3-0-0	3
16.	CML532	Energy Technology And Conservation	3-0-0	3
17.	CML534	Reliability Analysis In Process Industry	3-0-0	3

B. Tech Chemical Technology (Bioprocess Technology) Semester I

Code	Course	Type	L-T-P	Credits	Pre-requisites
CHLxxx	Chemical Science for Materials and Energy Systems	BS	3-0-0	3	None
CHP102	Chemistry	BS	0-0-2	1	None
AML1**	Engineering Mechanics	ES	3-0-0	3	None
AMP1**	Engineering Mechanics	ES	0-0-2	1	None
EEL102	Electrical Engineering	ES	3-0-0	3	None
EEP102	Electrical Engineering	ES	0-0-2	1	None
MAL101	Mathematics	BS	3-1-0	4	None
MELxxx	Basic Engineering Graphics	ES	2-0-2	3	None
MEP1xx	Engineering Workshop	ES	0-0-2	1	None
SAA101	Health Information and Sports–Part I	MNC	0-0-2	0	None
	Total Credits			**20**	

Course Code & Course Title:	**CHLxxx Chemical Science for Materials and Energy Systems**		
Course Type:	BS		
Name of the program (s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** i. To understand the fundamental principles of Water treatment, electrochemical phenomenon including corrosion, electrochemical series and battery Technology. ii. To explore the chemistry components and applications of fuel and lubricants. iii. To gain knowledge of chemistry of Engineering materials high energy materials and catalysis.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the fundamentals of water chemistry, electrochemistry
CO2	Understanding the fundamentals of fuels, lubricants and spectroscopic techniques.
CO3	Gaining the knowledge of the material synthesis and chemistry of engineering materials.
CO4	Recognize the role of high energy materials, adsorption and the catalytic process.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Water Chemistry: Sources, conservation of water, impurities in water and their effects. WHO guideline and BIS guideline for drinking water. Chemistry involved in sedimentation, coagulation and sterilization. Softening of water, lime- soda process. Ion-exchange process (zeolite and ion exchange resin) and numerical problem. Boiler troubles, causes and effects, methods of prevention.	CO1	2
Electrochemical Phenomenon and Corrosion: Electrochemical and galvanic series, polarization, decomposition potential, over voltage. Introduction to electrochemical characterization techniques – potentiometry, conductometry, cyclic voltammetry. Theories of corrosion, types of corrosion, factors influencing	CO1	2

corrosion. Corrosion Control: Design and material selection, anodic and cathodic protection, protective coatings, corrosion inhibitors.		
Battery Technology: Introduction, types and properties of batteries: Primary cells, Secondary cells (Lithium-ion battery: Chemistry involved, Cathode materials, Anode materials, Electrolytes and Separators). Fuel Cells. Solar cells.	CO1	1
Fuels and Lubricants: Fuels: Classification of fuels, Solid Fuels, Calorific Value, proximate and ultimate analysis, Carbonization, Liquid fuels, Knocking in I/C engine, Octane no, cetane no, combustion problems. Biofuels. Lubricants: Mechanism of friction, Classification: Solid, Semisolid, Liquid. Properties and applications of lubricants.	CO2	2
Spectroscopy: Interaction of radiation with matter, Molecular/Atomic Spectroscopy: Principles and applications of optical (UV-Vis) spectroscopy, Atomic absorption spectroscopy, Flame photometry, Inductively coupled plasma – Optical emission spectroscopy (ICP-OES), Vibrational (IR and Raman) spectroscopy and interpretation.	CO2	2
Industrially relevant processes for materials synthesis: Chemical methods of material synthesis: Sol-gel, co-precipitation, Pechini's method. Emulsions. Introduction to PVD and CVD, thin films. Thermochemistry, Heat and energy changes, Phase transitions.	CO3	1
Chemistry of Engineering Materials: Cement: Introduction, manufacturing and properties, fly ash utilization. Polymers: Structure property relationship. Synthesis, properties and applications of industrial grade polymers [polyester, polyethylene terephthalate (PET), silicone, nylon, polyurethane, isoprene and Bakelite]. Conducting Polymers.	CO3	2
Chemistry of High Energy Materials: Explosives: Introduction. Analytical techniques: trace and bulk level, requisites, oxygen balance, classification, properties and applications. Rocket propellants.	CO4	1
Adsorption and Catalysis: Physical adsorption, chemisorption, Freundlich's expression, Langmuir adsorption isotherm. Industrial applications of adsorption, Heterogeneous Catalysis.	CO4	1

4.	Text books

i. Dara, S. S. and S.S. Umare, A Text Book of Engineering Chemistry (Twelfth edition); S. Chand, 2014. ISBN-13: 978-8121903592
ii. Jain and Jain, Engineering Chemistry, 17th Eds; Dhanpat Rai publishing. ISBN-13: 978-9352165728
iii. Shashi Chawla, A Text Book of Engineering Chemistry. ISBN-13: 978-8177001938

5.	Reference Book(s) and Other Required Material

i. An Introduction to Electrochemistry, S. Glasstone, 2nd Edition, East west press (Pvt.) Limited. ISBN-13: 978-8176710138
ii. P.W. Atkins, Physical Chemistry, Oxford University Press. ISBN-13: 978-0198814740
iii. Bradley D. Fahlman, Materials Chemistry, 4th Eds; Springer, 2023. ISBN-13: 978-3031187834

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

Course Code & Course Title:	CHP 1** Chemistry Laboratory		
Course Type:	**BS**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**0-0-2**	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objectives:** To develop skills and capabilities of students in applying knowledge of chemistry for practically solving real life problems. Provide thorough understanding of the subject as many experiments are based on theory course.

2.	**Course Outcomes:**
CO1	Knows the proper procedures and regulations for safe handling and use of chemicals, and can follow the proper procedures and regulations for the safe handling when using chemicals.
CO2	Are able to design, carry out, record and analyze the results of chemical experiments. Are skilled in problem solving, critical thinking and analytical reasoning.
CO3	Ability to use modern instrumentation for chemical analysis and measurements.
CO4	Are able to communicate the results of their work to chemists and non-chemists.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Water and waste water analysis: Determination of i. Hardness ii. Alkalinity iii. Dissolved oxygen and free chlorine iv. Chloride, fluorides and COD v. Trace metal in water using Ion –selective electrodes, arsenic, lead, mercury		CO1, CO2, CO4	3
Determination of capacity of ion exchange resin		CO1, CO2, CO4	1
Analysis of ores and alloys: i. Determination of copper in brass ii. Calcium in limestone and dolomite.		CO1, CO2, CO4	2

Demonstration experiments on instrumental methods of analysis: i. pH-metric and conductometric titration ii. Colorimetric determination iii. Turbidity by nephelometer iv. Flame photometry v. Flashpoint of lubricants vi. Viscosity of lubricants vii. Calorific value of solid fuels viii. Proximate analysis of coal	CO1, CO2, CO3, CO4	4
Chemical kinetics / Adsorption: **i.** Determination of rate constant. **ii.** Verify Freundlich Adsorption isotherm (study adsorption of acetic acid on activated charcoal)	CO1, CO2, CO4	2
Synthesis of paracetamol and aspirin, and its characterization.	CO1, CO2, CO4	2

4.	Text books

i. Dara, S.S. and S.S. Umare, A Text Book on Experiments and calculations in Engineering Chemistry (Ninth edition); S. Chand, 2015. ISBN-13: 978-8121908641
ii. Shashi Chawla, Essentials of Experimental Engineering Chemistry, (Fourth Edition); Dhanpat Rai & Co. ISBN: 9788177000160.

5.	Reference Book(s) and Other Required Material

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

CO3	2	1	2	3	1	1	-	1	-	1	-	1	-	-	-
CO4	1	1	1	1	1	-	1	1	1	2	1	1	-	-	-

High - 3; Medium – 2; Low – 1;

Course Code & Course Title:	**AML 1** Engineering Mechanics**		
Course Type:	**ES**		
Name of the program(s):	B.Tech. in Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**-**		

1.	**Course Objective:** *To expose the students to the basic concepts of mechanics such as force, moment, static equilibrium, etc. to analyze basic force systems, and introduce basic concept of stress and strain.*

2.	**Course Outcomes:**
After completion of this course, student shall acquire:	
CO1	*Knowledge of basic theory and principles of forces, equilibrium and their engineering applications.*
CO2	*Knowledge of properties of planar section.*
CO3	*Ability to draw internal forces for beams with various boundary conditions under given set of loading.*
CO4	*Knowledge of the concepts of stresses and strains and their importance for engineering analysis and design.*

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Force systems: Planar force system, Moment of a force about a point and about an axis, Couple, Moment.		CO1	02
Equilibrium: Free Body Diagram, Equilibrium of statically determinate planar force systems, Analysis of statically determinate truss. Friction: inclined plane, wedge, ladder friction.		CO1	03
Properties of Plane area: Centroid and Moment of Inertia, Parallel Axis Theorem, Perpendicular Axis Theorem.		CO2	02
Internal forces in member: Determination of Axial Force (Axial Force Diagram), Shear Force (Shear Force Diagram), Bending Moment (Bending Moment Diagram) and Twisting Moment Diagram.		CO3	02
Concept of stress and strain: Normal and Shear Stress and Strain, Stress-Strain Curve, Hook's Law, Modulus of Elasticity, Poisson's Ratio, Modulus of Rigidity, Bulk Modulus, Shear Modulus,		CO4	03

Thermal Stresses.		
Determination of stress: Stress across a Rectangular Section due to bending moment, Stress across a Rectangular Section due to Shear Force.	CO4	02

4.	Text books

i. Beer, F. P., Johnston, E. R., Jr., Cornwell, P. J., Mazurek, D. F., & Sanghi, S., Vector Mechanics for Engineers: Statics and Dynamics. 10th ed., McGraw-Hill Education, 2019.
ii. Beer, F.P., Johnston, E.R., DeWolf, J.T., and Mazurek, D.F., Mechanics of Materials. 6th ed., McGraw-Hill, 2012
iii. Hibbeler, R. C. Engineering Mechanics. 7th ed., Pearson Education, 2004.

5.	Reference Book(s) and Other Required Material

i. Meriam, J. L., and L. G. Kraige. Engineering Mechanics: Dynamics. 7th ed., John Wiley & Sons, 2012.
ii. Popov, E. P. Engineering Mechanics of Solids. Prentice Hall, 1990.
iii. Pytel, Andrew, and Ferdinand L. Singer. Strength of Materials. Harper & Row Publishers, 1987.
iv. Shames, I. H. Engineering Mechanics: Statics and Dynamics. Pearson Education Asia Pvt. Ltd., 1996.
v. Timoshenko, S. Strength of Materials, Part 1: Elementary Theory and Problems. CBS Publishers and Distributors, 2021.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

7.	Relationship of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3		2			1			2				1	2	1	
CO2	2	1	1	1	1	1			2				2	2	2	
CO3	2	2	1	1	1	1			2				1	1	1	
CO4						1		1	1	2			3	2	2	

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	**AMP 1** Engineering Mechanics Laboratory**		
Course Type:	**ES**		
Name of the program(s):	B.Tech. in Chemical Engineering/ B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**-**		

1.	**Course Objective:** To expose the students to simple practical experiments based on fundamental concept of mechanics

2.	**Course Outcomes:**
After completion of this course, student shall acquire:	
CO1	*Knowledge of experimental verification of laws of mechanics.*
CO2	*Knowledge and ability to compare theoretical results with the experimental one.*
CO3	*Knowledge of frictional resistance between two surface and ability to determine coefficient of friction.*
CO4	*Knowledge of mechanical properties of metals and ability to obtain the same through experiment.*

3.	**Detailed Description of the Course**		
Topics (Any Eight)		**CO(s) Addressed**	**Duration in weeks**
Introduction to Engineering Mechanics		CO1	1
Proving the Law of Polygon of Forces		CO1, CO2	1
Verification of Lami's Theorem		CO1, CO2	1
Determination of forces in truss members by analytical and experimentally		CO2	1
Determination of Reactions of a Simply Supported Beam		CO1, CO2	1
Determination of Coefficient of Static Friction		CO3	1
Determination of centroid of Planar Figures		CO1, CO2	1

Tension Test on Metal Specimen	CO1, CO4	1
Bending Test on Wooden Beam	CO1, CO4	1
Shear test on metal specimen	CO1, CO4	1

4.	**Text books**

i. Beer, F. P., Johnston, E. R., Jr., Cornwell, P. J., Mazurek, D. F., & Sanghi, S., Vector Mechanics for Engineers: Statics and Dynamics. 10th ed., McGraw-Hill Education, 2019.
ii. Beer, F.P., Johnston, E.R., DeWolf, J.T., and Mazurek, D.F., Mechanics of Materials. 6th ed., McGraw-Hill, 2012
iii. Hibbeler, R. C. Engineering Mechanics. 7th ed., Pearson Education, 2004.

5.	**Reference Book(s) and Other Required Material**

i. Meriam, J. L., and L. G. Kraige. Engineering Mechanics: Dynamics. 7th ed., John Wiley & Sons, 2012.
ii. Popov, E. P. Engineering Mechanics of Solids. Prentice Hall, 1990.
iii. Pytel, Andrew, and Ferdinand L. Singer. Strength of Materials. Harper & Row Publishers, 1987.
iv. Shames, I. H. Engineering Mechanics: Statics and Dynamics. Pearson Education Asia Pvt. Ltd., 1996.
v. Timoshenko, S. Strength of Materials, Part 1: Elementary Theory and Problems. CBS Publishers and Distributors, 2021.

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2		2	2				3	3	1	1	2	1	1	
CO2	3	2		2	2				3	3	1	1	2	1	1	
CO3	2	2	1	1	1	1			2				1	1	1	
CO4						1		1	1	2			3	2	2	

High - 3; Medium – 2; Low – 1;

8	**List of Indicative Laboratory Experiment (if applicable):**

EEL1** Electrical Engineering (CSE, CHEM, ECE, MECH)

Course Code & Course Title:	**EELXXX Electrical Engineering**		
Course Type:	ES		
Name of the program(s):	B.Tech. - CSE, CHEM, ECE, MECH,CT-BPT		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	NIL		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**
	• To learn basic ideas and principles of Electrical Engineering • Understanding the details of electrical machines.

2.	**Course Outcomes : Students will be able to**
CO1	Understand the basics of electrical components and power system.
CO2	Calculate DC, AC, and magnetic circuits parameters using KCL and KVL.
CO3	Determine performance parameters of transformers.
CO4	Evaluate performance of electrical machines.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Electrical Circuits: Circuit elements: resistance, inductance, and capacitance; voltage and current sources, definition, ideal and practical sources, source conversions, Kirchhoff's Laws and star-delta transformation.		CO1	2
Magnetic Circuits: Flux, MMF, reluctance; analogy with electric circuits; simple calculations for composite magnetic circuits.		CO1	2
AC Circuits: Periodic signals, average and R.M.S. values, phasor representation, steady-state analysis of ac circuits with sinusoidal excitation, reactance and impedance, series and parallel AC circuits, power factor, active, reactive and apparent power, series and parallel resonance, principle of generating single-phase and three-phase voltages, Balanced three-phase AC systems: Voltages, currents, and powers in star and delta connected load.		CO2	3.5
Single phase Transformers: Construction, types, basic principles, EMF equation, ideal and practical transformers, equivalent circuits, voltage regulation, and efficiency.		CO3	2.5

DC Motors: Construction, types, applications, significance of Back EMF, Speed and Torque equations, speed control, and need of motor starter.	CO4	1.5
Induction Motors: Three-phase induction motor—construction, types, applications, revolving magnetic field, principle of operation, synchronous speed, rotor speed, slip, power flow diagram, torque equation, and T-s characteristics, Block diagram of induction motor drive. Single-phase induction motors—principle of operation, types and applications.	CO4	1.5
Introduction to Generation, Transmission and Distribution of Electricity	CO1	1

4.	Textbooks

i. D. C. Kulshreshtha, Basic Electrical Engineering, Second Edition, McGraw-Hill, 2019, ISBN: 9353167213.
ii. S.K. Bhattacharya, Basic Electrical and Electronics Engineering, Second Edition, Pearson Education, 2017, ISBN: 9789332586505.

5.	Reference Book(s) and Other Required Material

i. Edward Hughes, Electrical and Electronic Technology, Tenth Edition, Pearson Education, 2010, ISBN: 9788131733660.
ii. Kothari D.P. and Nagrath I.J., Basic Electrical Engineering, Fourth Edition, McGraw-Hill, 2019, ISBN: 9353165725.
iii. N. K. De, G. D. Roy, T. K. Bhattacharya, IIT Kharagpur, Basic Electrical Technology, Web course of NPTEL

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Sem: 20-30 Marks, End Sem: 50-60 Marks, Quiz/Internal assessment: 10-20 Marks, Total 100 Marks

7.	Relationship of Course Outcomes to Program Outcomes:

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

EEP1** Electrical Engineering Laboratory (CSE, CHEM, ECE, MECH)

Course Code & Course Title:	**EEPXXX Electrical Engineering Laboratory**		
Course Type:	ES		
Name of the program(s):	B.Tech. - CSE, CHEM, ECE, MECH, CT-BPT		
L – T – P	0-0-2	**No. of Credits**	1
Pre-requisites: Course Code(s) & Name(s)	NIL		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**
	• To verify basic ideas and principles of various Electrical Circuits. • Understanding the principle and operation of electrical machines.

2.	**Course Outcomes: Students will be able to**
CO1	Understand behaviour of R, L, C circuit elements, voltage and current sources.
CO2	Appreciate and analyse magnetic circuits.
CO3	Familiar with various machines operations
CO4	Verify various parameters of three phase circuits.

3.	**Detailed Description of the Course**		
Topics (List of Experiments)		**CO(s) Addressed**	**Duration in Weeks**
1. Study and verification of Kirchhoff's Laws applied to direct current circuit.		CO1	1
2. Determination of B-H curve of a magnetic material		CO2	1
3. Study of AC series circuits.		CO1	1
4. Study of AC Parallel circuits.		CO1	1
5. To determine Voltage regulation and efficiency of a single phase transformer by direct loading.		CO3	1
6. Reversal of direction of rotation of a three phase induction motor.		CO3	1
7. To study balanced three phase circuit- star connection.		CO4	1
8. To study balanced three phase circuit- delta connection.		CO4	1
9. Speed control of a DC motor by varying :- a. Field current with armature voltage kept constant b. Armature voltage with field current kept constant.		CO3	1
10. Assessment 1 + Assessment 2 + Quiz / Viva		All COs	5

4.	Textbooks

i. B.S. Umre and D. P. Kothari, Laboratory Manuals for Electrical Machines, 2nd Edition, I. K. International, 2018, ISBN: 978-93-85909-75-7
ii. S. G. Tarnekar and P. K. Kharbanda, Laboratory Courses in Electrical Engineering, 3rd Edition, S. Chand, ISBN: 9788121901048.

5.	Reference Book(s) and Other Required Material

i. D. C. Kulshreshtha, Basic Electrical Engineering, Second Edition, McGraw-Hill, 2019, ISBN: 9353167213.
ii. P. Tiwari & S. Gairola, Electrical Engineering Laboratory Practice, First Edition, S.K. Kataria & Sons, 2012, ISBN: 978-81-89757-89-2.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Continuous Evaluation, Total 100 Marks

7.	Relationship of Course Outcomes to Program Outcomes:

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

Course Code & Course Title:	**MAL1**-MATHEMATICS-I**		
Course Type:	BS		
Name of the program(s):	B.Tech.(CME, CIV, CSE, ECE, EEE, MIN, CT-BPT)		
L – T – P	3-1-0	**No. of Credits**	4
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s)& Name(s)			

1.	**Course Objective:** The objective of this subject is to expose students to understand the basic importance of Differential calculus, Integral calculus, Infinite series, and Matrix theory in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**After completing this course, students will be able to
CO1	Test the convergence of sequence and series.
CO2	Deal with differential calculus of functions of single variable and its applications.
CO3	Understand concepts of integration of functions of single variables and their applications.
CO4	Understand basic concepts of matrix theory and can apply it to solve problems of Engineering
CO5	

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Sequences and Series: Sequences of real and complex numbers, Monotonic sequence, Bounded Sequences, Convergence of Sequence. Infinite series, tests of convergence (Comparison test, Ratio test, Root test, Raabe’s test, Logarithm test and Integral test statements only), absolute and conditional convergence, power series, radius of convergence.	**CO1**	3-4 weeks
Differential Calculus of function of single variable: Review of limit, continuity, and differentiability. Mean value theorems: Rolle’s theorem, Lagrange’s theorem, Cauchy’s theorem, Taylor’s theorem with Lagrange’s form of remainder,	CO2	3-4 weeks

curve tracing.		
Integral Calculus: Fundamental theorem of Integral calculus, mean value theorems, evaluation of definite integrals. Differentiation under integral sign including variables limits-Leibnitz rule (without proof). Applications in area, length, volumes, and surface of solids of revolutions. Improper integrals and tests for convergence, Beta and Gamma functions,	CO3	3-4 weeks
Matrices: Gauss-Elimination and Gauss-Jordan Elimination methods for solving system of linear equations, Rank of matrix, consistency of a system of equations, linear dependence and independence, linear and orthogonal transformations, Eigenvalues and eigenvectors, Cayley-Hamilton theorem, reduction to diagonal form, Hermitian and skew Hermitian matrices, Quadratic forms.	CO4	3-4 weeks

4.	**Text books**

i) Jain,R.K. and Iyengar, S.R.K., Advanced Engineering Mathematics; Narosa Publishers.

ii) James Stewart, Calculus-Early transcendental, 5th edition, Thomson™ Brooks/Cole-Indian Edition, 2007

iii) Kreyszig, E, Advanced Engineering Mathematics, 8th Edition, John Wiley & Sons.

iv) Thomas, G. B. and Finney, R. L., Calculus and Analytic Geometry, 9th Edition, Addison-Wesley Longman, Inc.

5.	**Reference Book(s) and Other Required Material**

i) Piskunov, N., Differential and Integral calculus, Vol.1, Vol.2 MIR Publishers, Moscow–CBS Publishers and Distributors (India).

ii) Sudhir R. Ghorpade, Balmohan V. Limaye, A Course in Calculus and Real Analysis, 2nd Edition, Springer, New York, NY. 2018.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**

CO1	3	2	1									2			
CO2	3	2	1									2			
CO3	3	2	1									2			
CO4	3	2	1									2			
CO5															

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**MELXXX - Basic Engineering Graphics**		
Course Type:	ES		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	2-0-2	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s)& Name(s)			

1.	**Course Objective:**

1. To understand the principles and methods of projections as per the National Standards.
2. To develop the visualization skills for the interpretation of the use of various objects like lines, planes, solids, sections of solids & development of lateral surfaces.
3. To acquire skills to interpret and convert multi-view drawings into single-view drawings and vice versa.
4. To understand and acquire basic skills in Computer-Aided Drafting.
5. Students will be able to create, assemble, and generate professional engineering drawings from 2D and 3D models using a CAD software package

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand the conventions and standards for engineering drawing.
CO2	Students will be able to apply the knowledge of projections and methods to prepare the drawing for lines, planes, solids, sections of solids and development of lateral surfaces.
CO3	Students will be able to visualize and convert 2D to 3D drawing and vice versa.
CO4	Students will be able to understand and apply Computer Aided Drafting in real practice
CO5	Students will be able to create, assemble, and generate professional engineering drawings from 2D and 3D models using a CAD software package.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Introduction to BIS SP-46-2003, Use of various drawing instruments, Concept of scales, Representative Fraction (RF) and dimensioning.		CO1	01
Conversion of Pictorial views to orthographic/ profile views		CO3	1.5
Projections of points, lines, plane on principle planes		CO2	1.5
Projection of right regular solids inclined to both the planes. Section and development of surfaces of solids. (Preferably in normal position).		CO2	03

Drawing isometric views and projection from orthographic projection.	CO3	02
Introduction to Computer Aided Drafting (CADr)- Basic commands for Setting, Drawing, Editing, Writing, Dimensioning and other features.	CO4	02
3D modelling: 3D tools, bar/commands for creation of a solid model. Orthographic projections from 3D model. Assembly drawings of simple parts.	CO5	03

4.	Text books

i) Bhatt, N. D., Panchal, V. M., & Ingle, P. R., *Engineering Drawing (Plane and Solid Geometry)*, 53rd Edition, Charotar Publishing House Pvt. Limited, 2013, ISBN 978-93-80358-83-3.

ii) Dhananjay, A. J., *Engineering Drawing: With An Introduction To Auto Cad*. Tata McGraw-Hill Education Private Limited, 2010, ISBN 978-0-07-064837-1.

5.	Reference Book(s) and Other Required Material

i) Engineering Drawing Practices for School & Colleges SP46:2003, Bureau of Indian Standards, 2003, ISBN 81-7061-019-2

ii) Kuthe A.M., Computer Graphics including CAD, AutoCAD & C, 1st Edition, S.Chand, 2005, ISBN 9788121924610.

iii) Zeid I., CAD / CAM Theory & Practice, 3rd Edition, Tata McGraw-Hill, 1991, ISBN-0070728577.

6.	Evaluation Details:

Assessment: Mid Sem 30 % + TA 10 to 20% + End Sem 50 to 60%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

CO5	2	2	2	2	3	2	3	2	3	3	3	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative practical Assignments**

1. Orthographic Projection of objects
2. Projection of points and lines
3. Projections of planes
4. Projection of regular solids
5. Projection of sections of a solid
6. Development of the lateral surfaces of a solid
7. Isometric projection of objects.
8. 2D drawing/orthographic views using CAD software.
9. 3D models/part drawing using CAD software.

Course Code & Course Title:	**MEP1xx - Engineering Workshop**		
Course Type:	ES		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	**No. of Credits**	1
Pre-requisites: Course Code(s) & Name(s)	**NIL**		
Course Equivalence: Course Code(s)& Name(s)	**NIL**		

1.	**Course Objective:**

The objectives of the course are

i. To make the students aware with various skills involved in basic engineering processes for manufacturing and assembly.
ii. To make students aware of various basic engineering processes like cutting, filing and joining and to have hands on experience for the same.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Acquire skills in basic engineering practice.
CO2	Identify the hand tools and instruments.
CO3	Gain measuring skills.
CO4	Obtain practical skills in the various trades.
CO5	Enhance psycho motor skills and attitude

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Fitting: Use and setting of fitting tools for chipping, cutting, filing, and marking, center punching, drilling, and tapping. Term work to include one job involving following operations: Filing to size, drilling and tapping.	CO1 to CO5	04
Welding: Use and setting of tools and equipments for edge preparation for welding jobs and Arc welding for Jobs like, Lap welding of two plates, butt welding of plates.	CO1 to CO5	04
Machining: At least one metal turning job is to be demonstrated.	CO1 to CO5	02
CNC Machines: One job on CNC Lathe and CNC Milling	CO1 to	01

machine to be demonstrated.	CO5	
Plumbing: Use and setting of hand tools like hacksaws, Vices, V blocks, Taps, Tap wrenches, Pipe Course Book First Year B. Tech. (2024-2025) wrenches, Pipe threading dies, pipe bending dies, Pipe cutters, callipers etc for plumbing works. At least one job/ demonstration involving threading and joining of pipes.	CO1 to CO5	01

4. Text books

i. Hajra Choudhury, S. K., Hajra Choudhury, A. K., & Roy, Nirjhar, *Elements of Workshop Technology (Volume I: Manufacturing Processes)*, 14th (or 16th revised) Edition, Media Promoters & Publishers (Mumbai, India), 2008 (revised); ISBN 978-8185099149.
ii. Hajra Choudhury, S. K., Hajra Choudhury, A. K., & Roy, Nirjhar, *Elements of Workshop Technology (Volume II: Machine Tools)*, 16th Edition (Revised & Enlarged), Media Promoters & Publishers Pvt. Limited, 2014, ISBN 978-8185099156

5. Reference Book(s) and Other Required Material

i. Chapman, W. A. J., *Workshop Technology, Part I: Theoretical and Practical Workshop Technology*, 5th Edition, CBS Publishers & Distributors, 2001, ISBN 978-81-239-0401-6.
ii. Chapman, W. A. J., *Workshop Technology, Part II: Machine-Shop Practice and Workshop Calculations*, 3rd Edition, Edward Arnold (Publishers) Ltd., 1997, ISBN 978-0713134893.
iii. Chapman, W. A. J., *Workshop Technology, Part III: Special Workshop Practice*, 3rd Edition, Edward Arnold (Publishers) Ltd., 1961, ISBN 978-0713134992.

6. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

CO2	3	1	2	1	1	2	2	2	3	2	2	1			
CO3	3	1	2	1	1	2	1	2	3	2	1	2			
CO4	3	1	2	1	1	3	2	2	3	2	1	2			

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	**SAA101 - Health Information And Sports–Part I**		
Course Type:	MNC		
Name of the program(s):			
L – T – P	0-0-2	**No. of Credits**	0
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s)& Name(s)			

1.	**Course Objective:**
	a) To provide information about physical, physiological & psychological aspects of sports & physical. b) To create awareness among the students about their health status, by conducting various physical fitness tests and suggest them suitable remedial physical fitness program. c) To make students aware about the rules and regulation of different games & sports. d) To provide opportunity to mingle with each other through participating in different physical education & sports activities. e) To deliver the knowledge of daily calorie requirement to manage the obesity

2.	**Course Outcomes:**
CO1	Enriched proper knowledge among the students about emerging issues such as health & fitness, wellness etc.
CO2	Students will become aware about the sense of discipline & dedication in general life, develop the spirit of team work through various physical education & sports activities.
CO3	Development of rational thinking and scientific temper among the students.

3.	**Detailed Description of the Course**	
Topics	**CO(s) Addressed**	**Duration in weeks**

Introduction to psychological problem of a sports person	CO1,CO2,CO3	8-12
Warming up, cooling down & full body stretching and its importance	CO1,CO2,CO3	8-12
Obesity & its Management :Daily caloric requirements and daily energy expenditure	CO1,CO2,CO3	8-12
Scientific principles of training	CO1,CO2,CO3	8-12
Health &performance related physical fitness	CO1,CO2,CO3	8-12

4.	**Practical**	
Topics	**CO(s) Addressed**	**Duration in weeks**
Practice of skills of major games like: Badminton, Table Tennis, Chess, Yoga, Basketball, Football, Handball, Cricket, Kho-Kho , Lawn Tennis, Throw ball, Athletics & Kabaddi	CO1,CO2,CO3	8-12
Screening of health related physical Fitness	CO1,CO2,CO3	8-12
Participation in Intramural Sports Program	CO1,CO2,CO3	8-12
Preparation for Physical Efficiency Test Level-1	CO1,CO2,CO3	8-12

5.	**Reference Books & other required materials**
	i. Arnold G. Nelson,(2007),"Stretching Anatomy" Human Kinetics: Online available : https://www.therajordanmassage.com/doc/3_%20Stretching%20Anatomy.pdf
	ii. Matt Jarvis, Sports Psychology, Taylor & Francis e- library, 2005
	iii. Tudor O Bompaand G Gregory Haff, Periodization theory & methodology of training, 5th Edition, Human Kinetics 2009

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**
	Continuous evaluation Assessment- End Semester 100%

B. Tech Chemical Technology (Bioprocess Technology) Semester II

Code	Course	Type	L-T-P	Credits	Pre-requisites
CSL1**	Computer Programming	ES	3-0-2	4	None
ICLA101	Environmental Studies	IC	2-0-0	2	None
******	OC/HM	OC /HM	3-0-0	3	None
HULxxx	English and Corporate Communication	HU	2-0-2	3	None
PHL1**	Physics	BS	3-0-0	3	None
PHP1**	Physics	BS	0-0-2	1	None
IELxxx	Institute Elective-I	IE	3-0-0	3	None
CML1xx	General Biology	DC	3-0-0	3	None
SAA102	Health Information and Sports–Part II	MNC	0-0-2	0	None
	Total Credits			22	
Certificate Exit Additional Course					
CMP3xx	Bioprocess Technology Laboratory	DC	0-0-2	1	None

Course Code & Course Title:	**CSL1** Computer Programming**
Course Type:	**ES**
Name of the program(s):	**B.Tech. Computer Science & Engineering,** B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	**3-0-2** **No. of Credits** **4**
Pre-requisites: Course Code(s) & Name(s)	**None**
Course Equivalence: Course Code(s) & Name(s)	

Course Objective:

- To develop students' proficiency in structured programming using C by teaching them essential constructs (variables, data types, operators, I/O, control flow), foundational problem-solving algorithms, modular and structured data handling (arrays, functions, structures), and basic file operations—empowering them to design, implement, and debug efficient, maintainable programs for real-world computational tasks.

1.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Remember and understand the fundamental programming constructs—such as program structure, data types, operators, expressions, and formatted I/O
CO2	Implement computational logic using decision structures and loops to solve problem
CO3	Analyze and modularize solutions using arrays, strings, and user-defined functions (including recursion) to implement algorithms
CO4	Apply and design structured data and persistent storage solutions by using C structures (including nested and arrays of structs) and basic file-handling operations (text and binary I/O).

2.	**Detailed Description of the Course**		

	Topics	**CO(s) Addressed**	**Duration in weeks**
1	Introduction: Fundamentals of Computer programming, Program development and execution, basics of algorithms and flow charts and the software development lifecycle.	CO1	1.5
2	Basic constructs of C programming: Structure of Programs, Keywords and Identifiers, Variables and Data Types, Operators and Expressions (Precedence and Associativity, Type Conversions), Formatted Input/Output.	CO1	1.5
3	Control Flow: Decision Making and Branching (if, if-else), Loops (while, for). Algorithms such as swapping two variables, reversing digits, character-to-number conversion,	CO1,CO2	3

	generating primes, GCD, smallest divisor, factorial, and Fibonacci generation through loops, nested-loop pattern printing.		
4	Data Organization & Modularity: Arrays and Strings (1-D arrays, 2-D arrays, basic string operations), Functions (user-defined functions, scope and lifetime of variables, recursive functions); Algorithms like array reversal, finding maximum number in a set, factorial computation, Fibonacci sequence generation, reversing the digits of an integer; sorting and searching techniques and comparison	CO3	3
5	Composite Data Types: structures, defining struct types, declaring instances, accessing members using the dot operator, memory layout and padding. Array of Structures: Declaring arrays whose elements are structures; Nested Structures: Embedding one struct type within another (either defined separately or inline), accessing nested members.	CO4	3
6	File handling: Opening and creating files, Closing files, Text file reading, Text file writing, Binary file reading, Binary file writing.	CO4	2

3.	**Text books (Theory and Practical):** 1. The C Programming Language by Brian Kernighan and Dennis Ritchie. ISBN:9780131101630 2. How to Solve It by Computer by R. G. Dromey. ISBN-13. 978-8120303881

4.	**Reference Book(s) and Other Required Material**
	1. Algorithms in C by Robert Sedgewick ISBN-13:9780-0201314526 2. Algorithms (4th Edition) by Robert Sedgewick & Kevin Wayne ISBN-13: 978-0321573513 3. Introduction to Algorithms (commonly known as *CLRS*) by Cormen, Leiserson, Rivest & Stein ISBN-13: 978-0262033848

5.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Code	**Type**	**Structure L+T+P**	**Credits**	**Evaluation Weightage (%)**	
				Method	**Range**
L	**Lecture with built-in practical**	**L:3 T:0 P:4**	**L+0.5P**	**Mid Semester Exam.**	**25**

				End Semester Exam.	**50**
				Quiz	**10**
				Continuous Evaluation-I (Pr.)	**7.5**
				Continuous Evaluation-II (Pr.)	**7.5**

6.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

Sr. No.	Sample Lab Assignments	CO Addressed
1	Basic Input-Output/Data types/data operators Program to Swap two numbers. Calculation of simple interest and compound interest.	CO1
2	Conditional Statements/ Loops Input month number and print number of days in a month Factorial Of a given number. Check the entered no is prime or not. Print patterns using nested loops.	CO1, CO2

3	Arrays : 1-D array, 2-D array , Strings : String functions, string.h library Input two sorted arrays and merge to one array. Search element from an array. Reverse an array element.	CO2, CO3
4	Functions, Recursion and Structures. Call a simple function to find the sum of digits of a number. Recursive function to generate fibonacci series. Addition of complex numbers using structure. Store multiple records of student details using an array of structures.	CO3, CO4
5	File handling. Count the number of words and characters in a given text file. Replace the specific line from a file. Copy the content of source file into destination file	CO4

Course Code & Course Title:	**ICLA101: Environmental Studies**		
Course Type:	**IC**		
Name of the program(s):			
L – T – P	2 – 0 - 0	**No. of Credits**	**02**
Pre-requisites: Course Code(s) & Name(s)	--		
Course Equivalence: Course Code(s) & Name(s)	--		

	Course Objective

1. To introduce various natural resources, their importance and status.
2. To introduce the concepts of ecosystem, their structure and functions.
3. To introduce the concept of biodiversity conservation.
4. To introduce possible causes of various forms of environmental pollution and their consequences, methods of prevention.
5. To introduce various social and climatic changes due to pollution.

1.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand about various natural resources, their importance and status.
CO2	Understand the concepts of ecosystem and biodiversity, their structure, functions and conservation.
CO3	Understand the causes of various forms of environmental pollution and their consequences, and methods of prevention.
CO4	About the various changes in social and climate due to pollution and population and the environment.

2.	**Detailed Description of the Course**		
Topics		**CO(s)**	**Duration in weeks**
Natural resources: Forest resources, Water resources, Mineral resources, Food resources, Energy resources,Land resources.		CO1	04
Ecosystem: Concept of an ecosystem, Structure and functions of an ecosystem, Producers, consumers and decomposers, Food chain, food webs and pyramids. Biodiversity and its conservation: Introduction, definitions: genetics, species and diversity, Value of biodiversity, Biodiversity at global, national and local level, India as a mega-diversity nation, Hot-spot of biodiversity, Threat to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts, Conservation of biodiversity: in-situ and ex-situ conservation.		CO2	03
Environmental pollution: Definition, Causes, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards, Solid waste management: Causes, effects and control measures of urban and industrial wastes.		CO3	06

Social issues and environment: Sustainable development, Water conservation, Rain water harvesting, Watershed management, Climate change, Global warming, Acid rain, Ozone layer depletion, Nuclear accident, Environmental rules and regulations. Human population and environment: Population growth, Environment and human health, Human rights, Value education, Role of information technology in environment and human health.	CO4	02

3.	Text books

i. Rajgopalan R., Environmental Studies, 3rd Edition, Oxford University Press, 2023. ISBN: 13. 9789354978944
ii. Benny Joseph, Environmental Studies, 3rd Edition, McGraw Hill, 2017. ISBN: 10. 9352605179
iii. Erach Barucha, Environmental Studies, 3rd Edition, Universities press (India), 2025, ISBN: 9789389211788

4.	Reference Book(s) and Other Required Material

i) Rao M.N. and Rao H.V.N., Air Pollution, 1st Edition, McGraw-Hill Publishing Company Limited, 2007. ISBN: 13, 978-0074518717.
ii) Rao C.S., Environmental Pollution Control Engineering, 3rd Edition, Wiley Eastern Limited, New Age International Limited, 1995. ISBN: 13. 978-9386649898.

5.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Term Examination: 30 Marks
Continuous Assessment (Seminars): 10 Marks
End Term Examination: 60 Marks
Total Marks: 100

6.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

7.	List of Indicative Laboratory Experiment (if applicable):

NA

Course Code & Course Title:	**HULxxx English And Corporate Communication**		
Course Type:	**IC**		
Name of the program(s):	**B.Tech**		
L – T – P	**2-0-2**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**HUL101**		

1.	**Course Objective:**

To impart the students with the skills they need in their academics and later in their professional pursuit

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Acquaint learners with basic of communication
CO2	Familiarize learners with nuances of corporate communication
CO3	Emphasize the importance of verbal and non-verbal communication
CO4	Discuss key features of corporate communication
CO5	Prepare learners for workplace challenges

3.	**Detailed Description of the Course**		
	Topics	**CO(s)**	**Duration in weeks**
	Introduction to Communication • Principles of Communication • Channels of Communication • Inclusive Communication Practices • Speaking and Listening Skills for Communication	CO1	2
	Introduction to Corporate Communication • Different Forms of Corporate Communication • Factors Influencing Corporate Communication • Interpersonal Communication • Communication for Effective Leadership	CO2	2
	Verbal and Non-verbal Communication • Reading and Writing Skills for Corporate Communication • Nonverbal Communication in Corporate Setting • Interview and Group Discussion • Presentation Skills	CO3	4
	Features of Corporate Communication • Levels of Corporate Communication • Barriers to Communication • Organizational Communication • Dos and don’ts of corporate communication	CO4	2
	Strategies of Communication • Negotiating Conflict and Management • Crisis Communication	CO5	2

• Emotional Intelligence and Stress Management • Ethics in Corporate Communication		

4.	Text books

i. Joep Cornelissen, *Corporate Communication: A Guide to Theory and Practice*, 6^{th} Edition, SAGE Publications, 2020, ISBN 1526491982.
ii. Meenakshi Raman and Prakash Singh, *Business Communication*, 2^{nd} Edition, Oxford University Press, 2012, ISBN 9780198077053.
iii. Shirley Taylor and V. Chandra, *Communication for Business: A Practical Approach*, 1^{st} Edition, Pearson, 2010, ISBN 9788131727652.

5.	Reference Book(s) and Other Required Material

i. Ashraf Rizvi, *Effective Technical Communication*, 2^{nd} Edition, McGraw Hill Education, 2017, ISBN 9352605780.
ii. Courtland L. Bovee, John V. Thill, et al., *Business Communication Today*, 14^{th} Edition, Pearson, 2018, ISBN 9789353062682.
iii. Mary Ellen Guffey and Dana Loewy, *Business Communication: Process and Product*, 10^{th} Edition, South-Western College Publishing, 2021, ISBN 0357129237.
iv. Paul A. Argenti, *Corporate Communication*, 7^{th} Edition, McGraw-Hill Education, 2016, ISBN 9814636193.
v. Sharon Gerson and Steven Gerson, *Technical Communication: Process and Product*, 8^{th} Edition, Pearson Education India, 2014, ISBN 9332518599.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Semester Examination – 20 Marks
Teacher Defined Assessment – 20 Marks
End Semester Examination – 60 Marks

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Week 1.	Ice Breaker
Week 2.	Oral Presentation
Week 3.	Listening Activity
Week 4.	Role Play
Week 5.	Group Discussion
Week 6.	Writing Activities
Week 7.	Peer Interview
Week 8.	PPT Presentation
Week 9.	Debate
Week 10.	Corporate Meeting
Week 11.	Case Study
Week 12.	Interviewing Strangers

Course Code & Course Title:	PHL1** Physics		
Course Type:	**BS**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)			

1.	Course Objective:

1. To provide a strong foundation in physics in preparation for technical or scientific career.
2. To develop skills that enables to function as productive, qualified engineering professionals in areas where traditional science and engineering disciplines overlap.
3. Create awareness about the importance of continued professional development.

2.	**Course Outcomes (Min. 3 & Max. 5):** Student will be able to:
CO1	Understand the concepts of quantum mechanics and its application
CO2	Comprehend the primitive crystal systems through packing density and Miller indices.
CO3	Develop an understanding for basics of semiconductors based on band theory applied to electronic devices
CO4	Understand the concept of ultrasonics and their applications
CO5	Learn the basics of LASERs and its applications in optical fibers

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Quantum Mechanics: Origin of quantum mechanics, Compton effect, Concept of matter waves, Davisson and Germer's experiment, Heisenberg's Uncertainty principle, Schrodinger's Wave equation and its application and Quantization of energy.	CO1	3
Elementary crystal structure: Unit cell and its characteristics in SC, BCC, FCC crystal structure, Miller indices, Bragg's Law, inter-planer spacing.	CO2	2
Semiconductor Physics: Formation of energy bands in solid, classification of solids: intrinsic and extrinsic semiconductor, Fermi level in an intrinsic and extrinsic semiconductor, Hall effect, PN junction diode and BJT	CO3	3
Ultrasonics: Piezoelectricity, magnetostriction, ultrasonic waves and their application in non-destructive testing, sensors.	CO4	2
LASER Optics: Introduction to LASER, Spontaneous and Stimulated Emission, Different types of CW & Pulse lasers & their characteristics, Principle & characteristics of optical fibres, Different types of optical fibres	CO5	2

4.	**Text books**

i) M N Avadhanulu, P. Kshirsagar, A Textbook of Engineering Physics, 2017, S Chand Publications ISBN 13: 9789352833993

5.	**Reference Book(s) and Other Required Material**

i) A.J. Dekker, Solid State Physics, MacMillan, Student Edition (2000) ISBN-13. 9780333918333

ii) B.B. Laud, Lasers and nonlinear optics, New Age International limited (1991). ISBN-13. 978-9393159670.

iii) B. G. Streetman, Solid State Electronics, Prentice Hall India (2^{nd} Edition) (1986) ISBN-13. 978-0134363790

iv) B. E. Conway Electrochemical Supercapacitors Scientific Fundamentals and Technological Applications 2013 Springer US ISBN : 9781475730586

v) David J. Griffiths, Introduction to Quantum Mechanics, Cambridge India (2016) ISBN-13. 978-1107179868

vi) Kenneth Krane; Modern Physics, John Wiley Eastern (2^{nd} Edition); (1998) ISBN-13, 978-0471828723

vii) Resnick, Walker and Halliday, Fundamental of Physics, John Willey and Sons. Inc, 6^{th} Edition (2005). ISBN · 9788126508235

viii) S.M. Sze Semiconductor devices (Physics and Technology), II Edition, Wiley India Pvt. Ltd. ISBN-13. 978-0470873670

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Mid Sem: 30 Marks,

End Sem: 50 Marks,

Quiz/Internal assessment: 20 Marks,

Total 100 Marks

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	2			1					1
CO2	3	2	2			1					1
CO3	3	2	2			1					1
CO4	3	2	2			1					1
CO5	3	2	2			1					1

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	PHP1** Physics Lab		
Course Type:	**BS**		
Name of the program(s):	B Tech (MME/CIV/CME, CT-BPT)		
L – T – P	0-0-2	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)			

1.	Course Objective:

1. The Objective of this course is to make the students gain practical knowledge to co-relate with the theoretical studies.
2. To achieve perfectness in experimental skills and the study of practical applications will bring more confidence and ability to develop and fabricate engineering and technical equipment.
3. Design of circuits using new technology and latest components and to develop practical applications of engineering materials and use of principle in the right way to implement the modern technology.

