MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

DEPARTMENT OF CHEMICAL ENGINEERING

PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

B.Tech –Chemical Engineering | Academic Year: 2018-19

PROGRAM OUTCOMES

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

[PO.2].Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3].Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4].Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5].Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6].The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7].Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8].Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9].Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

Program Articulation Matrix

	Subject Code	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
SEM I	PY1101	3	3	3	3	3	2	3	3	3	3	3				
	MA1101	3	3	3	2	1		1			3		1			
	ES1101	3	3	1	2	3	3	3	3	3		1	3			
	EC1101	3	3	3	2	2	1	1					2			
	ES1102	3	3	3	3	3	2	2	1	2	3	1	1			
	CY1101	2	1	1	1	1	1	1	1		1		1			
SEM II	MA1201	3	3	3	2	1		1			1		1			
	EE1101	3	2	1			1	1					3			
	CS1101	3	3	3		1		1	1	1	2	2	2			
	ES1103	3	3	3	2		2	2								
	HS1102	2	2	2		2	2						3			
	EN1111	2	3	1				2	1	3	3	2	3			
SEM III	BB1101						1	3	2	1	2	1	2			3
	MA1310	2	3	2	1	1	1	1		2	1	2	1			
	CY 1321	3	2	2	2	3	2	2	1	2	1	2	2		1	1
	CE1305	3	2	2	2	1	2	1	1	1			3	3	2	1
	CE1306	3	3	2	1		1	3	1	2	1	2	2	2	1	2
	CE1307	3	3	3	2		3		3	2	3	2	3	3	2	2
	CE1304	2	3	2	1	2	1	2	1	1	2	1	2	1	2	1
SEM IV	CE1405	3	3			3		2		2		2		3	2	
	CE1406	3	3	2	1	1	3	1	1	3	2	2	1	3	3	2
	CE1407	3	3	1	1		2	2				2	3	3	1	
	CE1408	3	3	1		2	2	3	1	2	2	3	1	3	3	3
	CY1421	2	2	2		3		3	2		3		3	3	1	3
SEM V	CE1505	3	3		1	2	2	3		3	2		1	3	2	1

	CE1506	3	2	3	2	1	2	1	1	1		1	2	3	1	2
	CE1507	2	3	1	2	1	2	2		2	2	1	2	2	3	1
	CE1553	2	2	1	1	2	1	2	1					2	1	3
	CE1554		3	1	1	3	2	3	1	1	1		1			3
SEM VI	CE1604	1		2	3			2						2	1	1
	CE1605	3	3	1		2		2		2	2	1	1	3		2
	CE1606	3	3					1	2	3	2				1	
	CE1653	2	2		1		2	2	2	3		2		2		3
	CE1654	3	3	2	3	2	3	3	3	2		3	1	3	2	3
	PS1601	1	2	2			3		1			1	3			
SEM VII	CE1705	3	3	3	2	2	3	3		2	2	2	2	3	3	3
	CE1706	3	3	1		3		2	3	2	1	3		3	3	2
	CE1707	3	3	3		3	1	1		2	1		1	3	2	
	CE1708		2	1	1				2	1	2	3		1	2	
	CE1753	2	1	2	1		3	2	1				1	1	1	2
	CE1754	3	3	3	3		2	3	1	1	2	2	2	3	3	3
SEM VIII	CE1803	3	2			2			1	2		1	1	1	3	1
	CE1804	3	3	1		3	1	1		2	1	1	1	2	1	2
TOTAL		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

MANIPAL UNIVERSITY JAIPUR
School of Basic Sciences

Department of Physics
Course Hand-out

Engineering Physics | PY 1101 | 5 Credits | 3 1 1 5

Session: Jul- Nov, 2018| Faculty: Dr. Saikat | Class: B.Tech. I Sem.

A. Introduction: The mission of the Engineering Physics course is to prepare students for careers in engineering where physics principles can be applied to the advancement of technology. The course work will develop sufficient depth in physics skills to produce engineers who can relate fundamental physics to practical engineering problems, and will possess the versatility to address new problems in our rapidly changing technological base. The present course is meant to provide a more thorough grounding in applied physics for a selected specialty such as optics, quantum physics, atomic & molecular physics and solid-state physics. The discipline is also meant for cross-functionality and bridges the gap between theoretical science and practical engineering. It is notable the term “engineering physics" is also called as "technical physics" in several universities and colleges.

B. Course Objectives: At the end of the course, students will be able to

[1101.1] understand the wide range of diversity in science and technology with the help of knowledge of basic Physics along with practical approach of Engineering Physics.
[1101.2] explain various processes involved in understanding the nature of light.
[1101.3] identify the problems and applications of Quantum mechanics.
[1101.4] impart the knowledge of empirical laws based on Solid state Physics and Atomic and Molecular Physics.
[1101.5] achieve perfectness in experimental skills and the study of practical applications in Physics.
[1101.6] develop skills to impart practical knowledge in real time solution.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

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

[PO.2] Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3] Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4] Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5] Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6] The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7] Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

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[PO.9] Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10] Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11] Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12] Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Handwritten Note Book)	15
	Sessional Exam II (Open Handwritten Note Book)	15
	In class Quizzes (Accumulated and Averaged)	10
End Term Exam (Summative)	End Term Exam (Open Handwritten Note Book)	40
Lab Evaluation	Regular Lab Performance & viva-voce, laboratory end term exam	20
	Total	100
Attendance (Formative)	A minimum of 75% attendance separately for each component (Theory lectures and Practical) is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS

OPTICS: Two source interference, Double slit interference, Coherence, Intensity in Double slit interference, interference from thin films, Air-wedge, Newton`s rings, Michelson`s interferometer, Diffraction and wave theory of light, Single-slit diffraction, Intensity in single-slit diffraction (using Phasor Method), Diffraction at a circular aperture, Double-slit interference and diffraction combined-Intensity in double-slit diffraction (qualitative approach), Diffraction of light through multiples slits, Diffraction gratings, Dispersion and resolving power of gratings, Polarization of electromagnetic waves, Polarizing sheets, Polarization by reflection, Double refraction.