2.	**Course Outcomes (Min. 3 & Max. 5):** Student will be able to:
CO1	Apply the concepts of quantum mechanics.
CO2	Apply the understanding for basics of semiconductors based on band theory applied to electronic devices
CO3	Gain hands on experience of studying the characteristics of Ultrasonic waves
CO4	Understand the principle of LASER and apply it in optical fibers

3.	Detailed Description of the Course		
List of experiments		**CO(s) Addressed**	**Duration in weeks**
1.	To study the characteristics of Photocell and to determine the work function of the cathode material.	CO1	1
2.	To calibrate an electromagnet and to study the dependence of Hall voltage on magnetic field and current through the sample.	CO2	1
3.	To study the I/P, O/P and transfer characteristics and to determine ‘α’ of transistor in common base mode	CO2	1
4.	To study the forward and reverse characteristics of semiconductor diode.	CO2	1
5.	To determine the energy band gap in a semiconductor using reverse biased p-n junction diode.	CO2	1
6.	To determine the velocity of ultrasonic waves in a liquid	CO3	1
7.	To determine numerical aperture of the optical fibre	CO4	1
8.	To determine wavelength of He-Ne LASER	CO4	1

4.	Text books

1. Experiments of Engineering Physics M.N. Avadhanulu, A.A. Dani, P.M. Pokley, S Chand Publishers (2003) ISBN-13- 978-8121912235
2. A Textbook of Engineering Physics Practical C. S. Robinson, Ruby Das, Lakshmi

Publications Pvt Limited (2016) ISBN-13- 978-9380386867

5.	**Reference Book(s) and Other Required Material**

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Continuous evaluation

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

Course Code & Course Title:	**CMLxxx General Biology**		
Course Type:	DC		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objective:**

Course Objective 1: To provide student with an understanding of the cells, biomolecules, enzymes and biochemical pathways
Course Objective 2: To provide students with an understanding of DNA, RNA, Recombinant DNA Technology, Cell division and Genetics
Course Objective 3: To provide students with an understanding of human body, kidney, digestive system, control mechanism etc.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the cell, cell types and biomolecules and biochemical pathways
CO2	Understand the RNA, DNA and Recombinant DNA technology,
CO3	Understand the human body and its functioning

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Lectures**
Introduction to cells and cell types	CO1	4
The chemistry of life bio molecules, carbohydrates, lipids, proteins and nucleic acid	CO1	2
Enzymes, Bio-catalyses, Co-enzymes, enzyme activation and inhibition	CO1	2
Biochemical pathways, glycolysis, TCA Cycle, ETS, ATP Calculation and Fermentation, Protein and Fat Metabolism, Photosynthesis, C4 pathway	CO1	4
DNA and RNA, structure and function, Recombinant DNA	CO2	6

technology		
Cell division, Mitosis, Meiosis, Mendelian Genetics, Genetic diversity in species	CO2	8
Material exchange in the human body, Blood circulation, Gas exchange, mechanical & chemical processing of food, digestive system, kidney structure & function, Nutrition, Human Body's control mechanisms	CO3	9

4.	Text books

i) Eldon D. Enger, Frederick C. Ross and David B. Bailey, Concepts in Biology, 14th Edition, Tata McGraw Hill Publishing Company Limited, 2017

5.	Reference Book(s) and Other Required Material

(i) C. Starr, Biology: Concept and Applications, 6th Edition, Thomson Learning 2009.

6.	Evaluation Details:

i) Assignment /Quiz– 20%
ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	2	2	1	3	3	3	1	2	2	2	2	2	2	1	3
CO2	2	3	1	1	2	2	2	1	2	1	2	2	3	1	1
CO3	2	3	1	2	2	3	1	1	1	2	2	2	3	1	2

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Not Applicable

Course Code & Course Title:	**SAA102- Health Information and Sports-Part II**		
Course Type:	**MNC**		
Name of the program(s):	**SAA102 Health Information and Sports-Part II**		
L – T – P	0-0-2	**No. of Credits**	**0**

1.	**Course Objective:**
	a. To make the students understand the importance of doing regular physical activities and the effect of exercise on various physiological systems b. To provide information about the scientific principles of training and their implications in various games & sports c. To provide the basic information about avoiding the injuries and it's management d. To make the students understand about the importance of physical activities & sports in managing the stress in day to day life e. To make students aware about the rules and regulation of different games & sports

2.	**Course Outcomes:**
CO1	The students will be able to design their own physical fitness training program
CO2	The students will be able understand how to handle their stress by participating in regular physical activities
CO3	The students will follow proper exercise pattern to avoid injuries
CO4	The students will understand how yoga helps to manage stress and improve their academic performance

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Periodization: Preparatory period, competition period and transitional period	CO1,CO2,CO3, CO4	8-12
Effects of exercise on various physiological systems	CO1,CO2,CO3, CO4	8-12
Therapeutic exercises & therapeutic modalities	CO1,CO2,CO3, CO4	8-12
The science of stress & it's yogic management	CO1,CO2,CO3, CO4	8-12

4.	Practical	
Topics	**CO(s) Addressed**	**Duration in weeks**
Practice of skills of major games like: Badminton, Table Tennis, Chess, Yoga, Basketball, Football, Handball, Cricket, Kho-Kho, Lawn Tennis, Throw ball, Athletics & Kabaddi	CO1,CO2,CO3, CO4	8-12
Participation in Intramural Sports Program	CO1,CO2,CO3, CO4	8-12
Preparation for Physical Efficiency Test Level-2	CO1,CO2,CO3, CO4	8-12

5.	Reference Books & other required materials
i.	Tudor O Bompa and G Gregory Haff, Periodization theory & methodology of training, 5th Edition, Human Kinetics 2009
ii.	Skot K Powers and Edward T Howley, Exercise Physiology Theory & application to fitness and performance , 10th Edition, Mc Graw Hill Education 2015
iii.	William E. Prentice, Therapeutic Modalities for sports medicine & athletic training,6th Edition, Mc Graw Hill Education 2009

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]
	Continuous evaluation Assessment- End Semester 100%

Course Code & Course Title:	CML2** **Bioprocess Technology Laboratory**		
Course Type:			
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

	Course Objectives:
i.	To learn and demonstrate basic laboratory techniques such as aseptic technique, sterilization methods, and microbial culture preparation and preservation
ii.	To gain proficiency in using microscopes, laminar airflow, to observe microorganisms
iii.	To master laboratory techniques such as spectrophotometry, analyzing biomolecules.
iv.	To quantify and analyze biomolecules using appropriate methods

1.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Perform basic microbiological techniques (e.g., aseptic technique, streak plating) with proficiency and follow laboratory safety and ethical guidelines.
CO2	Understand factors affecting microbial growth and apply this knowledge in experiments.
CO3	Perform basic biochemical laboratory techniques with proficiency.
CO4	Quantify and analyze biomolecules using spectrophotometry and other assays.

2.	**Detailed Description of the Course**		
Sr. No.	**Practical (Any 8)**	**CO(s) Addressed**	**Duration (Weeks)**
1	Sterilization, disinfection and laboratory safety; preparation and sterilization of nutrient media	CO1	1
2	Inoculation of agar slants, plates and broth; culture of	CO1, CO2	1

	microorganisms		
3	Simple and differential staining procedures	CO1	1
4	Study of bacterial growth curve	CO2	1
5	Preparation of phosphate buffer and measurement of pH	CO3	1
6	Testing buffering capacity of a buffer	CO3	1
7	Qualitative testing of glucose using Benedict’s reagent	CO3	1
8	Determination of λmax	CO4	1
9	Long-term storage and preservation of microbial cultures	CO2	1
10	Protein estimation by Folin’s method	CO4	1

3.	**Text books**
i.	C.G. Cooper, Tools of Biochemistry, Wiley Interscience, 1977.
ii.	Cappuccino, J.G., & Welsh, C., Microbiology: A Laboratory Manual, Benjamin-Cummings, 2016.

4	**Reference Book(s) and Other Required Material**

None

5	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3	3	3	3	3	3		3	3	3	3	3
CO2	3	3	3		2							3	3	3	
CO3	3	3	3	2	1	2					3	3	3	3	2
CO4	3	3	3			3	3		3		3	3	3	3	

High - 3; Medium – 2; Low – 1;

5	Evaluation Details:

i) Assignment /Quiz– 20%
ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

6	List of Indicative Laboratory Experiment (if applicable):

None

3rd Semester B.Tech. Chemical Tech. (BPT)

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CML2**	Microbiology for Engineers	DC	3-0-0	3	None
CML2**	Biochemistry	DC	3-0-0	3	None
CML201	Chemical Process Calculations	DC	3-0-0	3	None
CML202	Fluid Mechanics	DC	3-0-0	3	None
CML203	Mechanical Operations	DC	3-0-0	3	None
CML204	Chemical Engineering Thermodynamics I	DC	3-0-0	3	None
CMP2**	Microbiology for Engineers Laboratory	DC	0-0-2	1	None
CMP2**	Biochemistry Laboratory	DC	0-0-2	1	None
IELxxx	Institute Elective -II	IE	3-0-0	3	None
AULxxx	Mandatory Non-Credit Category – I	MNC	0-0-2	0	None
	Electives				
CMLxxx	Elective 1	DE	3-0-0	3	None
Total Credits (DC +DE+ IE = 20+3+3=26)				**26**	

Course Code & Course Title:	**CML2** Microbiology for Engineers**		
Course Type:	**DC**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objectives:**
i.	To establish the concept, development and significance of microbiology related to bioprocesses
ii.	To train the students to handle, cultivate, utilize and eliminate microorganisms from different environments for different bioprocesses
iii.	To make the students aware of the ubiquitous nature, diversity, physiology, metabolism and growth of different microorganisms and their significance in bioprocesses

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be aware of significance of microbiology and principles of microbiology
CO2	Learn methods to isolate, identify, handle, cultivate and eliminate microorganisms from different environments
CO3	Ability to understand growth requirements of different microbes and importance of clean and aseptic techniques.
CO4	Awareness of different microbiology related processes especially bioprocess used for health, food, fuel, environment and other products etc.

3.	**Detailed Description of the Course**		
Sr. No.	**Description**	**CO Addressed**	**Duration (Weeks)**
1	Microbial taxonomy and diversity; Staining and microscopy; Microbial growth; Bacterial culture	CO1, CO2,	4

	methods; Physiology and morphology of bacteria, yeast, fungi and characteristics of viruses. Microbial nutrition, growth principles and growth measurement techniques	CO3	
2	Microbial metabolism; Control of microorganisms - physical and chemical methods for control of microorganisms, antimicrobial chemotherapy, resistance to antibiotics; Anaerobic respiration. Isolation strategies of bacteria, yeast, fungi and algae from different sources including soil samples, Identification of bacteria, yeast, fungi and algae using 16S rDNA approach	CO2, CO3	4
3	Preservation strategies of microbes/ industrial microorganisms using oil overlay method, glycerol stock method, Lyophilization methods, and Methodology for the strain improvement of industrially important microbes	CO2, CO4	3
4	Microorganisms in the environment – microbiology of soil, air, freshwater, and seawater; Biogeochemical cycles -carbon cycle, nitrogen cycle, sulphur cycle; Medical microbiology and virology- microbial diseases, detection and control; Industrial and food microbiology	CO1, CO4	4

4.	Text books
i.	Ananthanarayan, R., Ananthanarayan and Paniker's Textbook of Microbiology, Orient Blackswan, 2006, ISBN: 9789389211436
ii.	Chan, E. C. S., Pelczar, M. J., & Krieg, N. R., Microbiology, Tata McGraw-Hill, 2001, ISBN: 9780074623206
iii.	Salle, A. J., Fundamental Principles of Bacteriology, 7th Ed., Tata McGraw-Hill, 1973, ISBN: 9780070995628
iv.	Willey, J., Sandman, K., & Wood, D., Prescott's Microbiology, 11th Ed., McGraw-Hill, 2019, ISBN: 9781260211887

5.	Reference Book(s) and Other Required Material

None

6.	**Evaluation Details:**

Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%
End-Semester Examination (3 Hours)	50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3					3					1	3	2		
CO2	1	2	3	2	3	3	3				3	3	3	2	
CO3		2	3	3	3	3	3					2	3	2	
CO4	3	3	3			3	3					2	3		1

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

None

Course Code & Course Title:	**CML2** Biochemistry**		
Course Type:	**DC**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objectives:**
i.	To introduce the basic concepts of biochemistry necessary for biochemical and biotechnology/ bioprocesses.
ii.	To provide an understanding of the basic structure and behavior of biomolecules and its functions.
iii.	To examine the main pathways of the cell and how they are integrated with other pathways within the cell.
iv.	To provide an understanding about function of enzymes and their role in metabolism in the living cell

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Identify types of chemical bonds, know theories of chemical bonding and the forces that influence molecular shapes
CO2	Identify and explain the function and metabolism of carbohydrates, fats, and proteins in living systems
CO3	Understand how cellular components are used to generate and utilize energy in cells.
CO4	Identify applications and uses for biochemical processes and products

3.	**Detailed Description of the Course**		
Sr. No.	**Description (as per Expanded Course Description)**	**CO Addressed**	**Duration (Weeks)**
1	Introduction to Biomolecules; Basic principles of organic chemistry; Biochemical reaction mechanism- A thermodynamic concept; Molecular Control of	CO1, CO2	3

	Metabolism (Carbohydrate, Proteins); Molecular Control of Metabolism (Lipids, Nucleic acid)		
2	Structure and properties of Important Biomolecules- Carbohydrates, Lipids, Protein, Nucleic acids. Commercially important Natural Product/metabolite Biosynthesis-I; Commercially important Natural Product/metabolite Biosynthesis-II; Methods for metabolic characterization, Cellular communication and transport.	CO2, CO4	3
3	Proteins, Enzymes- catalysis and kinetics, metabolic pathways metabolic regulation. Glycolysis, TCA cycle, gluconeogenesis, pentose phosphate shunt & glyoxalate shunt.	CO2, CO3	4
4	Fatty acid synthesis and oxidation, reactions of amino acids, deamination, transamination and Decarboxylation, urea cycle, Bioenergetics.	CO3	3
5	Protein dynamics, Protein- Protein, Protein-ligand and Protein-DNA interactions, Protein engineering and design; Synthesis and degradation of biomolecules; Biology of Informational Molecules, Receptors and Bio signaling I; Biology of Informational Molecules, Receptors and Bio signaling II	CO3, CO4	2

4.	**Text books**
i.	Berg, J. M., Tymoczko, J. L., & Stryer, L., Biochemistry, W. H. Freeman, 2002.
ii.	Conn, E. E., Stumpf, P. K., Bruening, G., & Doi, R. Y., Outlines of Biochemistry, 5th Ed., John Wiley & Sons, 1987.
iii.	Nelson, D. L., & Cox, M. M., Lehninger Principles of Biochemistry, 6th Ed., W. H. Freeman, 2017.
iv.	Rastogi, S. C., Biochemistry, 2nd Ed., Tata McGraw-Hill, 2003.
v.	Satyanarayana, U., & Chakerapani, U., Biochemistry, 3rd Rev. Ed., Books & Allied, 2006.

5.	**Reference Book(s) and Other Required Material**
i.	Berg, J. M., Tymoczko, J. L., & Stryer, L., Biochemistry, 6th Ed., W. H. Freeman,

	2006.
ii.	Murray, R. K., Granner, D. K., Mayes, P. A., & Rodwell, V. W., Harper's Illustrated Biochemistry, 31st Ed., McGraw-Hill, 2018.

6.	**Evaluation Details:**
Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%
End-Semester Examination (3 Hours)	50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3										3	3		
CO2	3		3			2						3		3	
CO3	3	2	2			2						3	2	2	
CO4	3	2	3								3	3	2	3	

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

None

Course Code & Course Title:	**CML201 Chemical Process Calculations**
Course Type:	DC
Name of the program(s):	B.Tech. Chemical Engg./ B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-0-0 **No. of Credits** 3
Pre-requisites: Course Code(s) & Name(s)	None
Course Equivalence: Course Code(s) & Name(s)	None

1.	**Course Objective:**

Course Objective 1: To understand the fundamental concepts and calculations of process calculation.
Course Objective 2: To understand the material balance in various unit processes and unit operations.
Course Objective 3: To understand the energy balance related to various process equipments.
Course Objective 4: To understand the various heats and their calculations related to chemical reactions including combustion.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Ability to sort a process into different unit operations and processes and apply basic chemical calculations to it
CO2	Ability to apply material balances to different physical steps in a process
CO3	Ability to quantify heat and energy changes accompanying unit operations and unit processes
CO4	Ability to effectively combine the knowledge of material and energy calculations for processes

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Fundamental concepts, gas relationship, molarity, molality, normality, partial pressure, pure component volume and the related calculations.	CO1	1
Material balance in various unit processes and unit operations.	CO2	3
Material balance with chemical reactions	CO2	3

Fuels and combustion calculation, proximate and ultimate analysis, adiabatic reaction temperature, air to fuel ratio, complex processes calculation.	CO2	2
Energy balance related to various process equipment.Calculation of standard heat of reaction from the heat of formation and heat of combustion, thermo chemistry, energy balance in various unit operations, the heat of solutions, the heat of neutralization etc.	CO3	4
Humidity and saturation and their applications fundamental concepts of material balance.	CO2,CO4	1

4.	**Text books**

i) Bhatt B.I. and Thakore S.B. Stoichiometry, 5th Edition, McGraw Hill Education, 2017.

ii) Felder R.M., Rousseau R.W. and Bullard L.G.; Elementary Principles of Chemical Processess. 4th Edition, Wiley, 2004

iii) Himmelblau D.M.; Basic Principles and Calculations in Chemical Engineering, 8th Edition, Prentice Hall of India Ltd, 2015.

iv) Narayanan K V and Lakshmikutty B, Stoichiometry and Process Calculations, Prentice Hall of India Pvt Ltd, New Delhi 2006

5.	**Reference Book(s) and Other Required Material**

i. Nicholas P. Chopey and Tyler G. Hicks, P.E., Handbook of Chemical Engineering Calculations , McGraw Hill, 4th Edition, 2012.

6.	**Evaluation Details:**

i) Internal Assessment (Quiz, Assignment, Project etc.) – 20%

ii) Mid Sem Evaluation – 30%

iii) End Sem Evaluation -50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3		2						3	2	2	
CO2	3	3	3			2						2	2	2	

CO3	3	3	3	2		2						2	2	2	
CO4	3	3	3	2		2			2			2	2	2	

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Not Applicable

Course Code & Course Title:	CML 202 Fluid Mechanics		
Course Type:	**DC**		
Name of the programme(s):	Sachin A. Mandavgane		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

1. To introduce students to basics of fluid properties and fluid statics
2. To introduce energy and mass balance equations
3. To study fluid flow through pipe and flow measurement instruments
4. To study fluid transportation through pipe and solid bed
5. To perform fluid mechanics calculation of a process plant

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will know properties of the fluid
CO2	Students will be able to design a storage tank
CO3	Students will be able to know nature of flow through pipe
CO4	Students will be able to select pump for a given system
CO5	Students will be able to know nature of flow through porous media

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Properties of Fluid: Pressure, density, specific weight, viscosity, dynamic and kinemetic viscosity, Newton's law of viscosity and its applications	CO1	3
	Fluid Statics: Pascal's Law and Hydrostatic equation, absolute and gauge pressures - pressure measurements by manometers and pressure gauges.– Forces on plane and curved surfaces Fluid kinetics: Description of Fluid flow, Types of fluid Flows: Steady and unsteady, Uniform and non-uniform, Fluid Dynamics: Bernoulli's equation for incompressible fluid flow, Engineering applications of energy equation,	CO2 CO3	4

Flow Through Pipes: Critical Reynold's number, velocity distribution in pipes, friction factor, Moody's chart, Laminar flow through pipe, Hagen-Poiseulli's equation, Turbulent flow through pipe, Hydraulic gradient line and Total energy line. Minor head losses in pipes.Pipe Networking Transmission of power through pipe. Pitot – static probe, Current meters,Venturimeter, Orificemeter, Rotameter, Nozzlemeter, Notches & weirs	CO4	3
Flow Over Immersed Bodies: Packed bed and fluidized bed Pumps: definition and classifications - Centrifugal pump: classifications, working principles , specific speed, efficiency and performance curves cavitations in pumps -	CO5	2

4.	Text books

i) Gupta Santosh & Gupta Vijay, 'Fluid Mechanics and its applications', New Age International Publishers.

ii) Munson BR, Young D F and Okiishi T H , ' Fundamentals of Fluid Mechnics', 5th Edition, John Wiley & Sons

iii) Noel de Nevers, Fluid Mechanics for Chemical Engineers, TATA McGraw Hill 3rd Edition, 2011

iv) Warren McCabe, Julian Smith, Peter Harriott, Unit Operations of Chemical Engineering, McGraw Hill International Edition, 2005

5.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Component	Duration	Weightage
Mid Sem	1.30 hour	30
Design of Storage tank	One week	10
Design Project on Fluid Mech	One Month	20
End Semester Exam	3 hours	40

6.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3									3	3	3	3
CO2	3	3	3	3				2	1		2	1	3	3	3	3
CO3	3	3	3	3									3	3	3	3
CO4	3	3	3	3					1				3	3	3	3
CO5	3	3	3	3		1		3	3	2	3	1	3	3	3	3

High - 3; Medium – 2; Low – 1;

7.	**List of Indicative Laboratory Experiment (if applicable):**

Nil

Course Code & Course Title:	CML203 Mechanical Operation		
Course Type:	**DC**		
Name of the programme(s):	B.Tech in Chemical Engineering		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)			

1.	Course Objective:

To impart the basic concepts of mechanical operations. To develop understanding about size analysis, size reduction and solid handling. Understand mechanical separation methods such as filtration, sedimentation, classification etc and associated equipments used for achieving these methods. The students are exposed to basic theory, calculations and machinery involved in various solid handling operations

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Able to describe properties of particulate solid and particle size analysis calculations
CO2	To understand screening equipment and equipment for size reduction
CO3	To understand filtration, sedimentation and centrifugal separation
CO4	To understand motion of particles through fluid, agitation and mixing, different conveying system for handling of solids

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Size Analysis: Particle size distribution, Screen analysis. Properties of particulate solid, surface area distribution of powders.	CO1	02
Equipment for size reduction: crushing and grinding equipments and their characteristic, open and close circuit grinding, power laws. Types of Screening Equipments and their application	CO2	02
Filtration and centrifugal separation: Principles of filtration and theory, filtration equipments and their characteristics, pressure and vacuum filters, compressible and non-compressible cake and their effect on filtration rate, centrifugal separation equipments and their principles of operation as well as the characteristics, optimum filtration cycle, membrane filtration.	CO3	03

Motion of particles through fluid: Drag coefficient, free settling and hindered settling, gravity settlers, sedimentation theory and principle of operation. Batch and continuous thickeners as well as the design procedures, sedimenting centrifuges.	CO4	04
Agitation and mixing: Introduction to agitation and mixing of solids and liquids fundamentals, mixing and agitation equipments and their operational characteristics, power consumption in mixing and agitation, different types of agitators and their selection criteria.	CO4	01
Handling of solids: Storage and conveying of solids, bins, hoppers, silos and their operational characteristics, Loading and unloading of solids, different types of conveyors and elevators for solid materials. Dust collectors, cyclone separators, electrostatic precipitators, bag filters, operational characteristics of these and other similar dust separators.	CO4	01

4.	Text books

Note: *Kindly arrange the textbooks/references in* ***alphabetical order.***

i) Badger & Banchero Introduction to Chemical Enginerring Mc-Graw- Hill Education
ii) C.M. Narayannan and B.C. Bhattacharyya,Mechanical Operation for Chemical engineering, Third edition, Khanna Publishers,2014,81-7409-036-3
iii) D.V.Subba Rao, Mineral Beneficiation :A concise basic course, CRC Press, ISBN 978-0-203-84789-3(ebook)

5.	Reference Book(s) and Other Required Material

Note: *Kindly arrange the textbooks/references in* ***alphabetical order.***

i) Christie J. Gean Koplis Transport processes & Unit Operation Prentice Hall International
ii) Coulson J. M. and Richardson J.F; Chemical Engineering Vol. 1& 2 Publishers: Butter worth – Heinemann Ltd. 2001-2002
iii) McCabe W.L., Smith J.C. and Harriot P., Unit Operations of Chemical Engineering McGraw Hill, New York ,2001, 6th Edition

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High **-** *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	**CML204 Chemical Engineering Thermodynamics-I**		
Course Type:	DC		
Name of the program(s):	B.Tech. Chemical Engg.		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objective:**

Course Objective 1: Understand and apply the first and second laws of thermodynamics to processes.

Course Objective 2: Analyze energy and material balances for various chemical engineering systems.

Course Objective 3: Understand and predict fluid behaviour under different conditions.

Course Objective 4: Develop an understanding of thermodynamic properties and their relationships.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the fundamental concepts and I Law of Thermodynamics and its applications.
CO2	To understand the PVT behavior of pure substances.
CO3	To understand the II Law of Thermodynamics and its applications.
CO4	To understand the Thermodynamic properties of pure substances.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Basic concepts and definition: Classical and Statistical thermodynamics, system, boundary, surroundings, internal energy, work, heat, equilibrium, reversible process, intensive and extensive function, ideal gas temperature scale. First law of thermodynamics for non-flow process, flow process, State and path function, Enthalpy, Heat capacity		CO1	4
PVT behavior of gases: Ideal gas, definition, ideal gas law, equation of state for real gases, graphical representation of P-V-T behavior, T-V diagram, P-V diagram and P-T diagram, Thermodynamic analysis of processes. Generalized correlations for thermodynamic property of gases, reduced equation of state, two parameter and three parameter correlations.		CO2	4
Second law of thermodynamics: Spontaneous process, qualitative difference between heat and work, heat reservoir, heat pump, heat engine, Kelvin Plank statement, Clausius statement, irreversibility, entropy, Carnot principle, postulates, thermodynamic temperature scale, third law of thermodynamics.		CO3	3
Thermodynamic relations: Classification of thermodynamic		CO4	2

processes, Helmholtz and Gibbs free energy, fundamental property relations, Maxwell's relations and their applications, Clausius-clapeyron equation, modified equations for U, H and S, relationship between Cp and Cv, ratio of heat capacity, effect of pressure and volume on Cp and Cv, Gibbs Helmholtz equations		
Applications of laws of thermodynamics: Refrigeration, choice of refrigerant, Carnot cycle, vapour compression cycle, air refrigeration, Heat pumps, Liquefaction processes, free expansion, isotropic expansion, Steam power plant, Rankine cycle, Reheat and regenerative cycles. Internal combustion engines. Introduction to ideal mixtures.	CO3	1

4.	Text books

i) Smith J.M., Van Ness H.C., and Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 2005.
ii) Peter Atkins., Physical Chemistry, Oxford, Tenth Edition.

5.	Reference Book(s) and Other Required Material

i) Nag P.K., Engineering Thermodynamics, Sixth Edition.

6.	Evaluation Details:

i) Assignment – 20%
ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3	3	-	-	-	-	-	3	3	3	3	3
CO2	3	3	3	3	3	-	-	-	-	-	3	3	3	3	3
CO3	3	3	3	3	3	-	-	-	-	-	3	3	3	3	3
CO4	3	3	3	3	3	-	-	-	-	-	3	3	3	3	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Not Applicable

Course Code & Course Title:	CML*** **Microbiology for Engineers Laboratory**		
Course Type:	**DC**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	**No. of Credits**	1
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	Course Objective:
i.	To learn and demonstrate basic laboratory techniques such as aseptic technique, sterilization methods, and microbial culture preparation and preservation
ii.	To gain proficiency in using microscopes, laminar airflow, to observe microorganisms
iii.	To understand and apply various staining techniques

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Perform basic microbiological techniques (e.g., aseptic technique, streak plating) with proficiency and follow laboratory safety and ethical guidelines.
CO2	Use microscopes and staining techniques to visualize and identify microorganisms.
CO3	Understand factors affecting microbial growth and apply this knowledge in experiments.
CO4	Analyze and interpret microbiological data and report findings accurately.

3.	**Detailed Description of the Course**		
Sr. No.	**Practical (Any 8)**	**CO(s) Addressed**	**Duration (Weeks)**
1	Sterilization, disinfection and safety in microbiological laboratory. Preparation of nutrient media and sterilization.	CO1	1
2	Inoculation of agar slants, agar plate and nutrient broth. Culture of microorganisms using various techniques.	CO1, CO2	1
3	Simple and differential staining procedures.	CO1, CO2	1
4	Enumeration of bacteria- microscopic method and colony counting	CO2, CO3	1

5	Pour plate method for isolation of bacteria	CO2	1
6	Spread plate method for isolation of bacteria	CO2	1
7	Observation of different bacteria and fungi, actimomycetes under microscope	CO2	1
8	Isolation and characterization of microbes from soil samples (U.V. spectrophotometer, Colony Counter etc.).		1
9	Study of growth curve of bacteria	CO3, CO4	1
10	Serial dilution, isolation of pure bacterial colonies from soil and water	CO2	1
11	Long term storage / preservation techniques used for microbial cultures	CO2, CO4	1
12	Antimicrobial sensitivity test and demonstration of drug resistance	CO2, CO3	1

4.	Text books

i) Cappuccino, J. G., & Welsh, C. (2016). Microbiology: a Laboratory Manual. Benjamin-Cummings Publishing Company.

ii) Collins, C. H., Lyne, P. M., Grange, J. M., & Falkinham III, J. (2004). Collins and Lyne302222s Microbiological Methods (8th ed.). Arnolds.

iii) Tille, P. M., & Forbes, B. A. (2014) Bailey & Scott302222s Diagnostic Microbiology

5.	Reference Book(s) and Other Required Material

None

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

i. Quiz/Assignment = 20%

ii. Mid Sem Evaluation =30%

iii. End Sem Evaluation = 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4

CO1	3	3	3	3	3	3	3	3	3		3	3	3	3	3
CO2	3	3	3		2							3	3	3	
CO3	3	3	3	2	1	2					3	3	3	3	2
CO4	3	3	3			3	3		3		3	3	3	3	

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML2** Biochemistry Laboratory		
Course Type:	DC		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	No. of Credits	1
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	Course Objectives:
i.	To master laboratory techniques such as spectrophotometry, chromatography, and electrophoresis for analyzing biomolecules.
ii.	To quantify and analyze biomolecules using appropriate methods
iii.	To apply methods to separate and characterize biomolecules.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Perform basic biochemical laboratory techniques with proficiency.
CO2	Quantify and analyze biomolecules using spectrophotometry and other assays.
CO3	Apply chromatographic / electrophoretic /other methods to separate/identify biomolecules.
CO4	Analyse, interpret experimental data and draw biochemical conclusions.

3. Detailed Description of the Course		
Experiments (any 10)	**CO(s) Addressed**	**Duration in weeks**
Preparation of phosphate buffer and measurement of pH	CO1	1
Testing buffering capacity of a buffer	CO1	1
Qualitative testing of glucose using Benedict's reagent	CO1	1
Determination of λmax	CO2	1

Estimation of glucose using ortho-Toluidine method	CO2	1
Extraction of proteins from sprouted seeds	CO1, CO3	1
Protein estimation by Folin's method	CO2	1
Estimation of protein by Biuret assay method	CO2	1
Extraction of cholesterol	CO1	1
Estimation of cholesterol concentration	CO2	1
Isolation of polysaccharide	CO1, CO3	1
Biochemical tests and motility of bacteria	CO1, CO4	1
Thin layer chromatography	CO3	1
Electrophoresis: Agarose and SDS-PAGE	CO3	1
Detection of enzyme activity and calculation of specific activity	CO4	1

4.	**Text books**
i.	Cooper, C. G., Tools of Biochemistry, Wiley Interscience, 1977.
ii.	Holme, E. D. & Peck, H., Analytical Biochemistry, Longman, 1983.
iii.	Scopes, R., Protein Purification – Principles and Practices, Springer Verlag, 1982.

5.	**Reference Book(s) and Other Required Material**
	None

6.	**Evaluation Details:**
Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%

End-Semester Examination (3 Hours)	50%

7.	**Relationship of Course Outcomes to Program Outcomes:**														
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3	3	3	3	3	3		3	3	3	3	3
CO 2	3	3	3		2							3	3	3	
CO 3	3	3	3	2	1	2					3	3	3	3	2
CO 4	3	3	3			3	3		3		3	3	3	3	

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

None

4th Semester B.Tech. Chemical Tech. (BPT)

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CML2**	Fermentation Technology	DC	3-0-0	3	None
CML2**	Cell Biology for Engineers	DC	3-0-0	3	None
CML221	Mass Transfer I	DC	3-0-0	3	None
CML222	Heat Transfer	DC	3-0-0	3	None
CML223	Chemical Reaction Engineering I	DC	3-0-0	3	None
CML225	Chemical Engineering Thermodynamics II	DC	3-0-0	3	None
CMP2**	Fermentation Technology Laboratory	DC	0-0-2	1	None
CMP202	Fluid Mechanics Laboratory	DC	0-0-2	1	None
CMP322	Heat Transfer Laboratory	DC	0-0-2	1	None
AULxxx	Mandatory Non-Credit Category -II	MNC	0-0-2	0	None
	Electives				
CMLxxx	Elective 2	DE	3-0-0	3	None
Total Credits (DC + DE = 21+3=24)				**24**	
Diploma Exit Additional Course					
CMDXxx	Mini Project	DC	0-0-4	2	None

Course Code & Course Title:	CM2** Fermentation Technology		
Course Type:	**DC**		
Name of the programme(s):	Chemical Technology (Bioprocess Technology)		
L – T – P	**(3-0-0)**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:** The course aims: 1. Equip students with a detailed comprehension of the historical context, importance, and microbial mechanisms involved in fermentation, including both aerobic and anaerobic processes. 2. Students will acquire the skills necessary for the design, operation, and scaling of various fermenters, including continuous stirred-tank, airlift, and packed bed fermenters, emphasizing instrumentation and control. 3. Analyzing microbial growth kinetics, metabolic regulation, and the factors influencing microbial growth is essential for students, emphasizing the industrial significance of microorganisms. 4. Enhance students' competencies in selecting, optimizing, and sterilizing fermentation media, alongside conducting upstream and downstream processing, which encompasses product purification and recovery

2.	**Course Outcomes:**
CO1	Students will exhibit a thorough understanding of fermentation principles and will be capable of effectively applying both aerobic and anaerobic fermentation methods
CO2	Students will demonstrate the ability to design, operate, and scale different types of fermenters, thereby ensuring effective bioprocessing and control.
CO3	Students will possess the ability to analyze microbial growth kinetics and metabolic processes, utilizing this knowledge to improve industrial fermentation
CO4	Students will acquire expertise in the selection and optimization of fermentation media, along with upstream and downstream processing techniques, to ensure high-quality product recovery and formulation.

3.	**Detailed Description of the Course**		

Topics	CO(s) Addressed	Duration in weeks
Introduction: History and significance of fermentation, Overview of microbial fermentation processes. Types of Fermentation: Aerobic and anaerobic fermentation, Batch, fed-batch, and continuous fermentation	CO1	2
Microbial Growth and Metabolism: Industrial importance of microorganism and Various products of Fermentation Microbial growth kinetics, Factors affecting microbial growth (pH, temperature, nutrients), Metabolic regulation	CO3	3
Fermentation products, Biopesticide and biofertilizers, Bioprospecting, industrially important products, Selection and optimization of media, Sterilization methods	CO2, CO3	2
Instrumentation and control, Fermenter Design and Operation	CO2	2
Upstream Processing: Inoculum preparation, Culture maintenance and propagation	CO2, CO4	1
Downstream Processing: Cell separation and lysis, Purification of fermentation products, Product recovery and formulation	CO4	2
Industrial Applications, Case Studies and Practical Applications: production of Streptomycin and Tetracyclines, amino acids Lysine etc.	CO3, CO4	1

4.	**Text books**

1. Principles of Fermentation Technology by Stanbury P.F., Whitaker A. Elsevier 1993
2. Bioprocess Engineering: -Basic concept by Shuler & Kargi (PHI)
3. Biochemical Engineering fundamentals By Bailey ollis.
4. Bioprocess Engineering Principles by Pauline M. Doran (Elsevier Science & Technology Books,1995)

5.	**Reference book(s) and Other Required Material**

1. Fermentation Microbiology and Biotechnology by Mansi EI-manis and C.F. A. Bryce

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Class Tests and Assignments: 20%
Mid-Semester Exam (1.5 Hours): 30%
End-Semester Exam (3 Hours): 50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

Key: 3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	List of Indicative Laboratory Experiment (if applicable): NA

Course Code & Course Title:	**CML 2** Cell Biology for Engineers**		
Course Type:	**DC**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**(3-0-0)**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:** 1. To offer basic understanding of how eukaryotic and prokaryotic cell functions 2. To understand the role of various cell organelles with respect to cell function 3. Application of cell biology in bioprocess technology

2.	**Course Outcomes:**
CO1	Demonstrate understanding of the structure, function, and interactions of cellular components.
CO2	Explain cellular processes such as metabolism, cell signaling, and gene expression.
CO3	Describe the cell cycle and mechanisms of cell division.
CO4	Apply knowledge of cell biology to emerging fields like biotechnology and medical research.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Prokaryotic and eukaryotic cell organization: Different types of cells and their organization, differences; Distinguishing features of various groups of microorganisms: actinomycetes, bacteria, molds, yeasts and algae and their broad classification		CO1	
Cell organelles: Organization and functions of eukaryotic cell organelles Vesicular trafficking: Protein transport, protein sorting, vesicular transport, phagocytosis, pinocytosis		CO1, CO2	
Cytoskeleton: Organization and functions of microtubules, actins and intermediate filaments. Molecular motors, endocytosis, exocytosis		CO3	
Visualizing cells: Different types of microscopes, fluorophores and techniques to visualize cells Cell cycle: Steps of mitosis and meiosis and their regulation; omics approaches; flow cytometry/FACS		CO3, CO4	

4. Text books

1. Alberts, B., Johnson, A., Lewis, J., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th ed.). Garland Science.
2. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H., & Matsudaira, P. (2012). *Molecular Cell Biology* (7th ed.). W. H. Freeman.

5. Reference book(s) and Other Required Material

1. Cooper, G. M. (2018). *The Cell: A Molecular Approach* (8th ed.). Oxford University Press, USA.

6. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 20%
Mid-Semester Exam (1.5 Hours): 30%
End-Semester Exam (3 Hours): 50%

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	2	2	-	-	-	-	-	-	-	-	-	3
CO2	3	3	3	3	-	-	-	-	-	-	-	2	-	-
CO3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO4	3	3	3	3	-	-	-	-	-	-	-	-	2	-
CO5	3	3	3	3	3	2	2	-	-	-	3	-	-	-

High - 3; Medium – 2; Low – 1;

8. List of Indicative Laboratory Experiment (if applicable): NA

Course Code & Course Title:	**CML 221 Mass Transfer 1**		
Course Type:	**DC**		
Name of the programme(s):	Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**CML 203 & Mechanical Operation**		
Course Equivalence: Course Code(s) & Name(s)			

5.	**Course Objective: This course will provide basic knowledge of mass transfer operations and aims to develop skills for designing commercial separation equipments**

6.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Apply fundamentals of diffusion for gas, liquid and solid phase to solve engineering problems
CO2	Analyse complex purification systems and derive governing equations.
CO3	Understand the concept of mass transfer coefficients and design system with practical constraints.
CO4	Evaluate the industry implication of separation process.

7. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Introduction to mass transfer operations, Diffusion in gases, liquids, and solids. Steady state and unsteady state operations.	CO1	4 weeks
Individual and overall mass transfer coefficients, Theories, analogies of mass transfer.	CO2	3 weeks
Inter-phase mass transfer operation and Coefficients, Design of gas, liquid and solid contact equipment's like distillation column, spargers, scrubbers, wetted wall tower, fractionation tower and their types	CO3	4 weeks
Adsorption: Adsorption isotherms, adsorption agents, equipment's for adsorption, pressure swing adsorption technology, adsorption phenomena Drying: Constant rate and falling rate periods, equilibrium moisture contents, drying equipment's, rotary dryers, drum dryers, vacuum dryers, Spray dryer, fluidized bed dryers, dryer calculations and dryer selection criteria. Crystallization: Theory of Crystallization, various equipment's for crystallization, their operational and design characteristics.	CO4	5 weeks

Humidification: Equipment's operational characteristics, design procedures and selection criteria along with mass transfer calculations		

8.	Text books

i) C. J. Geankoplis, Transport processes and separation process principles, PHI publication

ii) Treybal R.E., Mass Transfer Operations, McGraw Hill Book Co., New York 1980, 3rd Edition

iii) McCabe W.L. and Smith J.C. & Harriot, Unit Operations of Chemical Engineering, , McGraw Hill Book Co., New York 1980, 5th Edition

iv) Binay K. Dutta, Principles of Mass Transfer and Separation Process, PHI Learning Pvt. Ltd., New Delhi, Eastern Economy Edition.

9.	Reference Book(s) and Other Required Material

i) Coulson J.M. and Richardson J.F, Chemical Engineering Vol. I, II & III, Pergamon Press, New York 1977

10.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Semester Exam: 25 %
Assignments/Presentation/Viva/Quiz: 20 %
End Semester Exam: 55 %

11.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

12.	List of Indicative Laboratory Experiment (if applicable):

Course Code and Name:	CML 222- Heat Transfer		
Course Type:	DC		
Name of the programme(s):	B.Tech. (Chemical Engineering), B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	Maths, CML204-Chemical Engg. Thermodynamics I, CML202-Fluid Mechanics		
Course Equivalence: Course Code(s) & Name(s)	**NIL**		

1.	**Course Objective:** The objective of this course is to study different modes of Heat Transfer, identify, formulate, and solve engineering problems involving conduction, convection, and radiation, apply energy balances and rate equations to model and analyze thermal systems, optimum use and its application in various chemical industries

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	To introduce the basic principles of heat transmission by conduction, convection, and radiation
CO2	To identify, formulate, and solve engineering problems involving conduction, convection, and radiation,
CO3	To apply energy balances and rate equations to model and analyze thermal systems.
CO4	To introduce application of heat transfer and its optimum use

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Basic modes of heat transfer, Fourier's law, thermal conductivity, steady state heat conduction through a plane, composite wall, cylinder, sphere, heat generation inside solids, unsteady state heat conduction, types of thermal insulation, critical thickness and optimum thickness of insulation, extended surfaces, fin performance evaluation, effectiveness of fins.	**CO1**	2-3 Weeks
Free and forced convection inside and outside the tubes as well as over the plates, individual and overall heat transfer coefficients. Heat transfer in laminar flow and turbulent flow, dimensional analysis, dimensionless numbers in heat transfer, heat transfer correlations for natural convection.	**CO2**	2-3 Weeks
Condensation and Boiling, Condensation over flat plate, condensation inside and outside the tubes in horizontal, vertical and inclined position,	**CO3**	2-3 Weeks

film condensation, dropwise condensing. Estimation of film coefficient of heat transfer for condensing vapours turbulence in condensing film. Heat Transfer to boiling liquids, pool boiling and forced convection boiling, boiling curve and its characteristics.		
Radiation heat transfer, laws of radiation, concepts of black body, gray body, green house effect, emissive power, heat flux by radiation, view factors, radiation shield, luminous and non luminous gases, heat exchangers, heat transfer fluids.	**CO4**	2-3 Weeks

4.	**Text books**

i) Hollman J.P.; Heat Transfer, McGraw Hill, 1993
ii) Incropera F.P. Fundamentals of Heat and Mass Transfer 5th Edition Wiley India Pvt.Ltd Ltd.,2008
iii) Cengel Y.A. Heat Transfer: A Practical Approach McGraw-Hill; 2 edition ,2002
iv) Kern D.Q., Process Heat Transfer, Tata McGraw Hill Book Co., New Delhi, 1990.
v) Dutta B.K. Heat Transfer; Principles and Applications PHI Pvt.Ltd New Delhi ,2006

5.	**Reference Book(s) and Other Required Material**

i) Coulson J.M., Richardson J.R. Chemical Engineering, Vol. I 5th Edition, Butterworth Heinemann, New Delhi.

6.	**Evaluation Details:**

- Class Tests and Assignments: 15%
- Mid-Semester Exam (1.5 Hours): 25%
- End-Semester Exam (3 Hours): 60%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**CML 223 Chemical Reaction Engineering-I**
Course Type:	Department Core (DC)
Name of the programme(s):	B.Tech Chemical Engineering , B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P:	3 – 1 – 0
Credits:	04
Class Schedule:	4 Classes per week (55 minutes each)
Pre-requisites:	CHL XXX Chemistry, MAL 101 Engineering Mathematics
Course Equivalence:	None

1.	**Course Objective:**
1	Provide students with a basic understanding of reaction engineering, type of reactions and their mechanisms, reaction kinetics and dependency.
2	Enhance their knowledge on types of reactors, working of reactors and different types of arrangements of reactors.
3	Development of mathematical model equations and applications of it in solving reaction engineering and design problems.
4	Improve the student's ability in deciding type of reactor and their arrangement for achieving desired conversion keeping economy in point of view.
5	Building engineering problem solving and critical thinking ability of students keeping in mind economical and sustainable approach to the problem.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Estimate reaction rates and their dependency, conversion and yield, reaction mechanisms and reaction path of a given chemical reaction.
CO2	Processing of various chemical constituents in the reactor and reactor design for different chemical reactions.
CO3	Design of multiple reactors, different types of reactors, sequential arrangement of the reactors, and their performance on product output.
CO4	Isothermal and non-isothermal effects on chemical reaction and design of chemical processes and reactors for a particular duty.

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Unit I: Introduction to CRE: • Basics of chemical reaction engineering • Role of Chemical Reaction Engineering in Process Industry Classification of reaction based on various	CO1	1.0 (4 Hours)

terms, reaction rate chemical kinetics • Variables affecting rate of reaction, Speed of reactions, problems.		
Unit II: Kinetics of Homogeneous Reactions: • Concentration dependent term and temperature dependent terms of rate equation • Single and multiple reactions, elementary and non-elementary reactions, molecularity and order of reaction, rate constant • Representation of reaction rate, kinetic models • Temperature dependency from Arrhenius' law, thermodynamics, various theories, activation energy, problems.	CO1	1.0 (4 Hours)
Unit III: Interpretation of Batch Reactor Data: • Constant volume batch reactor • Variable volume batch reactor • Integral method and differential method of analysis of kinetic data, other methods of analysis of kinetic data, problems.	CO1	1.0 (4 Hours)
Unit IV: Introduction to Reactor Design: • Types of reactors, PFR, CSTR etc., • Material & energy balances single ideal reactor, Space-time and space-velocity, Holding time, Introduction of non-ideal flow • Ideal reactors for a single reaction, ideal batch reactor, steady state mixed flow reactor, steady state plug flow reactor, problems.	CO2	1.0 (4 Hours)
Unit V & VI: Design for Single and Parallel Reactions: • Size comparison of single reactors • General graphical comparison • Multiple reactor system • recycle reactor • Autocatalytic reactions and problems ○ Introduction to design of parallel reactions ○ Qualitative and Quantitative discussion on product distribution ○ Contacting patterns, reactor size and arrangement, selectivity, yield, problems.	CO3	2.0 (8 Hours)
Unit VII: Potpourri of Multiple Reactions: • Reversible first order reaction • first order followed by zero order reaction, zero order followed by first order reaction	CO3	1.25 (5 Hours)

• Successive reversible reactions of different orders • Irreversible series-parallel reactions, Graphical representation, Denbigh reactions and their special cases, problems.		
Unit VIII: Temperature and Pressure Effects: • Single and multiple reactions • Heats of reaction from thermodynamics, equilibrium constant and its dependency, graphical design procedure • Optimum temperature progression, heat effects • Adiabatic and non-adiabatic operations, problems.	CO4	1.25 (5 Hours)

4. Textbooks

i) Fogler, H.S., Elements of Chemical Reaction Engineering, 4th Edition, Prentice-Hall, NJ, 2006.

ii) Froment, G.F. and Bischoff, K.B., Chemical Reactor Analysis, 2nd Edition, John Wiley & Sons, 1990.

iii) Levenspiel, Octave, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 1998.

iv) Smith, J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, NY, 1981.

5. Reference Book(s) and Other Required Material

i) Richardson, J.F. and Peacock, D.G., Coulson & Richardson's Chemical Engineering, Butterworth-Heinemann.

ii) Salmi, T.O., Mikkola, J.P., and Warna, J.P., Chemical Reaction Engineering and Reactor Technology.

6. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assessment Component	Weightage
Class Tests and Assignments	20%
Mid-Semester Exam (1.5 Hours)	20%
End-Semester Exam (3 Hours)	60%
Total	**100%**

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

Key for Mapping Correlation	
3	Strong Correlation
2	Moderate Correlation
1	Weak Correlation
-	No Correlation

8. List of Indicative Laboratory Experiment (if applicable):
1. Reaction in Batch reactor
2. Reaction in Semi-batch reactor
3. Reaction in Plug-flow reactor
4. Reaction in Continuous stirred tank reactor

Course Code & Course Title:	**CML – 225 Chemical Engineering Thermodynamics-II**		
Course Type:	**DC**		
Name of the programme(s):	B. Tech Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**L**	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**CML 204 : Chemical Engineering Thermodynamics - I**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**

Based on the concepts taught, Student shall be able to apply the concepts of thermodynamics to solve the given problem on thermodynamic process accurately.

2.	**Course Outcomes:**
CO1	Describe the Thermodynamic properties like free energy, activity, fugacity etc., for pure substances and solve the related problems.
CO2	Describe the thermodynamic properties of solutions and solve the related problems.
CO3	Use the concepts of phase equilibrium and solve the problems.
CO4	Apply the concepts of chemical equilibrium and solve the problems.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Thermodynamic properties of pure substances: fugacity, fugacity coefficient, compressibility factor, activity.		CO1	1
Solution thermodynamics: Ideal and non-ideal gas mixtures and liquid solutions, partial molar properties, physical significance and determination methods, chemical potential. Gibbs-Duhem equation: General form, various forms of Gibbs-Duhem equation, applications, limitations; Property changes of mixing, excess properties.		CO2	4

Criteria of phase equilibrium, Duhem theorem. Vapour liquid equilibrium, VLE equation, low pressure VLE, Phase diagrams for binary solution, T-x-y and P-x-y diagrams. Effect of pressure on VLE. Azeotropes and its types. Activity coefficient; equations used for the determination, Margules, van Laar, Wilson equations, VLE at high pressures, bubble point, dew point calculations, Thermodynamic consistency tests for VLE data.	CO3	5
Chemical reaction equilibrium; criteria of equilibrium, Reaction stoichiometry, equilibrium constant, Gibbs free energy change, choice of standard state, feasibility of chemical reactions, effect of temperature on equilibrium constant, evaluation of van't Hoff constant, Effect of parameters like temperature, pressure, composition on the equilibrium conversion.	CO4	3

4.	**Text books**

i) Narayan K.V., a text book of Chemical Engineering Thermodynamics, 2nd edition, PHI Learning Private Limited, 2013, ISBN 13: 978-81-203-4747-2.

ii) Smith J.M., Van Ness H. C., and Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 9th edition, McGraw Hill, 2021, ISBN 978-1-259-69652-7.

5.	**Reference Books**

i) Hill, T.L., An Introduction to Statistical Thermodynamics, Dover Publications, 1960, ISBN 13: 978-0486652429.

ii) Rao Y.V.C., Chemical Engineering Thermo dynamics, University press (INDIA) Ltd., 1997, ISBN 13: 978-8173710483.

iii) S.Sandler, Chemical, biochemical and engineering thermodynamics, 4th edition, John Wiley, 2006, ISBN 13: 978-0471661740.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Component	**Duration**	**Weightage**
Mid Term Exam	1.30 hour	30
Class tests and/ Viva	-	20
End Semester Exam	3 hours	50

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO225.1	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CO225.2	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CO225.3	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CO225.4	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CML225	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2

Course Code & Course Title:	CMP2** Fermentation Technology Laboratory		
Course Type:	**DC**		
Name of the programme(s):	Chemical Technology (Bioprocess Technology)		
L – T – P	**(0-0-2)**	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:** The course aims: 1. To introduce the fundamental principles of momentum, heat, and mass transfer. 2. To establish a solid theoretical foundation for solving transport phenomena problems. 3. To develop mathematical and computational skills for modelling transport processes. 4. To analyse industrial and environmental implications of transport phenomena. 5. To enhance critical thinking and problem-solving abilities for system design and optimization.

2.	Course Outcomes:
CO1	Apply fundamental principles of momentum, heat, and mass transfer to solve engineering problems.
CO2	Analyse complex transport systems using mathematical models and derive governing equations.
CO3	Utilize computational tools to solve transport equations and design systems with practical constraints.
CO4	Evaluate the environmental and industrial implications of transport processes

3.	Detailed Description of the Course (Any 08)		
Topics		**CO(s) Addressed**	**Duration in weeks**
1. To study the design and operation of CSTF fermenter		CO1-CO4	
2. To study the effect of pH over ethanol production from glucose			

using *Saccharomyces cerevisiae*.		
3. To study the effect of Nitrogen source over ethanol production from glucose using *Saccharomyces cerevisiae*		
4. To study the effect of substrate concentration over ethanol using *Saccharomyces cerevisiae*.		
5. How to ferment glucose or sucrose into ethanol using *Saccharomyces cerevisiae* yeast		
6. To study microbial growth kinetics of *Saccharomyces cerevisiae* in a batch culture		
7. To study microbial growth kinetics of *Aspergillus Niger* in a batch culture		
8. To determine mass transfer coefficient of fermentation broth.		
9. To produce amylase enzyme using solid state fermentation using *Aspergillus Niger* and starch substrate.		
10. To study – detection and quantification of fermentation products using different analytical techniques like titration, enzymatic methods, HPLC and other chromatographic methods are used to quantify lactic acid or ethanol information broths		

4.	Text books

1. El-Mansi, E.M.T., & Bryce, C.F.A. *Fermentation Microbiology and Biotechnology*.
2. Stanbury, P.F., Whitaker, A., & Hall, S. *Principles of Fermentation Technology*. Pergamon Press.
3. Friberg, S. *Handbook of Food and Beverage Fermentation Technology* (Food Science and Technology).
4. Reed, G. *Prescott and Dunn's Industrial Microbiology*0

5.	Reference book(s) and Other Required Material

1. Shuler, M.L., & Kargi, F. *Bioprocess Engineering: Basic Concepts*. Prentice Hall.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 0
Mid-Semester Exam: 0
End-Semester Exam: 100

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code and Name:	**CMP202 & Fluid Mechanics Lab**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech. (Chemical Engineering)**		
L – T – P	**0-0-2**	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s)& Name(s)	**None**		

1	**Course Objective:** 1) To impart the basic concepts of fluid mechanic 2) To develop understanding about flow measurement device 3) Understand frictional losses in pipes 4) The students are exposed to basic theory, calculations and machinery involved in various fluid handling operations

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand importance of various Fluid mechanics concept used in process industry.
CO2	To apply principles of basic sciences and chemical engineering for designing various Flow and pressure measuring instruments
CO3	To experience of handling different unit operations

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Friction in Pipeline To determine the friction coefficient factor for different size as well as different material of pipes.	CO1, CO2, CO3	2 hrs in a week
	Flow Through Notches To determine discharge coefficient C_d through different Notches.	CO1, CO2, CO3	2 hrs in a week
	Packed Bed Hydraulic study in Packed column.	CO1, CO2, CO3	2 hrs in a week
	Fluidized Bed To study the relation between the pressure drop & superficial velocity throughout the bed.	CO1, CO2, CO3	2 hrs in a week
	Pressure Drop In Fittings To study the losses in pressure due to different fitting in pipes.	CO1, CO2, CO3	2 hrs in a week

Impact of Jet on Vanes To study flow of fluid through Jet.	CO1, CO2, CO3	2 hrs in a week
Pressure Measurement Pressure measurement in pipeline.	CO1, CO2, CO3	2 hrs in a week
Two Phase Flow To study the flow pattern of two phase in singe tube.	CO1, CO2, CO3	2 hrs in a week
Orifice Meter To determine discharge coefficient $C_{d.}$.	CO1, CO2, CO3	2 hrs in a week
Venturi Meter To determine discharge coefficient C_d.	CO1, CO2, CO3	2 hrs in a week
Pitot Tube To determine discharge coefficient C_d & determine point velocity.	CO1, CO2, CO3	2 hrs in a week

4. Text books

i) Badger & Banchero Introduction to Chemical Enginerring Mc-Graw- Hill Education

ii) G.G. Brown Unit Operation John Willey

iii) Chattopadhyay O.P., Unit Operations of Chemical Engineering, Vol. 1 & 2, Khanna Publications, New Delhi, 1996.

iv) Hiremath R.S & Kulkarni A.P.,. Mechanical Operations Vol I Everest Publication

5. Reference Book(s) and Other Required Material

i) Christie J. GeanKoplis Transport processes & Unit Operation Prentice hall International

ii) Coulson J. M. and Richardson J.F; Chemical Engineering Vol. 1& 2 Publishers: Butter worth – Heinemann Ltd. 2001-2002.

iii) McCabe W.L., Smith J.C. and Harriot P., Unit Operations of Chemical Engineering McGraw Hill, New York 2001. 6th Edition.

6. Evaluation Details:

- **Performance = 60**
- **Viva = 20**
- **Slip test = 20**

7. Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	3			3	2					3	3	3	3
CO2	3	3	3	3			3	2	1		2	1	3	3	3	3
CO3	3	3	3	3		1	3	3	3	3	2	3	3	3	3	3

CO4																
CO5																

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable): NA

Nil

Course Code and Name:	**CMP 322- Heat Transfer Laboratory**		
Course Type:	DC		
Name of the programme(s):	B.Tech. (Chemical Engineering)		
L – T – P	0-0-2	No. of Credits	1
Pre-requisites: Course Code(s) & Name(s)	CML222- Heat Transfer		
Course Equivalence: Course Code(s)& Name(s)	**NIL**		

1.	**Course Objective:** 1) To give the in-hand experience of lab scale experiments on various equipments such as heat transfer through forced convection, pin fin, lagged pipe, emissivity apparatus, stefan's boltzmann apparatus, shell and tube heat exchanger, double pipe heat exchanger, open pan evaporator, single effect evaporator, heat transfer in agitated vessel system 2) To observe and note down the steady state temperatures of all equipments. 3) To determine the heat transfer rate, heat transfer coefficient, and overall heat transfer coefficient for various equipments such as shell and tube heat exchanger, double pipe heat exchanger etc. 4) To introduce application of heat transfer equipments and its optimum use

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	In-hand experience of lab scale experiments on various equipments such as heat transfer through forced convection, pin fin, lagged pipe, emissivity apparatus, stefan's boltzmann apparatus, shell and tube heat exchanger, double pipe heat exchanger, open pan evaporator, single effect evaporator, heat transfer in agitated vessel system
CO2	Observation of the steady state temperatures of all equipments
CO3	Determination of the heat transfer rate, heat transfer coefficient, and overall heat transfer coefficient for various equipments such as shell and tube heat exchanger, double pipe heat exchanger etc.
CO4	Application of heat transfer equipments and its optimum use

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
To find surface heat transfer coefficient for a pipe flowing heat by forced Convection of air flowing through it for different air flow		**CO1, CO2 CO3, CO4**	2 Hrs. in a week

rate and heat flow rate		
To study the temperature distribution along the length of a pin fin under free and forced convection heat transfer	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To determine heat flow rates through the lagged pipe for known value of thermal conductivity of lagged material and To plot the temperature distribution across the lagged material	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To find out Stefan's Boltzmann constant	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To determine the emissivity of grey surface	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To calculate biot number , fourier number and heat transfer coefficient for unsteady state heat transfer	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To determine cold water side and hot water side heat transfer coefficient, LMTD and overall heat transfer coefficient for parallel and counter flow	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To calculate rate of heat transfer, LMTD and overall heat transfer coefficient for plate type heat exchanger	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To determine the critical heat flux	**CO1, CO2 CO3, CO4**	2 Hrs. in a week
To study the filmwise and dropwise condensation	**CO1, CO2 CO3, CO4**	2 Hrs. in a week

4.	**Text books**

i) Coulson J.M., Richardson J.R. Chemical Engineering, Vol. I, Butterworth Heinemann, New Delhi.

ii) Kern D.Q, Process Heat Transfer, Tata McGraw Hill Book Co., New Delhi, 1990.

5.	**Reference Book(s) and Other Required Material**

i) Hollman J.P.; Heat Transfer, McGraw Hill, 1993

ii) Dutta B.K. Heat Transfer; Principles and Applications PHI Pvt.Ltd New Delhi ,2006

6.	**Evaluation Details:**

- Experiments and Journals : 50%
- Slip Tests and Assignments: 20%
- Practical Exam : 30%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**CMP xxx Mini Project**		
Course Type:	**DC**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**(0-0-4)**	**No. of Credits**	**2**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** 1. To identify and analyze engineering problems requiring innovative solutions. 2. To conduct a comprehensive literature review to establish project scope. 3. To develop a feasible methodology for experimentation or theoretical work. 4. To enhance technical communication through presentations and written reports

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Identify and define a problem in engineering.
CO2	Conduct a thorough literature review to establish a project framework.
CO3	Develop a feasible methodology for experimental or theoretical analysis.
CO4	Present a preliminary project report and communicate objectives effectively

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
Unit 1: Introduction to Problem Formulation • Overview of project planning and research. • Techniques for problem identification and formulation			(4 Hours)
Unit 2: Literature Review and Project Scope • Conducting and documenting a comprehensive literature review. • Defining project objectives and scope.			(6 Hours)
Unit 3: Methodology Development			(6 Hours)

• Designing experimental or computational frameworks. • Tools and techniques for data collection and analysis.		
Unit 4: Report Preparation and Presentation • Structuring a technical report. • Delivering a clear and concise presentation.		(4 Hours)

5. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]	
Component	**Weightage**
Literature Review	20%
Problem Formulation	20%
Proposed Methodology	30%
Presentation and Report	30%

6	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	**3**	**3**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	-	-
CO2	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	2	-	-
CO3	**3**	**3**	**3**	**3**	**-**	**-**	**-**	**-**	**2**	**-**	**2**	1	-	-
CO4	**-**	**2**	**-**	**3**	**-**	**-**	**2**	**3**	**3**	**-**	**-**	-	3	2
CO5	**3**	**3**	**2**	**3**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	-	-	1

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

5th Semester B.Tech. Chemical Tech. (BPT)

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CML3**	Downstream Processing	DC	3-0-0	3	None
CML3**	Computational Techniques and Biostatics	DC	3-0-0	3	None
CML3**	Molecular Biology and Genetic Engineering	DC	3-0-0	3	None
CML301	Mass Transfer II	DC	3-0-0	3	None
CML304	Chemical Reaction Engineering II	DC	3-0-0	3	None
CML302	Chem. Process Modeling & Simulation	DC	3-0-0	3	None
CMP3**	Molecular Biology & Genetic Engg. Laboratory	DC	0-0-2	1	None
CMP304	Chemical Reaction Engg. Laboratory	DC	0-0-2	1	None
CMP321	Mass Transfer Laboratory	DC	0-0-2	1	None
	Electives				
CMLxxx	Elective 3	DE	3-0-0	3	None
Total Credits (DC + DE = 21+3=24)				**24**	

Course Code & Course Title:	**CML3** Downstream Processing**		
Course Type:	**DC**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objectives:**
i.	To learn different separation techniques / methods used in different bioprocesses
ii.	To make student understand steps in bioseparation, its importance, complete process design for biological product with economics
iii.	To understand selection of unit operation / separation method for a particular product

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Ability to understand the governing mechanism and driving force of various separation processes used in bioprocesses
CO2	Ability to perform process and design calculations on various separation processes required for bioprocesses
CO3	Ability to understand the pros and cons of separation method
CO4	Ability to select/choose the suitable separation method for a particular product

3.	**Detailed Description of the Course**		
Sr. No.	**Description**	**COs Addressed**	**Duration (Weeks)**
1	Characteristics of biological materials; Pre-treatment / cell disruption methods- Mechanical, physical, chemical and biological methods	CO1	3
2	Microbial separation: Centrifugation and filtration, Protein precipitation, Isoelectric focusing, Extraction, Aqueous two phase systems, Supercritical fluid	CO1, CO3	4

	extraction, Adsorption, Electrophoresis		
3	Chromatography, types, principle and applications, design and operation aspects	CO1, CO2, CO4	4
4	Membrane processes, microfiltration, ultrafiltration, nanofiltration, Reverse osmosis, Affnity based separations	CO1, CO4	2
5	Hybrid separation processes, pervaporation, perstraction; Case Studies on above topics	CO3, CO4	2

4.	**Text book**
i.	Belter, P.A., Hu, W.S., & Cussler, E.L. *Bioseparation: Downstream Processing for Biotechnology*. Wiley, New York, 1988
ii.	Siva Shankar. *Bioseparations*. PHI Publications, 2006

5.	**Reference Books**
i.	Seader, J.D., & Henley, E.J., Separation Process Principles, Wiley.
ii.	Product Recovery in Bioprocess Technology, BIOTOL Series, VCH, 1990.
iii.	Asenjo, J.M., Separation Processes in Biotechnology, Marcel Dekker Inc., 1993.

6.	**Evaluation Details:**
Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%
End-Semester Examination (3 Hours)	50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**

CO1	3	3	3	3							1	3	2	2	1
CO2	3	3	3	1		2						3	3	2	1
CO3	2	3	3	2	3	3	3			2		2	3	2	1
CO4	3	3	3	3	3	3	3	2			3	3	3	2	1

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

None

Course Code & Course Title:	CML3** Computational Techniques and Biostatistics		
Course Type:	**DC**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	Course Objectives:
i.	To study various computational techniques of regression for curve fitting.
ii.	To study types of interpolation by understanding its importance and application in engineering system.
iii.	To study numerical integration methods and their applications in engineering systems
iv.	To make students aware of concept of biostatistics and importance of accurate sampling methods while analyzing the experimental data.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	An ability to apply knowledge of computational regression techniques for curve fitting, develop understanding towards numerical methods such as interpolation
CO2	Develops skill for solving engineering problems using numerical integration.
CO3	Improves logical thinking of students by applying different methodologies of solving a single problem.
CO4	Helps in gaining knowledge in design and conduction of experiments as well as in analyzing and interpreting data correctly.

3.	Detailed Description of the Course		
Sr. No.	**Description**	**COs Addressed**	**Duration (Weeks)**
1	Introduction to modelling, types of models, Regression	CO1	3

2	Types of averages, Data distributions: Binomial, Poisson, Geometric distribution. Normal, F, chi-square, Weibull, non-normal distribution	CO4	3
3	Interpolation and Finite differences: Forward differences, backward differences, central differences, Newton's Interpolation formulae with equal intervals, Interpolation with unequal intervals: Lagrange's formula, divided differences	CO1, CO2	3
4	Solutions of Algebraic equations and ordinary differential equations: formation of differential equations, solution methods	CO2, CO3	3
5	Biostatistics: Introduction to Biostatistics Sampling: Introduction, theoretical basis of sampling, Data representation: Significance of graphs and diagrams	CO4	3

4.	**Text books**
i.	Jain, M.K., Jain, R.K., Iyengar, S.R.K., Numerical Methods for Scientific and Engineering Computation, 5th Ed., New Age International Publishers.
ii.	Venkateshan, S.P., Swaminathan, P., Computational Methods in Engineering, Springer, Cham.
iii.	Gupta, S.P., Statistical Methods, Sultan Chand and Sons, New Delhi.

5.	**Reference Book(s) and Other Required Material**
i.	Chapra, S.C., Canale, R.P., Numerical Methods for Engineers with Software and Programming Applications.

6.	**Evaluation Details:**
Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%
End-Semester Examination (3 Hours)	50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	1	3							2	3	2	
CO2	3	3	3	1	3							2	3	2	
CO3	3	3	3	2	3						2	2	2	3	
CO4	3	3	3	3	3						2	2	3	3	1

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

None

Course Code & Course Title:	**CML3** Molecular Biology and Genetic Engineering**		
Course Type:	**DC**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**(3-0-0)**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:** The course aims: 1. To learn key processes like DNA replication, transcription, translation, and gene regulation in cells. 2. To gain a better understanding with techniques like PCR, gel electrophoresis, recombinant DNA technology, and CRISPR-Cas9. 3. To explore how molecular biology is used in biotechnology, including gene modification in medicine, agriculture, and industry. 4. To develop skills to analyze and interpret genetic data, including gene expression and sequencing results. 5. To understand the ethical, legal, and societal impacts of genetic engineering and molecular biology technologies.

2.	**Course Outcomes:**
CO1	Ability to apply molecular biology methods like PCR, gene cloning, and CRISPR for genetic analysis and modification.
CO2	Demonstrate a clear understanding of DNA replication, transcription, translation, and gene regulation mechanisms.
CO3	Use molecular biology tools to solve real-world problems in medicine, agriculture, and biotechnology.
CO4	Effectively analyze and interpret experimental data from genetic research, including sequencing and gene expression

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit I: Chemistry of Nucleic Acids Introduction to nucleic acids, Primary structure of DNA, Secondary Structure of DNA, Tertiary structure of DNA		CO1	3

Unit II: DNA replication & repair Central dogma, DNA replication and differences in prokaryotic and eukaryotic DNA replication, Telomere replication in eukaryotes, Mutagens, DNA mutations, various types of repair mechanisms	CO1, CO2	3
Unit III: Transcription Structure and function of mRNA, rRNA and tRNA. RNA synthesis: Initiation, elongation and termination of RNA synthesis, Differences in prokaryotic and eukaryotic transcription. Ribozymes, RNA processing, Splicing	CO2	2
Unit IV: Translation Genetic code, Steps in translation, Inhibitors of protein synthesis, Post translational modifications, Regulation of gene expression.	CO2, CO3	2
Unit V: Cell Division & Cell Cycle Cell division, Cell cycle, Regulation of cell cycle, Cell cycle modulators. Checkpoints in cell cycle, Programd Cell Death; Cancer – Preliminary idea of Oncogene, Proto-oncogene and Tumor suppressor gene Structure of chromosome and chromatin regulation: Organization of chromosomes, chromatin concept, chromatin regulation	CO3	2
Unit VI: Introduction to recombinant DNA technology Cutting and joining DNA molecules; Gene structure and replication; transcription genetic code and translation, gene transfer techniques	CO3, CO4	1

4.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

5.	Text books

1. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular Biology of the Cell* (6th ed.).
2. Cooper, G.M., & Hausman, R.E. (2015). *The Cell: A Molecular Approach* (7th ed.).
3. Friefelder, David, & Malacinski, George M. (1993). *Essentials of Molecular Biology* (2nd ed.). Panima Publishing.
4. Friefelder, David. (1999). *Molecular Biology*. Narosa Publications.
5. Karp, Gerald. (2005). *Cell and Molecular Biology: Concepts and Experiments* (4th ed.). John Wiley.

6. Krebs, J.E., Goldstein, E.S., & Kilpatrick, S.T. (2017). *Lewin's Essential Genes* (12th ed.).
7. Nelson, D.L., & Cox, M.M. (2012). *Lehninger Principles of Biochemistry* (6th ed.).
8. Primrose, S.B., & Twyman, R. (2014). *Principles of Gene Manipulation and Genomics* (7th ed.). Wiley-Blackwell. ISBN: 978-1-405-13544-3.
9. Sambrook, J., & Russell, D. (2012). *Molecular Cloning: A Laboratory Manual* (3rd rev. ed.). Cold Spring Harbor Laboratory Press. ISBN-13: 978-0879695774.

6.	Reference book(s) and Other Required Material

1. Tropp, B.E. (2008). *Molecular Biology: Genes to Proteins* (3rd ed.). Jones and Bartlett.
2. Weaver, Robert F. (2003). *Molecular Biology* (2nd ed.). Tata McGraw-Hill.

7	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	-	3	-	3	-	-	-	-	-	-	-	-	-
CO2	3	1	2	3	2	-	-	-	-	-	1	2	-	-
CO3	2	2	3	3	3	1	1	-	-	-	2	1	-	-
CO4	2	2	1	1	1	-	-	-	-	-	-	-	3	2
CO5	3	-	3	-	3	-	-	-	-	-	-	-	-	1

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

Course Code & Course Title:	**(CML301) Mass Transfer II**		
Course Type:	**DC**		
Name of the programme(s):	**B.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The objective of this course is to introduce the mass transfer operations and how to quantify, formulate, and solve engineering problems involving different mass transfer operations like distillation, leaching, liquid-liquid extraction, absorption. To demonstrate that how to apply mass balances and its transfer and analyze systems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the basic concepts and principles of mass transfer operation like distillation, absorption, liquid-liquid extraction, solid-liquid extraction (leaching).
CO2	How to identify, quantify or formulate, and solve the engineering problems involving mass transfer.
CO3	Design and analysis of mass transfer processes and equipments.
CO4	Applications of mass transfer phenomena and its optimum use.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Unit I (6 hrs) Distillation: Vapour – liquid equilibria, Raoult's law, X-Y and H-X-Y diagrams, differential distillation and equilibrium distillation, steam distillation, azeotropic distillation, extractive distillation.	CO1, CO2, CO3	2
Unit II (8 hrs)Fractionation, binary distillation, plate and packed columns for distillation, analytical and graphical methods for estimation of number of stages required in distillation column, minimum reflux ratio, optimum reflux ratio, number of stages at optimum reflux, murphree plate efficiency and overall plate efficiency, effect of feed conditions on number of plates for	CO1, CO2, CO3, CO4	2

separation.		
Unit III (4 hrs) Concept of HETP, HTU, NTU in distillation, plate and packed columns, packings for packed columns, pressure drop in plate and packed columns, bubble cap, sieve tray, valve tray plate columns.	CO1, CO2, CO3	2
Unit IV (6 hrs) Absorption Equilibrium relationships, two film theory, penetration theory, surface renewal rate theory, concept of driving force and mass transfer coefficient, plate column and packed columns for absorption, selection of solvent for absorption and absorbers design procedures.	CO1, CO2, CO3, CO4	2
Unit V (6 hrs) Liquid – Liquid Extraction fundamentals, selection of solvent for extraction, estimation of mass transfer coefficients, triangular diagram representation, equipments for liquid – liquid extraction, plate and packed columns, spray columns, rotary disc contactors, design procedures and equipment selection criteria. Single stage, multistage operations etc.	CO1, CO2, CO3, CO4	2
Unit VI (6 hrs) Solid – Liquid Extraction fundamentals, Solvent selection, equilibrium relationship, triangular diagram representation, single stage, multistage concurrent and counter current operation, equipments for solid – liquid extraction, their design procedure and selection criteria.	CO1, CO2, CO3, CO4	2

4.	Text books

i) **Coulson, J. M. and Richardson, J. F.,***Chemical Engineering*, Vol. I, II & III, Pergamon Press, New York, 1977.

ii) **Treybal, R. E.,***Mass Transfer Operations*, McGraw Hill Book Co., New York, 1980.

5.	Reference Book(s) and Other Required Material

i) **Badger, W. L. and Banchero, J. T.**, *Introduction to Chemical Engineering*, 4th Edition, Tata McGraw Hill Book Co.

ii) **Dutta, Binay K.**, *Principles of Mass Transfer and Separation Process*, PHI Learning Pvt. Ltd., New Delhi.

iii) **McCabe, W. L. and Smith, J. C. and Harriott**, *Unit Operations of Chemical Engineering*, 5th Edition, McGraw Hill Book Co., New York, 1980.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 15%

Mid-Semester Exam (1.5 Hours): 25%

End-Semester Exam (3 Hours): 60%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

***High – 3; Medium – 2; Low – 1**.;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

NIL

Course Code & Course Title:	**CML304 Chemical Reaction Engineering-II**		
Course Type:	**DC**		
Name of the program(s):	BTech Chemical Engineering/ B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**CML223 Chemical Reaction Engineering - I**		
Course Equivalence: Course Code(s)& Name(s)	**Nil**		

1.	**Course Objective:**
	• Provide students with a basic understanding of Flow Pattern, Non-ideal behavior; heterogeneous catalytic systems, fluid – fluid systems, fluid – particles systems. • Provide the kinetics and design concepts for these systems. • Increase the student's ability to apply these principles for the design of reactors and application in process industries.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand & Apply the basic knowledge of chemical reaction engineering in process industry
CO2	Analyse and utilize the knowledge of non-ideal flow and various models to evaluate the performance of chemical reactors and equipment and their design for specific applications.
CO3	Analyse and utilize the knowledge of catalysis and catalytic reactors to apply for reactor and catalyst design for various applications and to evaluate their performance specific applications.
CO4	Analyse and utilize the knowledge of kinetics and design for fluid-fluid and fluid-particle reactions to evaluate the performance and their design for specific applications.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in hours**
Revision of Chemical Reaction Engineering – I Overview and Basics of Chemical Reaction Engineering – II		CO1	2
Flow Pattern, Contacting, and Non-Ideal Flow: Non ideal flow in reactors, RTD of fluid in reactors, Age distribution, F curve, C curve and E curve.		CO2	6
Compartment model, Dispersion model, Tank in Series model for Non ideal flow in reactors.		CO2	6

Introduction to Heterogeneous Reactions and Solid Catalysed Reactions: Introduction and Spectrum of kinetic regimes, Surface kinetics and rate equation, pore diffusion, porous catalyst, Heat effects, Performance Equation, Experimental methods and rate equation, Controlling Resistance	CO3	6
Introduction to Catalyst and Catalytic Reactors: Typical Catalysts, Catalyst Characterizations, Catalyst Deactivation and Regeneration, Packed bed reactor, Fixed Bed, Fluid Bed, Trickle bed, Slurry Reactors etc.	CO3	6
Kinetics and Design of Fluid- Fluid Reactions: The rate equation, Kinetic regimes for mass transfer and reaction, Fast reaction, Intermediate reaction, Slow Reactions, Factors to select the contactor, Straight mass transfer, Various cases of mass transfer with chemical reaction, reaction kinetics.	CO4	6
Kinetics and Design of Fluid- Particle Reactions: Various models for fluid-solid reactions, Shrinking core model, Rate of reaction, Reaction/Mass transfer Control, Rate controlling steps, plug flow and mixed flow of solids.	CO4	6

4.	**Text books**
i)	Octave Levenspiel, "Chemical Reaction Engineering" John Wiley & Sons, Singapore, 1998 3rd Edition

5.	**Reference Book(s) and Other Required Material**
i)	Fogler H.S., "Elements of Chemical Reaction Engineering", Prentice-Hall, NJ, 2006, 4th Edition
ii)	G. F. Froment and K. B. Bischoff, "Chemical Reactor Analysis", John Wiley & Sons, Singapore, 1990 2nd Edition.
iii)	Smith J. M., "Chemical Engineering Kinetics", McGraw Hill, N Y, 1981, 3rd Edition

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Component	**Duration**	**Weightage**
Quiz / Assignments / Internal etc.	----	20-25%
Mid Term Examination	1.5 hrs	25-30%
End Term Examination	3 hrs	50-60%

7.	**Relationship of Course Outcomes to Program Outcomes:**

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

High - 3; Medium – 2; Low – 1

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML302 Chemical Process Modelling and Simulation (Theory)		
Course Type: DC	**BS/ES/HU/IC/DC/IE/DE/HM/OC**		
Name of the programme(s):	B.Tech. (Chemical Engineering), B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The objective of this course is to introduce mathematical modelling of chemical processes and the use of simulation tools for analysis and design. The course aims to develop steady-state and dynamic models of chemical engineering systems, apply numerical methods for solving model equations, and provide hands-on experience with process simulation software.

2.	**Course Outcomes**
CO1	Formulate mathematical models for chemical process systems using conservation laws
CO2	Develop steady-state and dynamic models of chemical engineering unit operations
CO3	Apply numerical methods to solve algebraic and differential equations arising in process models
CO4	Use process simulation software for modelling and simulation of chemical processes
CO5	Analyze and interpret simulation results for process performance and improvement

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in Weeks**
Introduction to Process Modeling and Simulation – Fundamentals of process modeling in chemical engineering, objectives and scope of modeling and simulation, types of models, and their role in process analysis, design, and optimization.		CO1	2
Mathematical Modeling of Chemical Engineering Systems – Principles of model formulation and mathematical consistency of models; development of governing equations including overall and component continuity equations, energy balance equations, equations of motion, transport equations, equilibrium relations, and chemical kinetics with		CO1, CO2	3

examples.		
Modeling of Chemical Kinetics and Reaction Systems – Development of kinetic models for different reaction schemes, formulation of rate expressions, and incorporation of chemical kinetics into reactor modeling and design.	CO2	3
Fundamentals of Reactor Design for Ideal Systems – General approach to reactor modeling; analysis of ideal isothermal reactors; reversible and series reactions; semibatch reactors; continuous flow stirred tank reactor (CFSTR); multistage CFSTR systems; equal-size CFSTRs in series; and numerical methods for reactor system design.	CO3	3
Applications in Chemical Engineering Systems – Modeling of practical systems including series of isothermal constant-holdup CSTRs, CSTRs with variable holdup, heated tank systems, gas-phase pressurized CSTRs, non-isothermal reactors, batch reactors, reactors with mass transfer, single-component vaporizers, multicomponent flash drums, and ideal and non-ideal distillation columns including batch distillation with holdup.	CO4	2
Treatment of Experimental Results and Numerical Solution – Analysis of experimental results, parameter estimation, and solution of developed modeling equations using computational tools such as Polymath, MATLAB, and C++ for simulation and process analysis.	CO5	1

4.	**Text books**

i. Mickley H. S., Sherwood T. S., Reed C. E., Application of Mathematical Modeling in Chemical Engineering ,Tata-McGraw-Hill, New Delhi, 2002.
ii. Jensen V.G., Jeffrey’s G.V., Mathematical Methods in Chemical Engineering”, 2nd Ed. Academic Press, London, 1978.
iii. Lubyen W. L., Process Modeling, Simulation and Control for Chemical Engineers, McGraw-Hill,New York, 1989.
iv. A. Kayode Coker, Modelling of Chemical Kinetics and Reactor Design, Gulf professional publication
v. Incropera F.P. Fundamentals of Heat and Mass Transfer 5th Edition Wiley India Pvt.Ltd Ltd., 2008

5.	**Reference Book(s) and Other Required Material**

i. Biegler, L. T., Grossmann, I. E., and Westerberg, A. W., *Systematic Methods of Chemical Process Design*, Prentice Hall, 1997, ISBN: 9780134924220.
ii. Finlayson, B. A., *Introduction to Chemical Engineering Computing*, Wiley, 2nd Edition, 2014, ISBN: 9781118135395.
iii. Aspen Plus / Aspen HYSYS / DWSIM User Manuals.

6.	**Evaluation Details:**

- Continuous Assessment (Assignments / Quizzes / Mid-Sem): **40%**
- End-Semester Examination: **60%**

Practical Evaluation:

- Continuous Evaluation: **50%**
- End-Semester Practical Examination: **50%**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	2	–	2	–	–	–	–	–	–	2	–	–
CO2	3	3	2	2	2	–	–	–	–	–	–	3	–	–
CO3	2	3	2	3	2	–	–	–	–	–	–	3	–	–
CO4	2	3	3	3	3	–	–	–	–	–	–	3	3	–
CO5	2	2	2	2	2	2	2	–	–	–	–	2	2	–

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

- Familiarization with process modelling and simulation software
- Steady-state modelling of material and energy balance problems
- Simulation of reactors (CSTR and PFR)
- Simulation of heat exchangers
- Dynamic simulation of simple process systems
- Sensitivity analysis and parametric studies
- Mini project on modelling and simulation of a chemical process

Course Code & Course Title:	**CMP3** Molecular Biology and Genetic Engineering Laboratory**		
Course Type:	**DC**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P		**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The course aims: 1. Understanding Regulatory Mechanisms: To provide a comprehensive understanding of the lac-operon system, including lactose induction, glucose repression, and the diauxic growth curve of *E.coli*. 2. Practical Applications of Genetic Manipulation: To equip students with practical skills in UV mutagenesis, genetic transfer techniques, and gene mapping for studying bacterial genetics and protein expression. 3. Molecular Biology Techniques: To train students in essential molecular biology techniques such as plasmid DNA isolation, quantitation, restriction enzyme digestion, agarose gel electrophoresis, PCR, and vector-insert ligation. 4. Protein Expression and Purification: To develop proficiency in the transformation of E.coli, recombinant protein expression, SDS-PAGE analysis, and purification of His-Tagged proteins using Ni-NTA columns.

2.	Course Outcomes:
CO1	Proficiency in Regulatory Mechanisms: Students will be able to explain and demonstrate the mechanisms of lactose induction, glucose repression, and the diauxic growth pattern in E.coli.
CO2	Genetic Manipulation Skills: Students will gain practical experience in conducting UV mutagenesis, conjugation, gene mapping, and isolation of amino acid auxotrophs.
CO3	Mastery of Molecular Biology Techniques: Students will be skilled in performing plasmid DNA isolation, quantitation, restriction enzyme digestion, agarose gel electrophoresis, PCR, and vector-insert ligation, including the preparation of competent cells and transformation efficiency calculations
CO4	Expertise in Protein Expression: Students will be proficient in expressing and analyzing recombinant proteins in E.coli, performing SDS-PAGE analysis, and purifying His-Tagged proteins, as well as conducting random primer labeling and Southern hybridization.

3.	**Detailed Description of the Course**		
	Topics (Any 8)	**CO(s) Addressed**	**Duration in weeks**
	1. Concept of lac-operon: a) Lactose induction of B-galactosidase. b) Glucose Repression. c) Diauxic growth curve of *E.coli*	CO1-CO4	1
	2. UV mutagenesis to isolate amino acid auxotroph		1
	3. Phage titre with epsilon phage/M13		1
	4. Genetic Transfer-Conjugation, gene mapping		1
	5. Plasmid DNA isolation and DNA quantitation		1
	6. Restriction Enzyme digestion of plasmid DNA		1
	7. Agarose gel electrophoresis		1
	8. Polymerase Chain Reaction and analysis by agarose gel electrophoresis		1
	9. Vector and Insert Ligation		1
	10. Preparation of competent cells		1
	11. Transformation of *E.coli* with standard plasmids, Calculation of transformation efficiency		1
	12. Confirmation of the insert by Colony PCR and Restriction mapping		1
	13. Expression of recombinant protein, concept of soluble proteins and inclusion body formation in E.coli, SDS-PAGE analysis		1
	14. Purification of His-Tagged protein on Ni-NTA columns a) Random Primer labeling b) Southern hybridization.		1

4.	**Text books**

i. El-Mansi, E.M.T., & Bryce, C.F.A. Fermentation Microbiology and Biotechnology.
ii. Stanbury, P.F., Whitaker, A., & Hall, S. Principles of Fermentation Technology. Pergamon Press.
iii. Friberg, S. Handbook of Food and Beverage Fermentation Technology (Food Science and Technology).
iv. Reed, G. Prescott and Dunn’s Industrial Microbiology.

5.	**Reference book(s) and Other Required Material**

i. Shuler, M.L., & Kargi, F. *Bioprocess Engineering: Basic Concepts*. Prentice Hall.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Component	Weightage
Regular Lab Performance	20%
Lab Reports and Assignments	30%
Viva-Voce	10%
End-Semester Practical Exam	40%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**3**	**3**	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**2**	**-**
CO3	**2**	**2**	**3**	**3**	**3**	**1**	**-**	**2**	**2**	**2**	**2**	**-**	**3**	**2**
CO4	**1**	**1**	**2**	**-**	**-**	**3**	**3**	**-**	**1**	**-**	**-**	**3**	**-**	**1**
CO5	**3**	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	CMP 304: Chemical Reaction Engineering II (Lab)		
Course Type:	DC		
Name of the programme(s):	B. Tech. in Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	No. of Credits	1
Pre-requisites: Course Code(s) & Name(s)	CML223: Chemical Reaction Engineering -I		
Course Equivalence: Course Code(s) & Name(s)	Nil		

1.	**Course Objective:**

The course aims to:

Provide practical exposure to various chemical reactors and their operating principles.

Enable students to analyse reactor performance and reaction kinetics.

Introduce concepts of residence time distribution (RTD) and its impact on reactor design and operation.

Develop problem-solving skills and teamwork through collaborative experimentation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Conduct experiments on different types of reactors and analyze their performance.
CO2	Evaluate reaction kinetics using experimental data.
CO3	Perform residence time distribution (RTD) studies and interpret F-curve and C-curve results.
CO4	Apply knowledge of reactor operations to optimize chemical processes.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Students are required to perform any eight of the following experiments during the semester: Reactor Performance Studies 1. Three CSTRs Connected in Series Study the kinetics of reaction for different combinations of three CSTRs in series. 2. PFR and CSTR in Series Analyze the reaction kinetics for a combination of PFR and CSTR in series. 3. Isothermal Continuously Stirred Tank Reactor Examine the performance of an isothermal CSTR for the reaction		All CO	1 exp. Every week

between ethyl acetate and NaOH. 4. Isothermal Plug Flow Reactor Evaluate the performance of an isothermal PFR for the reaction between ethyl acetate and NaOH. Residence Time Distribution (RTD) Studies 5. RTD in Plug Flow Reactor Plot the F-curve and C-curve for a given PFR. 6. RTD in Series and Parallel CSTRs Investigate the residence time distribution for series and parallel CSTR configurations. 7. RTD in Packed Bed Reactor Determine the F-curve and C-curve for a packed bed reactor. Batch and Semi-Batch Reactors 8. Semi-Batch Reactor Determine the overall order of reactions for bimolecular reactions. 9. Adiabatic Batch Reactor Study the reaction kinetics under adiabatic conditions. 10. Isothermal Batch Reactor Find the Arrhenius constant using an isothermal batch reactor. Specialized Reactor Studies 11. Condensation Polymerization Reactor Study the polymerization reaction in a condensation polymerization reactor. 12. Fluidized Bed Reactor Analyze the performance of a fluidized bed reactor.		

4.	Text books

i) Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons (Indian Adaptation – Wiley India), 2021, ISBN: 9789354244605

ii) H. Scott Fogler, Elements of Chemical Reaction Engineering, 6th Edition, Pearson, 2021, ISBN: 9780135486221

5.	Reference Book(s) and Other Required Material

i) Gilbert F. Froment, Kenneth B. Bischoff, Juray De Wilde, Chemical Reactor Analysis and Design, 3rd Edition, John Wiley & Sons, 2010, ISBN: 9780470565414

ii) J. M. Smith, Chemical Engineering Kinetics, 3rd Edition, McGraw-Hill (originally 1981), ISBN: 9780070587106

iii) Mark E. Davis and Robert J. Davis, Fundamentals of Chemical Reaction Engineering, 2nd Edition, McGraw-Hill Education, 2013, ISBN: 9780073397894.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Component Weightage

Regular Lab Performance	20%
Lab Reports and Assignments	30%
Viva-Voce	10%
End-Semester Practical Exam	40%

7.	Relationship of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	-	3	-	-	-	-	-	-	3	2	3
CO2	3	3	3	2	3	-	-	-	-	-	-	3	3	3
CO3	2	3	2	-	3	-	-	-	-	-	2	2	3	3
CO4	3	3	3	3	3	-	-	-	-	-	-	3	3	3
CMP304	3	3	3	2	3						1	3	3	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

As given in Detailed Description of the Course in point no 3

Course Code & Course Title:	**CMP321 Mass Transfer lCMPaboratory**
Course Type:	**DC**
Name of the programme(s):	**B.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)**
L – T – P	**0-0-2** | **No. of Credits** | **1**
Pre-requisites: Course Code(s) & Name(s)	**CML221-Mass Transfer I**
Course Equivalence: Course Code(s) & Name(s)	**None**

1.	**Course Objective:**

The objective of this course is to introduce the remaining mass transfer operations and how to quantify, formulate, and solve engineering problems involving various mass transfer operations. To demonstrate that how to apply mass balances and its transfer and analyze systems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the basic concepts and principles of mass transfer operation.
CO2	How to identify, quantify or formulate, and solve the engineering problems involving mass transfer.
CO3	Design and analysis of mass transfer processes and equipments.
CO4	Applications of mass transfer phenomena and its optimum use.