QUANTUM PHYSICS: Black body radiation and Planck`s hypothesis, Stefan`s Law, Wein`s displacement law, Photoelectric effect, Compton effect, Photons and electromagnetic waves, Wave properties of particles, de-Broglie hypothesis, Davisson-Germer Experiment, Quantum particle (wave packet, phase speed, ground speed), the uncertainty principle.

QUANTUM MECHANICS : An interpretation of quantum mechanics, Wave function and its significance, Schrodinger equation, particle in a box, Particle in a well of finite height (qualitative), Tunnelling through a potential barrier and its applications, The simple harmonic oscillator(qualitative).

ATOMIC PHYSICS & MOLECULAR PHYSICS : Atomic spectra of gases, Energy states and spectra of molecules(rotational and vibrational energy levels), X-rays-Types, Moseley law, Spontaneous and stimulated transitions, He-Ne and Ruby laser, Application of lasers.

SOLID STATE PHYSICS: Band theory of solids, Electrical conduction in metals, Insulators, and Semiconductors, Superconductivity- Type I and type II Super conductors, Meisner effect, BCS Theory (Introductory) and applications of Superconductivity.

E. TEXT BOOKS

1. Halliday, Resnick, Krane, PHYSICS, Volume 2, 5th edition, John Wiley & Sons, Inc, 2011 *(For Optics)*
2. Beiser & Mahajan, Modern Physics, Mc Graw Hill, 6th edition., 2009 *(For Quantum Physics, Quantum Mechanics, Atomic Physics, Solid State Physics)*

F. REFERENCE BOOKS

Serway & Jewett, PHYSICS for Scientists and Engineers with Modern Physics; Volume 2,6th edition,

G. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Discussion of Lecture Plan	To acquaint and clear teachers expectations and understand student expectations	Lecture	**1101.1**	NA
2	Introduction to OPTICS	To make the student understand the difference between physical and geometrical optics. Recall elementary idea of transverse and longitudinal waves. Develop mathematical representation of waves.	Flipped Classroom	**1101.1 & 1101.2**	In Class Quiz (Not Accounted)
3	Interference of light, Young's double slit interference, coherence	Understanding of the concept of coherent waves and interference	Lecture	**1101.2**	Class Quiz – I Home Assignment - I Mid Term I End Term
4	Intensity in double slit interference using Phasor method	Derivation of the formula for intensity distribution in double slit interference	Lecture	**1101.2**	Class Quiz – I Home Assignment -I Mid Term I End Term
5	Interference in thin film, antireflection coatings	Understand the concept of thin-film interference	Lecture	**1101.2**	Class Quiz – I Home Assignment - I Mid Term I End Term
6	TUTORIAL:1		Activity (Think Pair Share)	**1101.2**	
7	Interference in wedge shaped air film	Understand the concept of interference in wedge shaped films and introduction to Newton's ring	Lecture	**1101.2**	Class Quiz – I Home Assignment - I Mid Term I End Term

8	Newton's rings – theory and experiment	Describe the Newton's ring experiment and develop the theory of Newton's ring	Lecture	**1101.2**	Class Quiz – 1 Home Assignment-1 Mid Term I End Term
9	**TUTORIAL: 2**		Activity (Think Pair Share)	**1101.2**	
10-11	Michelson interferometer – construction & theory (Qualitative approach only), Applications of Michelson interferometer (determination of wavelength)	Description of Michelson interferometer and derivation of the formula for determination of wavelength using it.	Lecture	**1101.2**	Class Quiz – 1 Home Assignment -1 Mid Term I End Term
12	**TUTORIAL: 3**		Activity (Think Pair Share)	**1101.2**	
13-14	Diffraction and wave theory of light, Fraunhoffer diffraction at single slit – theory and intensity distribution	Introduction to diffraction and understand the difference between Fraunhoffer and Fresnel diffraction	Lecture, Activity	**1101.2**	Class Quiz – 2 Home Assignment- 2 Mid Term I End Term
15-16	Analysis by Phasor method, Intensity distribution curve, Diffraction at a circular aperture	Develop the theory and formula for single slit diffraction	Lecture	**1101.2**	Class Quiz – 2 Home Assignment - 2 Mid Term I End Term
17	**TUTORIAL:4**		Activity (Think Pair Share)	**1101.2**	
18	Fraunhoffer diffraction at double slit – theory (Qualitative approach only) and intensity distribution	Qualitatively develop the formula for intensity distribution in double slit diffraction	Lecture	**1101.2**	Class Quiz – 2 Home Assignment - 2 Mid Term I End Term
19	Fraunhoffer diffraction at multiple slit – theory and intensity distribution, Diffraction grating	Understand the multiple slit diffraction pattern and diffraction grating	Lecture	**1101.2**	Class Quiz – 3 Home Assignment- 2 Mid Term I End Term
20	**TUTORIAL:6**		Activity (Think Pair Share)	**1101.2**	
21	Rayleigh's criteria of resolution, Dispersion and resolving power of grating	Understand the Raleigh's criteria for resolution and derive the expression for dispersive and resolving power	Lecture	**1101.2**	Class Quiz – 3 Home Assignment-2 Mid Term I End Term
22	**TUTORIAL:7**		Activity (Think Pair Share)	**1101.2**	
23-24	Polarization of EM Waves, Polarizing sheets, Polarization by reflection, Double refraction, Malus law & Brewsters law	Understand the phenomena of polarisation and different approaches to polarise EM waves	Lecture	**1101.2**	Class Quiz – 3 Home Assignment - 3 Mid Term I End Term