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
To determine the Mass Transfer coefficient for Absorption of CO_2 in NaOH solution in packed Column.	CO1, CO2, CO3, CO4	1 exp. Every week
Study of adsorption of acetic acid on activated charcoal [To verify adsorption isotherms].		
To determine the number of Heat Transfer Units (HTU) & height equivalent to Theoretical plate (HETP) of Packed distillation column.		
To study the drying characteristics curve under constant drying condition in rotary vacuum or tray dryer.		
Diffusion (Liquid – Liquid) –To calculate the diffusion coefficient of vapour in still Air.		

To study the characteristics of Boiling point diagram.		
To study the characteristics Cooling Tower experiment.		
Experiments on Differential Distillation.		
To determine rate of distillation by Steam Distillation.		
Performance evaluation of fluid bed dryer.		
Study of factors affecting rate of Evaporation :-		
Effect of Surface Area.		
Effect of Temperature.		
Solid liquid extraction		
Liquid – Liquid Extraction– To determine Overall efficiency for a three-stage counter-current and cross current system.		
Diffusion (Liquid–Air):- To find the diffusion coefficient of vapour in still air.		
Experiments on Fractional Crystallization.		
Spray Column Dryer:- To study the Design and operating Principles of Spray Dryer.		
Plate Column Distillation:- To study the Performance of a rectification column.		
Determination of Rate of drying, Free moisture content and bound moisture content.		

4.	**Text books**

i) Badger, W. L.; Banchero, J. T. *Introduction to Chemical Engineering*, Tata McGraw Hill Book Co.
ii) Coulson, J. M.; Richardson, J. F. *Chemical Engineering Vol. I, II & III*, Pergamon Press, New York, 1977.
iii) Dutta, Binay K. *Principles of Mass Transfer and Separation Process*, Eastern Economy Edition, PHI Learning Pvt. Ltd., New Delhi.
iv) McCabe, W. L.; Smith, J. C.; Harriot, P. *Unit Operations of Chemical Engineering*, 5th Edition, McGraw Hill Book Co., New York, 1980.
v) Treybal, R. E. *Mass Transfer Operations*, 3rd Edition, McGraw Hill Book Co., New York, 1980.

5.	**Reference Book(s) and Other Required Material**

i) Mass Transfer Operations, Treybal R.E., McGraw Hill Book Co., New York 1980, 3rd Edition
ii) Chemical Engineering Vol. I, II & III, Coulson J.M. and Richardson J.F., Pergamon Press, New York 1977

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Component Weightage

Regular Lab Performance	20%
Lab Reports and Assignments	30%
Viva-Voce	10%
End-Semester Practical Exam/Slip Test	40%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High – 3; Medium – 2; Low – 1; No Correlation – –

Total Experiments to be conducted / designed: 8-10

8.	List of Indicative Laboratory Experiment (if applicable):

1. To determine the Mass Transfer coefficient for Absorption of CO2 in NaOH solution in packed Column.
2. Study of adsorption of acetic acid on activated charcoal [To verify adsorption isotherms].
3. To determine the number of Heat Transfer Units (HTU) & height equivalent to Theoretical plate (HETP) of Packed distillation column.
4. To study the drying characteristics curve under constant drying condition in rotary vacuum or tray dryer.
5. Diffusion (Liquid – Liquid) –To calculate the diffusion coefficient of vapor in still Air.
6. To study the characteristics of Boiling point diagram.
7. To study the characteristics Cooling Tower experiment.
8. Experiments on Differential Distillation.
9. To determine rate of distillation by Steam Distillation.
10. Performance evaluation of fluid bed dryer.
11. Study of factors affecting rate of Evaporation: -
    i) Effect of Surface Area.
    ii) Effect of Temperature.
12. Solid liquid extraction
13. Liquid – Liquid Extraction– To determine Overall efficiency for a three-stage

counter-current and cross current system.

14. Diffusion (Liquid–Air): - To find the diffusion coefficient of vapor in still air.
15. Experiments on Fractional Crystallization.
16. Spray Column Dryer: - To study the Design and operating Principles of Spray Dryer.
17. Plate Column Distillation: - to study the Performance of a rectification column.
18. Determination of Rate of drying, Free moisture content and bound moisture content.

6th Semester B.Tech. Chemical Tech. (BPT)

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
CMD401	Project Phase-I	DC	0-0-6	3	None
CML352	Transport Phenomena	DC	3-0-0	3	None
CM3***	Downstream Processing Laboratory	DC	0-0-2	1	None
CMP302	Chem. Process Modelling and Simulation Laboratory	DC	0-0-2	1	None
	Electives				
CMLxxx	Elective - 4 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 5 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 6	DE	3-0-0	3	None
CMLxxx	Elective – 7	DE	3-0-0	3	None
CMLxxx	Elective – 8	DE	3-0-0	3	None
Total Credits (DC + DE = 8+15=23)				**23**	
Advanced Diploma Exit is permitted without additional course					

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.

Course Code & Course Title:	**Project Phase I CMD *** **		
Course Type:	DC		
Name of the program(s):	B. Tech Chemical Technology (Bioprocess Technology)		
L – T – P	---	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s)& Name(s)	**None**		

1	**Course Objective:** a. An ability to identify, formulates, and solves engineering problems b. An ability to design a system, component, or process to meet desired needs c. An ability to design and conduct experiments, as well as to analyze and interpret data d. An ability to communicate effectively e. An understanding of professional and ethical responsibility f. An ability to function on multidisciplinary teams g. The broad education necessary to understand the impact of engineering solutions in a global and societal context h. A recognition of the need for, and an ability to engage in lifelong learning i. A knowledge of contemporary issues

2	Course Outcomes (Min. 3 & Max. 5):
CO1	Able to identify and formulate research problem
CO2	Able to design and develop solution to the problem
CO3	Able to analyze and solve the complex problems
CO4	Able to plan, implement and execute the project
CO5	Able to write effective technical report and demonstrate through presentation

3	Detailed Description of the Course		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit 1: Introduction to Problem Formulation • Overview of project planning and research. • Techniques for problem identification and formulation		CO1, CO2	3
Unit 2: Literature Review and Project Scope • Conducting and documenting a comprehensive literature		CO1, CO2	3

review. • Defining project objectives and scope.		
Unit 3: Methodology Development • Designing experimental or computational frameworks. • Carrying out experiments/ work as per plan (data generation) • Tools and techniques for data collection and analysis.	CO3, CO4	4
Unit 4: Report Preparation and Presentation • Data Analysis, Interpretation of results, discussion, conclusions • Structuring a technical report. • Delivering a clear and concise presentation.	CO5	4

4	Text books

5	Reference Book(s) and Other Required Material

6	Evaluation Details:

- Mid Sem Evaluation -I 20%
- Mid Sem Evaluation -II 20%
- End-Semester Exam: 60%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	–	–	–	3	–	3	–	–	–	3	3	–
CO2	3	3	3	–	2	–	3	3	–	–	3	3	3	3
CO3	–	–	3	3	3	2	3	3	–	–	3	–	–	3
CO4	–	–	–	–	3	3	3	3	3	3	3	–	–	–
CO5	–	–	–	–	–	–	2	3	3	–	3	–	–	–

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable): NA

Course Code & Course Title:	CML 352: Transport Phenomena		
Course Type:	DC		
Name of the programme(s):	B. Tech. in Chemical Engineering		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	CML202: Fluid Mechanics, CML221: Mass Transfer I, CML222: Heat Transfer		
Course Equivalence: Course Code(s) & Name(s)	Nil		

1.	**Course Objective:**

The course aims:

To introduce the fundamental principles of momentum, heat, and mass transfer.

To establish a solid theoretical foundation for solving transport phenomena problems.

To develop mathematical and computational skills for modelling transport processes.

To analyse industrial and environmental implications of transport phenomena.

To enhance critical thinking and problem-solving abilities for system design and optimization**.**

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Apply fundamental principles of momentum, heat, and mass transfer to solve engineering problems.
CO2	Analyze complex transport systems using mathematical models and derive governing equations.
CO3	Utilize computational tools to solve transport equations and design systems with practical constraints.
CO4	Evaluate the environmental and industrial implications of transport processes.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit I: Similarities Between Transport Mechanisms, Molecular and convective transport mechanisms, Newton's Law of Viscosity, Fourier’s Law, Fick’s Law, Dimensionless numbers in transport phenomena		CO1, CO2	1
Unit II: Inter-phase Transport and Transport Coefficients, Friction factor, heat and mass transfer coefficients, Transport analogies: Reynolds and Chilton-Colburn		CO1, CO2, CO4	3
Unit III: Shell Momentum Balances, Velocity distributions for laminar		CO1, CO2	2

flow Flow cases: Circular tubes, annuli, falling films, immiscible fluids		
Unit IV: Shell Energy Balances, Temperature distributions in solids and laminar flow, Scenarios involving electrical, nuclear, viscous, and chemical heat sources	CO1, CO2, CO4	2
Unit V: Shell Mass Balances, Diffusion with and without chemical reactions Applications: Stagnant films, porous catalysts, gas absorption	CO1, CO2, CO4	2
Unit VI: Equations of Change for Isothermal Systems, Equations for continuity, motion, energy, and angular momentum, Application in various flow scenarios	CO2, CO3	2

4.	Text books

i) İsmail Tosun, Modeling in Transport Phenomena: A Conceptual Approach, 2nd Edition, Elsevier Science, 2007, ISBN: 9780444530219.
ii) R.B. Bird, W. Stewart, E.N. Lightfoot, Transport Phenomena, 2nd Ed., Wiley, 2006. ISBN: 9780470115398.

5.	Reference Book(s) and Other Required Material

i) C.J. Geankoplis, Transport Processes and Separation Principles, 5th Ed., Prentice Hall, 2003. ISBN: 978-0134181660
ii) C.O. Bennet, J.E. Myers, Momentum, Heat & Mass Transfer, 3rd Ed., McGraw Hill, 1994. ISBN: 9780070661806
iii) G.S. Laddha, T.E. Degaleesan, Transport Phenomena in Liquid Extraction, Tata McGraw Hill, 1978.
iv) R. Brodkey, H.C. Hershey, Transport Phenomena – A Unified Approach, 2nd Ed., McGraw Hill, 1988. ISBN: 9780070079731

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 20%

Mid-Semester Exam (1.5 Hours): 30%

End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	3	2	1
CO2	3	3	3	2	2	-	-	-	-	-	-	3	3	2
CO3	2	2	3	3	3	-	1	-	2	2	2	2	2	3
CO4	1	1	2	-	-	2	3	3	-	1	-	1	1	2
CML352	3	2	3	2	2	1	1	1	1	1	1	3	2	2

High - *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

NIL

Course Code & Course Title:	CMP3** **Downstream Processing Laboratory**		
Course Type:	**DC**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objectives:**
i.	To understand the principles of downstream processing, including recovery, separation, and purification techniques.
ii.	To develop proficiency in separation techniques such as filtration, centrifugation, and precipitation, chromatography etc.
iii.	To gain experience with concentration methods

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Perform separation techniques to purify and recover biomolecules.
CO2	Separate proteins using various methods and evaluate purity using analytical techniques.
CO3	Optimize downstream processing protocols for maximum product yield and purity.
CO4	Analyze experimental data and communicate results effectively.

3.	**Detailed Description of the Course**		
Sr. No.	**Practical (Any 8)**	**CO(s) Addressed**	**Duration (Weeks)**
1	Separation of biomass/suspended solids by centrifugation, filtration, sedimentation and flocculation	CO1	1
2	Homogenization of baker's yeast	CO1	1
3	Ultrasonication of baker's yeast	CO1	1
4	Cell lysis using enzymes	CO1	1
5	Protein precipitation by salting out	CO2	1
6	Isoelectric precipitation of whey proteins	CO2	1
7	Thermal precipitation of proteins	CO2	1
8	Aqueous two-phase systems: salting-out ATPS of erythromycin	CO2, CO3	1
9	Chromatography	CO2	1
10	Crystallization of lactose	CO2	1
11	Ultrafiltration for separation of proteins	CO2, CO3	1
12	Separation and molecular weight determination of invertase by SDS-PAGE	CO2	1
13	Purification of invertase enzyme by FPLC	CO3	1

4.	**Text books and Reference Books**
i.	Belter, P.A., Hu, W.S., & Cussler, E.L., Bioseparation: Downstream Processing for Biotechnology, Wiley, New York.
ii.	Belter, P.A., & Cussler, E.L., Bioseparations, Wiley, New York, 1985.
iii.	Siva Shankar, Bioseparations, PHI Publications.

5.	**Reference Book(s) and Other Required Material**
i.	Asenjo, J.M., Separation Processes in Biotechnology, Marcel Dekker Inc., 1993.
ii.	Product Recovery in Bioprocess Technology, BIOTOL Series, VCH, 1990.
iii.	Seader, J.D., & Henley, E.J., Separation Process Principles, Wiley.

6	**Evaluation Details:**
Component	**Weightage**
Internal Evaluation (Viva/Slip Test)	20%
Performance	80%

7	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3	3	3	2	3	3	3		3	3	2	2	
CO2	3	3	3	1	2								3	3	2	
CO3	3	3	3	2	1		2					3	3	3	2	1
CO4	3	3	3			3	2	3		3		3	2	3	2	1

High - 3; Medium – 2; Low – 1;

8	**List of Indicative Laboratory Experiment (if applicable):**

None

Course Code & Course Title:	CMP302 – Chemical Process Modelling & Simulation (Laboratory)		
Course Type: DC	**BS/ES/HU/IC/DC/IE/DE/HM/OC**		
Name of the programme(s):	B.Tech. (Chemical Engineering), B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	0-0-2	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The objective of this laboratory course is to provide hands-on experience in modelling and simulation of chemical and bioprocess systems. The course aims to enable students to develop, simulate, and analyze steady-state and simple dynamic process models using computational and simulation tools.

2.	**Course Outcomes**
CO1	Develop mathematical models for basic chemical and bioprocess systems
CO2	Perform steady-state simulations of unit operations
CO3	Use numerical and simulation tools to solve process models
CO4	Analyze and interpret simulation results for process performance
CO5	Document modelling and simulation results in a structured manner

3.	**Detailed Description of the Course**		
Experiments / Exercises		**CO(s) Addressed**	
Introduction to process modelling and simulation environment		CO1	
Modelling and simulation of material balance problems		CO1, CO2	
Steady-state simulation of reactors (CSTR / PFR)		CO2, CO3	
Simulation of heat exchangers		CO2, CO3	
Simulation of separation processes		CO2, CO3	
Sensitivity analysis and parametric studies		CO4	
Mini exercise on modelling and simulation of an integrated process		CO4, CO5	

4.	Text books

i. Luyben, W. L., *Process Modeling, Simulation and Control for Chemical Engineers*, 2nd Edition, McGraw-Hill, 1990, ISBN: 9780070391598.
ii. Marlin, T. E., *Process Control: Designing Processes and Control Systems for Dynamic Performance*, 2nd Edition, McGraw-Hill, 2000, ISBN: 9780070393622.

5.	Reference Book(s) and Other Required Material

i. Finlayson, B. A., *Introduction to Chemical Engineering Computing*, Wiley.
ii. User manuals and tutorials of Aspen Plus / Aspen HYSYS / DWSIM.

6.	Evaluation Details:

- Continuous Evaluation (Lab Performance / Records): **50%**
- End-Semester Practical Examination: **50%**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	–	–	2	–	–	–	–	–	–	3	2	1
CO2	3	3	2	2	2	–	–	–	–	–	–	3	3	1
CO3	2	3	2	3	2	–	–	–	–	–	–	3	3	1
CO4	2	2	2	2	2	2	2	–	–	–	–	2	2	2
CO5	1	1	1	1	1	–	–	–	–	–	–	2	2	2

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Included under Section 3 (Detailed Description of the Course)

7th Semester B.Tech. Chemical Tech. (BPT)

Code	**Course Title**	**Category**	**Structure (L-T-P)**	**Credit**	**Pre-requisite**
CMD402	Project Phase-II	DC	0-0-6	3	None
	Electives				
CMLxxx	Elective - 9 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 10 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 11	DE	3-0-0	3	None
CMLxxx	Elective – 12	DE	3-0-0	3	None
Total Credits (DC + DE = 3+12=15)				**15**	

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.

VII and VIII semester will be interchanged if student opt for internship in VII semester.

Course Code & Course Title:	**CMD 402 Project Phase II**		
Course Type:	DC		
Name of the program(s):	B. Tech		
L – T – P	---	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s)& Name(s)	**None**		

1.	**Course Objective:** a. An ability to identify, formulates, and solves engineering problems b. An ability to design a system, component, or process to meet desired needs c. An ability to design and conduct experiments, as well as to analyze and interpret data d. An ability to communicate effectively e. An understanding of professional and ethical responsibility f. An ability to function on multidisciplinary teams g. The broad education necessary to understand the impact of engineering solutions in a global and societal context h. A recognition of the need for, and an ability to engage in lifelong learning i. A knowledge of contemporary issues

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Able to identify and formulate research problem
CO2	Able to design and develop solution to the problem
CO3	Able to analyze and solve the complex problems
CO4	Able to plan, implement and execute the project
CO5	Able to write effective technical report and demonstrate through presentation

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit 1: Introduction to Problem Formulation • Overview of project planning and research. • Techniques for problem identification and formulation		CO1, CO2	3
Unit 2: Literature Review and Project Scope • Conducting and documenting a comprehensive literature		CO1, CO2	3

review. • Defining project objectives and scope.		
Unit 3: Methodology Development • Designing experimental or computational frameworks. • Carrying out experiments/ work as per plan (data generation) • Tools and techniques for data collection and analysis.	CO3, CO4	4
Unit 4: Report Preparation and Presentation • Data Analysis, Interpretation of results, discussion, conclusions • Structuring a technical report. • Delivering a clear and concise presentation.	CO5	4

4.	Text books

5.	Reference Book(s) and Other Required Material

6.	Evaluation Details:

- Mid Semester Evaluation –I : 20%
- Mid Semester Evaluation –II : 20%
- End-Semester Exam: 60%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	3	–	–	–	3	–	3	–	–	–	3	3	–
CO2	3	3	3	–	2	–	3	3	–	–	3	3	3	3
CO3	–	–	3	3	3	2	3	3	–	–	3	–	–	3
CO4	–	–	–	–	3	3	3	3	3	3	3	–	–	–
CO5	–	–	–	–	–	–	2	3	3	–	3	–	–	–

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable): NA

B. Tech Chemical Technology (Bioprocess Technology) Semester VIII#

Code	Course Title	Category	Structure (L-T-P)	Credit	Pre-requisite
	Electives (Elective 13 + Elective 14 OR Internship)				
CMLxxx	Elective - 13 / MOOC*	DE	3-0-0	3	None
CMLxxx	Elective – 14 / MOOC*	DE	3-0-0	3	None
CMP4**	Internship	DE	6-0-0	6	
Total Credits (DC + DE = 0+6=6)				**6**	

* Maximum four MOOC/NPTEL/SWAYAM courses are allowed in a complete program and maximum two in a semester only for students going to internship.
MOOC/NPTEL/SWAYAM courses approved for UG Chemical Engineering are applicable for B.Tech. Chemical Technology (Bioprocess Technology)
VII and VIII semester will be interchanged if student opt for internship in VII semester.

Course Code & Course Title:	CMP4*** Internship		
Course Type:	**Elective**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	Semester Long	**No. of Credits**	**06**
Pre-requisites: Course Code(s) & Name(s)	**Completion of third-year courses in B.Tech. Chemical Technology (Bioprocess Technology)**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	1. To provide practical exposure to industrial or research environments. 2. To apply theoretical knowledge to solve practical engineering problems. 3. To foster professional communication through documentation and presentations

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Apply theoretical knowledge to practical problems in industry or research
CO2	Solve real-world bio-process/biotechnology/ bio-chemical engineering problems using modern tools
CO3	Document and present findings effectively in a professional setting.

3.	**tailed Description of the Course**		
Topics		**O(s) Addressed**	**Duration in weeks**
Overview of industrial or research internship requirements		CO1	4-6 weeks
Practical work under supervision		CO2	4-6 weeks
Learning modern tools and techniques used in the field		CO2	4-6 weeks
Preparing and submitting a detailed internship report		CO3	4-6 weeks

4.	**Text books**

None

5.	**Reference Book(s) and Other Required Material**

None

6. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Component	Weightage
Practical Work Evaluation	40%
Supervisor Feedback	20%
Internship Report	30%
Viva-Voce	10%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	2	3	3	2	-	-	-	-	-
CO2	3	3	3	3	3	-	2	2	-	-	-	-
CO3	3	3	3	3	3	-	2	2	3	3	-	3

8.	List of Indicative Laboratory Experiment (if applicable):

List of Electives for B.Tech. Chemical Technology (Bioprocess Technology)

CML3**	Biopharmaceutical Technology	3-0-0	3
CML3**	Industrial Biotechnology and Bioprocess Applications	3-0-0	3
CML3**	Nanotechnology for Bioprocess Technology	3-0-0	3
CML3**	Membrane Applications in Bioprocess Technology	3-0-0	3
CML4**	Bioreactor Design and Scale up	3-0-0	3
CML4**	Bioinformatics and Computational Biology	3-0-0	3
CML4**	Good Manufacturing Practices	3-0-0	3
CML4**	Systems Biology	3-0-0	3
CML4**	Biorefinery Engineering	3-0-0	3

$$ - In addition to above electives students can opt for other electives from different baskets

Course Code & Course Title:	CML3** Biopharmaceutical Technology		
Course Type:	**DE**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**(3-0-0)**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The course aims to: 1. Equip students with foundational knowledge in pharmaceutics to understand and analyze drug design and development processes. 2. Develop the ability to design and create novel products, focusing on new therapeutic drugs and enzyme solutions. 3. Impart knowledge of the standards and practices necessary to ensure the quality and safety of biopharmaceutical products. 4. Provide insight into the regulations and guidelines that govern the production, approval, and distribution of biopharmaceuticals.

2.	**Course Outcomes:**
CO1	Demonstrate the ability to understand and analyze the processes involved in the design, development, and formulation of pharmaceutical products.
CO2	Develop the skills to create novel biopharmaceutical products, including new therapeutic drugs and enzyme-based solutions.
CO3	Apply knowledge of standards, regulations, and practices to ensure the quality, safety, and efficacy of biopharmaceutical products.
CO4	Gain a thorough understanding of the regulatory frameworks and guidelines governing the production, approval, and distribution of biopharmaceuticals

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Unit I: Introduction to Biopharmaceuticals Overview of biopharmaceuticals and their importance. History of biopharmaceutical industry, growth, and significance in modern medicine. types of therapeutic agents and their uses; economics and regulatory aspects. Various categories of therapeutics like vitamins, laxatives, analgesics, contraceptives, antibiotics, hormones and biologicals.	CO1	2
Unit II: Biological Systems and Processes Understanding biological systems used in biopharmaceutical	CO1, CO2	3

production. Mechanism of drug action; physico-chemical principles of drug metabolism; radioactivity; pharmacokinetics.		
Unit III: Bioprocessing Techniques for the production and purification of biopharmaceuticals. Types of reaction process and special requirements for bulk drug manufacture.	CO1,CO2	3
Unit IV: Quality Control and Assurance Ensuring the quality and safety of biopharmaceutical products. Different quality analysis: QC, QA and Documentation Standard Operating Procedure Market complaint analysis. FDA India USFDA, WHO	CO3	2
Unit V: Regulatory Affairs Overview of regulations and guidelines governing biopharmaceuticals	CO4	2
Unit VI: Case Studies: Real-world examples and applications of biopharmaceutical technology	CO1, CO4	1

4.	Text books

i. Walsh, G. (2014). Biopharmaceuticals: Biochemistry and Biotechnology (2nd ed.). Wiley-Blackwell.
ii. Crommelin, D. J. A., Sindelar, R. D., & Meibohm, B. (2019). Pharmaceutical Biotechnology: Fundamentals and Applications (5th ed.). Springer.
iii. Douglas S. Clark, Harvey W. Blanch (1997) Biochemical Engineering, 2nd Edition, CRC press.

5.	Reference book(s) and Other Required Material

i. Shaik Harun Rasheed, Dr. (2017). A Textbook of Pharmaceutical Technology.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Class Tests and Assignments:** 20%
- **Mid-Semester Exam (1.5 Hours):** 30%
- **End-Semester Exam (3 Hours):** 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

CO3	2	2	3	1	3	1	3	-	-	1	2	1	1	-
CO4	1	1	2	1	-	3	3	-	1	-	-	-	3	-
CO5	3	3	2	-	1	-	-	-	-	-	-	-	-	-

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**CML3** Industrial Biotechnology and Bioprocess Applications**		
Course Type:	**DE**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	**Course Objectives:**
i.	To provide students with a solid foundation in the principles of bioprocesses, including microbial, plant, and animal cell culture techniques.
ii.	To enable students to understand the process of developing and commercializing bioproducts such as biofuels, bioplastics, pharmaceuticals, food additives, and enzymes.
iii.	To explore how biotechnological processes can reduce the environmental impact of industrial activities, focusing on waste minimization, bioremediation, and the production of renewable energy and bio-based materials.
iv.	To foster awareness of the ethical considerations in industrial biotechnology, including issues related to genetic modification, environmental impact, and societal implications.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Critically evaluate the technical, economic, and environmental factors in bioprocess development.
CO2	Identify and characterize microbial strains and enzymes used in industrial bioprocesses for applications such as fermentation, biodegradation, and bioremediation.
CO3	Analyze real-world case studies of successful industrial bioprocess applications in sectors like pharmaceuticals, biofuels, food and beverages, and environmental biotechnology.
CO4	Develop strategies for optimizing bioprocesses, including the optimization of parameters.

3.	;tailed Description of the Course		
S.N.	**Description**	**COs Addressed**	**Duration (Weeks)**
1	Industrial processes for Biofuels / Biorefinery: Liquid fuels, Gaseous Fuel, first generation, second generation and third generation biofuel, Biomass production, methods of fermentation, separation	CO1, CO2	4
2	Metabolic flux analysis, Process economics, Life cycle analysis, Use of AI /Statistical tools in bioprocess development	CO1, CO4	3
3	Industrial processes for Enzymes, Enzyme production, industrially used methods for enzyme	CO2	3
4	Industrial processes used for nutraceuticals and health related products	CO2, CO3	2
5	Economic and social benefits of modern biotechnology, Role of Knowledge economy; Case studies : Real world examples (Polymer, Biofuels, Biopesticides etc)	CO3	3

4.	Text books
i.	Soccol, C.R., Biofuel and Biorefinery Technologies, Springer, 2024.
ii.	Wittmann, C., & Liao, J.C., Industrial Biotechnology: Products and Processes, Wiley, 2016.
iii.	Cooke, P., Growth Cultures: The Global Bioeconomy and its Bioregions, Routledge, 2007.

5.	Evaluation Details:
Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%
End-Semester Examination (3 Hours)	50%

6.	Relationship of Course Outcomes to Program Outcomes:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	3	2	2	3	3	2		2	3	3	3	2	1
CO2	3	3	3	3	1	3	3	1		1	3	3	3	2	1
CO3	3	3	3	3	3	3	3	2		1	3	2	3	3	1
CO4	3	3	3	2	3	2	2			1	3	2	3	2	1

High **-** *3; Medium – 2; Low – 1;*

7.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	CML386 Nanotechnology for Bioprocess Technology		
Course Type: DE	**BS/ES/HU/IC/DC/IE/DE/HM/OC**		
Name of the programme(s):	B.Tech. (Chemical Engineering), B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The objective of this course is to introduce the fundamentals of nanotechnology with specific reference to bioprocess engineering and technology. The course aims to develop an understanding of nanomaterial synthesis, characterization, and interaction with biological systems, and to apply nanotechnology for enhancing efficiency, productivity, and sustainability of bioprocesses, while addressing safety and regulatory considerations.

2.	**Course Outcomes**
CO1	Understand the principles and applications of nanotechnology in bioprocessing
CO2	Design and develop nanomaterials for biotechnological applications
CO3	Analyze interactions between biological systems and nanomaterials
CO4	Apply nanotechnology for optimization of bioprocesses
CO5	Evaluate safety, regulatory, and ethical aspects of nanotechnology applications

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration**
Introduction to nanotechnology, nanoscale phenomena, properties, applications in biotechnology, safety aspects		CO1	2 Weeks
Nanomaterials synthesis and characterization techniques		CO2	3 Weeks
Nanomaterials for bioprocess applications: enzyme immobilization, membranes, nanofibers, nanogels		CO2, CO3	4 Weeks
Nanotechnology-enabled bioprocesses: biocatalysis, bioseparations, biosensors, drug delivery		CO3, CO4	3 Weeks

Case studies, regulatory frameworks, ethics, and sustainability	CO4, CO5	2 Weeks

4.	Text books

i. Torchilin, V., *Nanotechnology for Biomedical Applications*, Springer.
ii. Walker, J. M. (Ed.), *Nanobiotechnology: Methods and Protocols*, Humana Press.

5.	Reference Book(s) and Other Required Material

i) Cao, G. and Wang, Y., *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, World Scientific.
ii) Doran, P. M., *Bioprocess Engineering: Principles*, 2nd Edition, Academic Press.
iii) Recent review articles from peer-reviewed journals on nanobiotechnology.

6.	Evaluation Details:

Class Tests and Assignments: **20%**
Mid-Semester Examination (1.5 Hours): **30%**
End-Semester Examination (3 Hours): **50%**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	–	–	2	–	–	–	–	–	–	3	2	1
CO2	3	2	2	2	2	–	–	–	–	–	–	3	3	1
CO3	2	3	3	2	2	–	–	–	–	–	–	3	3	2
CO4	2	3	3	3	2	–	–	–	–	–	–	2	3	2
CO5	2	2	–	2	1	3	3	2	–	–	–	1	2	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Not applicable (Theory course)

Course Code and Name:	**CML XXX: Membrane Applications in Bioprocess Technology**		
Course Type:	DE		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	Basic Chemistry and Biology, Mass Transfer, Fluid Mechanics		
Course Equivalence: Course Code(s)& Name(s)	NIL		

1.	**Course Objective:** 1. Understand membrane principles and applications in bioprocess technology 2. Learn design and operation of membrane separation processes 3. Analyze membrane fouling and cleaning strategies 4. Explore membrane applications in biopharmaceutical, food, and biomedical industries

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Explain the principles of membrane processes and their relevance to bioprocessing
CO2	Design membrane separation systems and evaluate their performance
CO3	Identify and address membrane fouling challenges using effective cleaning strategies
CO4	Apply advanced membrane technologies to solve industrial and biomedical challenges

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Unit 1: Introduction to Membrane Technology (6 Hours) Membrane basics: transport mechanisms and materials. Membrane processes: microfiltration, ultrafiltration, nanofiltration, reverse osmosis.	**CO1**	2 Weeks
	Unit 2: Membrane Separation Principles Mass transfer and transport phenomena in membranes Membrane module designs: plate-and-frame, spiral wound, hollow fiber Applications in protein concentration and virus removal	**CO2**	2-3 Weeks

Unit 3: Membrane Fouling and Cleaning Fouling mechanisms: concentration polarization, cake formation Cleaning strategies: chemical, physical, and biological Sanitization and sterilization methods for membranes	**CO3**	2 Weeks
Unit 4: Membrane Applications in Bioprocessing Biopharmaceutical applications: protein purification, vaccine production Food processing: dairy, beverages, and wastewater treatment	**CO4**	2-3 Weeks
Unit 5: Advanced Membrane Technologies Membrane distillation and osmotic distillation Membrane bioreactors (MBRs) and dynamic membranes Membrane-integrated hybrid processes for enhanced performance	**CO4**	2-3 Weeks

4.	**Text books**

i) John Mulder, Membrane Technology and Applications, 2nd Ed., Wiley, 2006.

ii) Pauline M. Doran, Bioprocess Engineering: Kinetics, Sustainability, and Reactor Design, 3rd Ed., Wiley, 2012.

iii) KC Hayes and Zaid S. Abu-Rmaileh (Eds.), Biotechnology and Biopharmaceuticals: Transforming Technologies, 2nd Ed., Wiley, 2010.

iv) K. Nath, Membrane Separation Process, 1st Ed., Prentice-Hall of India, New Delhi, 2008.

v) WS Winston Ho and Kiran K. Sirkar (Eds.), Membrane Separations in Biotechnology, 1st Ed., Springer, 1992.

5.	**Reference Book(s) and Other Required Material**

i) D.J. Shaw, Membrane Filtration: A Guide to Filter Selection and Application, 1st Ed., Elsevier, 2010.

ii) Paul A. Belter and Ernest L. Cussler, Bioprocessing: Design, Operation, and Integration, 1st Ed., Elsevier, 1985.

6.	**Evaluation Details:**

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High **-** *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable): NA

Course Code & Course Title:	CML4** Bioreactor Design and Scale up		
Course Type:	**DE**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**(3-0-0)**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	Basic knowledge of mathematics Prerequisite courses can be Material and Energy Balances, Biological Rate processes, Enzyme science and Engineering		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** 1. To learn the fundamental principles involved in the design of bioreactors, including types, configurations, and their role in bioprocesses. 2. To develop the ability to control and optimize key parameters such as temperature, pH, oxygen, and nutrient levels for efficient bioreactor operation. 3. To understand the challenges and strategies involved in scaling bioprocesses from laboratory-scale to industrial-scale production. 4. To gain a deep understanding of mass transfer, heat transfer, and their impact on microbial and cell culture growth within bioreactors. 5. To acquire skills in evaluating bioreactor performance and troubleshooting issues related to efficiency, productivity, and product quality.

2.	**Course Outcomes:**
CO1	Demonstrate the ability to design and select appropriate bioreactor systems based on the specific requirements of a bioprocess
CO2	Effectively optimize critical parameters like temperature, pH, and nutrient levels to maximize bioreactor efficiency and productivity.
CO3	Apply knowledge of scale-up principles to successfully transfer bioprocesses from laboratory to industrial scale, addressing challenges in scalability.
CO4	Evaluate and analyze bioreactor performance, identifying and resolving issues related to mass and heat transfer, product yield, and process stability.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit I: Introduction to the bioprocesses and bioreactors Fundamentals of Bioprocesses and Bioreactors: bioreactor design-overview of bioreactor, its developments and types based on presence and absence of oxygen, type of bioprocess, type of microbe agent, mode of operation and method of generating		CO1	2

microbes- mammalian cell culture, plant cell culture & environmental applications, Components of bioreactors and importance		
Unit II: Design of Batch Bioreactors, Continuous Bioreactors, Fed-batch Bioreactors, Mass Transfer Operations, Heat Transfer Operations, Scale-up of Bioreactors Bioreactor operations and scale up: Batch bioreactors- cell death in bioreactors, endogenous metabolism, Plug flow reactors, fed batch reactors, chemostat- Chemostat in series, comparison of productivity in batch and continuous culture, large scale commercial biorecators- packed bed, fed batch reactors. Oxygen mass transfer in bioreactors – microbial oxygen demands; methods for the determination of mass transfer coefficients; mass transfer correlations. Scale up criteria for bioreactors. Power requirements in mixing under aerated and non aerated conditions, Heat transfer in bioreactors.	CO1, CO3, CO4	6
Unit III: Biochemical Aspects and Stability in Bioreactors Batch reactor- calculation of batch time, quantitative evaluation of batch processes, sources of non-ideality; continuous flow bioreactors- Gas-liquid mass transfer in bioreactors, concept of K_{La} and its measurement, aeration and agitation system in reactors. Design of immobilized enzyme reactors – packed bed, fluidized bed and membrane reactors mean residence time, washout condition; recycle bioreactors; combination of bioreactors. Stability conditions in bioreactors.	CO2, CO4	5

4.	Text books

i. Michael L. Shuler and FikretKargi, Bioprocess Engineering: Basic Concepts, 2nd Edition, 2002, Prentice Hall.
ii. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, 1999, Wiley.
iii. James E. Bailey and David F. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, 1986, McGraw Hill.

iv. H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, 2005, Prentice Hall

5.	Reference book(s) and Other Required Material

i. S. Liu, Bioprocess Engineering: Kinetics, Biosystems, Sustainability, and Reactor Design, 2013, Elsevier

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Class Tests and Assignments:** 20%
- **Mid-Semester Exam (1.5 Hours):** 30%
- **End-Semester Exam (3 Hours):** 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**CML 4** Bioinformatics and Computational Biology**
Course Type:	**DE**
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	**No. of Credits**
Pre-requisites: Course Code(s) & Name(s)	Basic Biology, Mathematic, Programming
Course Equivalence: Course Code(s) & Name(s)	

1.	**Course Objective:** The course aims: To introduce students to the fundamental principles and techniques in bioinformatics and computational biology for the analysis and interpretation of biological data. To familiarize students with biological databases, sequence analysis tools, and computational algorithms for tasks such as sequence alignment, gene prediction, and protein structure prediction. To develop proficiency in utilizing bioinformatics software and tools for data visualization, pattern finding, and genome analysis, including applications in genomics and proteomics. To understand the practical applications of bioinformatics in fields such as personalized medicine, drug discovery, genetic research, and the ethical considerations involved in bioinformatics. To cultivate critical thinking and problem-solving skills for analyzing complex biological data and solving real-world biological and biomedical challenges using computational techniques.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Apply fundamental principles of momentum, heat, and mass transfer to solve engineering problems.
CO2	Analyse complex transport systems using mathematical models and derive governing equations.
CO3	Utilize computational tools to solve transport equations and design systems with practical constraints.
CO4	Evaluate the environmental and industrial implications of transport processes.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit I: Introduction to Bioinformatics (4 Hours) Introduction to bioinformatics, Operating systems (including		CO3	1

Windows and Unix), Networks- including the Intranets and the Internet, Experimental sources of biological data, publicly available databases, High throughput sequencing,		
Unit II: Review of DNA replication (8 Hours) Introduction, Review of DNA replication, transcription, and translation, Genome organization, concept of homology, Review of molecular biology methods	CO1	3
Unit III: Introduction to DNA and protein databases (6 Hours) Introduction to DNA and protein databases, data storage, file formats, information retrieval, Database queries, sequence retrieval, Creation of restriction endonuclease maps, Pattern finding in DNA and protein sequencing, Gibbs Sampler, Hidden Markov Models, Profiles construction and searching	CO2, CO3	2
Unit IV: Sequence alignments (6 Hours) Sequence alignment, Dot plots, Dynamic programming, Local alignment, Global alignment, Multiple alignments, Alignment scores, Scoring matrices, gap penalty, statistical significance of alignment, BLAST, Sequence logos , RasMol, Oligo, Molscript, treeview, Alscript, Genetic analysis software, Basic algorithms for sequence alignment, Visualization of sequence data, Homology searching	CO2, CO3	2.5
Unit V: Consensus sequences (6 Hours) Consensus sequences, Finding genes and open reading, frames in DNA sequences, Microarrays and the transcriptome, Microarray analysis, and applications of microarrays, Gene expression informatics, Introduction to gene finding and automated prediction, gene arrays, Visualization of sequence data, Drug discovery, Genetic basis of disease, Personalized medicine and gene-based diagnostocs, Legal, ethical and commercial ramifications of bioinformatics.	CO3, CO4	2.5
Unit VI: Introduction to proteomics (6 Hours) Introduction to proteomics, Prediction of protein structure and function, Comparative genomics, Future directions of bioinformatics and computational biology	CO1,CO2	2

4.	**Text books**

i. Practical Bioinformatics, 1st ed., Agostino, M., Garland Science, 2013
ii. Introduction to Bioinformatics Algorithms" by Neil Jones and Pavel Pevzner.
iii. Bioinformatics" by David Mount (2nd edition).
iv. Introduction to Bioinformatics; Arthur M Lesk,Oxford, ISBN (Pbk)0 19 925196 7

5.	**Reference book(s) and Other Required Material**

i. Bioinformatics: A Practical Guide to the Analysis of Genes and Proteins by Andreas D. Baxevanis and B. F. Francis Ouellette

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and**

	Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	**List of Indicative Laboratory Experiment (if applicable): NAsys**

Course Code & Course Title:	CML4** Good Manufacturing Practices		
Course Type:	**DE**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1.	Course Objectives:

The course aims:

Equip students with in-depth knowledge of all stages involved in the preparation of biologicals, from material receipt to the distribution of finished goods, ensuring adherence to industry standards. Train students to implement quality control services and documented quality assurance management, ensuring the stability and safety of active biologicals throughout their lifecycle, including prequalification and regulatory compliance. Enable students to design quality biologicals and manufacturing processes that meet performance standards consistently, while understanding the WHO's international standards and applying quality assurance in the supply chain to deliver safe medicines to patients. Prepare students to effectively conduct inspections, manage biosafety and bioburden, perform quality control experiments, and utilize HAZOP and risk analysis methodologies to identify and mitigate potential hazards in bio processes.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Prepare students to effectively conduct inspections, manage biosafety and bioburden, perform quality control experiments, and utilize HAZOP and risk analysis methodologies to identify and mitigate potential hazards in bio processes.
CO2	Students will be able to implement and manage quality control and assurance processes, maintaining the stability and safety of biologicals and adhering to regulatory standards.
CO3	Students will design and develop high-quality products and processes, ensuring performance consistency and compliance with WHO standards, while effectively managing supply chains to deliver safe medicines to patients.
CO4	Students will apply HAZOP and risk analysis methodologies to identify and address potential hazards in bio processes, conducting thorough inspections and managing biosafety and bioburden effectively.

3.	Detailed Description of the Course		
S.N.	Description	COs Addressed	Duration (Weeks)
1	Production covers all operations involved in the preparation of a product, from receipt of materials, through processing, packaging and repackaging, labelling and relabelling, to completion of the finished product	CO1	3
2	Prequalification and Regulatory standards: To offering quality control services, the documented quality assurance management and quality control testing activities of the laboratory. Care must be taken to ensure that active biochemical products remain stable and unaffected by packaging materials or storage conditions	CO2	4
3	Development and Distribution: Quality needs to be built into the product. The aim of development is to design a quality product and its manufacturing process to consistently deliver the intended performance of the product; WHO international standards and supply chain quality assurance	CO3	3
4	Inspections, Biosafety and Bioburden: Pharmaceutical inspection is monitoring the quality of pharmaceutical products in distribution channels	CO1, CO4	2
5	Quality Control and Quality Assurance: Managing and responding to product quality issues effectively; HAZOP and Risk Analysis	CO4	3

4.	Text books
i.	Nally, J.D. (Ed.), Good Manufacturing Practices for Pharmaceuticals, 6th Ed., CRC Press, 2007.
ii.	Avis, K.E., & Wu, V.L. (Eds.), Biotechnology and Biopharmaceutical Manufacturing, Processing, and Preservation, CRC Press, 1996.
iii.	Bunn, G.P., Good Manufacturing Practices for Pharmaceuticals, 7th Ed., CRC Press, 2018.

5.	Reference Books

i.	John Sharp, Good Pharmaceutical Manufacturing Practice, 1^{st} Edition CRC Press, 2016

6.	**Evaluation Details:**
Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Examination (1.5 Hours)	30%
End-Semester Examination (3 Hours)	50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1						1			2	2	1	
CO2	3	3	3	2	2						1	3	3	2	1
CO3	2	2	3	3	2	1		2	2	2	2	2	3	2	1
CO4	1	1	2			2	3		2			2	2	2	1

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

None

Course Code & Course Title:	**CML 461 Systems Biology**		
Course Type:	**DE**		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P		**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	Basic biology, Biotechnology, Mathematics and Statistics		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The course aims: 1. To introduce students to the concept of systems biology and its interdisciplinary approach, combining biological processes with computational and analytical techniques to understand complex biological systems at various levels. 2. To explore cellular-level systems, focusing on genetic switches, oscillators, network motifs, and genetic network evolution, and how these mechanisms contribute to cellular decision-making and behavior. 3. To provide hands-on knowledge of cell systems, including plant and animal cell cultures, methods for cell isolation, characterization, and transfection, enabling students to understand experimental techniques used in systems biology research. 4. To examine population-level systems in biological contexts, including models of pattern formation, cell-cell communication, and evolutionary systems biology, and their applications in understanding biological complexity and development.

2.	**Course Outcome:**
CO1	Understand and explain the fundamental principles of systems biology, integrating biological data with computational tools to model and analyze complex biological systems.
CO2	Analyze cellular-level systems, including genetic switches, oscillators, and network motifs, and understand their role in cellular decision-making and genetic network evolution.
CO3	Gain proficiency in laboratory techniques related to plant and animal cell cultures, including methods for cell isolation, characterization, and transfection, and apply them in systems biology research.
CO4	Model and analyze population-level systems such as pattern formation, cell-cell communication, and evolutionary processes, applying these concepts to real-world biological

3.	**Detailed Description of the Course**		

Topics	CO(s) Addressed	Duration in weeks
Unit I: Cellular level systems Genetic switches and oscillators, network motifs, genetic network evolution, and cellular decision-making.	CO1, CO2	3
Unit II: Plant cells Plant cells, animal cells, different media for growth of animal cells and animal cells, primary cells, cell lines, method of sorting out cells, Isolation, characterization and stimulation of B cells, CD4 cells and CD8 cells and methods of transfection and application of animal cells.	CO3	6
Unit III: Population-level systems Population-level systems: models of pattern formation, cell-cell communication, and evolutionary systems biology	CO1, CO4	4

4.	Text books

1. Alon, Uri. An Introduction to Systems Biology: Design Principles of Biological Circuits. Chapman & Hall / CRC, 2006. ISBN: 9781584886426. (2006)
2. Nowak, M. A. Evolutionary Dynamics: Exploring the Equations of Life. Belknap Press, 2006. ISBN: 9780674023383.
3. Biochemical Engineering fundamentals by James E.Bailey and David f Oillis McGraw hill: New York.