25	**TUTORIALS: 8**		Activity (Think Pair Share)	**1101.2**	
26-27	Black body radiation , Wein's law, Stefan-Boltzmann law, Raleigh-Jeans Law, UV Catastrophe, Planck's hypothesis and Planck's law of black body radiation	Understand the laws of Black Body radiation and introduction to Planck's hypothesis	Flipped Class, Lecture	**1101.1 & 1101.3**	Class Quiz – 4 Home Assignment - 4 Mid Term II End Term
28-29	Photoelectric effect, Experimental observations of Photoelectric effect, Compton effect (Qualitative approach)	Describe the theory of Photoelectric effect and Compton effect	Lecture	**1101.1 & 1101.3**	Class Quiz – 4 Home Assignment - 4 Mid Term II End Term
30	**TUTORIAL:9**		Activity (Think Pair Share)	**1101.3**	
31	Photons and electromagnetic waves, de-Broglie hypothesis of matter wave, Davisson-Germer Experiment	Understand the concept of de-Broglie hypothesis and describe the Davission-Germer Experiment	Lecture	**1101.1 & 1101.3**	Class Quiz – 5 Home Assignment - 4 Mid Term II End Term
32-33	Quantum particle, Concept of wave packet. Group and phase velocity, Relation between V_g & V_p in dispersive medium, Uncertainty Principle (Statement and expression only) and its Physical significance	Understand the Group Velocity and Phase Velocity and the concept of Uncertainty Principle	Flipped Classroom, Lecture	**1101.3**	Class Quiz – 5 Home Assignment - 5 Mid Term II End Term
34	**TUTORIAL: 10**		Activity (Think Pair Share)	**1101.3**	
35	An Interpretation of Quantum mechanics, Wave function and its physical significance, SchrŐdinger wave equation	Introduction to wave function and Schrodinger wave equation	Lecture	**1101.3**	Class Quiz – 5 Home Assignment - 5 Mid Term II End Term
36	Particle in a box of infinite potential height	Derive the wave-function and energy of a particle confined in a one dimensional box	Lecture	**1101.3**	Class Quiz – 6 Home Assignment - 5 Mid Term II End Term
37	**TUTORIAL: 11**		Activity (Think Pair Share)	**1101.3**	
38-39	Particle in a well of finite height (qualitative), Tunnelling through a potential barrier (	Qualitatively describe the phenomena of particle in a finite well and the phenomena of tunnelling	Lecture	**1101.3**	Class Quiz – 6 Home Assignment -5 Mid Term II End Term

	qualitative) and its applications				
40	Quantum mechanical simple harmonic oscillator (Qualitative)	Qualitative discussion of the wave function and energy of a harmonic oscillator	Lecture	**1101.3**	Class Quiz – 6 Home Assignment - 5 Mid Term II End Term
41	**TUTORIAL: 12**		Activity (Think Pair Share)	**1101.3**	
42-43	Bohr's Theory, Atomic Spectra of gases, Continuous and characteristic X-rays, Duane – Hunt relation, Moseley's law	Recall Bohr's theory and atomic spectra. Understand the continuous and characteristic X-rays and derive the related formula.	Flipped Classroom, Lecture	**1101.1 & 1101.4**	Class Quiz (Not Accounted) Home Assignment - 6 End Term
44-45	Energy states and spectra of molecules (Rotational and Vibrational spectra)	Qualitative discussion of Rotational and Vibrational spectra and the related formulas	Lecture	**1101.4**	Class Quiz – 7 Home Assignment - 6 End Term
46	**TUTORIAL: 13**		Activity (Think Pair Share)	**1101.4**	
47	Lasers-Spontaneous and stimulated transitions, Population inversion and metastable state,	Understand the lasers and the related optical phenomena.	Lecture	**1101.4**	Class Quiz – 7 End Term
48-49	Construction and working of Ruby laser , Construction and working of He-Ne laser, Energy level diagram of He-Ne laser, Application of Laser	Description of Ruby laser and He-Ne laser and understand their working	Flipped Classroom, Lecture	**1101.4**	Class Quiz – 7 End Term
50	**TUTORIAL: 14**		Activity (Think Pair Share)	**1101.4**	
51	Band Theory of solids, Electrical conduction in Metals, Insulators, and Semiconductors	Understand qualitatively the band theory of solids	Lecture	**1101.4**	Class Quiz – 8 End Term
52-53	Superconductivity: Type-I and Type- II Superconductivity, Meisner effect	Introduction to super conductivity and superconductors and the related phenomena	Lecture	**1101.4**	Class Quiz – 8 End Term
54	**TUTORIAL: 15**		Activity (Think Pair Share)	**1101.4**	
55	BCS Theory (Introductory) and Applications of superconductivity	Qualitatively understand the BCS theory and their applications	Lecture	**1101.4**	Class Quiz – 8 End Term
56	**TUTORIAL: 16**		Activity (Think Pair Share)	**1101.4**	