5.	Reference book(s) and Other Required Material

1) Alberts, Bruce. Essential Cell Biology. Garland Science, 2009. ISBN: 9780815341291.
2) Strogatz, Steven H. Nonlinear Dynamics and Chaos: with Applications to Physics, Biology, Chemistry, and Engineering. Westview Press, 2014. ISBN: 9780813349107

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3

CO1	**-**	**3**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
CO2	**-**	**3**	**1**	**2**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**-**	**-**
CO3	**-**	**2**	**3**	**3**	**3**	**1**	**-**	**2**	**2**	**2**	**2**	**1**	**-**	**-**
CO4	**-**	**1**	**2**	**-**	**-**	**3**	**3**	**-**	**1**	**-**	**-**	**-**	**1**	**1**

3 = Strong correlation, 2 = Moderate correlation, 1 = Weak correlation, - = No correlation

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	CML5XX&Biorefinery Engineering		
Course Type:	**ES/DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	Basic understanding of Unit Operations and Unit Process		
Course Equivalence: Course Code(s)& Name(s)	None		

1.	**Course Objective:** The primary aim of this course is to teach valorisation of different bio feedstocks, their conversion technologies and separation processes. **1)** To introduce students to concept of bio refinery engineering, waste valorisation and circular economy **2)** To introduce students newer sources of Carbon and Hydrogen for development of platform chemicals **3)** To teach students conversion techniques and separation processes involved in bio refinery with suitable case studies

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will learn to categories the feed stock based on origin
CO2	Students will understand concept of bio refinery
CO3	Students will learn bio based plateform chemicals, bio fuels and other bio based products
CO4	Students will be able to apply knowledge of unit operations and process to bio based processes

3.	**Detailed Description of the Course**		**Duration in weeks**
Introduction to Biorefinery : Definition, Necessity of biorefinery, Overview of Biorefining, Role of biorefinery in bio-economy and circular economy **Biomass Characterization:** Biomass as a resource, Biomass properties, Classification of biomass (Energy crops; Agricultural residues and waste; Forestry waste and residues; Industrial and municipal waste), Chemistry of biomass (Triglycerides feedstock; Sugar and starchy feedstock; Lignocellulosic feedstock; Algae as a biomass)		**CO1**	1-2
Biorefinery: Triglyceride biorefinery, Sugar and starchy biorefinery,		**CO2**	3-4

Lignocellulosic biorefinery, Oil biorefinery, Microalgae biorefinery		
Platform Chemicals : C-3 Platform Chemicals, (Glycerol; 3-Hydroxypropionic Acid), C-4 Platform Chemicals (Succinic Acid; Fumaric Acid; Malic Acid; Aspartic Acid), C-5 Platform Chemicals (Levulinic Acid; Glutamic Acid; Itaconic Acid; Xylitol), C-6 Platform Chemicals (Sorbitol; Glucaric Acid; 2,5-Furan Dicarboxylic Acid)	**CO3**	2-3
Conversion Technologies: Thermochemical conversion processes (Gasification; Fast pyrolysis), Chemical conversion processes (Transesterification; Microalgal biorefinery), Biochemical conversion processes (Pre-treatment; Hydrolysis; Fermentation; Products separation; Clean fractionation) **Biorefinery vs Refineries** : Availability and cost of bio-refinery, Feedstock diversity, Edible vs non-edible feedstock, Availability of biomass, Economics of biorefinery **Case Studies:** Waste orange bio refinery, paddy straw bio refinery, potato bio refinery etc	**CO4**	3

4.	Text books

i) Jhuma Sandhukhan, Kok Siew Ng, Elias Martinez Hernandez, Biorefineries and Chemical Processes: Design, Integration and Sustainability Analysis,1st Edition,John Wiley and Sons, , 2014https://onlinelibrary.wiley.com/doi/book/10.1002/9781118698129

ii) Juan-Rodrigo Bastidas-Oyanedel, Jens Ejbye Schmidt,Biorefinery , Springer, 1st Edition. 2019

5.	Reference Book(s) and Other Required Material

i) Thallada Bhaskar, Ashok Pandey, S.Venkata Mohan, Waste Biorefinery: Potential and Perspectives,1stEdition, Elsevier, 2018

ii) Michele Aresta, Angela Dibenedetto, Franck Dumeignil; Biorefineries: An Introduction, 1stEdition ,De Gruyter, 2015

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Mid semester = 30**
- **Quiz/ class test = 10**
- **Project = 20**
- **Final exam = 40**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3									3	3	1	3
CO2	3	3	3	3					2	2			2	2	1	3
CO3	3	3	3	3					1	1			3	2	2	3
CO4	3	3	3	3		1			1	1			1	3	2	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

LIST OF PROPOSED HONORS PROGRAM IN B.TECH. CHEMICAL TECHNOLOGY (BIOPROCESS TECHNOLOGY)

Sr. No.	PROPOSED HONORS PROGRAM IN CHEMICAL TECHNOLOGY (BPT)
1.	Computation & Design
2.	Advanced Chemical Technology
3.	Advanced Chemical Engineering
4.	Sustainability & Management

ELECTIVES*
(* This is tentative list, few courses may be overlapped in other baskets also. The courses with syllabus overlapping more than 10% will not be allowed. Faculty advisor will check for the same.)

		Computation & Design	**L-T-P**	**Credits**
1.	MAL208	Probability Theory and Statistical Methods	3-0-0	3
2.	MLA205	Numerical Methods and Probability Theory	3-0-0	3
3.	CML232	Introduction To Computing Software For Chemical Engineers	3-0-0	3
4.	CML389	Chemical Informatics	3-0-0	3
5.	CML401	Data Analytics For Chemical Engineers	3-0-0	3
6.	CML402	Molecular Simulation And Informatics	3-0-0	3
7.	CML415	Computational Methods In Chemical Engineering	3-0-0	3
8.	CML428	CFD For Chemical Engineers	3-0-0	3
9.	CML432	Computational Transport Processes	3-0-0	3
10.	CML435	Computer Aided Design In Chemical Engineering	3-0-0	3
11.	CML504	Mathematical Methods In Chemical Engineering	3-0-0	3
12.	CML506	Process Analysis, Simulation And Design	3-0-0	3
13.	CML521	Chemical Engg. Computational Fluid Dynamics	3-0-0	3
14.	CML529	Optimization Techniques In Process Design	3-0-0	3
15.	CML536	Analysis And Design Of Experiments	3-0-0	3

Course Code & Course Title:	MAL-208 Probability and Statistics for Engineering
Course Type:	**Elective**
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-1-0 | **No. of Credits** | **04**
Pre-requisites: Course Code(s) & Name(s)	**Nil**
Course Equivalence: Course Code(s) & Name(s)	**Nil**

1.	**Course Objective:**
	The objective of this subject is to expose student to understand the importance of probability theory and statistical analysis in science and engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand the significance of probability and statistics in real life, engineering and industrial applications.
CO2	Be able to grab the theoretical foundations of conditional probability, random variables, joint distributions, transformations.
CO3	Learn some significant special discrete and continuous distributions.
CO4	Be able to use sampling theory, estimation, decision making and regression.
CO5	Formulate probabilistic and statistical models of real life/ engineering problems and use them.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Random Variable & Probability Distributions: Random Variables, Density function, distribution function for continuous and discrete random variables, Joint distributions.		CO2, CO3	2 weeks
Mathematical Expectation: Mathematical Expectation, The variance and Standard deviation, Moment Generating Function, Characteristic Function.		CO2	2 weeks
Special Probability Distributions: Some special probability distributions like Binomial Poisson, Geometric, Normal, Uniform, Exponential Gamma Beta, Chi-Square, Students't', F-distribution		CO3	2 weeks

and Weibull Distribution		
Moments, correlation, covariance and regression.	CO4, CO5	2 weeks
Sampling Theory: Population Parameter, Sample Statistics, Sampling distributions, Sample mean, Sampling distribution of means, The Sample variance, The sampling distribution of variance	CO4	2 weeks
Estimation Theory: Point estimate and Interval Estimates, Reliability, Confidence interval estimates of population parameters, confidence intervals for means, proportions and variance.	CO4, CO5	2 weeks
Tests of Hypothesis and Significance: Statistical decisions, Tests of hypothesis and significance. Type I and Type II errors. Level of significance, one tailed and two tailed tests. Tests involving small samples and large samples. Fitting theoretical distributions to sample frequency distribution .The chi-square test for goodness of fit.	CO1, CO4, CO5	2 weeks

4.	Text books

1. Paul L. Meyer, Introductory Probability and Statistical Applications, Addison Wesley.
2. Miller and Freund: Probability and Statistics for Engineers Eastern Economy Edition, PHI.
3. E.Parzen: Modern Probability Theory and Its Applications J. Wiley and Sons Inc., New York.

5.	Reference Book(s) and Other Required Material

1. M.R.Speigal: Probability and Statistics, McGraw-Hill, 1995.
2. V.K. Rohatgi and A.K.M. Ehsanes Sateh: An Introduction to Probability and Statistics, John Wiley & Sons.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	–	–	–	2	–	–	–	–	2	3	2	–	2
CO2	3	3	–	–	2	–	–	–	–	–	–	3	3	–	2

CO3	3	2	–	2	–	–	–	–	–	–	–	3	2	–	2
CO4	–	3	–	3	2	–	–	–	–	2	–	–	3	–	–
CO5	–	3	2	3	2	2	–	–	–	–	–	–	3	2	2

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	MAL-205 (Numerical Methods and Probability Theory)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-1-0	**No. of Credits**	**04**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	The broad objective of the course is to teach basic concepts of the numerical methods, their rate of convergence and applications to physical problems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Employ a number of techniques to solve transcendental and algebraic equations. Know how to solve a system of nonlinear equations by Newton-Raphson method.
CO2	Efficiently solve a system of linear equations and find their eigenvalues and eigenvectors. Design and implement numerical methods for numerical approximation of initial value problems as well as two-point boundary value problems.
CO3	Apply the concepts such as random variables, probability density function, cumulative distribution function, and joint probability density function in the engineering and science problems.
CO4	Analyze and apply the concepts such as mathematical expectation, functions of random variables, variance, standard deviations, moment generating function, Skewness and Kurtosis.
CO5	Exploit different probability distributions such as Binomial, Geometric distribution, Poisson distribution, and normal distribution in the engineering and science problems.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Numerical Analysis I: Solutions of algebraic and transcendental equations by Iteration method, Method of False Position, Newton–Raphson method and their convergence.	CO1	2
Numerical Analysis II: Solutions of system of linear equations by Gauss Elimination method, Gauss Seidel method, LU Decomposition method. Newton–Raphson method for system of nonlinear equations.	CO1, CO2	2
Eigenvalues and Eigenvectors: Power and Jacobi methods for finding eigenvalues and eigenvectors.	CO2	1
Numerical Solution of ODEs: Taylor's series method, Euler's modified method, Runge–Kutta method, Adam's Bashforth and Adam's Moulton	CO2	3

methods, Milne's predictor–corrector method.		
Boundary Value Problems: Shooting method, Finite Difference methods.	CO2	1
Probability Theory I: Random variables, discrete and continuous random variables, probability density function; probability distribution function for discrete and continuous random variables, joint distributions.	CO3	2
Expectation & Central Tendency: Definition of mathematical expectation, functions of random variables, variance and standard deviation, moment generating function, central tendency and dispersion, skewness and kurtosis.	CO4	1
Probability Distributions: Binomial distribution, Geometric distribution, Poisson distribution, relation between Binomial and Poisson distribution, Normal distribution, relation between Binomial and Normal distribution.	CO5	1
Stochastic Processes: Introduction to stochastic processes.	CO5	1

4.	**Text books**

i) Jain, Iyengar and Jain, *Numerical Methods for Engineers and Scientists*, 1st Edition, Wiley Eastern, 2003, ISBN: 9780852264348.

ii) V.K. Rohatgi and A.K.M. Ehsane, *An Introduction to Probability and Statistics*, 3rd Edition, John Wiley & Sons, 2015, ISBN: 9781118799642.

iii) S. D. Cante and C. de Boor, *Elementary Numerical Analysis, an algorithmic approach*, 3rd Edition, McGraw-Hill, 1980, ISBN: 9780070662285.

5.	**Reference Book(s) and Other Required Material**

i) Gerald and Wheatley, *Applied Numerical Analysis*, 7th Edition, Addison-Wesley, 2003, ISBN: 9780321133045.

ii) Spiegel, M.R., *Theory and problems of Probability and statistics,* 1st Edition, McGraw-Hill Book Company, 1980, ISBN: 9780070602205.

iii) K.S. Trivedi, *Probability Statistics with Reliability, Queuing and Computer Science applications*, 2nd Edition, Prentice Hall of India Pvt. Ltd., 2001, ISBN: 9780471333418.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PSO 1	PSO 2	PSO 3	PSO 4

CO 1	3	3	1	1	3	1	2	1	2	-	1	3	1	1	3
CO 2	3	3	1	1	3	1	2	1	2	-	1	3	1	1	3
CO 3	3	3	1	2	-	2	-	2	-	-	2	3	1	2	-
CO 4	3	3	1	2	-	-	-	2	-	-	2	3	1	2	-

High **-** *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

Not Applicable.

Course Code & Course Title:	**CML 232 Introduction to computing softwares for chemical engineers**		
Course Type:	**DE**		
Name of the programme(s):	Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	-		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** This course will provide basic knowledge of Computing softwares and knowledge of simulation in the learned softwares

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understanding the basic of software useful for Chemical Engineering
CO2	Abled to write the programs for Chemical Engineering Equations
CO3	System Modeling and Simulation of Chemical Engineering problems
CO4	Control and optimization problem using learned software’s

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Introduction to Software’s- Documentation; Development Environment; Desktop Tools, Other development environment tools.		CO1	2 weeks
Manipulating Matrices-Matrices and Magic squares, Expressions, Working with Matrices, more about Matrices and Arrays, controlling command window input and output; Graphics-Basic plotting, editing plots, Mesh and surface plots, Printing and Handling the Graphics. Programming with MATLAB-Flow control, other data structures, Scripts and Functions.		CO2	5 weeks

Examples of Chemical engineering solved problems using MATLAB-Equations of state, Vapour liquid equilibrium	CO3	3 weeks
Chemical reaction equilibria, Reaction-kinetic system, Transport processes, etc	CO4	2 weeks

4.	Text books

i) W. Fred Ramirez, Computational Methods in Process Simulation, Elsevier Science & Technology Books

ii) P, Rudra, Getting started with MATLAB, OUP, USA

iii) S. Toan, H. Adidharma, B. Nojabei, Introduction to Matlab for Chemical and Petroleum Engineering, CreateSpace Independent Publishing Platform

5.	Reference Book(s) and Other Required Material

1. Maxwell Vector, Fundamentals of MATLAB for Chemical Process Modeling

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Mid Semester Exam: 25 %**
- **Assignments/Presentation/Simulation: 20 %**
- **End Semester Exam: 55 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML 389 Chemical Informatics
Course Type:	DE
Name of the programme(s):	Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-0-0 **No. of Credits** 3
Pre-requisites: Course Code(s) & Name(s)	Nil
Course Equivalence: Course Code(s) & Name(s)	Nil

1.	**Course Objective:**
1.	To introduce cheminformatics concepts for handling the molecular data and prediction of properties.
2.	To make use of cheminformatics tools for the discovery, design and development of novel chemicals, drugs and materials.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To learn and utilize cheminformatics tools for pharmaceutical drug design and development.
CO2	To learn and utilize cheminformatics tools for the design and development of novel materials and chemicals
CO3	To learn chemical structure representation and ways to handle it on computers

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in hours**
Cheminformatics Introduction • Introduction to cheminformatics, History and evolution of cheminformatics • Use of cheminformatics, Prospects of cheminformatics, Molecular modeling and structure elucidation	CO1, CO2	6
Representation of Molecules and Chemical Reactions • Nomenclature; Different types of notations; SMILES coding; Matrix representations; Structure of Molfiles and Sdfiles; Libraries and tookits; Different electronics effects; reaction classification • Representing 2D and 3D structures, Kinds of 2D structures representation; atom lookup and connection tables; graph theory; SMILES; SD files; representation nuances; descriptors	CO3	6
Database screening by Similarity Search • Database screening by similarity search: Database concepts, Design of chemical databases	CO3	4

• Structure search, Pharmacophore search, Fingerprints.		
Molecular Mechanics • Calculation of physical and chemical data, molecular mechanics • Descriptors for chemical compounds, Artificial intelligence systems in chemical engineering • Methods for data analysis, Chemical markup language (CML)	CO2, CO3	6
Prediction of Physical and Chemical Properties • Prediction of physical and chemical properties, Structure–Activity correlations, Regression methods • Chemical reactions and synthesis design, Elements of bioinformatics and genomics, Docking	CO1, CO2	8
Drug Design • Drug design • Absorption-Distribution-Metabolism-Excretion (ADME) Pharmacokinetics • Drug delivery	CO1	6

4.	Text books
1.	Leach A. R. and Gillet V. J., An Introduction to Cheminformatics, Revised edition, Springer, 2007, ISBN 978-1-4020-6291-9.
2.	Karthikeyan M., Vyas R., Practical Cheminformatics, Springer, 2014, ISBN 978-81-322-1779-4.

5.	Reference Book(s) and Other Required Material
1.	Andrew Bender, Jonathan M Goodman, Cheminformatics, Oxford University Press-2007
2.	Gasteiger J. and Engel T., Chemoinformatics, A Text Book, Wiley VCH, 20023, ISBN 978-3-527-30681-7.
3.	Stuart Schreiber, Tarun M. Kapoor, Chemical Biology: From Small Molecules to Systems Biology and Drug Design Chemical Release 2001.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]
	Class Tests and Assignments: 20%
	Mid-Semester Exam (1.5 Hours): 25%
	End-Semester Exam (3 Hours): 55%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	**CML 401 Data Analytics for Chemical Engineers**		
Course Type:	**DE**		
Name of the programme(s):	Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**-**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:** The primary aim of this course is to present the principles of data analytics to the student of chemical engineering

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Learn the basics about data analytics techniques.
CO2	Learn software languages for carrying data analysis
CO3	Implement data analytic techniques for chemical engineering problem.
CO4	Evaluate the industry related process using data analysis.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Statistics: Descriptive (Central Tendencies, Measure of variability, Variance and Standard deviation, and skewness). Univariate, Bivariate and multivariate analysis. Inferential statistics (Estimation of parameters, Hypothesis test, Permutation and Randomization test) **Machine learning introduction:** Types of Machine Learning (Supervised, Unsupervised, Reinforcement), Features and Labels.		CO1	4 weeks
Supervised Learning: Logistic Regression, Polynomial Regression, Support Vector Machine, Multiclass Classification, Decision Tree, Random Forest.		CO2	3 weeks
Unsupervised Learning: Clustering Models (Singular Value Decomposition, K-means), Hidden Markov Model and Python basics			4 weeks
Application to Chemical Engineering: Useful life estimation of battery, chemical reactors. Failure mode identification of chemical equipment's. Sensitivity analysis of the parameters. Introduction to		CO3	5 weeks

software like Pythons, R and MATLAB.		
Battery charging Problem with NASA data, Micorbial fuel cell control problem with ML applications etc	CO4	

4.	Text books

1. Miroslav Kubat, An Introduction to Machine Learning, Springer, 2017
2. Hastie, Trevor, The elements of statistical learning. Vol. 2. No. 1. New York: springer, 2009.

5.	Reference Book(s) and Other Required Material

1. Ethem Alpaydin, Introduction to Machine Learning, PHI.
2. Chris Bishop, Pattern Recognition and Machine Learning.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Semester Exam: 25 %
Assignments/Presentation/Viva/Quiz: 20 %
End Semester Exam: 55 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML 402 Molecular Simulation and Informatics
Course Type:	DE
Name of the programme(s):	Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	Nil
Course Equivalence: Course Code(s) & Name(s)	Nil

1.	**Course Objective:**
1.	To model and simulate the molecular interactions of various chemical systems.
2.	To analyze the molecular information of various chemical systems for designing new molecules.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To build and apply molecular force field to chemical structures.
CO2	To understand and utilize molecular modeling, molecular simulation and data analysis tools to understand molecular level interactions
CO3	To understand and utilize molecular informatics tools for designing small molecular systems.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in hours**
Introduction • Introduction and background of molecular computations • Introduction to Windows and Linux based freeware molecular modeling, simulation and informatics tools	CO1, CO2	6
Chemical File Formats • Chemical structure representation and manipulation • SMILES specification rules and coding • Various chemical file formats and their interconversion	CO1, CO3	4
Molecular Modeling and Simulation • Applications of molecular computations in material design and development • Molecular modeling, Molecular force field	CO2	8

• Fundamentals of molecular simulations		
Molecular Simulations Concepts • Molecular dynamics simulations • Integrating algorithms, Periodic box and Minimum image convention • Long range forces and Non-bonded interactions • Monte Carlo simulations and other advanced topics	CO2	8
Simulation Data Analysis • Energy minimization, System relaxation • Radial distribution function, • Gromacs, Ambertools, Visual molecular dynamics • Trajectory analysis	CO2	6
Virtual Screening Techniques • Virtual screening • Ligand-based drug design: Quantitative structure activity relationship (QSAR) modeling • Molecular descriptors, Lipinski's rule of five • Structure-based drug design: Molecular docking, Search algorithms, Scoring functions	CO3	4

4.	Text books
1.	Allen M. P. and Tildesley D.J., Computer Simulation of Liquids, 2nd Edition, Oxford University Press, 2017, ISBN 978-0-19-880320-1.
2.	Frenkel D. and Smith B., Understanding Molecular Simulation: From Algorithms to Applications, 2nd Edition, Academic Press, San Diego, California, 2001, ISBN 978-0-12-267351-1.

5.	Reference Book(s) and Other Required Material
1.	Haile J. M., Molecular Dynamics Simulation: Elementary Methods, Wiley-Interscience, 1997.
2.	Leach A. R., Molecular Modeling: Principles and Applications, Pearson, 2001, 2nd Edition.
3.	Leach A. R. and Gillet V. J., An Introduction to Cheminformatics, Revised edition, Springer, 2007.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

	Class Tests and Assignments: 20%
	Mid-Semester Exam (1.5 Hours): 25%
	End-Semester Exam (3 Hours): 55%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	2	2	0	0	1	0	0	2	2	0	0	2	2	0
CO2	3	3	3	2	3	2	1	2	3	3	0	3	3	3
CO3	2	3	3	2	3	3	0	2	3	2	1	2	3	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-415 (Computational Methods in Chemical Engineering)		
Course Type:	Core / Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	This course focuses on the use of modern computational and mathematical techniques in chemical engineering, including solving linear/nonlinear algebraic equations, ODEs, and DAE systems, and applying finite difference and finite element methods in MATLAB.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will be able to solve linear and nonlinear algebraic equations using methods such as Gaussian elimination, Gauss-Jordan, Jacobi, and Gauss-Seidel.
CO2	Student will be able to formulate and solve ordinary differential equations and differential-algebraic systems using finite difference and finite element techniques.
CO3	Student will be able to apply computational techniques to chemical engineering problems using MATLAB and other computational tools.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Linear/nonlinear algebraic equations; root-finding techniques; Gaussian, Gauss-Jordan, Jacobi, Gauss-Seidel methods	CO1	4
Ordinary differential equations and differential-algebraic (DAE) systems; finite difference and finite element methods for PDEs from transport phenomena	CO2	5
Application of computational techniques to chemical engineering problems using MATLAB; numerical solution for 1D heat equation (implicit/explicit) and other chemical engineering examples	CO3	5

4.	**Text books**

1. Chapra, S. C., & Canale, R. P., *Numerical Methods for Engineers*, 4th Edition, Tata McGraw Hill, New Delhi.
2. Finlayson, B. A., Biegler, L. T., & Grossmann, I. E., *Mathematics in Chemical Engineering*, 2006, Wiley-VCH Verlag GmbH & Co.

5.	**Reference Book(s) and Other Required Material**

1. Jeffrey, A., *Advanced Engineering Mathematics*, Academic Press, 2002.
2. Mickley, H. S., *Applied Mathematics in Chemical Engineering*, Tata McGraw-Hill, 2000.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	3	3	2	2	3	–	–	1	–	–	–	1	–	1	2
CO 2	3	2	3	3	3	–	2	2	–	–	2	2	1	3	1
CO 3	2	2	2	2	3	2	2	–	2	–	2	–	2	1	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML 428 – CFD for Chemical Engineers		
Course Type:	**DE**		
Name of the programme(s):	B. Tech.		
L – T – PCML	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s)& Name(s)	**None**		

1.	**Course Objective:** Students shall be able to apply CFD techniques for simulation of practical problems in fluid flow and heat transfer.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Able to apply basic principles used in CFD.
CO2	Able to formulate the problem and apply discretisation techniques.
CO3	Design and solve heat transfer problems using CFD techniques.
CO4	Design and solve fluid flow problems using CFD techniques.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
History; Comparison of the three basic approaches for engineering problems in solving by analytical, experimental and computational methods; Beam advance in computational techniques; Softwares available for CFD.	CO1	1
Formulation of problem; Physical and mathematical classification of problems; Types of governing differential equations; Truncation and Round-off error; Explicit and Implicit approaches; Basic of finite difference method; Finite element method; Finite volume method and Spectral method; Treatment of boundary conditions; Examples using Comsol Multiphysics Software on Dirichlet boundary condition, Neumann boundary condition, etc.	CO2	3
Steady-state problems; One dimensional heat conduction transfer through a pin-fin; Two dimensional conduction through a plate unsteady state problem; One dimensional transient heat conduction; Explicit and implicit methods; Assessing accuracy and stability of numerical methods; Examples using Comsol Multiphysics Software	CO3	5

on state heat transfer in one dimension, transient heat transfer in one dimension, heat transfer in two dimensions, heat conduction with a hole, etc.		
Types of fluid flow and their governing equation; Viscous incompressible flows calculation of flow field using the stream function-vorticity method; Calculation of boundary layer over a flat plate; Numerical algorithm for solving complete Navier-Stokes equation-MAC method SIMPLE algorithm; Introduction to standard κ-ε model for turbulent incompressible flow; Project problem; Examples using Comsol Multiphysics Software on flow of newtonian fluid in a pipe, flow of non-newtonian fluid in a pipe, reaction and diffusion, turbulent flow in a pipe, determining arrhenius parametrs using parameter estimation, etc.	CO4	5

4.	**Text books**

i) P. S. Ghoshdastidar, Computer simulation of flow and heat transfer, Tata McGraw-Hill Publishing, 1st Edition, 1998.

ii) K. Muralidhar and T. Sundararajan, Computational fluid flow and heat transfer, Narosa Publications, 2nd Edition, 2003.

5.	**Reference Book(s) and Other Required Material**

i) H. K. Versteeg and W. Malalasekera, An introduction to CFD, Longman Scientific and Technical, 1st Edition, 1995.

ii) E. S. Oran and J. P. Boris, Numerical simulation of reactive flow, Cambridge University Press, 2nd Edition, 2001.

iii) J. H. Ferriger, M. Peric, Springer, Computational methods for fluid dynamics, 1st Edition, 1996.

iv) S. V. Patankar, Numerical heat transfer and fluid flow, Mc Graw-Hill Book Company, 1st Edition, 1980.

v) W. Rodi, Turbulence models and their applications – a state of the art review, IAHR – AIRH Monograph series, 3rd Edition, 1993.

vi) Finlayson, B A, Introduction to Chemical Engineering Computing, Wiley, 2nd Edition, 2014.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Mid Semester Exam: 20-30 Marks

Teacher Defined Assessment: 20 Marks

End Semester Exam: 50-60 Marks

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

8.	List of Indicative Laboratory Experiment (if applicable):

Not Applicable

Course Code & Course Title:	CML-432 (Computational Transport Processes)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	Objective of this subject is to expose students to understand the solving technique for basic transport processes and its application to chemical engineering

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will be able to understand and apply integral and differential conservation equations for mass, momentum, and energy to solve basic transport problems.
CO2	Student will be able to formulate and implement numerical methods including finite difference and finite volume techniques for solving linear and nonlinear transport equations.
CO3	Student will be able to apply computational modeling techniques to real-world transport problems, including flow through porous media, capillaries, human circulatory systems, and cheminformatics applications.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Integral laws for conservation of mass, momentum, angular momentum and energy; Constitutive laws; Differential forms of mass and energy conservation equations; Bernoulli equation; Navier-Stokes equations; Shear stress, pressure gradient relations; Laminar flow in pipes and parallel plates	CO1	4
Governing equations for fluid flow systems; Solutions of linear and nonlinear algebraic equations; Time-marching solutions; Discretization of derivatives using finite difference and finite volume methods	CO2	5
Applications of fluid dynamics: flow through porous media, capillaries, human circulatory systems; Introduction to cheminformatics, molecular modeling, structure elucidation, prediction of properties, drug design	CO3	5

4.	**Text books**

1. Patankar, S. V., *Numerical Heat Transfer and Fluid Flow*, Hemisphere Publishing Corporation, 1980.

2. Anderson, D. A., Tannehill, J. C., Pletcher, R. H., *Computational Fluid Mechanics and Heat Transfer*, Hemisphere Publishing Corporation, 1984.

5.	Reference Book(s) and Other Required Material

1. Muralidhar, K., Sundararajan, T., *Computational Fluid Flow and Heat Transfer*, Narosa Publishing House, 2nd Edition.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	-	1	-	3	3	-	3	3	-	-	3	1
CO2	3	2	3	3	3	-	2	2	-	2	2	-	3	3	2
CO3	2	2	2	2	2	2	-	-	2	-	2	-	2	3	1

High - *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML435 Computer Aided Design		
Course Type: DE	**BS/ES/HU/IC/DC/IE/DE/HM/OC**		
Name of the programme(s):	B.Tech. (Chemical Engineering)		
L – T – P	3-0-0	**No. of Credits**	**1**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The objective of this course is to introduce students to the principles and applications of computer-aided design in chemical engineering and to develop an understanding of how computational tools are used in the analysis and design of chemical processes. The course aims to enable students to formulate mass and energy balance equations, develop process flowsheets, and apply appropriate thermodynamic models using process simulation software. It also seeks to provide hands-on experience in the design and analysis of basic chemical engineering equipment and to train students in interpreting simulation results for process evaluation, improvement, and preliminary optimization.

2.	**Course Outcomes**
CO1	Understand the fundamentals of computer-aided process design
CO2	Develop process flowsheets using mass and energy balance principles
CO3	Apply thermodynamic models for property estimation and phase equilibrium
CO4	Design and analyze chemical engineering equipment using simulation tools
CO5	Interpret simulation results for process evaluation and improvement

3.	**Detailed Description of the Course (Theory)**		
Topics		**CO(s) Addressed**	**Duration in Weeks**
Introduction to computer-aided design, design hierarchy, design basis, degrees of freedom analysis		CO1	2
Process flow sheeting, mass and energy balances, recycle and purge systems		CO2	3
Thermodynamic models, equations of state, property estimation, phase equilibrium		CO3	3

Computer-aided design and simulation of reactors and heat exchangers	CO4	3
Simulation of separation processes and process analysis	CO4	2
Sensitivity analysis, parametric studies, case studies	CO5	1

4.	**Text books**

i. Turton, R., Bailie, R. C., Whiting, W. B., and Shaeiwitz, J. A., *Analysis, Synthesis, and Design of Chemical Processes*, 5th Edition, Prentice Hall, 2018, ISBN: 9780132618121.
ii. Ulrich, G. D., and Vasudevan, P. T., *Chemical Engineering Process Design and Economics*, 2nd Edition, Process Publishing, 2004, ISBN: 9780970876811.

5.	**Reference Book(s) and Other Required Material**

i) Douglas, J. M., *Conceptual Design of Chemical Processes*, McGraw-Hill, 1988, ISBN: 9780070177628.
ii) Towler, G., and Sinnott, R., *Chemical Engineering Design*, 2nd Edition, Elsevier, 2013, ISBN: 9780080966595.
iii) Aspen Plus / Aspen HYSYS / DWSIM User Manuals.

6.	**Evaluation Details:**

- Continuous Assessment (Assignments / Quizzes / Mid-Sem): **40%**
- End-Semester Examination: **60%**

Practical Evaluation:

- Continuous Evaluation: **50%**
- End-Semester Practical Examination: **50%**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	–	–	1	–	–	–	–	–	–	2	–	–
CO2	3	3	2	2	2	–	–	–	–	–	–	3	–	–
CO3	3	3	3	2	2	–	–	–	–	–	–	3	2	–
CO4	2	3	3	3	3	–	–	–	–	–	–	3	3	–
CO5	2	2	2	2	2	2	2	–	–	–	–	2	2	–

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

- Introduction to process simulation software (Aspen Plus / Aspen HYSYS / DWSIM)
- Simulation of material and energy balance problems
- Simulation of chemical reactors (CSTR and PFR)
- Simulation of heat exchangers
- Simulation of separation processes (distillation / absorption)
- Sensitivity analysis and parametric studies
- Mini project on computer-aided design of a chemical process

Course Code & Course Title:	CML504-Mathematical Methods in Chemical Engineering		
Course Type:	**DE**		
Name of the programme(s):	B. Tech. Chemical Engieering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s)& Name(s)	**None**		

1.	**Course Objective:** The primary objective of this course is to show the connection that underlies the different mathematical techniques. The aim is present a unified approach, which will enable student to have better philosophy towards mathematical modeling and analysis.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Basic principles used in mathematical methods.
CO2	To develop solution techniques for PDEs.
CO3	To solve PDEs for any engineering applications.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
An introduction to mathematical modelling and simulation; vector and tensor spaces; metric, norm and inner products; orthonormalization; matrices, operators and transformations; eigen values and eigen vectors; Fredholm alternative, Rayleigh quotient and its application to chemical engineering systems.		CO1	6
Self adjoint and non-self adjoint systems; partial differential equations and their applications in chemical engineering; Strum-Louisville theory; separation of variables and Fourier transformations.		CO2	4
Application of Greens function for solution of ODE and PDEs in chemical engineering; numerical techniques for solution of ODE and PDEs; linear stability and limit cycles; bifurcation theory; secondary bifurcation and chaos; Role of computer packages like Comsol Multiphysics in problem solving.		CO3	4

4.	**Text books**

i) Pushpavanam S, Mathematical Methods in Chemical Engineering. Prentice Hall India, New Delhi, 4th Edition, 2009.
ii) Chapra S C, Applied Numerical Methods with Matlab for Engineers and Scientists, McGraw Hill, 1st Edition, 2005.
iii) Finlayson B A, Introduction to Chemical Engineering Computing, Wiley, 2nd Edition, 2014.

5.	**Reference Book(s) and Other Required Material**

i) Ghoshdastidar P S, Computer simulation of flow and heat transfer, Tata McGraw-Hill Publishing, 1st Edition, 1998.
ii) Gupta S K, Numerical Methods for Engineers. Wiley Eastern, New Delhi, 1st Edition, 1995.
iii) Thomas F and Himmelblau D M, Optimization of Chemical Processes, McGraw Hill, 2nd Edition, 2001.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Mid Semester Exam: 20-30 Marks

Teacher Defined Assessment: 20 Marks

End Semester Exam: 50-60 Marks

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

8.	**List of Indicative Laboratory Experiment (if applicable):**

Not Applicable

Course Code & Course Title:	CML-506 (Process Analysis, Simulation and Design)		
Course Type:	**Core / Elective**		
Name of the programme(s):	M.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	Reaction Engineering, Heat Transfer, Mass Transfer		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	Course Objective:
1	To understand the knowledge of modeling chemical engineering systems.
2	To understand the systematic approach to process design.
3	To perform simulation of various chemical engineering processes.
4	To understand Cost Estimation and Plant Economics Analysis.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Ability to develop and solve mathematical models for steady-state and dynamic chemical processes.
CO2	Capability to select appropriate thermodynamic property packages and phase equilibria models for simulation.
CO3	Proficiency in using commercial simulators to design and optimize unit operations like distillation columns, reactors, and heat exchangers.
CO4	Competence in performing relief rate calculations, piping design, and comprehensive plant economic analysis (IRR, Payback).

3. tailed Description of the Course		
Topics	**CO(s) Addressed**	**uration in weeks**
Introduction to Simulation: Steady State vs. Dynamic simulation; features, applications, and limitations. Physical and thermodynamic properties of pure components and mixtures.	CO1, CO2	1
Thermodynamics & Phase Equilibria: VLE, LLE, VLSE; Equation of States (PR, SRK, SAFT, etc.); Activity Models (Wilson, NRTL, UNIQUAC, UNIFAC); Special systems (Polymers, Electrolytes).	CO2	2
Simulator Operations: Introduction to commercial packages; Stream/Unit blocks; Two-phase flow patterns (Baker's Chart); Sizing of separators, control valves, and relief valves (API 520/521).	CO3, CO4	2
Distillation Column Simulation: Strippers, Rectifiers; Shortcut vs. Rigorous columns; Inside-out and Newton-Raphson algorithms; Optimization of	CO3	2

reflux ratio and feed tray location.		
Advanced Distillation: Azeotropic and Extractive distillation; Residue curve mapping; Binodal plots; Batch distillation systems and operation sequencing.	CO3	1
Heat Exchangers & Reactors: Heat curve generation; Sizing of condensers/evaporators (TEMA guidelines); Simulation of Gibbs, Conversion, Kinetic, and Batch reactors; Custom subroutines.	CO3	2
Optimization & Numerical Methods: Theoretical background; Generalized Reduced Gradient method; Successive Quadratic Programming (SQP) in modular environments.	CO3	1
Project Engineering: Development of Block Diagrams, PFDs, P&IDs; Plant layout, elevation, and piping isometrics interpretation.	CO4	1
Plant Economics: Capital cost estimation; Equipment, utilities, and labor costs; Depreciation, Cash Flow, IRR, and Payback period calculations.	CO4	1
Refinery Simulation: Crude Assay Analysis (ASTM D86, TBP); Pseudo-component concept; Characterization (Watson Factor, Octane Number); Simulation of FCC main fractionators.	CO3, CO4	1

4.	Text books

i) Richard Turton, Richard C. Bailie, Wallace B. Whiting, and Joseph A. Shaeiwitz, *Analysis, Synthesis and Design of Chemical Processes*, 3rd Edition, Prentice Hall, 2008, ISBN: 9780135129661.

ii) Gerald L. Kaes, *Refinery Process Modeling*, 1st Edition, Elliott & Thompson, 2000, ISBN: 9780963396242.

5.	Reference Book(s) and Other Required Material

i) International Research Papers (current) as provided for case studies.

ii) API 520/521 and NFPA-30 Standards for relief and safety design.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3	PSO 4
CO	3	3	3	-	3	3	3	3	1	1	1	1	-	3	1

1														
CO 2	3	3	3	-	-	3	3	-	3	2	3	2	3	3	2
CO 3	3	-	-	-	-	3	3	-	3	2	3	2	2	3	1
CO 4	3	-	-	-	-	3	3	-	2	-	-	3	2	2	-

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Note: Alternately, an industrial process plant detailed simulation project is included as an assignment

Course Code & Course Title:	CML-521 (Chemical Engineering Computational Fluid Dynamics)		
Course Type:	**Core / Elective**		
Name of the programme(s):	M.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	CML263 (Fluid Mechanics)		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	Students shall be able to apply basic principles used in computational fluid dynamics.
2	Students shall be able to formulate problems and apply discretization techniques.
3	Students shall be able to design and solve heat transfer problems using CFD.
4	Students shall be able to design and solve fluid flow problems using CFD.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand and derive governing equations in conservation form for CFD modelling.
CO2	Apply discretization methods and manage truncation/round-off errors in numerical schemes.
CO3	Perform accuracy and stability analysis for steady and transient heat conduction problems.
CO4	Implement numerical algorithms (MAC/SIMPLE) to solve Navier-Stokes and coupled flow-heat transfer problems.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Foundations of CFD: Introduction to CFD and flow modelling; summary of governing equations; conservation form of equations; well-posed and ill-posed problems.	CO1	2
Discretization Techniques: Discretization of equations; truncation and round-off errors; explicit and implicit approaches; concepts of numerical/artificial viscosity; boundary conditions.	CO2	3
Steady & Unsteady Problems: Finite Difference methods for steady-state problems (1D pin-fin, 2D plate); 1D transient heat conduction; accuracy and stability assessment of numerical methods.	CO3	3
Flow Algorithms: Numerical methods for boundary layer type equations; Navier–Stokes equations; outline and implementation of MAC and SIMPLE algorithms.	CO4	3
Advanced Applications: Coupled heat transfer (forced and natural	CO4	2

convection); outline of reactive flow (combustion) and multi-phase flow; commercial CFD package introduction.		
CFD Case Studies: Design of stirred tank reactors, heat transfer in rotary kiln reactors, and biomass particle pyrolysis simulation.	CO3, CO4	1

4.	Text books

- P. S. Ghoshdastidar, *Computer Simulation of Flow and Heat Transfer*, 1st Edition, Tata McGraw-Hill Publishing, 1998, ISBN: 9780074631492.
- K. Muralidhar and T. Sundararajan, *Computational Fluid Flow and Heat Transfer*, 2nd Edition, Narosa Publications, 2003, ISBN: 9788173195204.

5.	Reference Book(s) and Other Required Material

- H. K. Versteeg and W. Malalasekera, *An Introduction to Computational Fluid Dynamics*, 1st Edition, Longman Scientific and Technical, 1995.
- J. H. Ferriger and M. Peric, *Computational Methods for Fluid Dynamics*, 1st Edition, Springer, 1996.
- S. V. Patankar, *Numerical Heat Transfer and Fluid Flow*, 1st Edition, McGraw-Hill Book Company, 1980.
- Finlayson, B. A., *Introduction to Chemical Engineering Computing*, 2nd Edition, Wiley, 2014.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	1	-	-	-	-	-	-	1	1	1	1	-	3	1
CO2	3	3	-	1	1	-	-	-	3	2	3	2	3	3	2
CO3	3	3	3	3	2	2	-	2	3	2	3	2	2	3	1
CO4	3	3	3	3	2	2	-	2	2	-	-	3	2	2	-

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Not Applicable (Software-based case studies included in Section 3).

Course Code & Course Title:	CML-529 (Optimization Techniques in Process Design)		
Course Type:	**DE**		
Name of the programme(s):	M.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Basic Maths**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	To understand the basics of optimization techniques, and problem formulation for optimization
2	To understand the single variable and multivariable optimization techniques and their application
3	To understand the linear programming application for optimization
4	To understand the advance optimization technique like genetic algorithm

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will understand necessary and sufficient condition for optimization and will be able to formulate the optimization problem.
CO2	Student will be able to solve different optimization problem and their application to the case studies like heat exchanger, evaporator etc.
CO3	Student will be able to apply linear programming and genetic algorithm based optimization techniques for engineering design and process optimization problems.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Nature and organization of optimization problems: what optimization is all about, why optimize, scope and hierarchy of optimization, examples of applications of optimization, essential features of optimization problems, general procedure for solving optimization problems, obstacles to optimization. Classification of models, model building, fitting functions to empirical data, method of least squares, factorial experimental designs, fitting a model to data subject to constraints.	CO1	2
Basic concepts of optimization: continuity of functions, unimodal versus multimodal functions, convex and concave functions, convex region, necessary and sufficient conditions for an extremum of an unconstrained	CO1	2

function, interpretation of the objective function in terms of its quadratic approximation.		
Optimization of unconstrained functions (one-dimensional search): numerical methods for optimizing a function of one variable, scanning and bracketing procedures, Newton's, Quasi-Newton's and Secant methods, region elimination methods, polynomial approximation methods, application of one-dimensional search in multi-dimensional problems and evaluation of uni-dimensional search methods.	CO1	2
Unconstrained multivariable optimization: direct methods (random search, grid search, uni-variate search, simplex method, conjugate search directions, Powell's method). Indirect methods – first order (gradient method, conjugate method). Indirect methods – second order (Newton's method, Hessian matrix, search direction, termination criteria).	CO2	3
Linear programming and applications: basic concepts, degenerate LPs, graphical solution, natural occurrence of linear constraints, simplex method, standard LP form, obtaining first feasible solution, revised simplex method, sensitivity analysis, duality in linear programming, Karmarkar algorithm, LP applications.	CO3	2
Optimization of unit operations: recovery of waste heat, shell & tube heat exchangers, evaporator design, liquid-liquid extraction process, optimal design of staged distillation column, optimal pipe diameter, optimal residence time for maximum yield in an ideal isothermal batch reactor, chemostat, optimization of thermal cracker using linear programming.	CO2	2
Genetic Algorithms: working principles, differences between GAs and traditional methods, similarities between GAs and traditional methods, GAs for constrained optimization, other GA operators, real coded GAs, advanced GAs (qualitative treatment).	CO3	1

4.	Text books

1. Edgar, T.F., Himmelblau, D.M., Lasdon, L.S., *Optimization of Chemical Processes*, 2nd Edition, McGraw-Hill International Edition, Singapore, 2001, ISBN.
2. Rao, S.S., *Engineering Optimization: Theory and Practice*, 4th Edition, Wiley-Interscience Publication, Canada, 2009, ISBN.
3. Deb, Kalyanmoy, *Optimization for Engineering Design: Algorithms and Examples*, 2nd Edition, PHI Learning Private Limited, New Delhi, 2012, ISBN.

5.	Reference Book(s) and Other Required Material

1. Reklaitis, G.V., Ravindran, A., Ragsdell, K.M., *Engineering Optimization: Methods and Applications*, 2nd Edition, John Wiley, New York, 2006, ISBN.
2. Fletcher, R., *Practical Method of Optimization*, 2nd Edition, John Wiley, New York, 2000, ISBN.
3. Chong, E.K.P., Zak, S.H., *An Introduction to Optimization*, 2nd Edition, John Wiley, New York, 2001, ISBN.