LAB SESSIONS	Lab sessions based on different aspects of physics	Experiment and test different aspects of physics related to the theory taught in the class	Lab Sessions	**1101.5 & 1101.6**	Experimental results and viva-voce of 14 lab sessions Laboratory End Term Exam

H. Course Articulation Matrix: (Mapping of COs with POs and PSOs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
PY 1101.1	understand the wide range of diversity in science and technology with the help of knowledge of basic Physics along with practical approach of Engineering Physics	3	1		2		2		3								
PY 1101.2	explain various processes involved in understanding the nature of light		3	3		2		2					1				
PY 1101.3	identify the problems and applications of Quantum mechanics	3					1	1				3	2				
PY 1101.4	impart the knowledge of empirical laws based on Solid state Physics and Atomic and Molecular Physics	1			3	2				1			1				
PY 1101.5	achieve perfectness in experimental skills and the study of practical applications in Physics			2		3	2		2	3			3				
PY 1101.6	develop skills to impart practical knowledge in real time solution	2			2		1	3			3	1					
	Max correlation -->	**3**	**3**	**3**	**3**	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**				

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

Faculty of Engineering

B.Tech. First Year (All branches)

DEPARTMENT OF MATHEMATICS AND STATISTICS

Course Hand-out

Engineering Mathematics-I| MA1101 | 4 Credits | 3 1 0 4

Session: July – Dec., 2018 | Faculty: Dr. Mohd. Rizwanullah & Dr. Reema Jain | Class: B.Tech. First Year

A. Introduction: An engineering student needs to have some basic mathematical tools and techniques which emphasize the development of rigorous logical thinking and analytical skills. Based on this, the course aims at giving adequate exposure to the theory and applications. The course is aimed at developing the basic Mathematical skills of engineering students that are imperative for effective understanding of engineering subjects.

B. Course Objectives: At the end of the course, students will be able to

[MA1101.1] Solve the problem on Radius of curvature, Circle and chord of curvature, Asymptotes, curve tracing for Cartesian and polar curves.

[MA1101.2] Demonstrate the understanding of the derivatives of functions of several variables and it will enhance the problem solving skills.

[MA1101.3] Optimize the functions of several variables using Hessian method and Lagrangian method and further will improve the logical skills hence Employability.

[MA1101.4] Use matrices, determinants and techniques for solving systems of linear equations in the different areas of Linear Algebra

[MA1101.5] Solve Eigen value problems, Applications of integral calculus: area and length of curves and volume of solid of revolution of simple curves.

C. Program Outcomes and Program Specific Outcomes

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

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment ÷ Plan

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes	30
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Differential Calculus: Radius of curvature, Circle and chord of curvature, Asymptotes, curve tracing for Cartesian and polar curves. Taylor's theorem for a function of one variable. Taylor's and Maclaurin's expansion of functions. **Partial Differentiation**: Euler's theorem on homogeneous functions, total derivative, derivatives of composite and implicit functions, Taylor's theorem for a function of two variables, extreme values of a function of

two variables, Lagrange's method of undetermined multipliers, Errors and approximations. **Integral Calculus**: Reduction formulae. Applications of integral calculus: area and length of curves and volume of solid of revolution of simple curves. **Matrices**: Elementary transformations, Inverse and rank of a matrix by elementary transformation, consistency and solution of system of simultaneous equations, eigenvalues, eigenvectors, Caley-Hamilton theorem, diagonalization of a matrix

F. Text Books

T1. S. Pal & S. C. Bhunia, "Engineering Mathematics", Oxford University Press, 2015.
T2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, Delhi, 2006.
T3. B. V. Ramana, "Higher Engineering Mathematics", McGraw Hill, 2014.

G. Reference Books

R1. E. Kreyszig, "Advanced Engineering Mathematics", Wiley India Edition, 2006.

R2. B. Ram, "Engineering Mathematics", Vol. I & II, Pearson, 2012.

R3. S. Narayan, "Differential Calculus", Shyam Lal Charitable Trust, Delhi, 2002.
R4. S. Narayan, "Integral Calculus", S. Chand & Co., Delhi, 2005

H. Lecture Plan:

Lecture No.	Description of the Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
	Curvature & Asymptotes:				
1	Introduction, Definition, Radius of curvature (Cartesian Coordinate)	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
2	Radius of curvature (Parametric Coordinate)	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
3	Radius of curvature (Polar Coordinate)	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
4	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.1**	Quizzes, Two Sessional, End Term Examination
5	Circle of curvature	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
6	Chord of curvature	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
7	Asymptotes (Parallel)	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination

8	Asymptotes (Inclined)	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
9	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.1**	Quizzes, Two Sessional, End Term Examination
	Curve Tracing				
10	Procedure for tracing Cartesian curves	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
11	Problems based on above topic	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
12	Procedure for tracing polar curves	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
13	Problems based on above topic	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.1**	Quizzes, Two Sessional, End Term Examination
14	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.1**	Quizzes, Two Sessional, End Term Examination
15	Taylor's theorem for a function of one variable	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination

16	Taylor's and Maclaurin's expansion of functions	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
17	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.2**	Quizzes, Two Sessional, End Term Examination
	Partial Differentiation				
19	Introduction & problems	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
20	Euler's theorem on homogeneous functions	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
21	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.2**	Quizzes, Two Sessional, End Term Examination
22	Total derivative	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
23	Derivatives of composite and implicit functions	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
24	Change of variables	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
25	**Tutorial Class**	Identify, formulate, apply appropriate techniques,	Problem solving	**1101.2**	Quizzes, Two Sessional, End Term Examination

		professional ethics, Communicate effectively & life-long learning			
27	Taylor's theorem for a function of two variables	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.2**	Quizzes, Two Sessional, End Term Examination
28	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.2**	Quizzes, Two Sessional, End Term Examination
29	Extreme values of a function of two variables	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.3**	Quizzes, Two Sessional, End Term Examination
30	Lagrange's method of undetermined multipliers	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.3**	Quizzes, Two Sessional, End Term Examination
31	Errors and approximations	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.3**	Quizzes, Two Sessional, End Term Examination
32	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**1101.3**	Quizzes, Two Sessional, End Term Examination
	Matrices:				
33	Matrices, elementary column and row transformations	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**1101.4**	Quizzes, Two Sessional, End Term Examination
34	Inverse of a matrix by elementary transformations	Identify, formulate, apply appropriate techniques, professional ethics,	Lecture, Discussion & Examples	**1101.4**	Quizzes, Two Sessional, End Term Examination

		Communicate effectively & life-long learning			
35	Rank of a matrix by elementary transformations	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.4**	Quizzes, Two Sessional, End Term Examination
36	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**I101.4**	Quizzes, Two Sessional, End Term Examination
37	Solution of systems of linear equations, consistency	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.4**	Quizzes, Two Sessional, End Term Examination
39	Solution by Gauss elimination	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.4**	Quizzes, Two Sessional, End Term Examination
40	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**I101.4**	Quizzes, Two Sessional, End Term Examination
41	Cayley-Hamilton theorem, Eigenvalues	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.5**	Quizzes, Two Sessional, End Term Examination
42	Eigenvectors	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.5**	Quizzes, Two Sessional, End Term Examination
43	Diagonalization of a square matrix	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.5**	Quizzes, Two Sessional, End Term Examination

44	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**I101.5**	Quizzes, Two Sessional, End Term Examination
	Integral Calculus:				
46	Reduction formulae	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.6**	Quizzes, Two Sessional, End Term Examination
47	Area of simple curves	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.6**	Quizzes, Two Sessional, End Term Examination
48	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**I101.6**	Quizzes, Two Sessional, End Term Examination
49	Lengths of simple curves	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.6**	Quizzes, Two Sessional, End Term Examination
51	Volume of revolution of simple curves	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Lecture, Discussion & Examples	**I101.6**	Quizzes, Two Sessional, End Term Examination
52	**Tutorial Class**	Identify, formulate, apply appropriate techniques, professional ethics, Communicate effectively & life-long learning	Problem solving	**I101.6**	Quizzes, Two Sessional, End Term Examination

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												~~CORRELATION WITH PROGRAM SPECIFIC OUTCOMES~~		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	~~PSO 1~~	~~PSO 2~~	~~PSO 3~~
MA1101.1	Solve the problem on Radius of curvature, Circle and chord of curvature, Asymptotes, curve tracing for Cartesian and polar curves.	3	2	3	1			1			1		1			
MA1101.2	Demonstrate the understanding of the derivatives of functions of several variables and it will enhance the problem solving skills.	3	2	1	2	1										
MA1101.3	Optimize the functions of several variables using Hessian method and Lagrangian method and further will improve the logical skills hence Employability.	3	3	2	2						3		1			
MA1101.4	Use matrices, determinants and techniques for solving systems of linear equations in the different areas of Linear Algebra	3	2	2	2	1		1					1			
MA1101.5	Solve Eigen value problems, Applications of integral calculus: area and length of curves and volume of solid of revolution of simple curves	2	3	1	1	1							1			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Civil Engineering
Course Hand-out

Environmental Studies | ES 1101 | 3 Credits | 3 0 0 3

Session: July – Nov 2018 | Faculty: Dr. M. Prabhu Inbaraj | Class: B. Tech Semester I

Introduction: This course is offered to B. Tech. first year students to make them aware of the importance of our natural environment. The course offers insights into the basics of environment, its components, functions; impacts of natural and anthropogenic activities on environment; methods to tackle such environmental issues. Further, this course emphasises on the significance of life on earth and thus, the need for its protection. Overall, this course is aimed to sensitise students to realise links between the natural and man-made environment.

A. Course Outcomes: At the end of the course, students will be able to;

[1101.1]. Apply the fundamental knowledge of environment, ecology and ecosystem to save the environment for sustainable development.

[1101.2]. Apprehend environmental problems and its linkage to the health and safety of society; think and act with a sense of responsibility, committing to the professional ethics.

[1101.3]. Develop the skill of the technique / procedures to predict / qualitatively assess the reduction in the environmental impact for sustainable development.

[1101.4]. Realise the active involvement of oneself and society in designing the activities / processes with which the environment and ecosystem would be preserved, considering public health and safety.