4. Nocedal, J., Wright, S.J., *Numerical Optimization*, 2nd Edition, Springer, 2000, ISBN.
5. Mitsuo, G., Runwei, C., *Genetic Algorithms and Engineering Optimization*, John Wiley, New York, 2000, ISBN.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-	1	-	-	-	1	1	-	1	-	3	1
CO2	3	3	2	2	2	-	1	2	3	3	-	1	1	1	1
CO3	2	2	3	2	3	-	-	-	-	1	2	3	3	2	3

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-536 (Analysis and Design of Experiment)		
Course Type:	**DE**		
Name of the programme(s):	M.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	Course Objective:
	To enable students to design, analyze, and optimize experiments by applying statistical methods such as ANOVA, factorial and regression approaches, advanced techniques including response surface methodology, orthogonal arrays, parameter design, and multivariate analysis, while also developing the ability to construct and evaluate nested and confounded experimental schemes for complex process constraints.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Student will be able to perform Analysis of Variance, Factorial Experiment design, and Regression Approach.
CO2	Student can apply Response Surface Methodology, Orthogonal Arrays, Parameter Design, and Multivariate Analysis of Variance to the experimental data.
CO3	Student will be able to design and evaluate Nested and Confounded experimental schemes to handle complex process constraints and nuisance variables.

3. tailed Description of the Course		
Topics	**CO(s) Addressed**	**uration in weeks**
Introduction to experimental design – importance and applications	CO1	1
Analysis of Variance (ANOVA) – one-way and two-way	CO1	2
Factorial experiment design – full and fractional factorials	CO1	2
Regression approach – linear and multiple regression in experiments	CO1	2
Response Surface Methodology (RSM) – first and second order designs	CO2	2
Orthogonal arrays – Taguchi methods – parameter design	CO2	2
Multivariate Analysis of Variance (MANOVA) – applications in experiments	CO2	2

Nested design – confounded design – handling nuisance variables	CO3	1

4.	Text books

- Douglas C. Montgomery, *Design and Analysis of Experiments*, 8th Edition, Wiley.

5.	Reference Book(s) and Other Required Material

- Gary W. Oehlert, *A First Course in Design and Analysis of Experiments*.
- Howard J. Seltman, *Experimental Design and Analysis*.
- R. Panneerselvam, *Design and Analysis of Experiments*, PHI Learning Private Ltd., 2012.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3	PSO 4
CO 1	3	3	-	3	2	-	1	-	1	-	1	-	-	3	1
CO 2	3	3	3	3	3	-	2	-	1	-	1	-	3	3	2
CO 3	3	3	2	3	2	-	1	-	1	-	1	-	2	3	1

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

		Advanced Chemical Technology	L-T-P	Credits
1.	CML336	Polymer Engg.	3-0-0	3
2.	CML388	Pulp And Paper Technology	3-0-0	3
3.	CML390	Technology Of Paints Pigments And Powder Coating	3-0-0	3
4.	CML391	Surface Coating Engineering	3-0-0	3
5.	CML392	Corrosion Engineering	3-0-0	3
6.	CML424	CME	3-0-0	3
7.	CML425	Membrane Technology	3-0-0	3
8.	CML426	Polymer Processing	3-0-0	3
9.	CML429	Nanotechnology	3-0-0	3
10.	CML468	Ore And Mineral Processing	3-0-0	3
11.	CML522	Membrane Separation Processes	3-0-0	3
12.	CML524	Polymer Science And Engineering	3-0-0	3
13.	CML527	Mineral Beneficiation	3-0-0	3
14.	CML535	Advanced Nanotechnology	3-0-0	3
15.	CML***	Space Technology for Chemical Engineers	3-0-0	3

Course Code & Course Title:	CML-336 (polymer engineering)		
Course Type:	Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	To understand the different types of plastics
2	To understand the processing of plastics
3	To understand the preparation and testing of plastics
4	To understand the factors affecting properties of polymers
5	To understand the fundamentals of waste management

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will understand the different types of plastics, including thermoplastics, thermosets, blends, alloys, and specialty plastics.
CO2	Student will understand the processing techniques of plastics, including molding, forming, post-processing, additives, compounding, and rheological behavior.
CO3	Student will understand the preparation and testing of plastics according to national and international standards.
CO4	Student will understand the factors affecting polymer properties, including mechanical, thermal, and barrier properties.
CO5	Student will understand the fundamentals of waste management and recycling of plastics, including sustainability, legislation, and energy recovery.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Types of plastics: Thermoplastics, Thermosets, blends, alloys, IPNs, cellular plastics, liquid crystal plastics, oriented plastics	CO1	3
Processing of plastics: Molding, forming, post-processing, additives, compounding, rheology, temperature effects on polymer properties	CO2	3
Preparation and testing of plastics: Standards, specimen preparation,	CO3	2

visual, density, melting point, solubility, flame, and chemical tests		
Factors affecting polymer properties: Mechanical, thermal, barrier properties, flammability, shrinkage, thermal stability, glass transition, etc.	CO4	3
Waste management and recycling: Plastics waste, sustainability, energy recovery, environmental legislation in India, polymerization kinetics	CO5	3

4.	Text books

1. Gruenwald, G., *Plastics – How Structure Determines Properties*, Hanser Publishers, 1993.
2. Baird, D. G., & Collias, D. I., *Polymer Processing Principles and Design*, Butterworth-Heinemann, 1995.
3. Vishu Shah, *Handbook of Plastics Testing Technology*, John Wiley & Sons, New York.

5.	Reference Book(s) and Other Required Material

1. Anand, J. S., Ramamurthy, K., & Palanivelu, K., *How to Identify Plastics by Simple Methods*, CIPET, Chennai, 2nd Edition.
2. Andrady, A. L. (Ed.), *Plastics and the Environment*, Wiley Interscience, New York.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-	-	-	-	-	-	-	-	1	-	3	1
CO2	3	2	2	2	3	2	1	-	2	1	2	1	1	1	1
CO3	3	2	3	2	3	2	1	1	2	1	2	3	3	2	3
CO4	2	2	2	2	2	2	-	1	2	-	2	3	2	2	-
CO5	2	2	-	-	-	3	3	1	-	-	2	-	1	1	-

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	**Pulp and Paper Technology (CML 388)**		
Course Type:	DE		
Name of the programme(s):	B. Tech		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s)& Name(s)	None		

1.	**Course Objective:** Understand the processes involved in pulp preparation starting from composition of wood, chipping, pulping processes, washing of pulp, bleaching and stock preparation. In the next part, sheet forming process, drying of paper and description of paper making machines are described.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the pulp & paper making processes
CO2	To get the basic information on chemical and energy recovery
CO3	To have general information paper and paper properties

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Unit-1 Introduction, raw materials for paper making, structure, physical, chemical properties, morphology, reaction of cellulose with different chemicals	**CO1**	1-2
	Unit-2 Aqueous pulping systems, commercial pulping process, variables associated with raw materials and pulping process, optimization of process parameters, materials and energy balance calculations	**CO1**	1-2
	Unit-3 Pulp washing, screening, recovery of spent chemicals involving	**CO2 & CO3**	2-3

multiple effect evaporators, cascade evaporators, incineration, recaustising and calcinations		
Unit-4 Pulp bleaching and stock preparation, internal sizing, filling and loading, colouring, wet end strength additives, surface sizing	**CO2 & CO3**	2
Unit-5 Sheet forming process, Fourdnui and cylinder mould machine, drainage characteristics, water marking, head box, slice, wire, couch, pressing of sheet for water removal.	**CO2 & CO3**	2
Unit-6 Paper drying, drying characteristics, heat and mass transfer aspects, ventilation, dryer performance calculations, air-drying, radiant drying	**CO2 & CO3**	1-2

4.	Text books

1) Pulp and Paper: Chemistry and Chemical Technology Vol I to IV, Casey J P, Ed., Wiley Interscience, New York,
2) MacDonald R G, Pulp and Paper Manufacture Vol I to III, 2nd Ed., McGraw Hill, New York.
3) Britt K W, Handbook of Pulp and Paper Technology, Reinhold Publishing Corporation, New York.
4) Pulp and Paper Manufacture, Kocurek, Tappi Publication.
5) Mark, Handbook of Physical and Mechanical testing of Paper and Board, Vol.I & II, Dekker Publication

5.	Reference Book(s) and Other Required Material

1) S.A. Rydholm, Pulping Processes, Wiley Interscience (1965).
2) C.J. Biermann, Essentials of Pulping and Paper Making, Academic Press (1996).
3) J.D.A. Clark, Pulp Technology and Treatment for Paper, Miller Freeman (1985).
4) P. Bajpai, P.K. Bajpai and R. Kondo, Biotechnology for Environmental Protection in the Pulp and Paper Industry, Springer-Verlag Berlin Heidelberg (1999).

6.	Evaluation Details:

- Internals: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	CML-390 (Technology of Paints, Pigments and Powder Coatings)		
Course Type:	Core / Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	To understand the fundamentals of paints, pigments, resins, and oils, including chemistry, types, and properties.
2	To understand the working principles of paint machinery and formulation of various types of paints, coatings, and powder coatings.
3	To understand industrial applications of paints, perform testing, identify defects, and learn corrective measures.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will be able to understand the fundamentals of paints, pigments, resins, and oils, including chemistry, types, and properties.
CO2	Student will be able to understand the working principles of paint machinery and formulate various types of paints, coatings, and powder coatings.
CO3	Student will be able to analyze industrial applications of paints, perform testing, identify paint film defects, and understand corrective measures.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Fundamentals of paints, pigments, resins, and oils; classification; film formers; drying and semi-drying oils; modifications		CO1	3
Resins: Natural and synthetic; thermosets and thermoplastics; processing additives; rheological behavior		CO1	2
Paint machinery: Ball mill, attritor, dynomill, triple roll mill, edge runner, sand mill; working principles and selection		CO2	3
Formulation of paints: Primers, synthetic enamels, wall finishes,		CO2	3

wood finishes; computerized colour matching; testing of paints		
Industrial applications: Stoving paints, acrylic paints, marine paints, automotive paints; powder coatings; pigment classification and properties	CO3	3

4.	Text books

1. Morgans, W. M., *Outline of Paint Technology*, CBS Publishers, New Delhi.
2. Wieks Jr., Zeno, Jones, Frank, & Peppar, S. Peter, *Organic Coating Science and Technology, Vol I & II*, Wiley Interscience, New York, 1992.

5.	Reference Book(s) and Other Required Material

1. Lambourne, R., *Paint and Surface Coating*, Ellis Horwood Ltd., John Wiley & Sons, New York, 1987.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-	-	-	-	-	-	-	-	1	-	3	1
CO2	3	2	2	2	3	-	-	-	-	-	2	2	3	1	1
CO3	2	2	2	2	2	2	-	-	2	-	2	3	3	2	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML-391 (Surface Coating Engineering)		
Course Type:	Core / Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	Students will be able to understand the difference between pigments and paints.
2	Students will understand the manufacturing process and utility of paints and pigments.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will understand details about pigments, including white, red, orange, yellow, green, blue, and black pigments.
CO2	Student will understand details about drying oils, driers, solvents, plasticizers, resins, gums, waxes, bitumen, varnishes, lacquers, paints, enamels, cellulose ester products, and synthetic resins.
CO3	Student will understand paint and varnish plant operations, manufacturing processes, cost accounting, R&D, fire protection, and safety & health aspects.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Preparation of Pigments: White, red, orange, yellow, green, blue, and black pigments		CO1	4
Drying oils and driers; solvents and plasticisers; resins, gums, waxes, bitumen; varnishes and lacquers; paints and enamels; cellulose ester products; synthetic resins		CO2	5
Paints and varnish plant operations; manufacturing processes; factory cost accounting; research, development and control; fire protection; safety and health		CO3	5

4.	**Text books**

1. Turner, G. P. A., *Introduction to Paint Chemistry and Principles of Paint Technology*.

5.	**Reference Book(s) and Other Required Material**

1. Holmberg, K., *Coatings Tribology*.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	-	-	-	-	-	-	-	-	-	1	-	3	1
CO2	3	2	2	2	3	-	-	-	-	-	2	2	3	1	1
CO3	2	2	2	2	2	2	-	-	2	-	2	3	3	2	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML 392 Corrosion Engineering
Course Type:	Department Elective (DE)
Name of the programme(s):	B. Tech Chemical Engineering , B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P:	3 – 0 – 0
Credits:	03 (55 minutes each)
Class Schedule:	3 Classes per week
Pre-requisites:	None
Course Equivalence:	None

1. Course Objective:
At the end of the course, the student will understand the reaction kinetics, types and thermodynamics of corrosion, its preventive methods and may able to devise novel equipment's from MOC point of view to prevent corrosion.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Provide students with a basic understanding of corrosion phenomena, its types, reaction kinetics and thermodynamics.
CO2	Enhance their knowledge on industrially important corrosion types and forms, factors responsible for corrosion, its preventive methods and minimizing losses due to corrosion.
CO3	Mathematical analysis of corrosion engineering problems and development of problem solving ability.
CO4	Improve student's ability in handling on site industrial corrosion problems and devise novel equipment' from MOC point of view.

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Thermodynamics and Kinetics of Electrochemical Corrosion: Theory of corrosion; reaction mechanisms and reaction kinetics; thermodynamic aspects of corrosion; Nernst equation. Basic wet corrosion cell; electrode potential; potential-ph diagram; Butler-Volmer equation; polarization; mixed potential theory; passivity; immunity.	CO1, CO3	1.5 (6 Hours)
Types of Corrosion – Recognition and Mechanisms and Theory: Uniform corrosion; galvanic corrosion; pitting; dealloying; crevice corrosion; intergranular corrosion; stress corrosion cracking (SCC); stray current corrosion; graphite corrosion; high temperature corrosion; flow-assisted corrosion;	CO2	2.0 (8 Hours)

cavitation's corrosion; fretting corrosion cracking process.		
Corrosion Measurements: Methods of measurements of corrosion based on study of various ASTM standards for corrosion–electrochemical and non-electrochemical methods- Weight, electrical, thickness, ultrasonic etc.	CO2	1.5 (6 Hours)
Microbially Influenced Corrosion (MIC): Definitions, environment and microbiology; Electrochemical aspects and general mechanisms; Bacterial transport, attachment [16]and affected materials; Role of aerobic and anaerobic microorganisms; Mechanisms and models for SRB corrosion; MIC and biofilms; MIC-case studies and mechanisms.	CO3, CO4	1.5 (6 Hours)
Corrosion Protection and Surface Engineering: Principles of different methods of corrosion protection and surface treatment, chemical and electrochemical surface treatments of metals, protective coatings like plating, pvd, cvd, thermal spray, hot dip, applications of inhibitors, and electrochemical methods for corrosion protection.	CO4	1.5 (6 Hours)

4. Textbooks
Rajagopalan, K.S., Corrosion and its Prevention, 1st Edition, Chemical Engineering Education Development Centre, I.I.T. Madras, 1975.

5. Reference Book(s) and Other Required Material
Butlar, G. and Ison, H.C.K., Corrosion and its Prevention in Waters, Leonard Hill - London, 1966.
Uhlig, H.H., Corrosion and Corrosion Control, John Wiley and Sons, 1971.

6. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]	
Assessment Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Exam (1.5 Hours)	20%
End-Semester Exam (3 Hours)	60%
Total	**100%**

7. Relationship of Course Outcomes to Program Outcomes:
Mapping with POs (Departmental Reference)

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

Key for Mapping Correlation	
3	Strong Correlation
2	Moderate Correlation
1	Weak Correlation
-	No Correlation

8. List of Indicative Laboratory Experiment (if applicable):
None

Course Code & Course Title:	**(CML424) Petroleum Refinery Engineering**		
Course Type:	**DE**		
Name of the programme(s):	**B.Tech. Chemical Engineering,** B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**Mass Transfer I**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

1. To develop the fundamentals of refining of petroleum crude oil and its fractionation in different useful petroleum products.
2. The student will be aware to the product quality, related environmental concern and the standards by applying the different primary, secondary and advanced refinery processes.
3. The student will be aware to problems and remedies in petroleum sector.
4. To develop the skill and knowledge for upgradation of petroleum refineries as per present and future demand.
5. To develop the responsibility of technological inputs related to energy and environmental demand.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	The students will understand the basic concepts and fundamentals of exploration and refining of petroleum crude oil and its fractionation in various useful petroleum products.
CO2	The students will be aware to the product quality, standards, related environmental concerns and its solution by applying the updated techniques and remedies in petroleum sector.
CO3	The students will acquire the skill and knowledge for upgradation of petroleum refineries as per present and future demands.
CO4	The students will understand the responsibility of updated technological inputs related to energy demands and environmental standards.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Fundamental principles of origin and occurrence of petroleum crude and its exploration, Composition of petroleum, classification and physical properties, Characterization of crude oil and petroleum products, status of petroleum refining in India, future refining trends.		CO1, CO2, CO3	2
Crude oil Distillation Process, Pretreatment of crude, atmospheric and vacuum distillation process		CO1, CO2, CO4	2

Secondary conversion processes: Thermal and catalytic cracking, Catalytic reforming, Pyrolysis	CO2, CO3, CO4	2
Heavy Residue Upgradation Technologies: Hydrocracking, Hydrotreating, visbreaking and coking, alkylation, Isomerisation, dehydrogenation processes, polymerization.	CO2, CO3, CO4	2
Lubricating oil, grease and Bitumen: Dewaxing and deoiling, deasphalting, lube hydrofinishing, bitumen air blowing, Sweetening and Desulphurization, Hydrodesulphurisation of petroleum products.	CO2, CO3, CO4	2
Energy conservation in petroleum refineries. New Trends in petroleum refinery operations, Biorefinery concept.	CO2, CO3, CO4	2

4.	Text books

i. Bhaskara Rao, B. K., *Modern Petroleum Refining Processes*, 3rd Edition, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi.
ii. Gary, J. H. and Handwerk, G. E., *Petroleum Refining Technology and Economics*, 3rd Edition, Marcel Dekker, Inc., New York.
iii. Hobson, G. D. and Rohl, W.,*Modern Petroleum Technology*, 4th Edition, Applied Science Publication.
iv. Noel, H. M.,*Petroleum Refining Manual*, Reinhdd Pub. Corp., New York.

5.	Reference Book(s) and Other Required Material

i. Nelson, W. L., *Petroleum Refining Engineering*, 4th Edition, Tata McGraw Hill Publication Co. Ltd. (1985).

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High – 3; Medium – 2; Low – 1; No Correlation – –

8.	List of Indicative Laboratory Experiment (if applicable):

NIL

Course Code and Name:	CML425: Membrane Technology		
Course Type:	DE		
Name of the programme(s):	B.Tech. (Chemical Engineering)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	Mass Transfer		
Course Equivalence: Course Code(s)& Name(s)	NIL		

1.	**Course Objective:** **1)** To introduce the concept of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation, liquid membrane permeation, gas permeation **2)** Identifying, formulating, and solving engineering problems involving various membrane separation processes **3)** To designand analysis of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation etc. **4)** To introduce application of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration etc.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	To introduce the concept of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation, liquid membrane permeation, gas permeation
CO2	Identifying, formulating, and solving engineering problems involving various membrane separation processes
CO3	To designand analysis of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation etc.
CO4	To introduce application of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration etc.

3.	Detailed Description of the Course		
Topics		**CO(s) Addressed**	**Duration in weeks**
CO1: Principles, characteristic, and classification of membrane separation processes; Membrane materials, structures, and preparation techniques; Membrane modules; Plant configurations		**CO1**	2-3 Weeks

CO2: Membrane characterization: Pore size and pore distribution; Bubble point test; Challenge test; Factors affecting retentivity, concentration polarization, gel polarization, fouling, cleaning and regeneration of membranes	**CO2**	2-3 Weeks
CO3: Mechanisms of separation: Porous membranes, dense membranes, and liquid membranes. Membrane separation models: Irreversible thermodynamics; Capillary flow theory; Solution diffusion model; Viscous flow models; Models for separation of gas (vapour) mixtures	**CO3**	2-3 Weeks
CO4: Science and technology of microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis and electrodialysis, pervaporation, liquid membrane permeation, gas permeation. Membrane reactors: Polymeric, ceramic, metal and bio-membrane	**CO4**	2-3 Weeks

4.	**Text books**

i) Geankoplis, Transport Processes And Separation Process principles, Prentice-Hall of India Private Ltd , New Delhi.

ii) Nath K., Membrane Separation Process, Prentice-Hall of India Private Ltd , New Delhi 2008

5.	**Reference Book(s) and Other Required Material**

i) Richardson J.F., Harker J.H., Chemical Engineering, Vol. II, Butterworth Heinemann, New Delhi.2006.

6.	**Evaluation Details:**

- Class Tests and Assignments: 15%
- Mid-Semester Exam (1.5 Hours): 25%
- End-Semester Exam (3 Hours): 60%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**CML - 426 Polymer Processing**		
Course Type:	**DE**		
Name of the programme(s):	**B. Tech**		
L – T – P	**L**	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**

Based on the topics discussed in the class, Student shall be able to describe the principles of polymer processing techniques and evaluation of polymer properties as per standard.

2.	**Course Outcomes:**
CO1	Differentiate and describe the processing technique employed for manufacturing plastic products.
CO2	Describe the flow behavior of polymers.
CO3	Identify the polymer by which the given product is made.
CO4	Describe the testing method for evaluation of specified property of a polymer.
CO5	Illustrate the importance of plastic materials and describe the plastic waste management techniques.

3.	**Detailed Description of the Course**

Topics	**CO(s) Addressed**	**Duration in weeks**
Comparison of thermoplastics and thermoset plastics; Thermoset plastics - Types of resins, Interpenetrating Polymer Networks (IPN); Thermoplastics- Types of aliphatic and aromatic thermo plastics, copolymers, Blends and alloys; Liquid crystal plastics; cellular plastics; oriented plastic materials. Basics of process design, Classification & general aspects ofprocesses - molding& forming operations, Post die processing; Decoration of plastics - Printing, Vacuum Metalizing, In-mold decoration.Additives & Compounding - Different types of additives, Batch mixers, continuous mixers, Dispersive and distributive mixing, Characterization of mixed state.	CO1	5
Fundamentals on Viscous & Viscoelastic behavior of polymer melt, Rheological measurements and Polymer	CO2	2

processability. Non isothermal aspects - Temperature effect on rheological properties, Crystallization, Morphology & Orientation, plastic memory, Molecular weight effects on processing and properties.		
Identification of plastics by simple test - Visual examination, Density, Melting point, Solubility test, Flame test, Chemical tests.	CO3	0.5
Basic concepts of testing, National & International standards, Test specimen preparation, Pre conditioning & Test atmosphere. Effect of shape & structure on material properties, Long - term & short - term mechanical properties, crazing, Permeability & barrier properties, Environmental-stress cracking, Melt flow index, Heat deflection temperature, Vicat softening temperature, Glass transition temperature, thermal conductivity, Co-efficient of thermal expansion, Shrinkage, Thermal stability, Flammability.	CO4	4
Plastics waste and the associated problems, Integrated waste management - source reduction, recycling & sustainability correlation, energy recovering process. Environmental issues, policies and legislation in India.	CO5	1.5

4.	**Text books**

i) Gruenwald G, Plastics - How Structure Determines Properties, Hanser Publishers, 1993, ISBN 3-446-16520-7.

ii) Vishu Shah, Hand Book of Plastics Testing Technology, 3rd edition, John Wiley & Sons Inc., New York, 2007, ISBN 13: 9780471182023.

5.	**Reference Books**

i) Anthony L. Andrady (Ed.), Plastics and the Environment, Wiley Interscience, New York, 2003, ISBN-13. 978-0471095200.

ii) Baird D. G. and Collias D. I., Polymer Processing Principles and Design, 2nd edition, Butterworth-Heinemann, 2014, ISBN 13: 978-0470930588.

iii) J.S.Anand, K.Ramamurthy, K.Palanivelu, How to identify Plastics by Simple Methods, 2nd edition, CIPET, Chennai, 1998.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Component	**Duration**	**Weightage**
Mid Term Exam	1 hour	30
Class Tests and Assignments	-	20

End Semester Exam	3 hours	50

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

Course Outcomes	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO426.1	3	-	3	3	-	-	-	-	3	-	3	3	-	3	3
CO426.2	3	3	3	3	3	-	-	-	3	-	3	3	3	3	3
CO426.3	3	3	3	3	-	-	-	3	3	3	3	3	3	3	3
CO426.4	3	3	3	3	-	-	3	-	3	-	3	3	3	3	3
CO426.5	3	3	3	3	-	3	3	-	3	-	3	3	3	3	3
CML426	3	3	3	3	1	1	2	1	3	1	3	3	3	3	3

8.	**List of Indicative Laboratory Experiment (if applicable):**

Nil.

Course Code & Course Title:	CML 429 – Nanotechnology		
Course Type: DE	**BS/ES/HU/IC/DC/IE/DE/HM/OC**		
Name of the programme(s):	B.Tech. (Chemical Engineering)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The objective of this course is to introduce the fundamental concepts of nanotechnology and nanomaterials, their unique physical and chemical properties arising due to nanoscale dimensions, methods of synthesis and characterization, and applications of nanotechnology in chemical engineering and related areas. The course also aims to provide awareness about environmental, health, and safety aspects of nanomaterials.

2.	**Course Outcomes**
CO1	Understand basic concepts, length scales, and classification of nanomaterials
CO2	Explain various synthesis techniques used for nanomaterials
CO3	Describe characterization techniques for nanomaterials
CO4	Understand applications of nanotechnology in chemical engineering and allied fields
CO5	Understand environmental, health, safety, and regulatory issues related to nanotechnology

3.	**tailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in Weeks**
	Introduction to Nanotechnology – Basic concepts of nanotechnology, significance of nanoscale materials, and overview of nanomaterials used in chemical engineering and related technologies.	CO1	2
	Physical Chemistry of Solid Surfaces – Surface phenomena at nanoscale including electrostatic stabilization, steric stabilization, and fundamental surface interactions governing nanoparticle	CO1	1

stability.		
Synthesis of Nanomaterials – Methods for preparation of nanomaterials including matrix-mediated growth techniques, sol–gel method, chemical precipitation method, and other commonly used synthesis approaches.	CO2	3
Applications in Chemical Engineering Systems – Polymer nanocomposites including synthesis, characterization, and evaluation of mechanical and thermal properties.	CO2	1
Carbon Nanotubes and Advanced Nanomaterial Applications – Structure and types of carbon nanotubes (SWCNT and MWCNT), theoretical models, synthesis methods such as arc discharge, laser ablation, and chemical vapor deposition (CVD), and applications in drug delivery systems.	CO3	3
Nanofluids and Characterization of Nanomaterials – Preparation of nanofluids and their applications in thermal conductivity enhancement, heat transfer coefficient improvement, and heat exchanger systems; study of dimensionless analogies; characterization techniques for nanoparticles including XRD, TEM, SEM, AFM, DSC, TGA, DMA, and rheometry	CO4	3

4.	Text books

i. Bhushan, B., *Springer Handbook of Nanotechnology*, 4th Edition, Springer, 2017, ISBN: 9783642050559.

ii. Poole, C. P., and Owens, F. J., *Introduction to Nanotechnology*, 1st Edition, Wiley, 2003, ISBN: 9780471079359.

iii. Gipzjpmg Cap, Ying Wang, Nanostructures and Nanomaterials(synthesis properties and applications, 2nd Edition, USA 2011

iv. Jurgen Schulte, Nanotechnology (strategies, industry trends and applications, Willey ,1st Edition, England 2005

v. S.Reich, C.Thomsen, J.Maultzsch, *Carben Nanotubes (Basic concept and physical property, Wiley-VCH,1st Edition, 2004, Weinheim*

5.	Reference Book(s) and Other Required Material

i. Cao, G., and Wang, Y., *Nanostructures and Nanomaterials: Synthesis, Properties and Applications*, 2nd Edition, World Scientific, 2011, ISBN: 9789814322508.

ii. Ratner, M., and Ratner, D., *Nanotechnology: A Gentle Introduction to the Next Big Idea*, Pearson Education, 2003, ISBN: 9780131014008.

iii. Recent review articles from peer-reviewed journals on nanoscience and nanotechnology.

6.	Evaluation Details:

Class Tests and Assignments: **20%**
Mid-Semester Examination (1.5 Hours): **30%**
End-Semester Examination (3 Hours): **50%**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	2	–	–	1	–	–	–	–	–	–	3	2	1
CO2	3	2	2	2	2	–	–	–	–	–	–	3	3	1
CO3	3	2	2	3	2	–	–	–	–	–	–	3	3	1
CO4	2	3	3	3	2	–	–	–	–	–	–	3	3	2
CO5	2	2	–	2	1	3	3	2	–	–	–	2	2	3

High **-** *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

Not applicable (Theory course)

Course Code & Course Title:	**Ore and Mineral Processing (CML 468)**		
Course Type:	DE		
Name of the program(s):	B. Tech		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	CML203 Mechanical Operations		

1.	**Course Objective:** 1. The objective of this course is to understand the fundamentals of minerals processing 2. To give the basic principles of different unit operation used in mineral dressing 3. To identify various processes and equipment used in mineral processing.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Knowledge of basics of mineral processing and their relevance
CO2	Calculate technical-economic conditions for winning of mineral resources
CO3	Describe and explain commonly occurring processes for mineral beneficiation
CO4	Analyze reasons for selection of processes based on raw material properties

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit-1 Mineralogy Studies of important metallic and non-metallic minerals, their characteristics, origin etc. Application of non-metallic minerals. Sea as a source of minerals, Status of mineral beneficiation industry in India. Study of some representative beneficiation practices with flow sheets. Sampling methodology and equipments.		**CO1**	1-2

Unit-2 Comminution Primary, secondary and special crushers and their performances. Cylindrical and cylindro-conical ball mills, Rod mills, Tube / Pot mills and their performances, capacities, reduction ratios etc. Dry and Wet Grinding. Open and closed circuit grinding. Work Index calculations. Interlocking and liberation of minerals.	**CO3**	1-2
Unit-3 Screening Sizing and Classification: Standard screening tests and graphical representations of the results. Particle size distribution, Sorting, Sizingand Pneumatic classifiers and their performances. Thickeners, Hydrocyclones etc. Theory and practice of sedimentation and filtration. Working of Rotary vacuum filters.	**CO3 & CO4**	2
Unit-4 Gravity Concentration Techniques Principles of Jigging, Tabling and Heavy Media Separation. Processes with equipments used, important controlling factors in operation and application. Beneficiation practice for arsenopyrite containing schelite.	**CO3 & CO4**	2-3
Unit-5 Froth Flotation Natural and Artificial Floatability of minerals. Frothers, Collectors, Depressants, Activators / Deactivators, PH Modifiers, etc. Flotation machines. Study of representative sulphide and non sulphide minerals and non-metallic ores. Multistage flotation and Column Flotation.	**CO3 & CO4**	2
Unit-6 Electrostatic and Magnetic Separation Principles of Electrostatic and Magnetic Separation (Dry and Wet type). Separation units used in practices and examples in the industries. Calculation of Recovery and ratio of concentration and Mass balance calculations in ore dressing. Industrial set up of Ore Dressing plant.	**CO2, CO3 & CO4**	2

4.	**Text books**

1. Elements of Mineral Dressing Author Gaudin A.M.; Publisher New York Edition 2nd Edition

2. Mineral Processing Author Pryor E.J; Publisher Kluwar Academic Publishers Edition 3rd Edition

3. Elements of Mineralogy Author Rutley F. Publisher Thomas Murray & Co., London
4. A Text Book of Ore Dressing, Author Robert H. & Locke, Richards C.E; Publisher McGraw Hill Co.

5.	Reference Book(s) and Other Required Material

1. Richard O. Burt, Chris Mills, 1984, Gravity Concentration Technology, Elsevier.
2. Drzymala, J. (2007). Mineral processing. Foundations of theory and practice of minerallurgy.
3. Gaudin, A. M., Flotation, McGraw-Hill Book Company, Incorporated, 1932.

6.	Evaluation Details:

- Internal: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable): NA

Course Code & Course Title:	CML-522 (Membrane Separation Processes)		
Course Type:	Core / Elective		
Name of the programme(s):	M.Tech. Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Heat Transfer, Fluid Mechanics**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	To introduce the concept of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis, electrodialysis, pervaporation, liquid membrane permeation, and gas permeation.
2	To design various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis, and electrodialysis, pervaporation, etc.
3	To introduce applications of various membrane separation processes such as microfiltration, reverse osmosis, ultrafiltration, nanofiltration, etc.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will be able to characterize membranes, including pore size, pore distribution, bubble point and challenge tests, and factors affecting performance such as fouling, concentration and gel polarization.
CO2	Student will be able to explain mechanisms of separation using porous, dense, and liquid membranes.
CO3	Student will understand membrane separation models including irreversible thermodynamics, capillary flow, solution diffusion, viscous flow, and models for gas/vapour mixtures, as well as membrane reactors using polymeric, ceramic, metal, and bio-membranes.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
Membrane characterization: Pore size, pore distribution; bubble point test; challenge test; retentivity factors; concentration and gel polarization; fouling, cleaning, and regeneration of membranes		CO1	4

Mechanisms of separation: Porous membranes, dense membranes, liquid membranes	CO2	4
Membrane separation models: Irreversible thermodynamics, capillary flow, solution diffusion, viscous flow; gas/vapour separation; microfiltration, reverse osmosis, ultrafiltration, nanofiltration, dialysis, electrodialysis, pervaporation; liquid and gas membrane permeation; membrane reactors: polymeric, ceramic, metal, bio-membranes	CO3	6

4.	**Text books**

1. Geankoplis, C. J., *Transport Processes and Separation Process Principles*, Prentice-Hall of India Private Ltd., New Delhi.
2. Richardson, J. F., Harker, J. H., *Chemical Engineering, Vol. II,* Butterworth Heinemann, New Delhi, 2006.

5.	**Reference Book(s) and Other Required Material**

1. Nath, K., *Membrane Separation Process*, Prentice-Hall of India Private Ltd., New Delhi, 2008.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	2	2	3	-	-	2	1	-	2	1	-	3	1
CO2	3	3	2	2	3	-	-	2	2	-	2	2	3	1	1
CO3	3	3	3	3	3	2	2	2	3	3	3	3	3	2	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	**CML524 Polymer Science and Engineering**
Course Type:	DE
Name of the program(s):	B.Tech. Chemical Engg.
L – T – P	3-0-0 **No. of Credits** 3
Pre-requisites: Course Code(s) & Name(s)	None
Course Equivalence: Course Code(s) & Name(s)	None

1	Course Objective:

Course Objective 1. Understand the various types of polymerization and important polymer reactions

Course Objective 2. Understand how the molecular structure of polymer determines its properties.

Course Objective 3. Understand the applications of some important polymers

2	Course Outcomes (Min. 3 & Max. 5):
CO1	To understand the chemistry of polymerization and polymer degradation.
CO2	To understand the factors affecting properties of polymers.
CO3	To understand the applications of polymers.

3 Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Introduction to polymers, mechanisms of polymerization, polymerization techniques, types and mechanism of polymer degradation, important polymer reactions.	CO1	6
Molecular weight and size of polymers, significance of polymer molecular weight, glass transition temperature, experimental methods	CO2	4
Commodity and Engineering polymers and their applications-Polyethylene, Polystyrene, Polypropylene, Polycarbonates etc.	CO3	2

4	Text books

i) Polymer Processing Principles and Design, Baird D.G. and Collias D. I., Butterworth-Heinemann, 1995.
ii) Polymer Science, Gowariker V.R., Viswanathan N.V., Sreedhar J, 2015.
iii) Encyclopedia of Polymer Applications, Edited By Munmaya Mishra, CRC Press, 2018.

5	Reference Book(s) and Other Required Material

6	Evaluation Details:

i) Assignment – 20%
ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

7	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	2	2	3	-	-	3	1	-	-	2	2	2	2	3	-
CO2	2	2	3	-	-	3	1	-	-	1	2	2	2	3	-
CO3	2	2	3	-	-	3	1	-	-	1	2	2	2	3	-

High - 3; Medium – 2; Low – 1;

8	List of Indicative Laboratory Experiment (if applicable):

Not Applicable

Course Code & Course Title:	CML527 Mineral Beneficiation		
Course Type:	**DE**		
Name of the programme(s):	M.Tech in Chemical Engineering		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

To provide students with fundamental knowledge of mineral beneficiation, including exploitable characteristics of minerals, economic aspects, sampling, and liberation. The course covers principles of crushing, grinding, particle size analysis, screening, and classification. It also introduces various separation techniques such as gravity, magnetic, electrostatic, and solid–liquid separation, along with surface behaviour and flotation principles for designing efficient mineral processing circuits.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to understand the different steps used for the processing of various minerals
CO2	To understand the basic principles of different unit operation used in mineral beneficiation
CO3	To identify various processes and equipment used in mineral processing
CO4	Able to solve basic calculation involve in performance evaluation

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Exploitable characteristics of minerals. Economics of mineral beneficiation. Important beneficiation circuits of minerals like chalcopyrite's, sphalerite, galena, bauxite etc.	CO1	01
Different sampling methods and Mechanism and importance of liberation of material. Power laws. Principles of crushing and grinding ability. Classification, design and application of crushers and grinders.	CO2, CO3, CO4	04
Evaluation of particle size analysis, size distribution curves and their significance. Industrial screening, classification and	CO2, CO3, CO4	04

performance of screens. Dry and wet classifiers. Free and hindered settling, Thickeners, hydro cyclones, filtration, tabling, jigging,		
Magnetic and Electrostatic separation. Principles, agitation and mixing,	CO2, CO3	02
Surface behaviour and flotation machines, differential flotation and flotation circuit design.	CO2, CO3, CO4	02

4.	Text books

i) D.V Subbarao,Mineral beneficiation a concise basic course, CRC Press , ISBN:978-0-203-84789-3

ii) Vedula V. Ramana Murty, Operational hand book of Mineral processing , Denett & Co. publisher, ISBN 978-81-89904-87-9

5.	Reference Book(s) and Other Required Material

i) M. Gaudin, Principal of mineral Dressing, tata MacGraw-hill publication ISBN 0-07-099321-1

ii) C.M. Narayannan and B.C. Bhattacharyya,Mechanical Operation for Chemical engineering, Third edition, Khanna Publishers,2014,81-7409-036-3

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	**CML 535 Advanced Nanotechnology**		
Course Type:	**DE**		
Name of the programme(s):	**Chemical Engineering**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1.	To train students on advances in nanotechnology, synthesis of nanoparticles, fullerenes, nanotubes and various nanostructures, as well as the characterization and properties of nanomaterials.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To analyze the fundamental physical and chemical principles of nanomaterials.
CO2	To explore the fundamental properties and applications of nanomaterials.
CO3	To learn the various methods for the synthesis of nanomaterials and identify their characterization techniques.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in hours**
Introduction to Nanotechnology • Introduction, Emergence of Nanotechnology, Bottom-Up and Top-Down Approaches, Challenges in Nanotechnology • Surface Energy, Chemical Potential as a Function of Surface Curvature, Electrostatic Stabilization, Surface charge density, Electric potential at the proximity of solid surface, • Van der Waals attraction potential, Interactions between two particles: DLVO theory, Steric Stabilization, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions.		CO1, CO2	
Synthesis of Nanostructures		CO3	

• Synthesis of metallic nanoparticles, Influences of reduction, reagents, Influences by other factors, Influences of polymer stabilizer, Synthesis of semiconductor nanoparticles, Synthesis of oxide nanoparticles • Introduction to sol-gel processing, Forced hydrolysis, Controlled release of ions		
Special Nanomaterials • Carbon Fullerenes and Nanotubes: Carbon fullerenes, Fullerene-derived crystals, • Carbon Nanotubes, Micro and Mesoporous Materials: Ordered mesoporous structures, Random mesoporous structures, • Crystalline microporous materials: zeolites, Core-Shell Structures: Metal-oxide structures, Metal-polymer structures, Oxide-polymer structures	CO1, CO2,	
Characterization of Nanomaterials • Introduction, Structural Characterization X-ray diffraction (XRD), Small angle X-ray scattering (SAXS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning probe microscopy (SPM), Gas adsorption	CO3	
Applications of Nanotechnology • Application in Nanofluids, Applications in Polymer, Applications in Separation Technology	CO2	

4.	Text books
1.	G. Cao and Y. Wang, "Nanostructures and Nanomaterials: Synthesis, Properties, and Applications," World Scientific Publishing Company, USA, 2011, ISBN 978-981-4324-55-7.
2.	J. Schulte, "Nanotechnology: Challenges and Opportunities in Realizing the Full Potential of Nanotechnology," John Wiley & Sons, England, 2005, ISBN 978-0-470-85400-6.

5.	Reference Book(s) and Other Required Material
1.	S. Reich, C. Thomsen, and J. Maultzsch, "Carbon Nanotubes: Basic Concepts and Physical Properties," Wiley-VCH, Weinheim, 2004, ISBN 978-3-527-40386-8.
2.	Y. G. Yanovsky, "Polymer Rheology: Theory and Practice," Chapman and Hall, London, 1993, ISBN 978-0-412-53450-8.
3.	G. Wilde, "Nanostructured Materials," Elsevier, Netherlands, 2009, ISBN 978-0-08-044913-5.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and

	Regulations]
	Class Tests and Assignments: 20%
	Mid-Semester Exam (1.5 Hours): 25%
	End-Semester Exam (3 Hours): 55%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML XXX Space Technology for Chemical Engineers		
Course Type:	DE		
Name of the programme(s):	Chemical Engineering		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	Nil		
Course Equivalence: Course Code(s) & Name(s)	Nil		

1.	**Course Objective:**
1.	To introduce chemical engineering principles to space technology
2.	To identify innovative materials and solutions for space exploration challenges.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand chemical engineering principles related to space technology
CO2	To develop innovative solutions for space exploration challenges
CO3	To identify and design newer chemicals and materials for space applications

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in hours**
	Introduction to Space Technology • History of space exploration, Space organizations, Space missions and applications, • Relevance to chemical engineering	CO1	6
	Propulsion systems • Propellants (fuel and oxidizer) • Chemical propulsion, Electric propulsion, Nuclear propulsion • Solar sails	CO2, CO3	6
	Material Science • Nanomaterials for space applications, Materials selection	CO3	6

for spacecraft design • Thermal protection systems, Smart materials		
Energy generation and storage Concepts • Spacecraft power systems • Solar power generation, Nuclear power generation • Fuel cells and battery systems	CO2, CO3	6
Life support systems • Oxygen generation, Carbon dioxide removal • Water recycling and purification, Food production and processing, • Waste management	CO1, CO2, CO3	6
Space exploration • Space exploration • Planetary resource extraction and utilization • Use of artificial intelligence and robotics • Space policies and regulation	CO2	6

4.	Text books
1.	Space Technology: A short introduction, Springer, 2023, ISBN 978-3-031-34817-4.
2.	Future Spacecraft Propulsion Systems: Enabling Technologies for Space Exploration, Paul A. Czysz and Claudio Bruno, Springer, 2006, ISBN 978-3-540-23161-5.

5.	Reference Book(s) and Other Required Material
1.	Solid Rocket Propulsion Technology, A. Davenas, Pergamon Press, 1993.
2.	Space Material Sciences, A. I. Feonychev, 2011.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]
	Class Tests and Assignments: 20%
	Mid-Semester Exam (1.5 Hours): 25%
	End-Semester Exam (3 Hours): 55%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

		Advanced Chemical Engineering	L-T-P	Credits
1.	CML383	Advance Heat Transfer	3-0-0	3
2.	CML394	Introduction To Measuring Instruments	3-0-0	3
3.	CML427	Advanced Separation Process	3-0-0	3
4.	CML436	Advanced Separation Technology	3-0-0	3
5.	CML440	Chemical Reactor Analysis	3-0-0	3
6.	CML481	Instrumental Analytical Techniques	3-0-0	3
7.	CML501	Thermodynamics Of Phase And Chemical Equilibria	3-0-0	3
8.	CML502	Chemical And Catalytic Reaction Engineering	3-0-0	3
9.	CML503	Momentum Mass And Heat Transfer	3-0-0	3
10.	CML505	Industrial Process Control	3-0-0	3
11.	CML507	Novel Separation Processes	3-0-0	3
12.	CML525	Catalysis: Theory And Practice	3-0-0	3
13.	CML528	Interfacial Science And Engineering	3-0-0	3
14.	CML533	Mass Transfer With Chemical Reaction	3-0-0	3

Course Code & Course Title:	**Advance Heat Transfer (CML 383)**		
Course Type:	DE		
Name of the programme(s):	B. Tech Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	CML222, Heat Transfer		
Course Equivalence: Course Code(s)& Name(s)	**None**		

1.	**Course Objective:** To understand the fundamental theories, design processes of heat transfer occurring in heat exchangers, evaporators, jacketed vessels, boilers, reactors, reboilers, agitated vessels with and without coils, packed and fluidized beds.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Ability to understand the design approach and its application for various heat exchange equipment like heat exchangers, evaporators, jacketed vessels, etc.
CO2	Ability to identify, formulate, and solve engineering problems involving heat transfer equipments.
CO3	Ability to apply energy balances and rate equations to model and analyze thermal systems.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Unit-1 Classification of heat exchangers, recuperative, regenerative and direct contact type, double pipe heat exchangers, co-current counter, current flow arrangement, overall heat transfer coefficient.	**CO1**	1-2
	Unit-2 Fixed tube sheet, floated head and U–tube shell and tube heat exchangers, their design procedures, number of passes in heat exchangers, fouling of heat exchangers, baffles in heat exchangers,	**CO1**	1-2

selection of heating and cooling media for heat exchangers, Troubleshooting of shell and tube heat exchangers, thermal stresses and vibrations in shell and tube heat exchangers.		
Unit-3 Plate heat exchangers, design procedure, advantages over shell and tube heat exchangers, spiral plate heat exchangers, helical coil heat exchangers.	**CO2 & CO3**	1-2
Unit-4 Heat Regenerators, fixed and fluidized bed, Evaporators types and their operational characteristics.	**CO2 & CO3**	2
Unit-5 Single stage and multistage evaporation system, Steam economy, boiling point rise of solution and its effect on evaporation system, rising film and falling film evaporators.	**CO2 & CO3**	2
Unit-6 Effectiveness of heat exchanges, NTU method. Heat Transfer in jacketed vessels, boilers, furnaces and reactors, reboilers, heat transfer in agitated vessels with and without coils, Heat transfer in packed and fluidized beds.	**CO2 & CO3**	2-3

4.	**Text books**

i. Hollman J.P.; Heat Transfer, McGraw Hill, 1993
ii. Incropera F.P. Fundamentals of Heat and Mass Transfer 5th Edition Wiley India Pvt.Ltd Ltd., 2008
iii. Cengel Y.A. Heat Transfer: A Practical Approach McGraw-Hill; 2 edition, 2002
iv. Coulson J.M., Richardson J.R. Chemical Engineering, Vol. I 5th Edition, Butterworth Heinemann, New Delhi.
v. Dutta B.K. Heat Transfer; Principles and Applications PHI Pvt.Ltd New Delhi, 2006

5.	**Reference Book(s) and Other Required Material**

i. Kern D.Q., Process Heat Transfer, Tata McGraw Hill Book Co., New Delhi, 1990.