[1101.5]. Explore the impacts of various man-made activities from an environmental context. Students can demonstrate the knowledge by participating in class debates and presentations on various topics of environmental concern with effective communication.

B. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

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

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

D. SYLLABUS

Introduction to Environmental Studies; Multidisciplinary Nature of Environmental Studies, Scope and importance, concept of sustainability and sustainable development; spheres of the earth; structure of atmosphere.

Ecosystems; concept, structure and function, energy flow in an ecosystem, food chain, food webs and ecological succession, Forest, Grassland, Desert and Aquatic (Ponds, Streams, Lakes, River, Oceans, Estuaries) ecosystem.

Natural Resources (Renewable & Non Renewable Resources); Land Resources and land use change, Land degradation, soil erosion and desertification; Deforestation; Causes and impacts. Water; Use and over-exploitation of surface and ground water, floods, droughts, conflicts over water (international & inter-state). Energy resources; Renewable and non- renewable energy sources, use of alternate energy sources, growing energy needs.

Biodiversity and Conservation; Genetic, species and ecosystem diversity; Biogeographic zones of India; Biodiversity patterns and global biodiversity hot spots, threats to biodiversity; Habitat loss, poaching of wildlife, man-wildlife conflicts, biological invasions; Conservation of biodiversity; *In-situ* and *ex-situ* conservation of biodiversity. Ecosystem and biodiversity services; Ecological, economic, social, ethical, aesthetic and Informational value.

Environmental Pollution; Environmental Pollution; type, causes, effects, and controls; Air, Water, Soil and Noise pollution, Nuclear hazards and human health risks, ill effects of fireworks, Solid waste management; control measures of urban and industrial waste, pollution case studies.

Environmental Policies and Practices; Climate change, global warming, ozone layer depletion, acid rain and impacts on human communities and agriculture, Environment laws; Environmental Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act; International agreements; Montreal and Kyoto protocols and Convention on Biological Diversity (CBD). Nature reserves, tribal populations and rights, and human wildlife conflicts in Indian context.

Human Communities and the Environment; Human population growth; impact on environment, human health and welfare, Resettlement and rehabilitation of project affected persons; case studies, Disaster management; flood, earthquake, cyclone and landslides. Environmental movements; Chipko, Silent valley, Bishnois of Rajasthan, Environmental ethics; Role of Indian and other religions and cultures in environmental conservation, Environmental communication and public awareness, case studies (e.g., CNG vehicles in Delhi), Environmental Impact Assessment (EIA).

Field Work and field visits.

E. TEXT BOOKS (number as T1, T2 etc)

1. Bharucha, E. (2013). Text book of Environmental Studies for undergraduate courses, Universities Press, Hyderabad, 2nd Edition
2. Carson, R. (2002). Silent Spring. Houghton Mifflin Harcourt.
3. De, A. K. and De, A. K. (2007). Environmental Studies, New Age International Publishers, New Delhi.
4. Gadgil, M. and Guha, R. (1993). This Fissured Land; An Ecological History of India. University of California, Press.
5. Groom, Martha J., Gary, K. Meffe and Carl Ronald Carroll (2006). Principles of Conservation Biology. Sunderland; Sinauer Associates.
6. Grumbine, R. Edward and Pandit, M. K. (2013).Threats from India's Himalaya dams. Science, 339; 36-37.
7. Rajagopalan, R. (2016). Environmental Studies; From Crisis to Cure, Oxford University Press.
8. Singh, J. S., Singh, S. P. and Gupta, S. R. (2014). Ecology, Environmental Science and Conservation. S. Chand Publishing, New Delhi.

F. REFERENCE BOOKS (number as R1, R2 etc)

1. Molles, M. C. (2015). Ecology: Concepts and Applications. McGraw Hill Higher Education, 7th Edition, 592 P.
2. Chiras, D. D. (2014). Natural Resource Conservation: Management for a Sustainable Future. Pearson India.

Lecture Plan:

LEC NO	TOPICS
1	**Multidisciplinary Nature of Environmental Studies:** Scope of environmental studies, a multidisciplinary view, Importance of environmental studies
2	**Ecosystems and Environment:** Spheres of the earth: atmosphere, lithosphere, hydrosphere, biosphere
3	**Structure of the atmosphere:** troposphere, stratosphere, mesosphere, thermosphere, exosphere
4	**Ecology**: structure and function of the ecosystem
5	**Bio-geochemical cycles:** Nitrogen, Carbon
6	**Bio-geochemical cycles:** Sulphur, Phosphorous
7	**Ecological succession**
8	**Natural resources (Renewable & Non Renewable Resources):** Water Resources
9	**Energy Resources**: Conventional and non-conventional
10	**Energy Resources:** Conservation and Management
11	Forest Resources
12	Land Resources
13	**Biodiversity and its Conservation:** Biodiversity: Importance of biodiversity
14	Threats to biodiversity
15	Factors affecting biodiversity
16	Conservation of biodiversity
17	**Environmental pollution and control** : **Air pollution**: sources of air pollution and classification of air pollutants
18	Primary and secondary air pollutants
19	**Fireworks:** Chemical used, toxic fall out and their persistent in soil and water, Its ill effects on air quality pertaining to gaseous and particulate matter, Health hazards prevention and Control
20	**Water pollution:** Sources of water pollution, water quality standards (physical, chemical and biological characteristics of water quality parameters)
21	Effects of water pollution and Water Borne Diseases and its control
22	Basic water treatment process (filtration, sedimentation and overview of treatment plant)
23	**Soil pollution:** sources, effects and control of soil pollution
24	**Noise pollution:** sources, effects and control of noise pollution
25	**Solid waste management:** sources, characteristics
26	**Solid waste management:** control measures of urban and industrial wastes
27	Hazardous Waste – Environmental problems and health risks
28	**Environmental impact assessment(EIA):** Methodology and importance
29	**Social Issues and Environment:** Environmental concerns: urbanization, industrialization, agricultural revolution and their impact on environment
30	**Global warming** and greenhouse effect.
31	**Acid rain:** Causes and effects
32	**Ozone depletion** & depletion of ozone hole over Antarctica.
33	Urban problems related to energy
34	Water conservation, rain water harvesting, watershed management
35	Resettlement and rehabilitation of people; its problems and concerns. Case Studies
36	Wasteland reclamation
37	Environment Protection Act, Air (Prevention and Control of Pollution) Act, Water (Prevention and control of Pollution) Act, Wildlife Protection Act, Forest Conservation Act.
38	**Human Population and the Environment:** Population growth, variation among nations, Population explosion – Family Welfare Programme.
39	Environment and human health, Women and Child Welfare, Role of Information Technology in Environment.
40	Concept of sustainability and sustainable development.
41	**Field Work:** Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc. Study of common plants, insects, birds and basic principles.
42	Visit to a local polluted site-Urban/Rural/Industrial/Agricultural.
43	Study of simple ecosystems-pond, river, Delhi Ridge, etc.

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES				
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5
[1101.1].	Apply the fundamental knowledge of environment, ecology and ecosystem to save the environment for sustainable development.	3		1			1	2					3					
[1101.2].	Apprehend environmental problems and its linkage to the health and safety of society; think and act with a sense of responsibility, committing to the professional ethics.		3				3		3	2								
[1101.3].	Develop the skill of the technique / procedures to predict / qualitatively assess the reduction in the environmental impact for sustainable development.	3	1			3	2	3		1			3					
[1101.4].	Realise the active involvement of oneself and society in designing the activities / processes with which the environment and ecosystem would be preserved, considering public health and safety.			1	1					3								
[1101.5].	Explore the impacts of various man-made activities from an environmental context. Students can demonstrate the knowledge by participating in class debates and presentations on various topics of environmental concern with effective communication.	2			2		3					1	3					

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics & Communication Engineering (SEEC)

Course Hand-out

Basic Electronics | EC 1101| 4 Credits | 3 1 0 4

Session: Jul 18 – Nov 18 | Faculty: Dr. Prashant Povel Dwivedi | Class: Core Subject

A. Introduction:

The growth of mobile telephony, broadband and wireless internet has led to the growth of career opportunities in the field of communication engineering. This course is a basic overview of electronic components and their common uses. It covers the characteristics and applications of analog and digital circuit components. Emphasis is placed on analysis, selection and applications. The coverage is not as deep as an electronics course aimed at electrical engineers. There are a number of physical applications demonstrated in this course that serve to motivate a wider audience. The course is ideal for someone who wants to gain a basic understanding of electrical circuits, hobbyists, or for someone who is considering electrical engineering as a career.

Review of physics, introduction to semiconductor devices: diodes and transistors. Equivalent circuits and models of semiconductor devices. DC biasing circuits for transistors. Analysis and design of transistor amplifiers. Operational amplifier systems. Number System, Boolean Algebra, Specification and implementation of combinational and sequential systems. Introduction to basic electronic communication systems.

B. Course Outcomes: At the end of the course, students will be able to

[EC1101.1] Apply principles of physics to describe and analyse the working of semiconductor devices and integrated circuits their impacts and hence develop employability skills.

[EC1101.2] Analyse different biasing configurations of bipolar junction transistor and hence result in scope of entrepreneurship.

[EC1101.3] Analyse inverting or non-inverting amplifier structures comprising of operational amplifiers for lifelong learning and encouraging entrepreneurship.

[EC1101.4] Demonstrate interconversion on different number systems

[EC1101.5] Demonstrate minimization of Boolean expressions

[EC1101.6] Identify different parameters pertaining to analog modulation techniques

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

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[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment Plan:

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E. SYLLABUS

PN Junction: Formation of depletion region, Effect of forward and reverse bias on depletion region, I-V characteristics and equivalent circuits of ideal and practical diode, Diode equation.

Application of Diode: Series and parallel combination of diodes circuits, Half Wave and Full Wave rectifiers, Capacitor filter, clipper, clamper circuits, Zener Diode; I-V Characteristics, Zener Regulators, LEDs.

Bipolar Junction Transistor: Construction, schematic diagram and characteristic of CE, CB Configuration, CC configuration w.r.t. CE, Relation between α and β, transistor biasing, Q-point, load line, fixed bias, self-bias, bias stabilization, Transistor as amplifiers, frequency response.

Operational Amplifier: Characteristics of an Op. Amp., Inverting and Non-inverting, amplifiers, Linear Circuit applications as voltage follower, integrator, differentiator, summing amplifier, subtractor.

Digital Electronics: Number systems, Boolean algebra, DeMorgan's Theorem, logic gates; Truth tables, SOP, POS form, K-map for minimization of Boolean expressions, Implementation of Boolean expressions with logic gates, Designing combinational circuits: Half and full adders, Half and full subtractor. Flip-flop: S-R flip-flops.