6.	**Evaluation Details:**

- Internals: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable): Heat Transfer Lab**

Course Code & Course Title:	CML394 Introduction to Measuring Instrument		
Course Type:	**DE**		
Name of the programme(s):	B.Tech in Chemical Engineering		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)			

1.	Course Objective:

The objective of this course is to familiarize the students with basic working principal and construction of various measuring instrument used in Process industry

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Know the operation of various measuring instruments.
CO2	Use, calibrate and maintenance of different types of instrumentation systems.
CO3	Understanding of the construction, material used and principle of operation of various types of measuring instruments.

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Introduction to Instrumentation Role of instruments in industrial processes; Block representation of measurement systems; Need for calibration and standards; Instrument parameters: sensitivity, accuracy, resolution, span, range; Static errors: zero error, proportionality error, hysteresis and maximum non-linearity error, role of transducer.	CO1, CO2, CO3	01
Pressure Measurement Definition and units; Relationship between absolute, atmospheric and gauge pressures; Relationship between height of a column of liquid and pressure; Use of manometers for pressure measurement; Principle of operation and installation of the following pressure gauges: diaphragm gauges, bellows gauges, Bourdon gauges, strain gauges; Gauge calibration using manometers, dead-weight testers, portable field calibrators and comparators; Pressure transmitters: standard pneumatic and electrical signals.	CO1, CO2, CO3	04
Level Measurement Factors influencing level measurement; Direct level measuring systems: the dip stick, the sight glass, floats; Pressure operated	CO1, CO2, CO3	03

systems: purged dip pipe, diaphragm box, differential pressure transmitter, manometer; Suitability of specific devices for different liquid conditions; Relationship between level and content (volume and mass) for spherical and cylindrical tanks		
Flow Measurement Volume and mass flow rate; Turbulent flow, streamlined flow and Reynolds number; The Continuity Equation, Bernoulli's Equation and application to differential pressure devices; Differential pressure primary elements: orifice plate, Venturi tube, Dall tube, flow nozzle and pitot-static tube; Installation procedures; Positive displacement flow meters: reciprocating piston, rotating impeller, semi-rotary type; Variable area flow meters; Flow integration and linearization; Calibration of liquid flow meters: volumetric tank, gravimetric tank, pipe prover, reference meter, standing start and finish, flying start and finish.	CO1, CO2, CO3	02
Temperature Measurement Thermal expansion thermometers: liquid in glass, bimetallic, liquid in metal, vapour pressure, and constant volume gas; Metal resistance thermometers an thermistors : theory, types, industrial installation and applications; Thermocouples: Seabeck effect, base metal and rare metal thermocouples, their metal combinations, operating ranges and uses; Law of Intermediate Metals and Law of Intermediate Temperatures; Practical application of these laws in the use of thermocouples; Installation techniques; Thermowells; Thermometer calibration procedures	CO1, CO2, CO3	01
Control valve Pressure drops across the valve, valve noise, flow characteristics of linear & equal percentage control valves on load changes. Control valve selection, Seat leakage & calibration	CO1	01

4.	Text books

i) Measurement and Instrumentation Principles, Alan S. Morris, Butterworth-Heinemann, (2001), ISBN: 0750650818
ii) Temperature Measurement, L. Michalski, John Wiley & Sons, (2001), ISBN: 0471867799
iii) Industrial Flow Measurement, 3rd Edition, David W. Spitzer, ISA (2000) ISBN: 1556178719
iv) Measurement and Control Basics,3rd Edition, T. A. Hughes, ISA (2002) ISBN: 155617764X

5.	Reference Book(s) and Other Required Material

i) Instrument Engineers' Handbook 4th Edition – Process Measurement and Analysis, Volume 1,B.G. Liptak, ISA, (2003), ISBN: 0849310830.

ii) Industrial Instrumentation and Control, W. Buchanan, Butterworth- Heinemann, (1999), ISBN: 0340719222.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	**CML427 Advanced Separation Processes**		
Course Type:	DE		
Name of the program(s):	B.Tech. Chemical Engg. /B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1	**Course Objective:**

Course Objective 1: To explore the principles, design, and application of membrane-based separation techniques such as microfiltration, ultrafiltration, nanofiltration, and reverse osmosis.
Course Objective 2: To examine a wide range of advanced separation methods, such as, Surfactant based separation methods, ATPS, chromatography, isoelectric focusing, salting out etc and its applications
Course Objective 3: To focus on the specific applications of advanced separation methods in biotechnology, bioprocessing, and chemical engineering, including cell harvesting, protein purification, and product isolation.
Course Objective 4: To investigate emerging separation techniques

2	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Ability to understand the governing mechanism and driving force of various advanced separation processes
CO2	Ability to perform process and design calculations on membrane separation processes Ability to understand process and design consideration on chromatography, aqueous two phase separations, bio separations
CO3	Ability to understand process and design consideration on hybrid and reactive separations
CO4	Ability to select/choose the suitable separation method for a particular product

3	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Overview of Separation Processes: Introduction / Revision of various Conventional Separation Processes and their applications, advantages, and disadvantages, Need of advance Separation processes, types.		CO1	1

Membrane Separations: Introduction, type of membrane separations, membrane, membrane materials, ultrafiltration, microfiltration, nanofiltration, reverse osmosis, pervaporation, type of membrane modules, membrane fouling, concentration polarization, various mathematical models for membrane processes, application, design considerations.	CO2, CO4	3
Bio-separation Processes: Introduction, overview of bioseparations, cell disruption/ pretreatment methods, filtration, centrifugation, adsorption, extraction / aqueous two phase systems, membrane separation, precipitation, chromatographic separation, Applications. Isoelectric focusing, Various case studies	CO2, CO4	4
Chromatographic Separation: Introduction, Principles, Classifications, High performance liquid chromatography, ion exchange chromatography, affinity chromatography, reversed phase chromatography, gas chromatography, application.	CO2,CO4	2
Hybrid Separations: Introduction, Concept of hybrid separations, types of hybrid separations, networking or combination of various separation processes, applications, design aspects, scope for future.	CO3, CO4	2
Reactive Separations: Introduction, Concept of reactive separations, types of reactive separations, reactive distillation, membrane based reactive separations, reactive extraction, reactive adsorption, reactive absorption, reactive crystallization, applications, design aspects, scope for future.	CO3, CO4	2

4	**Text books**

i) Richardson J. F., Harker J. H., Chemical Engineering Vol. 2, Elsevier, 5th Edition, 2002.
ii) Mukhopadhyay M., Natural Extract using Supercritical CO_2, CRC Press, 1st Edition, 2000.
iii) Nath K., Membrane Separation Processes, Prentice Hall of India, 1st Edition, 2008.
iv) Sivasankar B., Bio-separations: Principles and Techniques, Prentice Hall of India, 1st Edition, 2005.

5	**Reference Book(s) and Other Required Material**

(i) Seader J. D., Henley E. J., Separation Process Principles, Wiley, 2nd Edition, 2001

6	**Evaluation Details:**

i) Class test / Assignment – 20%

ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	3	3							1	3			
CO2	3	3	3	1		2						3	3	3	3
CO3	3	3	3	2	3	3	3			2	2		3	3	2
CO4	3	3	3	3	3	3	3	2			3	3	3	3	3

High - 3; Medium – 2; Low – 1;

8	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	CML-436 (Advanced Separation Technology)		
Course Type:	Core / Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
1	This course introduces advanced separation processes—reactive, hybrid, membrane, supercritical, chromatographic, bio-, and electro-kinetic—covering principles, applications, design considerations, and challenges for chemical engineering practice

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will gain understanding of conventional and advanced separation processes including overview, applications, advantages, disadvantages, and types of separation processes.
CO2	Students will understand reactive, hybrid, and membrane separation processes including types, applications, design aspects, and problems.
CO3	Students will gain knowledge of supercritical fluid extraction, multi-component distillation, chromatographic, bio-separation, and electro-kinetic separation processes including principles, applications, and problem-solving.

3.	**tailed Description of the Course**		
	Topics	**CO(s) Addressed**	**uration in weeks**
	Overview of Separation Processes: Introduction / revision of various conventional separation processes and their applications, advantages, and disadvantages, need of advance separation processes, types, problems.	CO1	2
	Reactive Separations: Concept of reactive separations, types of reactive separations, reactive distillation, membrane-based reactive separations, reactive extraction, reactive adsorption, reactive absorption, reactive crystallization, applications, design aspects, scope for future, problems.	CO2	2
	Hybrid Separations: Concept of hybrid separations, types of hybrid separations, networking or combination of various separation processes, applications, design aspects, scope for future, problems.	CO2	1
	Membrane Separations: Type of membrane separations, membrane materials, ultrafiltration, microfiltration, nanofiltration, reverse osmosis, pervaporation, type of membrane modules, membrane fouling, concentration polarization, various mathematical models for membrane	CO2	2

processes, application, design considerations, problems.		
Supercritical Fluid Extraction: Concept of supercritical extraction, factors affecting supercritical extraction, properties of supercritical fluid, applications, design considerations, problems.	CO3	1
Multi-component Distillation: Need of multi-component distillation, methods of multi-component distillation, design methods, problems.	CO3	1
Chromatographic Separation: Principles, classifications, High Performance Liquid Chromatography (HPLC), ion exchange chromatography, affinity chromatography, reversed phase chromatography, gas chromatography, application, problems.	CO3	2
Bio-separation Processes: Overview, cell disruption, filtration, centrifugation, adsorption, extraction, membrane separation, precipitation, chromatographic separation, applications, problems.	CO3	2
Electro-kinetic Separation: Various methods, electrophoresis, capillary electrophoresis, isoelectric focusing, esotachophoresis, electro-flotation, applications, problems.	CO3	1

4.	**Text books**

1. **Seader, J. D., Henley, E. J., & Roper, D. K.,** *Separation Process Principles*, 2nd Edition, John Wiley & Sons, 2001, ISBN-13: 9780471787365
2. **Richardson, J. F., & Harker, J. H.,** *Chemical Engineering, Vol. 2*, 5th Edition, Elsevier, 2002, ISBN: 9780750667388 (Coulson & Richardson context)
3. **Mukhopadhyay, M.,** *Natural Extract using Supercritical CO2*, 1st Edition, CRC Press, 2000, ISBN: 9780849306921

5.	**Reference Book(s) and Other Required Material**

1. **Nath, K.,** *Membrane Separation Processes*, 2nd Edition, Prentice-Hall of India, 2008, ISBN: 9788120352919
2. **Sivasankar, B.,** *Bio-separations: Principles and Techniques*, 1st Edition, PHI Learning Private Limited, New Delhi, 2005, ISBN: 9788120326491

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

CO	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO1	PO1	PSO	PSO	PSO	PSO

s	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**	**1**	**1**	**2**	**3**	**4**
CO 1	3	3	2	2	3	2	-	-	-	2	2	-	-	-	-
CO 2	3	3	2	2	3	2	1	-	-	2	2	-	-	-	-
CO 3	3	3	2	2	3	2	1	-	-	2	2	3	3	2	3
CO 4	3	3	2	2	3	2	1	-	-	2	2	3	2	2	-
CO 5	3	3	2	2	3	2	1	3	2	3	2	-	1	1	-

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-440 (Chemical Reactor Analysis)
Course Type:	Core / Elective
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-0-0 **No. of Credits** **03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**
Course Equivalence: Course Code(s) & Name(s)	**Nil**

1.	**Course Objective:**
1	Objective of this subject is to expose students to understand basic reactor analysis and its application to chemical engineering.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand homogeneous and non-ideal reactor design and analysis.
CO2	Learn special reactors and techniques, including adsorption, packed-bed, and fluidized-bed reactors.
CO3	Apply process intensification and nanomaterials in reaction engineering.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Review on Chemical Reaction Engineering Homogeneous reactor design and analysis-II: Non-ideal reactors- Review of the basic concepts of residence time distributions, single parameter models for real reactor behavior, Macromixing and micromixing, segregated flow model and Zweitering`s analysis of maximum mixedness, IEM and other models for micromixing	CO1	5
Models for Reactors with Nonideal-Flow Patterns Adsorption and Ion Exchange, Transient-Response Techniques, Packed-Bed Reactors (including Radial-Flow Reactor), Fluidized-Bed reactors , Gas-Liquid Reactions, Process Intensification and Special Reactors	CO2	6
Process Intensification and Special Reactors Applications of Nano Materials in Reaction Engineering (including Photocatalysis, Fuel Cells etc.)	CO3	3

4.	**Text books**

- Octave Levenspiel, *Chemical Reaction Engineering*, 3rd Edition, John Wiley & Sons, Singapore, 1998, ISBN: 9780471254246
- Fogler H.S., *Elements of Chemical Reaction Engineering*, 4th Edition, Prentice-Hall, NJ, 2006, ISBN: 9780133887518
- G. F. Froment and K. B. Bischoff, *Chemical Reactor Analysis*, 2nd Edition, John Wiley & Sons, Singapore, 1990, ISBN: 9780471816696

5.	Reference Book(s) and Other Required Material

- Smith J. M., *Chemical Engineering Kinetics*, 3rd Edition, McGraw Hill, NY, 1981, ISBN: 9780070616794
- Doraiswamy, L.K. and Sharma, M.M., *Heterogeneous Reactions* Vol. I & II, Wiley, 1984, ISBN: 9780471881088

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	3	2	2	3	2	-	-	1	1	2	-	-	-	-
CO2	3	3	2	2	3	2	-	-	-	-	2	-	-	-	-
CO3	3	3	2	2	3	2	-	1	1	-	2	3	3	2	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML 481: Instrumental Analytical Techniques		
Course Type:	DE		
Name of the programme(s):	B.Tech. in Chemical Engineering		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	CML202: Fluid Mechanics, CML221: Mass Transfer I, CML222: Heat Transfer		
Course Equivalence: Course Code(s) & Name(s)	Nil		

1.	**Course Objective:**

The course aims to:

Introduce students to the basic principles and methodologies of instrumental techniques used in chemical analysis.

Provide an understanding of key analytical tools, such as chromatographic and spectroscopic techniques.

Develop skills to interpret analytical data and apply it to solve chemical engineering problems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Describe the principles and functioning of common analytical instruments.
CO2	Apply chromatographic and spectroscopic methods for chemical analysis.
CO3	Process, analyze, and interpret data obtained from analytical instruments

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Unit 1: Introduction to Analytical Techniques Overview of analytical methods in chemical engineering. Sampling, sample preparation, and choice of methodology. Tools for quantitative chemical analysis and quality assurance.		CO1, CO3	1
Unit 2: Chromatographic Techniques Principles of gas chromatography (GC) and high-performance liquid chromatography (HPLC). Detectors and applications of chromatographic methods. Introduction to hyphenated techniques: GC-MS and LC-MS.		CO1, CO2, CO3	3
Unit 3: Spectroscopic Methods Fundamentals of UV-visible (UV-VIS) and infrared (IR) spectroscopy. Introduction to atomic absorption spectroscopy (AAS) and inductively coupled plasma mass spectrometry (ICP-MS). Applications of		CO1, CO2, CO3	4

spectroscopic techniques in chemical analysis.		
Unit 4: Data Processing and Statistical Analysis Error analysis and accuracy in chemical measurements. Statistical methods for data analysis and presentation. Introduction to chemometrics for analytical data interpretation.	CO3, CO1	2
Unit 5: Method Development and Validation QA/QC principles in analytical techniques. Method development, evaluation, and validation. Introduction to uncertainty analysis in chemical analysis.	CO2, CO3	2

4.	Text books

i) McNair, H. M., Miller, J. M., & Snow, N. H., Basic Gas Chromatography, 3rd Ed., Wiley, 2019, ISBN: 9781119450757.

ii) Snyder, L. R., Kirkland, J. J., & Dolan, J. W., Introduction to Modern Liquid Chromatography, 3rd Ed., Wiley, 2010, ISBN: 9780470167540.

iii) Pavia, D. L., Lampman, G. M., Kriz, G. S., & Vyvyan, J. R., Introduction to Spectroscopy, 5th Ed., Cengage Learning, 2015, ISBN: 9781285460123.

5.	Reference Book(s) and Other Required Material

i) Harris, D. C., & Lucy, C. A., Quantitative Chemical Analysis, 11th Ed., Macmillan Learning, 2026, ISBN: 9781319490294

ii) Bruno, T. J., & Svoronos, P. D. N., CRC Handbook of Basic Tables for Chemical Analysis: Data-Driven Methods and Interpretation, 4th Ed., CRC Press, 2020, ISBN: 9780367517199.

iii) Skoog, D. A., Holler, F. J., & Crouch, S. R., Principles of Instrumental Analysis, 7th Ed., Cengage Learning (likely 2017), ISBN: 9781305577213

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 20%

Mid-Semester Exam (1.5 Hours): 30%

End-Semester Exam (3 Hours): 50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**
CO1	3	3	-	-	-	-	-	-	-	-	-	3	3	1
CO2	3	3	2	-	3	-	-	-	-	-	-	3	3	3
CO3	2	2	3	3	2	2	-	-	-	-	2	2	3	3
CML 481	3	3	2	1	2	1					1	3	3	3

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Nil

Course Code & Course Title:	**CML-501 Thermodynamics of Phase and Chemical Equilibria**		
Course Type:	**DC**		
Name of the programme(s):	**M. Tech**		
L – T – P	**L**	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**

Based on the concepts taught, Student shall be able to apply the concepts of thermodynamics to solve the given problem on thermodynamic process accurately.

2.	**Course Outcomes:**
CO1	Describe the basic concepts (Thermodynamic properties like free energy, activity, fugacity etc.,)
CO2	Use the concepts of phase equilibrium and solve the problems.
CO3	Apply the concepts of chemical equilibrium and solve the problems.

3. Detailed Description of the Course

Topics	**CO(s) Addressed**	**Duration in weeks**
Classical thermodynamics: Laws and its significance, Review of Basic principles, Properties of pure substances and mixtures, Phase rule, Phase diagrams, and equations of state,	CO1	4
Phase Equilibria: Criteria of phase criteria, Duhem's theorem, Vapour Liquid Equilibria, Consistency Tests for VLE data	CO2	6
Chemical Reaction Equilibria: Effect of Temperature, Pressure, Presence of Inert materials, Excess reactants and Products. Phase Rule for Reacting Systems.	CO3	3

4.	**Text books**

i) Narayan K.V., a text book of Chemical Engineering Thermodynamics, 2nd edition, PHI Learning Private Limited, 2013, ISBN 13: 978-81-203-4747-2.

ii) Smith J.M., Van Ness H. C., and Abbott M.M., Introduction to Chemical Engineering Thermodynamics, 9th edition, McGraw Hill, 2021, ISBN 978-1-259-69652-7.

5.	Reference Books

i) S.Sandler, Chemical, biochemical and engineering thermodynamics, 4th edition, John Wiley, 2006, ISBN 13: 978-0471661740.

ii) Rao Y.V.C., Chemical Engineering Thermo dynamics, University press (INDIA) Ltd., 1997, ISBN 13: 978-8173710483.

iii) Borgnakke and Sonntag, Fundamentals of Thermodynamics, 11th edition, Wiley, 2024, ISBN 13: 978-1-394-21291-0.

iv) Hansen, J.B., and McDonald, I.R., Theory of Simple Liquids, 3rd edition, Academic, 2006, ISBN 13: 978-0-12-370535-8.

v) Tester, J.W., and Modell, M., Thermodynamics and its Applications, 3rd edition, Prentice Hall, 1997, ISBN 13: 978-0139153563.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Component	Duration	Weightage
Mid Term Exam	1 hour	30
Class Tests and Assignments	-	20
End Semester Exam	3 hours	50

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

Course Outcomes	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO501.1	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CO501.2	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CO501.3	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2
CML501	3	3	2	2	1	1	-	2	3	-	3	3	3	2	2

8.	List of Indicative Laboratory Experiment (if applicable):

Nil.

Course Code & Course Title:	CML 502 Chemical & Catalytic Reaction Engineering
Course Type:	Department Core (DC)
Name of the programme(s):	B.Tech/ M.Tech Chemical Engineering
L – T – P:	3 – 0 – 0
Credits:	03
Class Schedule:	3 Classes per week (55 minutes each)
Pre-requisites:	CHL XXX Chemistry, MAL 101 Engineering Mathematics
Course Equivalence:	None

1.	Course Objectives:
1	Provide students with a basic understanding of Non-isothermal processes, runway conditions, and safer industrial operations.
2	Enhance their knowledge on heat and mass transfer in reactors, catalytic multi-phase systems, biochemical systems and reactor designs
3	Development of mathematical model equations and applications of it in solving reaction engineering and reactor design problems
4	Building engineering problem solving and critical thinking ability of students keeping in mind economic, environmental and sustainable approach to the problem solving

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Non-isothermal effects on chemical reaction, processes engineering aspects and reactors performance evaluation for a particular duty
CO2	Process engineering aspects and design of multi-phase reaction systems
CO3	Development of mathematical model equations and applications of it in solving reaction engineering and reactor design problems
CO4	Hydrodynamics and mixing characteristics of different reactor configurations and selection of reactors for a particular duty

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
UNIT I. Non-isothermal processes (steady & unsteady) and Reactor designs Reaction Engineering overview-emerging challenges- ideal reactor design equations- multiple reactions, • Energy balance in stirred batch, semi-batch and continuous stirred vessels, plug flow vessels,	CO1, CO2, CO3, CO4	1.0 (9 hours)

• optimal design for exothermic reversible reactions, • stability and multiplicity of steady states in CSTR, • Catalysis and reactor design		
Unit II. Types, Classifications and Applications of Industrially Important Reactors • Batch, Semi-batch, Continuous, • Packed Bed, • Fluidized Bed, • Bubble Column, • Membrane, • Slurry, • Trickle Bed reactors, • Bioreactors	CO1, CO2	1.0 (8 hours)
Unit III. Introduction to Multiphase Reactor Engineering • Kinetics and Design aspects of multiphase reactors • Mass Balance in packed bed and fluidized bed reactors, • Chemical reaction and diffusion inside a catalyst particle, • Catalytic three-phase reactors: Mass balance and heat balance, • Bioreactors and biocatalysis, design of stirred tank fermentor	CO1, CO2, CO3, CO4	1.0 (9 hours)
Unit IV Hydrodynamic & Mixing Characteristics of Reactors • Hydrodynamics in flow reactors, • RTD, micromixing and macromixing and segregation phenomenon, • Tank-in-series model, Axial dispersion model	CO1, CO2, CO3, CO4	1.0 (9 hours)

4. Textbooks

i) Fogler, H.S., Elements of Chemical Reaction Engineering, 4th Edition, Prentice-Hall, NJ, 2006.

ii) Froment, G.F. and Bischoff, K.B., Chemical Reactor Analysis, 2nd Edition, John Wiley & Sons, 1990.

iii) Levenspiel, Octave, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 1998.

iv) Smith, J.M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, NY, 1981.

5. Reference Book(s) and Other Required Material
i) Richardson, J.F. and Peacock, D.G., Coulson & Richardson's Chemical Engineering, Butterworth-Heinemann.
ii) Heterogeneous reactions: Analysis, examples, and reactor design. L. K. Doraiswamy and M. M. Sharma, John Wiley and Sons, New York, 1984, Vol. I and II.
iii) Fluid Mixing and Gas Dispersion in Stirred Reactors, G.B. Tatterson, McGraw Hill Inc. New York, 1991.
iv) Salmi, T.O., Mikkola, J.P., and Warna, J.P., Chemical Reaction Engineering and Reactor Technology.

6. Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]	
Assessment Component	**Weightage**
Class Tests and Assignments	20%
Mid-Semester Exam (1.5 Hours)	20%
End-Semester Exam (3 Hours)	60%
Total	**100%**

7. Relationship of Course Outcomes to Program Outcomes:
Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	3	2	3	2	2	-	-	-	-	1
CO2	3	2	3	2	2	2	-	-	1	-	1
CO3	2	3	2	3	2	-	-	-	-	-	1
CO4	2	1	1	2	2	2	-	-	-	-	1

8. List of Indicative Laboratory Experiment (if applicable):
1. Reaction in Batch reactor
2. Reaction in Semi-batch reactor
3. Reaction in Plug-flow reactor
4. Reaction in Continuous stirred tank reactor

Course Code and Name:	**CML503: Momentum, Mass and Heat Transfer**		
Course Type:	DC		
Name of the programme(s):	M.Tech. (Chemical Engineering)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	Fluid mechanics, Heat Transfer and Mass Transfer		
Course Equivalence: Course Code(s)& Name(s)	NIL		

1.	**Course Objective:** **1.** To introduce the concept of theoretical similarities between heat, mass and momentum transfer **2.** To develop the shell balance approach for heat transfer, mass transfer and momentum transfer **3.** To develop model equations for important properties in the area of heat ,mass transfer and momentum transfer **4.** To introduce application of heat, mass and momentum transfer

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To introduce the concept of theoretical similarities between heat, mass and momentum transfer
CO2	To develop the shell balance approach for heat transfer, mass transfer and momentum transfer
CO3	To develop model equations for important properties in the area of heat ,mass transfer and momentum transfer
CO4	To introduce application of heat, mass and momentum transfer.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
CO1: Viscosity and the mechanisms of momentum transport, thermal conductivity and the mechanism of energy transport, diffusivity and the mechanisms of mass transport		**CO1**	2-3 Weeks

CO2: Shell momentum balances and velocity distribution in laminar flow and turbulent flow, shell energy balance and temperature distributions in solids, laminar and turbulent flow, concentration distributions in solids, laminar and turbulent flow	**CO2**	2-3 Weeks
CO3: The equation of change for isothermal systems, nonisothermal systems, multicomponent systems.	**CO3**	2-3 Weeks
CO4: Velocity distribution, temperature distributions, concentration distributions with more than one independent variable	**CO4**	2-3 Weeks

4.	**Text books**

i) R.B. Bird, W. Stewart and E.N Lightfoot, Transport Phenomena, John Wiley & Sons, 2 nd Edition, 2006

ii) J.R. Wilty, R.W. Wilson, and. C.W. Wicks,Fundamentals of Momentum Heat and Mass Transfer4th Edition, John Wiley, New York, 2001

iii) C.O. Bennet and J.E. Myres, Momentum, Heat & Mass Transfer, McGraw Hills, 3 rd Edition, 1994

5.	**Reference Book(s) and Other Required Material**

i) R. Brodkey and H. C. Hershey, Transport Phenomena – A Unified Approach, volume 1, McGraw Hill Book Co., 2 nd Edition, 1988

ii) C.J. Geankoplis, Transport Processes and Separation Process Principles, Prentics Hall India Ltd., 4 th edition, 2003

iii) G.S. Laddha and T.E. Degaleesan, Transport Phenomena in Liquid Extraction, Tata McGraw Hill Book Co., 1 st edition, 1978

6.	**Evaluation Details:**

- Class Tests and Assignments: 15%
- Mid-Semester Exam (1.5 Hours): 25%
- End-Semester Exam (3 Hours): 60%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable): NA**

Course Code & Course Title:	**CML 505 Industrial Process Control**		
Course Type:	**DC /DE**		
Name of the programme(s):	Chemical Engineering, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)			
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective: To learn advanced and industrial control strategies**

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To learn the basics about linear control development
CO2	Lean to design advanced control system.
CO3	To learn designing of controller for the complex system.
CO4	To develop controller for multi-input multi output system and analyse it.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Review of dynamic behaviour of linear systems and their control system design: Introduction to basic concept of control, Laplace transform. Analysis of dynamic response, development of model for simple system.		CO1	4 weeks
Linear processes with difficult dynamics. Nonlinear process dynamics; phase-plane analysis; multiple steady-state and bifurcation behaviour.		CO2	3 weeks
Model based control; Cascade, feed-forward & ratio control; Auctioneering, cascade controller. Controller design for nonlinear systems: Smith predictor, Inverse response predictor, open loop unsteady state controller development.		CO3	4 weeks
Introduction to multivariable systems. Interaction analysis and multiple single loop design. Design of multivariable controllers; identify potential manipulated variable using RGA analysis. Design of decouplers, understanding of controllability and observability of the system. Model predictive control of MIMO systems.		CO4	5 weeks

4.	**Text books**

1. Process Control, Thomos Marlin, Mc Graw Hill

2. Process system analysis and control, D. R. Coughanowr, S.E. LeBlanc, Mc Graw Hill
3. Chemical Process Control, G. Stephanopoulos, EEE.

5.	**Reference Book(s) and Other Required Material**

1. Process dynamics, modeling, and control, Babatunde Ougannaike, Harmon Ray, Oxford

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Mid Semester Exam: 25 %

Assignments/Presentation/Viva/Quiz: 20 %

End Semester Exam: 55 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	**CML507 Novel Separation Processes**		
Course Type:	DE		
Name of the program(s):	B.Tech. Chemical Engg. /B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1	**Course Objective:**

The course presents the concept, types and design of various conventional and emphasizing more on novel separation processes from a chemical engineering viewpoint. Various approaches and applications on novel separation processes are stressed in this course.
Based on the concepts taught, Student shall be able to apply various novel separation processes to resolve the various issues in process industry.

2	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Ability to understand the basics of separation processes
CO2	Ability to perform various conventional and novel separation processes
CO3	Ability to understand process and design consideration of novel separation processes
CO4	Ability to select/choose the suitable separation method for a particular product and the application of novel separation processes

3	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Overview of Separation Processes: Introduction / Revision of various Conventional Separation Processes and their applications, advantages, and disadvantages, Need of advance Separation processes, types.		CO1	1
Membrane Separations: Introduction, type of membrane separations, membrane, membrane materials, ultrafiltration, microfiltration, nanofiltration, reverse osmosis, pervaporation, type of membrane modules, membrane fouling, concentration polarization, various mathematical models for membrane processes, application, design considerations.		CO2, CO4	3

Bio-separation Processes: Introduction, overview of bioseparations, cell disruption/ pretreatment methods, filtration, centrifugation, adsorption, extraction / aqueous two phase systems, membrane separation, precipitation, chromatographic separation, Applications. Isoelectric focusing, Various case studies	CO2, CO4	4
Chromatographic Separation: Introduction, Principles, Classifications, High performance liquid chromatography, ion exchange chromatography, affinity chromatography, reversed phase chromatography, gas chromatography, application.	CO2,CO4	2
Hybrid Separations: Introduction, Concept of hybrid separations, types of hybrid separations, networking or combination of various separation processes, applications, design aspects, scope for future.	CO3, CO4	2
Reactive Separations: Introduction, Concept of reactive separations, types of reactive separations, reactive distillation, membrane based reactive separations, reactive extraction, reactive adsorption, reactive absorption, reactive crystallization, applications, design aspects, scope for future.	CO3, CO4	2

4	**Text books**

i) Richardson J. F., Harker J. H., Chemical Engineering Vol. 2, Elsevier, 5th Edition, 2002.
ii) Mukhopadhyay M., Natural Extract using Supercritical CO_2, CRC Press, 1st Edition, 2000.
iii) Nath K., Membrane Separation Processes, Prentice Hall of India, 1st Edition, 2008.
iv) Sivasankar B., Bio-separations: Principles and Techniques, Prentice Hall of India, 1st Edition, 2005.

5	**Reference Book(s) and Other Required Material**

(i) Seader J. D., Henley E. J., Separation Process Principles, Wiley, 2nd Edition, 2001

6	**Evaluation Details:**

i) Assignment – 20%
ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

Course Code & Course Title:	CML-525 (Catalysis: Theory & Practice)
Course Type:	Core / Elective
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-0-0 **No. of Credits** **03**
Pre-requisites: Course Code(s) & Name(s)	Chemical Reaction Engineering I & II
Course Equivalence: Course Code(s) & Name(s)	**Nil**

1.	**Course Objective:**
1	Provide students with a basic understanding of catalytic processes.
2	Explain problems in catalytic and non-catalytic processes and advantages of catalytic processes over non-catalytic processes.
3	Understand internal and external mass transfer in catalytic processes and reactor design.
4	Introduce biocatalysis, external mass transfer in biocatalysis, bioreactor design, and process modeling.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand catalytic processes, reaction mechanisms, and catalyst behavior.
CO2	Analyze mass transfer, diffusion, and reaction phenomena in catalytic reactors.
CO3	Apply process modeling and reactor design principles in catalytic and biocatalytic systems.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Heterogeneous processes. Global rates of reaction. Catalysis. General characteristics of catalysis. Physical adsorption and chemisorption. Adsorption isotherms, Determination of surface area of a catalyst. Classification of catalyst, catalyst preparation. Catalyst deactivation. Langmuir-Hinshelwood and Eley–Rideal model. Rate equation when surface reaction, adsorption and desorption control.	CO1	2
External Diffusion effects on heterogeneous catalytic reaction. Modeling diffusion without reaction. External resistance to mass transfer. Mass transfer limited reaction in packed beds. Diffusion and reaction in porous catalyst pellets. Effective diffusivity and effective thermal conductivity. Internal effectiveness factor. Thiele modules. Mass transfer and reaction in a packed bed reactor.	CO2	3

Gas-solid non-catalytic reaction – shrinking core model – Diffusion through ash layer, chemical reaction and gas film controls. Limitation of shrinking core model. Determination of the rate controlling step. Design of gas-solid particle reaction.	CO2	2
Gas–liquid reaction. Absorption combined with chemical reaction. Mass transfer coefficients and kinetic constants. Application of film penetration and surface renewal theories. Hatta number and enhancement factor for first order reaction. Tower reactor design.	CO2	2
Phenomena of Fluidization, liquid like behavior of fluidized beds, advantages and disadvantages of fluidized beds, different types of fluidized beds and applications of fluidization technique in process industries.	CO3	2
Heat and Mass Transfer in Fluidized Beds: Variables affecting heat transfer rate, heat transfer at the wall of containing vessel, heat transfer to immersed tubes. Models proposed by (i) Wicke-Fetting, (ii) Mickley and Fair Banks and (iii) Levenspiel and Walton. Heat transfer in fixed and fluidized beds. Definition and evaluation of mass transfer coefficient.	CO3	3

4.	**Text books**

1. Smith J.M., *Chemical Engineering Kinetics*, McGraw Hill
2. Fogler H.S., *Elements of Chemical Reaction Engineering*, Prentice Hall of India

5.	**Reference Book(s) and Other Required Material**

1. Hill C.G., *An Introduction to Chemical Engineering Kinetics & Reactor Design*, John Wiley

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	3	2	-	-	-	-	2	1	-	-	-
CO2	3	3	2	2	3	2	-	-	1	-	-	-	1	1	1
CO3	3	3	2	2	3	2	3	1	-	1	2	3	3	2	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-528 (Interfacial Science and Engineering)		
Course Type:	Core / Elective		
Name of the programme(s):	M.Tech. Chemical Engg, B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	Course Objective:
1	Understand basic properties of colloidal materials and forces governing them.
2	Analyze particle aggregation behavior in aqueous and organic dispersions.
3	Design colloidal dispersions with long-term stability.
4	Learn methodologies to prepare emulsions and microemulsions using surfactants and polymers.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Understand surface and interfacial energies, capillarity, adhesion, and interfacial forces.
CO2	Analyze mesoscale thermodynamics, soft matter phenomena, and nanoparticle dispersion stability.
CO3	Apply principles to prepare emulsions, microemulsions, and foams with long-term stability.

3. tailed Description of the Course		
Topics	**CO(s) Addressed**	**uration in weeks**
Surface Tension, Adhesion and capillarity: Effects of confinement and finite size; Concepts of surface and interfacial energies and tensions; A polar (van der Waals) and polar (acid-base) components of interfacial tensions. Young-Laplace equation of capillarity; examples of equilibrium surfaces; multiplicity, etc. Stability of equilibrium solutions; Contact angle and Young's equation; Determination of apolar (van der Waals) and acid-base components of surface/interfacial tensions. Free energies of adhesion; Kinetics of capillary and confined flows.	CO1	2
Intermolecular, nanoscale and interfacial forces in organic, polymeric, biological and aqueous systems: Van der Waals, Electrostatic double layer, Acid-base interactions including hydrophobic attraction and hydration pressure.	CO1	2

Mesoscale thermodynamics: Gibbs treatment of interfaces; concept of excess concentration; variation of interfacial tensions with surfactant concentration.	CO2	2
Mesoscale phenomena in soft matter and applications: Adhesion, wetting, nucleation, flotation, patterning of soft material by self-organization and other techniques.	CO2	2
Stability of nanoparticle dispersions: DLVO and DLVO-like theories and kinetics of coagulation plus general principles of diffusion in a potential field/Brownian movement. Micellization, Emulsions, Foam, Micro-emulsions.	CO2, CO3	3

4.	Text books

1. P.C. Hiemenz, and R. Rajagopalan, *Principles of Colloid and Surface Chemistry*, 3rd Edition, Marcel Dekker, N.Y., 1997. ISBN: 9780824792870
2. M.J. Rosen, *Surfactants and Interfacial Phenomena*, Wiley-Interscience Publication, New York, 2004. ISBN: 9780471334876

5.	Reference Book(s) and Other Required Material

1. A.W. Adamson, A. P. Gast, *Physical Chemistry of Surfaces*, Wiley-Interscience, New York, 1997. ISBN: 9780471473364
2. J. Israelachvili, *Intermolecular and Surface Forces*, Academic Press, New York, 1992. ISBN: 9780123751829
3. R. J. Hunter, *Foundations of Colloid Science*, Clarendon, Oxford, Volumes 1 & 2, 1989. ISBN: 9780198556934
4. W. B. Russel, D. A. Saville, W. R. Schowalter, *Colloidal Dispersions*, Cambridge University Press, 1989. ISBN: 9780521337927
5. D.J. Shaw, *Colloid & Surface Chemistry*, Butterworth Heinemann, Oxford, 1991. ISBN: 9780750639278
6. H. Butt, K. Graf, M. Kappl, *Physics and Chemistry of Interfaces*, WILEY-VCH, 2003. ISBN: 9783527308471
7. D. Myers, *Interfaces, and Colloids: Principles and Applications*, Wiley, 2nd Edition, 2002. ISBN: 9780471321854

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- **Assignment: 20 %**
- **Mid Sem Exam: 30 %**
- **End Sem Exam: 50 %**

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PSO 1	PSO 2	PSO 3	PSO 4

CO 1	3	3	2	2	3	2	-	-	-	-	2	1	-	-	-
CO 2	3	3	2	2	3	2	1	1	1	3	2	-	1	1	1
CO 3	3	3	2	2	3	2	1	1	1	1	2	3	3	2	3

High **-** *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	**(CML533) Mass Transfer with Chemical Reaction**		
Course Type:	**DE**		
Name of the programme(s):	**1st Semester M.Tech. Chemical Engineering**		
L – T – P	**3-0-0**	**No. of Credits**	**3**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

To train students on theory of mass transfer accompanied by irreversible and reversible reactions, discussion and examples of systems falling in different regimes, use of models in the simulation and design of fluid-fluid reactors.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the coupling of chemical reaction in mass transfer operation, its advantages and disadvantages.
CO2	How to identify, quantify or formulate, and solve the engineering problems involving mass transfer and chemical reaction.
CO3	Design and analysis of mass transfer processes and equipments involving chemical reaction.
CO4	Applications of mass transfer and reaction phenomena and its optimum use.

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Unit I Introduction to mass transfer and reaction engineering Theory of mass transfer accompanied by irreversible and reversible reactions of general order; methods of discerning controlling mechanism: Very slow reactions, slow reactions, fast reactions, instantaneous reactions, overlapping of regimes, controlling mechanisms	CO1, CO2, CO3, CO4	3
	Unit II Discussion and examples of systems falling in different regimes: gas-liquid system, liquid-liquid system, special cases, reversible reactions	CO1, CO2, CO3, CO4	2
	Unit III Mass transfer accompanied by consecutive and two-step	CO1,	2

reactions	CO2, CO3	
Unit IV Absorption of a gas into a solution containing two reactants, Simultaneous absorption and reaction of two gases, Reaction in both (liquid) phases, Desorption with chemical reaction; simultaneous absorption-desorption with reaction, Complex reactions	CO1, CO2, CO3, CO4	3
Unit V Use of models in the simulation and design of fluid-fluid reactors, Solid-liquid reactions	CO1, CO2, CO3, CO4	2

4.	Text books

i) L. K. Doraiswamy and M. M. Sharma, Heterogeneous reactions: Analysis, examples, and reactor design, John Wiley and Sons, New York, 1984, Vol. II.

5.	Reference Book(s) and Other Required Material

i) G. F. Froment and K. B. Bischoff, Chemical Reactor Analysis, 2nd Edition, John Wiley & Sons, Singapore, 1990.

ii) Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, Singapore, 1998.

iii) Fogler H.S., Elements of Chemical Reaction Engineering, 4th Edition, Prentice-Hall, NJ, 2006.

iv) Smith J. M., Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, N Y, 1981.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 15%

Mid-Semester Exam (1.5 Hours): 25%

End-Semester Exam (3 Hours): 60%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

CO4	2	2	2	1	1	1	-	-	-	-	2	2	3	3

***High – 3; Medium – 2; Low – 1**.;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

NIL

S. No	Course Code	**Sustainability & Management**	**L-T-P**	**Credits**
1.	CML233	Environmental Engineering	3-0-0	3
2.	CML231	Material Science And Engineering	3-0-0	3
3.	CML422	Plant Utility	3-0-0	3
4.	CML234	Industrial Waste Treatment	3-0-0	3
5.	CML342	Safety And Risk Analysis	3-0-0	3
6.	CML393	Innovative Design	3-0-0	3
7.	CML364	Green Chemistry & Engg.	3-0-0	3
8.	CML303	Process Control and Instrumentation	3-0-0	3
9.	CML439	Energy Management	3-0-0	3
10.	CML442	Reliability Engineering	3-0-0	3
11.	CML475	New And Renewable Energy Engineering	3-0-0	3
12.	CML479	Entrepreneurship Development	3-0-0	3
13.	CML491	Project Planning And Management	3-0-0	3
14.	CML526	Total Quality Management	3-0-0	3
15.	CML530	Process Intensification	3-0-0	3
16.	CML532	Energy Technology And Conservation	3-0-0	3
17.	CML534	Reliability Analysis In Process Industry	3-0-0	3

Course Code & Course Title:	CML233 Environmental Engineering		
Course Type:	DE		
Name of the program(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	No. of Credits	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1	Course Objective:

Course Objective 1. To identify the sources of pollutants and its hazards on human and environment
Course Objective 2. To learn the nutrient cycle, ecosystem and ways to restore the ecosystem and cycles
Course Objective 3. To learn the methods for prevention and control / treatment of various pollutants
Course Objective 4. To understand the life cycle and the sustainability concept related to environment
Course Objective 5. To learn the basic environmental legislation

2	Course Outcomes (Min. 3 & Max. 5):
CO1	Understand key current environmental problems.
CO2	Be able to analyse an industrial activity and identify the environmental problems
CO3	Be able to plan strategies to control, reduce and monitor pollution
CO4	Be able to select the most appropriate technique to purify and/or control the emission of pollutants
CO5	Be conversant with basic environmental legislation.

3	Detailed Description of the Course		
Topics		CO(s) Addressed	Duration in weeks
Man and environment, biogeochemical cycles, Biosphere and ecosystem, Forest Nutrient cycles and the parameters responsible for the disturbance of these cycles.		CO1	1
Mobile and stationary sources of air pollutants, air pollution, behaviour of pollutants and atmospheric chemical reactions, Atmospheric dispersion of pollutants, models for dispersion, limitations of models, effective stack height concept, gas sampling and analysis. CO, CO_2, H_2S, SO_x, NO_x emissions and their		CO2	3

control, desulphurization. Sources of water and pollutants, classification and characterization of solid, liquid and gaseous waste.		
Air pollution control processes, Unit operations such as screening, coagulation, flocculation, filtration, clarification, solvent extraction. measurement of levels of pollution such as DO, BOD, COD, TOC,ThOD, soluble and suspended volatile solids, Water quality and discharge standards	CO2, CO3,CO4	5
Chemical treatment of waste material, oxidation, chlorination, Ozonation, incineration etc. Biological treatment, biochemical kinetics, microbial kinetics, microbial growth. Aerobic and anaerobic waste treatment, activated sludge process, aerated lagoons, anaerobic digesters, Biogas & trickling filters & its utilization. Solid Waste & its disposal pyrolysis (Incineration, Composing and filling etc.).	CO2, CO3,CO4	5
Measuring environmental impacts, life cycle analysis, legislation controlling discharges, optimal degree of abatement, and policies for regulation of environmental impacts.	CO2,CO5	2

4	Text books

i) Mahajan S.P. Pollution Control in Process Industries, Tata McGraw Hill Book Co., 2017

ii) Pandey G.N. and Camey G.C.; Environmental Engineering, Tata – McGraw Hill Book Co., New Delhi (1989)

iii) Rao C.S.; Environmental Pollution Control Engineering, New Age International Publishers, 3rd Edition, 2018

5	Reference Book(s) and Other Required Material

i) Sincero A., Environmental Engineering, A Design Approach. , Prentice – Hall of India, New Delhi (1996).

6	Evaluation Details:

i) Class test/ Assignment – 20%

ii) Mid Sem Evaluation – 30%

iii) End Sem Evaluation -50%

7	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	2		3	3			2	3	3	2	2	
CO2	3	3	3	3		3	3					3	3	2	
CO3	3	3	3	3	1	3	3				3	3	3	3	
CO4	3	3	3	3	1	3	3	1	1			2	2	2	
CO5				3		3	3			3	3	1			

High - 3; Medium – 2; Low – 1;

8	**List of Indicative Laboratory Experiment (if applicable):**

Not Applicable

Course Code & Course Title:	CML-231 (Materials Science and Engineering)		
Course Type:	Core / Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1	**Course Objective:**
1	To provide basic knowledge and application of different types of materials.
2	To study short-term and long-term mechanical behavior of materials.
3	To understand the science behind the fracture, fatigue, and failure of materials.
4	To provide knowledge on phase diagrams in selection of alloy materials with appropriate composition.
5	To understand the heat treatment methods involved in preparation of materials.

2	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand atomic structure, bonding, and basic principles of materials.
CO2	Learn mechanical properties and deformation behavior of materials.
CO3	Understand dislocations and strengthening mechanisms.
CO4	Analyze fracture, fatigue, and creep of materials.
CO5	Interpret phase diagrams for alloy preparation and selection.

3	**tailed Description of the Course**		
	Topics	**CO(s) Addressed**	**uration in weeks**
	Introduction: Introduction to materials and their principle properties, Atomic bonding, crystal structure and defects, Basic principles in their selection for fabrication and erection of chemical plant.	CO1	2
	Deformation: Plastic deformation - Mechanism of plastic deformation, slip, work hardening, deformation in polycrystalline materials, Effect of cold working and annealing, hot working. Elastic deformation, Anelastic deformation, Viscoelastic deformation – models for viscoelastic behavior.	CO2	2
	Fracture: Types of fracture, cleavage, brittle, ductile, Griffith crack theory, Theories of crack initiation, ductile – brittle transition.	CO4	1

Testing of materials: Destructive tests - Tensile testing, stress-strain curves, condition for necking, compression testing, Hardness testing. Creep - testing method, creep curve, requirements for creep resistance materials. Fatigue – testing method, fatigue prevention. Non-destructive tests.	CO2, CO4	2
Thermal properties: Heat capacity and specific heat, Thermal expansion, thermal conductivity, thermal shock.	CO2	1
Heat treatment: Annealing, quenching, normalizing, hardening, martempering, austempering, case hardening, cyaniding, nitriding, flame hardening, induction hardening, diffusion coating, furnaces and temperatures.	CO5	2
Phase diagram: Basic terms, Hume-Rothery rules of solid solubility, Gibb's phase rule, polymorphism, solidification of pure metal. Types of cooling curves, plotting of equilibrium diagram, lever rule, common types of phase diagram, other transformations in alloy system; Non-equilibrium cooling.	CO5	2
Engineering materials – overview: Organic, inorganic and biological materials: Polymers, Metals & alloys, ceramics, glasses, leather, wood. Electronic materials, photonic materials, smart materials, composites and nanostructured materials.	CO1	2

4	**Text books**

1. William D. Callister Jr., *Materials Science and Engineering: An Introduction*, 8th Edition, John Wiley & Sons, USA, 2010. ISBN: 9780470509392
2. James F. Shackelford, *Introduction to Materials Science for Engineers*, McGraw-Hill, 1990. ISBN: 9780070289935
3. William D. Callister Jr., *Materials Science and Engineering*, John Wiley & Sons, Inc., 2012. ISBN: 9781118324578

6.	**Reference Book(s) and Other Required Material**

1. D.Z. Jastrzebski, *Properties of Engineering Materials*, Toppers Co. Ltd., 3rd Edition. ISBN: 9780135537991
2. Askeland, Fulay, Wright, Balani, *The Science and Engineering of Materials*, 6th Edition, Cengage Learning, 2012. ISBN: 9788131516416
3. S.K. Hajra Choudhury, A.K. Hajra Choudhury, *Materials Science and Processes*, Indian Book Distributing Corporation. ISBN: 9788170382152

6	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	3	3	2	2	3	2	-	-	-	-	2	1	-	-	-
CO 2	3	3	2	2	3	2	-	-	-	-	2	-	1	1	1
CO 3	3	3	2	2	3	2	-	-	-	-	2	3	3	2	3
CO 4	3	3	2	2	3	2	-	-	-	-	2	3	3	2	2
CO 5	3	3	2	2	3	2	-	-	-	-	2	3	3	2	2

High - 3; Medium – 2; Low – 1;

8	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML422 Plant Utility		
Course Type:	**DE**		
Name of the programme(s):	B.Tech in Chemical Engineering		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)			

1.	**Course Objective:**

Understand **and explain** the role of various utility systems (steam, water, air, refrigeration, power, etc.) in chemical process plants. **Learn the principles of generation, distribution, and efficient use** of these utilities in industrial operations. **Develop competence in selecting utility equipment** based on process requirements and performance criteria. **Apply basic engineering calculations** related to steam generation, psychrometrics, cooling, and refrigeration systems. **Foster analytical reasoning** for troubleshooting utility system issues for safe, reliable plant operation.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the principals and working of different utilities like water treatment, generation of steam, compressor, and refrigeration cycles.
CO2	Describe the different equipment used to run the process plant with different utilities.
CO3	Acquire the knowledge for selection of different utility
CO4	Understand basic calculation (performance) involved in steam generation, compressor, psychometric operation and refrigeration

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Importance of utilities: Sources of water, hard and soft water, Requisites of industrial water and its uses, Methods of water treatment, Chemical softening, Demineralization, Resins used for water softening, Reverse osmosis and membrane separation, Effects of impure boiler feed water & its treatments., Scale & sludge formation, Corrosion, Priming & foaming, Caustic embrittlement.		CO1	01

Refrigeration: Refrigeration cycles 04, Different methods of refrigeration used in industry, Vapour compression, Vapour absorption: Lithium bromide (eco-Friendly) Different refrigerants like Monochlorodifluoro methane (R-22) Chlorofluorocarbons (CFC-Free). Secondary refrigerants: Brines Simple calculation of C.O.P. Refrigerating effects.	CO3	04
Steam and steam generation: Properties of steam, Problems based on enthalpy calculation for wet, steam, dry saturated steam, superheated steam,, Types of steam generator / boilers: water tube & fire tube, Solid fuel fired boiler. , waste gas fired boiler., Waste heat boiler., Fluidized bed boiler., Scaling, trouble shooting, preparing boiler for inspection, Steam traps, boiler mountings and accessories , Boiler Act.	CO4	03
Psychrometry: Properties of Air-water vapours. Use of humidity chart, Equipment used for humidification, dehumidification, Evaporative cooling, spray ponds, cooling towers.	CO4	02
Air: Use of Compressed air, process air and instrument air, Process of getting instrument air.	CO4	01
Non steam heating system, Thermic fluid heater, Down- thermo heater, Temperature range.		01

4.	Text books

Note: *Kindly arrange the textbooks/references in* ***alphabetical order.***

v) R.S. Khurmi and J.K.Gupta, Thermal Engineering, S. Chand Technical Publication, 15th Edition ,2004, ISBN:81-219-1337-3

5.	Reference Book(s) and Other Required Material

Note: *Kindly arrange the textbooks/references in* ***alphabetical order.***

i) Mahesh m. Rathod , Thermal Engineering , Mc Graw hill, ISBN: 978-0-07-068113-2
ii) Narayan K.V., a text book of Chemical Engineering Thermodynamics, PHI, 2001.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

- Class Tests and Assignments: 20%
- Mid-Semester Exam (1.5 Hours): 30%
- End-Semester Exam (3 Hours): 50%

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

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

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	**CML234 Industrial Waste Treatment**		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Engineering		
L – T – P	**3-0-0**	**No. of Credits**	**03 credits**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	Our objective is to discuss engineering aspects of industrial Pollution Control Technologies so that student shall be able to apply different control strategies to protect the ecosystem.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student will gain the knowledge of different pollutants and their effects on public health and on ecosystem.
CO2	Students will learn the different methods of sampling and measurement of air, water and solid pollutants.
CO3	Students will gain the knowledge of conventional methods as well as new methods to control the pollution.
CO4	Students will able to identify air, water, and solid waste management practices and technologies adapted by different industries.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Nature and characteristics of industrial wastes; Sources and types of wastes: solid, liquid, and gaseous wastes; Pre-treatment of Industrial wastes, unit operations and unit processes; Sampling Techniques.		CO1, CO2	2
Methods for Treating industrial waste gases or air discharges- physical method, chemical method, combined method, biological method.		CO3, CO4	3
Solid and Hazardous wastes: definitions, concepts. Incineration, recycling, composting, landfill, On-Site Monitoring and Analysis of Industrial Pollutants.		CO1, CO2, CO3, CO4	3
Waste water treatment-physical, chemical and biological method. Recent trends in Industrial waste treatment. Application of Biotechnology for Industrial Waste Treatment.		CO1, CO3, CO4	3-4

Case Studies:- Example (Treatment of Pharmaceutical Wastes, Treatment Refinery Wastes, Treatment of Textile Wastes, Treatment of Pulp and Paper Mill Wastes, Treatment of Dairy Processing Wastewaters, Treatment of Pesticide Industry Wastes, Food Waste Treatment, Treatment of Rubber Industry Wastes, Treatment of Tannery Industry Wastes and Radioactive waste etc.).	CO3, CO4	3

4.	Text books

i) C. S. Rao, Environmental Pollution Control Engineering, 3rd Edition, New Age International, 2018, ISBN: 9789386649898.

ii) S. P. Mahajan, Pollution Control in Process Industries, 1st Edition, McGraw Hill, 2017, ISBN : 9780074517727.

5.	Reference Book(s) and Other Required Material

i) F. Woodard, Industrial Waste Treatment Handbook, 1st Edition, Butterworth-Heinemann, 2001, ISBN: 9780750673174

ii) H. M. Freeman, Industrial Pollution Prevention Handbook, 1st Edition, McGraw Hill Education, 2017, ISBN: 9789339218089

iii) N. L. Nemerow, Industrial Waste Treatment: Contemporary Practice and Vision for the Future, 1st Edition, Butterworth-Heinemann, 2006, ISBN: 9780123724939

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Semester Exam : 30

Teacher Defined Assessment: 20

End Semester Exam: 50

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1			3					1
CO2	2	3		3	2	1					1
CO3	3	2	3	1	2	3					2
CO4	2	2	3	1	2	3		1	1	1	1
Avg.	3	2	2	2	2	3		1	1	1	2

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Not Applicable.

Course Code & Course Title:	**(CML 342) Safety and Risk Analysis**
Course Type:	**DE**
Name of the programme(s):	**8th Semester B.Tech. Chemical Engineering**

L – T – P	**3-0-0**	**No. of Credits**	**3**

Pre-requisites: Course Code(s) & Name(s)	**None**
Course Equivalence: Course Code(s) & Name(s)	**None**

1.	**Course Objective:**

1) To give students the knowledge on safety programs, engineering ethics, plant safety measures, safety warning symbols, handling of hazardous chemicals, fire and explosion hazards and different methods of hazard identification and its analysis in qualitative and quantitative scales.
2) To gain knowledge on different mathematic models used to predict the rate of leakage of fuels from various unit operations.
3) To gain knowledge on the design to prevent fires and explosion, risk assessment and case study problems.
4) To develop the safety concepts among the students with detailed understanding of technical knowledge.
5) To develop the responsibility and ability for precautions and remedial actions for any untoward event.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Basic procedures to be followed to ensure safety in chemical process industries
CO2	Fire-flammability characteristics of vapors and liquids
CO3	Designs to prevent fires and explosions
CO4	Mathematical models to understand the rate of discharge of materials
CO5	Risk assessment of various chemical process plants

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Unit-I: Introduction to process plant safety, handling of hazardous chemicals, OSHA standards, importance of plant layout in safety, importance of site selection, personnel safety, role of human error in losses. Case studies of fires, explosions, disasters in chemical process plants.	CO1, CO2, CO3	2
Unit-II: Lower flammability limit (LFL), UFL, LEL, UEL, TLV, electrostatic hazards, Hazard code and explosive limit, TWA,	CO1, CO2, CO3, CO5	3

Ceiling level, Safety in handling of gases, liquids and solids, Flammable liquid hazards, fire and explosion index, fire ball hazards, oil spillage hazards, Bleveuvce, pool fires, jet fires, radiation hazards. Explosion, emergency and disasters in chemical process plants, onsite and offsite emergency plan, Fire detectors, smoke detectors. Resources for combating fires, dry chemical powders, fire fighting foam, fixed and portable fire extinguishers, FMEA.		
Unit-III: Designs to Prevent Fires and Explosions- Vacuum Purging, Pressure Purging, Combined Pressure-Vacuum Purging, Vacuum and Pressure Purging with Impure Nitrogen, Advantages and Disadvantages of the Various Pressure and Vacuum inerting procedures, Sweep-Through Purging, Siphon Purging.	CO1, CO2, CO3, CO4	3
Unit-IV: Introduction to Source Models, Flow of Liquid through a Hole, Flow of Liquid through a Hole in a Tank, Flow of Vapor through Holes, Flashing Liquids, Flow of Gases through Pipes-Adiabatic Flows and isothermal flows, Liquid Pool Evaporation or Boiling.	CO2, CO3, CO4, CO5	2
Unit-V: Safely audit of chemical process plants, HAZOP studies, RiskAssesment- fault tree and event tree analysis. Risk analysis of chemical processes, risk management, risk identification, personnel training, risk to environment.	CO2, CO3, CO4, CO5	2

4.	Text books

i. **Crowl, Daniel A. and Louvar, Joseph F.**, *Chemical Process Safety: Fundamentals with Applications*, 2nd Edition, Prentice Hall International Series.
ii. **Dekkar Marcel**, *Safety Management and Practices for Hazardous Units*, McGraw Hill Book Co., New York, 1995.
iii. **Greene, R.**, *Safe and Efficient Plant Operation and Maintenance*, McGraw Hill Book Co., New York.

5.	Reference Book(s) and Other Required Material

i. **Saxena,** *Safety and Good House Keeping*, 3rd Edition, National Productivity Council, New Delhi (1976).
ii. **Wells, G. L.,** *Safety in Process Plant Design*, George Godwin Ltd., (1980).

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Class Tests and Assignments: 20%

Mid-Semester Exam (1.5 Hours): 30%

End-Semester Exam (3 Hours): 50%

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	**2**	**2**	**1**	**–**	**–**	**3**	**2**	**–**	**–**	**–**	**1**	**2**	**3**	**1**
CO2	**3**	**2**	**–**	**1**	**–**	**2**	**–**	**–**	**–**	**–**	**1**	**3**	**2**	**–**
CO3	**2**	**2**	**3**	**1**	**2**	**3**	**–**	**–**	**–**	**–**	**1**	**3**	**2**	**1**
CO4	**3**	**3**	**–**	**2**	**2**	**–**	**–**	**–**	**–**	**–**	**2**	**2**	**3**	**–**
CO5	**2**	**3**	**2**	**2**	**2**	**3**	**1**	**–**	**–**	**1**	**2**	**3**	**2**	**2**

High – 3; Medium – 2; Low – 1; No Correlation – –.

8.	List of Indicative Laboratory Experiment (if applicable):

NIL.

Course Code & Course Title:	CML 393 & Innovative Design		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Engineering		
L – T – P	2-0-2	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

1. To contribute to the understanding of human creativity
2. To orient students outward, toward the rest of society and to create a broader outlook to face the challenges of the real world effectively
3. To augment engineering education by adding the design component in thinking and doing
4. To impart product and system building knowledge and skills
5. To tackle real life problem by cross-functional and multi-disciplinary team approach

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students will be able to identify and define a problem
CO2	Learn to frame the design challenge properly
CO3	Ideate and iterate solutions
CO4	Develop skills and attitudes such as experimentation, design thinking, teamwork, communication, societal context and business context
CO5	Learn to participate more fully in society

3.	**Detailed Description of the Course**		
	Topics	**CO(s) Addressed**	**Duration in weeks**
	Designing attitude in day-to-day life: Everybody design/innovate/ jugaad on almost daily basis, examples of everyday research, survey, observations, experimentation and problem solving What is the problem? How do people deal with it now? Key pain points? Understanding user context (social, family, community, ecological, cultural, institutional, technological, political-economic etc.,)What,	**CO 1** **CO 2**	3

Why, How, for whom and Novelty (comparison with existing solutions)		
Seeking solutions from existing designs, embedded thumb rules in people's practices, nature's patterns and strategies; constellation of technological, institutional, cultural and ecological endowments in which local practice is embedded	**CO 3**	2
Design thinking: Design thinking including socio-ecological design/empathetic design, traditional wisdom based/ ancient wisdom based	**CO 4**	4
Paper design of the proposed solution Review of the design by functional experts from Technical, Design, Social Sciences, Finance and Fabrication disciplines to give feedback to each team on their shortlisted ideas	**CO 5**	3

4.	**Text books**

i) Santiago Ramón Caja, Advice to Young Investigator, The MIT Press, Edition 1st

ii) Sir Peter Medawar, .Advice to Young Scientist, Alfred P. Sloan Foundation Series, Edition 1st

iii) Ulrich, Karl T. and Steven D. Eppinger, Product Design and Development, 5th edition , Irwin/McGraw-Hill, 2012

5.	**Reference Book(s) and Other Required Material**

Note: *Kindly arrange the textbooks/references in* ***alphabetical order.***

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

- **Mid semester = 30**
- **Quiz/ Class test = 10**
- **Project = 20**
- **Final exam = 40**

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1.	3	3	3	3		3	2		3				3	3	3	3
CO2.	3	3	3	3		3	2		3		2	1	3	3	3	3
CO3.	3	3	3	3		3							3	3	3	3
CO4.	3	3	3	3	2	3	3	3	3				3	3	3	3
CO5.	3	3	3	3		1	3	3	3	2	3	1	3	3	3	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-364 (Green Chemistry and Engineering)		
Course Type:	Core / Elective		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1	**Course Objective:**
1	Understand environmental issues, laws, and green chemistry principles for safer chemical processes.
2	Evaluate and improve environmental performance of chemical processes using green engineering and sustainable practices.

2	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Understand environmental issues, regulations, and green chemistry principles.
CO2	Evaluate environmental performance and design safer chemical processes.
CO3	Apply green engineering principles to reduce pollution and improve sustainability.

3.	**tailed Description of the Course**		
	Topics	**CO(s) Addressed**	**uration in weeks**
	Introduction to environmental issues: Air, Water, Land, Biodiversity, Solid waste, Air quality issues – NOx, HCs and VOCs. Ground level ozone, Pb, particulates, SOx, NOx and acid deposition; Water Quality issues Ecology; Waste flows – sources, trends, preventive environmental management (PEM). Global environmental and energy issues, Global warming, Ozone depletion.	CO1	2
	Environmental Laws and Regulations: Indian rules and regulations; Indian scenario vis-à-vis global scenario; paradigm shift from end-of-pipe to front-end pollution prevention and waste minimization.	CO1	1
	Green Chemistry: Green Chemistry principles and methodologies – alternative feedstocks, green solvents, synthesis pathways, inherently safer chemistry; Environmental ethics; roles and responsibilities of chemical engineers; Industrial ecology.	CO1	2
	Evaluation and Improvement of Environmental Performance of Chemical Processes: Evaluation of environmental fate, estimation of ecosystem risks,	CO2	2

classification of environmental risks. Evaluation of exposures – workplace characterization, exposure pathways, monitoring worker exposure; Designing safer chemicals; Design for Environment (DFE), Life cycle assessment.		
Evaluation of environmental performance during process synthesis: Environmental performance tools – Economic criteria, environmental criteria, Threshold limit values (TLVs), permissible exposure limits (PELs), and Recommended exposure limits (RELs), Toxicity weighting; evaluating alternative synthetic pathways; Environmental release assessment. Release quantification methods and modeled release assessments; Integration with HAZOP analysis.	CO2	2
Green Engineering: Principles of green engineering, pollution prevention for chemical reactors, storage tanks, fugitive emissions; Assessment of environmental performance; Concepts of sustainability and sustainable processes.	CO3	2
Flowsheet Analysis for Pollution Prevention: Process and energy integration; optimizing strategies for segregation, mixing, and recycling of streams; Evaluation of environmental performance of a flow sheet – Fugacity capacity, intermedia transport, reaction loss processes, Metrics for environmental risk evaluation of process design with respect to environment.	CO3	3

4.	Text books

1. V.K. Ahluwalia, M. Kidwai, *New Trends in Green Chemistry*, Anamaya Publishers, New Delhi. ISBN: 9788170171927
2. P.T. Anastas, T.C. Williamson, *Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes*, Oxford University Press, 1998. ISBN: 9780195102296

5.	Reference Book(s) and Other Required Material

1. David T. Allen, David R. Shonnard, *Green Engineering: Environmentally Conscious Design of Chemical Processes*, Prentice Hall PTR, 2002. ISBN: 9780131422120
2. Mike Lancaster, *Green Chemistry: An Introductory Text*, Royal Society of Chemistry, 2002. ISBN: 9780854043621

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	3	2	2	3	2	-	-	-	-	2	3	3	2	2
CO2	3	3	2	2	3	2	-	-	-	-	2	3	3	2	2
CO3	3	3	2	2	3	2	-	-	-	-	2	3	3	2	2

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML303 & **Process Control and Instrumentation**		
Course Type:	**DC**		
Name of the programme(s):	B.Tech. **Chemical Engineering**		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**None**		
Course Equivalence: Course Code(s) & Name(s)	**None**		

1.	**Course Objective:**

The core subject "Process Control and Instrumentation" provides introduction to process control and in-depth discussion on process modelling. The methods of analysis used in the control area are so different from the previous experiences of students that the materials come to be regarded as a sequence of special mathematics techniques, rather than the integrated design approach to a class of real and practically significant industrial problems.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Students shall be able to formulate the dynamic model of different chemical processes.
CO2	Students shall be able to identify the different measuring instruments and their working principle.
CO3	Student shall be able to apply analytical tools and design methodologies to tackle process control problems.
CO4	Student shall be able to apply control schemes along with tuning techniques in chemical processes.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Importance, aims and objectives of process control, introduction to system dynamics, concept of dynamic response, first order, second order interacting and non-interacting systems, concepts of transfer function, time constant, process gain, overshoot, decay ratio, dead time.	CO1	4 weeks
Introduction to set point, disturbance, closed loop and open loop control. Feedback and feed forward configurations, dynamics of feedback control system. Introduction to set point, error, accuracy, sensitivity. Types of controllers, P, PI and PID controllers, controller gain, stability analysis, Routh stability criteria. Bode and Nyquist stability criteria. discontinuous control modes – two position, classical and modern control actions.	CO3, CO4	5 weeks

Process instruments used for measurement of pressure, temperature, liquid level, flow rate and compositions, pressure gauge, strain gauge, McLeod gauge, vacuum measurement, transducers, transmitters, digital signal processing.	CO2	1 week
Design of controllers using open loop response, Zigeler – Nichols controller settings. Control valve and choice of controller settings. Basic design of pneumatic controllers, electric / electronic controllers. Application of control systems to chemical process equipment such as chemical reactors, heat exchangers, distillation columns, boilers etc.	CO3, CO4	3 weeks

4.	Text books

i) Donald R. Coughanowr and L.B. Koppel, Process Systems Analysis and Control, 1st Edition, McGraw-Hill Book Company, 1965, ISBN 0-07-013210-0.

ii) George Stephanopoulos, Chemical Process Control: An Introduction to Theory and Practice, Prentice-Hall, New Jersey, 1984, ISBN 0131288480.

iii) R.P. Vyas, An Introduction to Process Dynamics & Control, Central Publication, Nagpur, 2001.

5.	Reference Book(s) and Other Required Material

i) Thomas E. Marlin, Process Control, McGraw-Hill, 1995, ISBN 0070393620.

ii) W.L. Luyben, Process Modelling Simulation and Control for Chemical Engineers, 2nd Edition, McGraw-Hill, 1990, ISBN 0070393093.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Mid Semester Exam : 20-30 Marks

Teacher Defined Assessment : 20 Marks

End Semester Exam : 50-60 Marks

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

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

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Nil

Course Code & Course Title:	CML-439 (Energy Management)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	Students will be able to develop the correlation between energy input and output, energy requirement for proper management of energy intensive operations..

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To study the methodology and measurement for energy audit.
CO2	To study the economics involved in energy audit.
CO3	To determine the performance of different energy intensive systems.
CO4	To study the energy efficiency of electrical systems and lighting.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addresse d**	**ıration in weeks**
Energy Auditing: Methodology, analysis of past data, measurements of various parameters, portable and online instruments.		CO1	3
Energy Economics: Payback period, Rate of Return (RoR), and life cycle costing analysis for energy projects.		CO2	3
Steam Systems: Boiler-efficiency testing, excess air control, Steam distribution and use, steam traps, condensate recovery, and flash steam utilization.		CO3	4
Electrical & Utility Systems: Demand control, power factor correction, load scheduling. Motor drives: efficiency testing, energy efficient motors, and speed control.		CO4	2
Conservation & Recovery: Lighting systems; Conservation in Pumps and Fans (flow control); Compressed Air Systems;		CO4	2

Refrigeration/AC systems; Waste heat recovery and heat pipes.		

4.	Text books

6. Dryden I.G.C, The Efficient Use of Energy, 2nd Edition, Butterworth-Heinemann, London, 1982, ISBN: 9780408012508.

5.	Reference Book(s) and Other Required Material

- Murphy W.R. and McKay G.A, *Energy Management*, 1st Edition, Butterworth-Heinemann Ltd., 2001, ISBN: 9780750650991.
- Turner W.C, *Energy Management Handbook*, 2nd Edition, Fairmont Press, 1993, ISBN: 9780881731460.
- Callaghan O' Paul, *Energy Management*, 1st Edition, McGraw Hill, 1981, ISBN: 9780070096677.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	2	–	–	–	1	2	-	–	1	–	1	–	1	2
CO2	3	1	2	–	1	3	1	1	1	3	–	2	1	3	1
CO3	–	3	2	–	2	1	3	1	2	1	–	–	2	1	3
CO4	–	–	1	3	1	1	–	–	–	–	3	1	2	1	–

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML-442 (Reliability Engineering)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	Students will be able to understand and apply the various reliability engineering to suitable applications.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the basics of reliability Engineering and its models.
CO2	To understand time dependent failure models and State dependent systems.
CO3	To understand physical reliability models and Maintainability.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Introduction to Probability: Review of sets, events, definitions, finite sample spaces, conditional probability, partitions theorem, total probability theorem, and Bayes' theorem.		CO1	2
Reliability Engineering Introduction: Concepts, terms, definitions, applications, and history. Failure distribution: Reliability function, MTF, HRF, bathtub curve, and conditional reliability.		CO1	2
Constant Failure Rate Model: Exponential function, failure modes, applications, two-parameter exponential distribution, and Poisson process.		CO1	2
Time Dependent Failure Models: Weibull distribution, normal distribution, and lognormal distribution. Reliability of systems: serial/parallel configurations, SSF, minimal cuts/paths, and common-mode failures.		CO2	3

State Dependent Systems: Markov analysis, load sharing systems, standby systems, degraded systems, and three state devices.	CO2	2
Physical Reliability Models: Covariate, static, and dynamic models; physics of failure models. Design for reliability: specification, reliability allocation, and fault tree analysis.	CO3	2
Maintainability & Availability: Analysis of downtime, repair time distribution, preventive maintenance, and system availability. Data collection and empirical methods.	CO3	1

4.	**Text books**

1. Hines W. W., Montgomery D. C., Goldsman D. M., and Borror C. M., *Probability and Statistics in Engineering*, 4th Edition, John Wiley and Sons (Asia) Pte Ltd., 2003, ISBN: 9780471240877.

5.	**Reference Book(s) and Other Required Material**

1. Ebeling C. E., An Introduction to Reliability and Maintainability Engineering, 1st Edition, Tata McGraw-Hill, 2000, ISBN: 9780070421387.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

COs	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	1	-	-	1	-	–	1	2	-	–	1	1	–	1	2
CO2	2	1	1	1	-	1	3	2	1	1	3	2	1	3	1
CO3	1	1	-	1	-	2	1	3	1	2	1	–	2	1	3

High - 3; Medium – 2; Low – 1;

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-385 (New and Renewable Energy Engineering)
Course Type:	**DE**
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)
L – T – P	3-0-0 **No. of Credits** **03**
Pre-requisites: Course Code(s) & Name(s)	Thermodynamics, Heat Transfer-I
Course Equivalence: Course Code(s) & Name(s)	**Nil**

1.	**Course Objective:**
1	To understand concept of various forms of renewable energy.
2	To outline division aspects and utilization of renewable energy sources for both domestics and industrial applications.
3	To analyze the environmental and cost economics of using renewable energy sources compared to fossil fuels.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	At the end of the course the student will have knowledge about various renewable energy sources.
CO2	Students will be able to choose the appropriate renewable energy as an alternate for conventional power in any application.
CO3	Students will be able to evaluate the techno-economic feasibility, environmental impact, and sustainability of renewable energy systems for diverse industrial and societal applications.

3. **Detailed Description of the Course**		
Topics	**CO(s) Addressed**	**Duration in weeks**
Introduction to energy scenario – conventional vs. renewable sources	CO1	1
Solar energy fundamentals – solar radiation, photovoltaic & thermal systems	CO1	2
Wind energy – principles, turbines, site selection	CO1	1
Biomass energy – conversion technologies, biogas, biofuels	CO1	1
Hydropower, geothermal, tidal and emerging sources	CO1	1

Selection of renewable energy systems for specific applications	CO2	2
Response Surface Methodology (RSM) and optimization of renewable systems	CO2	2
Orthogonal arrays, parameter design, and multivariate analysis of renewable energy data	CO2	2
Nested and confounded experimental schemes – handling constraints & nuisance variables	CO3	1
Techno-economic feasibility, environmental impact, and sustainability evaluation	CO3	1

4.	Text books

- G. D. Rai, *Solar Energy Utilization*, 1st Edition, Khanna Publishers, Delhi.
- G. D. Rai, *Non-Conventional Energy Sources*, 1st Edition, Khanna Publishers, Delhi.
- J. Twiddle and T. Weir, *Renewable Energy Resources*, 1st Edition, Cambridge University Press, 1986, ISBN: 9780419144700.

5.	Reference Book(s) and Other Required Material

1. N. Veziroglu, Alternative Energy Sources (Volume 5 & 6), 1st Edition, McGraw-Hill, 1978, ISBN: 9780891161295.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	3	3	-	3	3	3	3	-	1	1	1	-	3	1
CO2	1	1	1	-	1	-	-	1	-	1	1	-	-	1	1
CO3	3	2	3	-	3	2	3	3	3	2	3	3	3	2	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	**CML431 Entrepreneurship Development**		
Course Type:	DE		
Name of the program(s):	B.Tech. Chemical Engg.		
L – T – P	3-0-0	**No. of Credits**	3
Pre-requisites: Course Code(s) & Name(s)	None		
Course Equivalence: Course Code(s) & Name(s)	None		

1	**Course Objective:**

Course Objective 1. Explore the characteristics of successful entrepreneurs, the entrepreneurial mindset, and the impact of entrepreneurship on the economy and society.

Course Objective 2. Learn how to identify business opportunities, develop innovative ideas, and assess their potential in the market.

Course Objective 3. Learn how to develop marketing strategies, create branding, and understand customer behaviour to attract and retain clients.

2	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the role of an entrepreneur.
CO2	To understand the factors influencing an entrepreneur.
CO3	To understand the steps involved in setting up a business.
CO4	To understand the financial aspects of a business.

3	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Traits of Entrepreneurs - Types of Entrepreneurs – Intrapreneur, Difference between Entrepreneur and Intrapreneur - Entrepreneurship in Economic Growth, Factors affecting Entrepreneurical Growth.		CO1	2
Major motives influencing Entrepreneur- Achivement Motivation Training, Self Rating, Business game, Thematic Apperception Test - Stress Management. Entrepreneurship Development Programs - Need, objectives		CO2	1
To understand the steps involved in setting up a business. Small Enterprises-definition, Classification - Characteristics, ownership structure Project Formulation – Steps involved in setting up a Business - Identifying, Selecting a good business opportunity Market survey and Research, Techno economic Feasibility Assessment- Preliminary Project Report-Project Appraisal-Sources of information-Classification of needs and		CO3	5

Agencies		
Marketing: Functions and strategies, Product protection: Patents , Trademarks and Copyrights.	CO3	2
Need-Sources of Finance, Term Loans, Capital structure, Financial Institutions, Management of working capital,Costing Break Even Analysis, Network analysis Techniques of PERT/CPM - Taxation - Income Tax, Excise Duty - Sales Tax	CO4	2

4	**Text books**

i) Dr Sharma D. D., Total Quality Management, Sultan Chand and Sons, New 2017
ii) Gupta C. B. and Srinivasan P., Entrepreneurship Development, Sultan Chand and Sons, New Delhi
iii) Khanna S.S, Entrepreneurial Development, S.Chand & Co. Ltd NewDelhi, 1999.
iv) Philip Kotler, Marketing Management, Prentice Hall of India, New Delhi.
v) Rathore B.S. and Dr. Saini J. S, A Handbook of Entreprenuership, Aapga Publications, Panchkula (Haryana).

5	**Reference Book(s) and Other Required Material**

6	**Evaluation Details:**

i) Assignment – 20%
ii) Mid Sem Evaluation – 30%
iii) End Sem Evaluation -50%

7	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	-	-	-	-	-	2	3	3	3	3	1	-	-	-	-
CO2	-	-	-	-	-	3	3	2	1	3	1	-	-	-	-
CO3	-	-	-	-	-	3	3	2	1	3	1	-	-	-	-
CO4	-	-	-	-	-	2	2	-	-	3	-	-	-	-	-

High - 3; Medium – 2; Low – 1;

8	**List of Indicative Laboratory Experiment (if applicable):**

Not Applicable

Course Code & Course Title:	CML-433 (Project Planning and Management)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	To develop the ability to apply project management fundamentals for planning, scheduling, analyzing, and controlling projects through tools such as CPM, PERT, project crashing, MS Project, earned value management, and risk, communication, and stakeholder management plans.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Formulate a project charter based on project management fundamental
CO2	To undertake critical path and PERT analysis for a given project
CO3	To perform project crashing for a given project information
CO4	Develop a project management plan in MS project
CO5	Analyze the progress of the project using earned value management concept
CO6	Formulate risk management, communication management, stakeholder management plans

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
The World of Project Management: Project Management, Project Management vs General Management, Life cycles of projects, Project selection methods, Case studies, Examples		CO1	2 weeks
The Manager, The Organization and The Team: PM’s role, PM’s responsibilities to the project, Selection of project manager, Project management as a Profession, Fitting projects into the parent organization, Project team, Case studies		CO2	2 weeks
Planning the Project: The contents of a project plan, Planning process,		CO3	2 weeks

Work breakdown structure, Multidisciplinary teams, Case studies		
Budgeting the Project: Methods of budgeting, Cost estimating, Improving cost estimates, Budget uncertainty and risk management, Case studies	CO4	2 weeks
Scheduling the Project: PERT and CPM networks, Project uncertainty and risk management, Simulation, Gantt chart, Extensions to PERT and CPM, Case studies	CO5	3 weeks
Allocating Resources to the Project: Expediting a project, Resource loading, Resource leveling, allocating scarce resources to project	CO6	3 weeks

4.	Text books

1. C. F. Gray, E. W. Larson, G. V. Desai, *Project Management: The Managerial Process*, McGraw Hill Education (India) Private Limited.

5.	Reference Book(s) and Other Required Material

2. Project Management Institute, *A Guide to the Project Management Body of Knowledge (PMBOK)*, Fifth Edition.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	2	1	–	1	2	3	–	–	–	1	3	1	–	1	2
CO2	–	2	1	3	–	–	–	3	–	3	–	2	1	3	1
CO3	–	1	2	1	–	–	–	3	–	–	–	–	2	1	3
CO4	2	1	–	1	1	1	–	3	–	–	1	–	–	1	2
CO5	–	2	1	3	–	–	–	3	–	3	–	2	1	3	1
CO6	2	1	2	1	2	3	–	–	–	1	3	1	2	1	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML-526 (Total Quality Management)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	To train students on studies in TQM, SWOT analysis, failure rate analysis, TQM road map.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Explain the fundamentals of quality, vision and mission statements, and the evolution and models of Total Quality Management.
CO2	Apply strategic tools such as SWOT analysis, QFD, benchmarking, Six Sigma, and failure mode and effect analysis to enhance customer focus and continuous improvement.
CO3	Evaluate system reliability and maintainability using concepts like failure rate analysis, MTTF, MTBF, hazard models, and quality assurance practices including 5S and quality circles.
CO4	Analyze quality costs and implement the TQM roadmap, including ISO certifications, quality auditing, and quality awards, to achieve organizational excellence.

3. **tailed Description of the Course**		
Topics	**CO(s) Addressed**	**uration in weeks**
Definition of quality – customers – vision, mission, objectives, goals – evolution & models of TQM	CO1	2
Stages in TQM implementation – defining TQM	CO1	1
SWOT analysis – strategic planning – customer focus – QFD – customer satisfaction measurement	CO2	2
Seven new management tools – Deming wheel – zero defect – benchmarking – Six Sigma	CO2	2
FMEA – Poke Yoke – Five S – quality circles	CO2, CO3	2
Failure rate analysis – MTTF – MTBF – hazard models – system reliability – availability – maintenance	CO3	2
Quality and cost – characteristics – micro analysis – measurement of quality	CO4	1
TQM roadmap – ISO 9000/9001/14000 certifications – QS 9000 auditing – quality auditing – quality awards	CO4	2

4.	Text books

1. L. Suganthi, Anand A. Samuel, *Total Quality Management*, PHI.
2. Lt. Gen. Lal H., *Total Quality Management*, Wiley Eastern Limited.

5.	Reference Book(s) and Other Required Material

1. Greg Bounds, *Beyond Total Quality Management*, McGraw Hill Publishers.
2. H. G. Menon, *TQM in New Product Manufacturing*, McGraw Hill Publishers.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PSO 1**	**PSO 2**	**PSO 3**	**PSO 4**
CO 1	3	3	3	-	3	3	3	3	1	1	1	1	-	3	1
CO 2	1	1	1	-	1	1	1	1	1	1	1	1	1	1	1
CO 3	3	2	3	-	3	2	3	3	3	2	3	3	3	2	3
CO 4	3	-	-	-	-	3	3	-	2	-	-	3	2	2	-

High - *3; Medium – 2; Low – 1;*

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML530 Process Intensification		
Course Type:	**DE**		
Name of the programme(s):	BTech Chemical Engineering		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	Course Objective:
	Based on the concepts taught, student shall be able to apply the concepts and philosophy of process intensification to resolve the various issues in process industry such as cost, waste minimization, size etc.

2.	Course Outcomes (Min. 3 & Max. 5):
CO1	Understand & apply the basic knowledge of philosophy and concepts of process intensification
CO2	Analyze and utilize the knowledge of **various methods of process intensification** for specific applications.
CO3	Analyze and utilize the knowledge of **Various equipment of process intensification for** specific applications.
CO4	Analyze and utilize the knowledge of **application of process intensification.**

3. Detailed Description of the Course		
Topics	**CO(s) Addressed**	**Duration in weeks**
Introduction to Process Intensification: History, definitions, and the philosophy	CO1	2
Methods of Process Intensification (Multifunctional reactors, alternative energy sources, hybrid separations)	CO2, CO3	4
Equipment used for Process Intensification (Reactors, Equipment for non-reactive operations)	CO2, CO3	4
Industrial Applications and Case Studies	CO1, CO2, CO3, CO4	4

4.	**Text books**

iv) Stankiewicz, Andrzej and Moulijn, Jacob A., Re-engineering the Chemical Processing Plant: Process Intensification, 1st Edition, Marcel Dekker, Inc., 2004, ISBN 0-8247-4302-4.

5.	**Reference Book(s) and Other Required Material**

i) De Weerd, Cornelis, Process Intensification in Practice, 1st Edition, John Wiley & Sons, 2005, ISBN 978-0-470-02500-0.

6.	**Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]**

Assignment: 25 %

Mid Sem Exam: 25 %

End Sem Exam: 50 %

7.	**Relationship of Course Outcomes to Program Outcomes:**

Mapping with POs (Departmental Reference)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PSO1**	**PSO2**	**PSO3**	**PSO4**
CO1	3	2	1	–	2	2	1	–	1	1	2	3	3	1	2
CO2	2	3	2	2	3	2	–	1	2	2	2	2	3	1	2
CO3	2	3	3	2	3	2	–	1	2	2	2	2	3	1	2
CO4	2	3	3	2	3	3	1	2	2	2	2	2	3	2	3
Avg	3	3	3	2	3	3	1	4	2	2	2	3	3	2	3

High **-** *3; Medium – 2; Low – 1;*

8.	**List of Indicative Laboratory Experiment (if applicable):**

Course Code & Course Title:	CML-532 (Energy Technology and Conservation)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology BIOPROCESS TECHNOLOGY		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	To train students on advances in various energy technologies, recent developments in the fields and future challenges

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	Student should be able to understand the principles behind different conventional and non conventional energy sources
CO2	Student will get acquainted with idea of the challenges in the field of energy management and will able to provide a perspective on energy technology.
CO3	Students will learn the systems scope of the energy troubles and its chronological perspective on energy technology and system progress.

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Furnaces and furnace streams, material and energy balance, consumption and heat transfer efficiency, furnace design, oxidation of sulfur and sulfur compounds		CO1	2 weeks
Alternate sources of energy, energy auditing, case studies, principle of renewable energy, technical and social implications		CO2	2 weeks
Solar radiation, measurement and estimation, solar heating devices, solar water heaters, sheltered and unsheltered heaters, systems with separate storage, selective surfaces, solar ponds, solar concentrators and other devices		CO2	2 weeks
Bio fuels: classification, combustion and pyrolysis, production of alcohol and bio gas, bio diesel fundamentals, transesterification of vegetable oils for bio diesel production, characterization of bio diesel,		CO3	3 weeks

economics, current trends, future prospects		
Hydrogen energy: system and analysis, hydrogen infrastructure, safety, codes and standards, hydrogen production – electrolysis, thermochemical, hydrogen from fossil fuels, hydrogen storage, carbon storage materials	CO3	2 weeks
Biomass as a renewable source of energy, metal and chemical hydrides, cryogenic hydrogen storage, hydrogen fuel cells, recent developments and future challenges, concept of exergy	CO3	1 week

4.	Text books

1. Francis W., Peter M. C., *Fuels and Fuel Technology*, Pergamon Press.
2. S. N. Saha, *Fuel Combustion Energy Technology*, Dhanpat Rai Publishing Company, New Delhi.

5.	Reference Book(s) and Other Required Material

1. 1. S. B. Pandya, *Conventional Energy Technology*, Tata McGraw Hill.
2. M. Sittig, *Practical Techniques of Saving Energy in Chemical Industries*, Noyes Data Corporation, USA.
3. J. S. S. Brame, J. G. King, *Fuel, Solid, Liquid and Gases*, Edward Arnold Publishers.
4. S. P. Sukhatme, *Solar Energy*.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	3	–	–	–	–	2	1	–	–	–	–	3	–	–	–
CO2	3	3	3	–	–	–	–	3	–	–	–	3	3	3	3
CO3	3	2	–	–	–	–	–	3	–	–	–	3	2	–	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):

Course Code & Course Title:	CML-534 (Reliability Analysis in Process Industry)		
Course Type:	**DE**		
Name of the programme(s):	B.Tech. Chemical Technology (Bioprocess Technology)		
L – T – P	3-0-0	**No. of Credits**	**03**
Pre-requisites: Course Code(s) & Name(s)	**Nil**		
Course Equivalence: Course Code(s) & Name(s)	**Nil**		

1.	**Course Objective:**
	To develop the ability to apply reliability engineering principles, failure models, and maintainability concepts for enhancing system performance in process industries.

2.	**Course Outcomes (Min. 3 & Max. 5):**
CO1	To understand the basics of reliability Engineering and its models
CO2	To understand time dependent failure models are explained and State dependent systems
CO3	To understand physical reliability models and Maintainability

3.	**Detailed Description of the Course**		
Topics		**CO(s) Addressed**	**Duration in weeks**
Introduction to probability: review of sets, events, definitions, finite sample spaces and enumeration, conditional probability, partitions theorem, total probability theorem, Bayes' theorem		CO1	2 weeks
Reliability Engineering Introduction: concept, terms, definitions, applications, history		CO1	2 weeks
Failure distribution: reliability function, MTF, HRF, bathtub curve, conditional reliability, constant failure rate model, exponential function, failure modes, applications, two-parameter exponential distribution, Poisson process		CO1	3 weeks
Time dependent failure models: Weibull distribution, normal distribution, lognormal distribution; reliability of systems – serial and parallel configuration, SSF, minimal cuts, minimal paths, common-mode failures, three state devices		CO2	3 weeks

State dependent systems: Markov analysis, load sharing systems, standby systems, degraded systems, three state devices	CO2	2 weeks
Physical reliability models: covariate, static, dynamic models, physics of failure models; design for reliability – specification and system measurements, reliability allocation, design methods, failure analysis, system safety and fault tree analysis	CO3	1 week
Maintainability: analysis of downtime, repair time distribution, stochastic point processes, system repair time, reliability under preventive maintenance; availability – concepts and definitions, models, system availability, design analysis; data collection and empirical methods identifying failure and repair distribution	CO3	1 week

4.	Text books

1. W. W. Hines, D. C. Montgomery, D. M. Goldsman, C. M. Borror, *Probability and Statistics in Engineering*, John Wiley and Sons (Asia) Pte Ltd., Singapore.

5.	Reference Book(s) and Other Required Material

2. C. E. Ebeling, *Introduction to Reliability and Maintainability Engineering*, Tata McGraw Hill, New York.

6.	Evaluation Details: [Refer Table No. 5 of Academic Ordinances, Rules and Regulations]

Assignment: 20 %

Mid Sem Exam: 30 %

End Sem Exam: 50 %

7.	Relationship of Course Outcomes to Program Outcomes:

Mapping with POs (Departmental Reference)

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1	1	–	2	–	–	2	–	–	–	–	–	1	–	1	2
CO2	3	2	1	–	–	3	–	–	–	–	–	2	1	3	1
CO3	2	1	3	–	–	2	–	–	–	–	–	1	2	1	3

High - 3; Medium – 2; Low – 1;

8.	List of Indicative Laboratory Experiment (if applicable):