Communication Systems: Elements of communication systems, Examples of communication systems: Analog and optical communications.

F. TEXT BOOKS

1. R. L. Boylestad, L. Nashelsky, Electronic Devices and Circuit Theory, Ninth edition, PHI.
2. A. P. Malvino, David J Bates, Electronic Principles, Seventh edition, TMH.
3. G. Kennedy, B. Davis, Electronic Communication systems, TMH.

G. REFERENCE BOOKS

Refer all course related books, other than text books here.

1. J. Millman and C. C. Halkias, Integrated Electronics, Tata McGraw Hill, New Delhi. (1994).
2. B. P. Singh and Rekha Singh, Electronic Devices and Circuits, Second Edition, Pearson Education, 2013.

H. Lecture Plan:

LEC NO.	TOPICS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Overview of Semiconductors	Recall concept of Semiconductors		EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
2	Introduction to Extrinsic Semiconductors	Understanding of Doping	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
3	Introduction to PN junction diode, Formation of depletion region	Understanding of switches	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
4	Forward and reverse bias, I-V Characteristics	Understanding of switch operation and their characteristics	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
5, 6	Equivalent circuits of ideal and practical diode	Model of the diode for circuits	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
7	Diode equation	Introduction to the drift and diffusion in diode equation.	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
8	Tutorial				
9-11	Application to Diodes: Series and Parallel combination of diode circuits	Use of switches to get different function in electrical circuits	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
12	Half and Full wave rectifiers	Introduction to pulsating D.C	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
13	Capacitor Filter	Introduction to Filters	Lecture	EC1101.1 (CO 1)	Class Quiz
14,15	Clipper circuits	Understanding of wave shaping circuits	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
16	Clamper circuits	Understanding of wave shaping circuits	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term I, End Term
17	Zener diode and its I-V characteristics	Understanding of voltage regulating device.	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term II, End Term
18, 19	Zener regulators, LEDs	Understanding of voltage regulating circuits	Lecture	EC1101.1 (CO 1)	Class Quiz, Mid Term II, End Term
20	Tutorial		Quiz 1		
21	Introduction to BJT	Understanding of three terminal devices	Lecture	EC1101.2 (CO 2)	Class Quiz
22	Operation of BJT	Understanding of minority carrier movement	Lecture	EC1101.2 (CO 2)	Class Quiz

23	Transistor configuration: symbolic representation and CB Characteristics.	Characteristics of BJT under various config.	Lecture	EC1101.2 (CO 2)	Class Quiz
24	Transistor configuration: symbolic representation and CE Characteristics,	Characteristics of BJT under various config.	Lecture	EC1101.2 (CO 2)	Class Quiz
25	CC configuration w.r.t. CE, Relation between α and β	Characteristics of BJT under various config.	Lecture	EC1101.2 (CO 2)	Class Quiz, Mid Term II, End Term
26	Transistor Biasing, Q-point, Load line	Effect of load on the characteristics	Lecture	EC1101.2 (CO 2)	Class Quiz, Mid Term II, End Term
27	Fixed biasing	Effect of load on the characteristics	Lecture	EC1101.2 (CO 2)	Class Quiz, Mid Term II, End Term
28	Self-biasing, Bias stabilization	Effect of load on the characteristics	Lecture	EC1101.2 (CO 2)	Class Quiz, Mid Term II, End Term
29	Transistor as an amplifier, Frequency response	Understanding of amplifier characteristic and its response with frequency variation	Lecture	EC1101.2 (CO 2)	Class Quiz
30	Tutorial		Quiz 2		
31	Introduction to Operational Amplifier, Op. Amp Characteristics.	Understanding the OPAMP characteristics and it's difference from BJT as an amplifier.	Lecture	EC1101.3 (CO 3)	Class Quiz
32	Inverting amplifier	Application of OPAMP	Lecture	EC1101.3 (CO 3)	Class Quiz, Mid Term II, End Term
33	NON-Inverting amplifier, Linear applications of Op. Amp as voltage follower	Application of OPAMP	Lecture	EC1101.3 (CO 3)	Class Quiz, Mid Term II, End Term
34	Summing amplifier, Subtractor	Application of OPAMP	Lecture	EC1101.3 (CO 3)	Class Quiz, End Term
35	Integrator, Differentiator	Application of OPAMP	Lecture	EC1101.3 (CO 3)	Class Quiz, End Term
36	Tutorial		Quiz 3		
37	Digital Electronics: Number system	Mathematical understanding of Number System	Lecture	EC1101.4 (CO 4)	Class Quiz, End Term
38	Number conversion, Binary addition	Application of a Number System in Digital Electronics.	Lecture	EC1101.4 (CO 4)	Class Quiz, End Term
39	Binary subtraction with complements (1's and 2's complement)	Understanding of Subtraction in Digital Electronics	Lecture	EC1101.4 (CO 4)	Class Quiz, End Term

40	Boolean algebra, DeMorgan's theorem	Understanding the Algebra in Digital Electronics	Lecture	EC1101.5 (CO 5)	Class Quiz, End Term
41	Logic gates, Truth table.	Basic entities of Digital Electronics	Lecture	EC1101.5 (CO 5)	Class Quiz, End Term
42	Implementation of Boolean expression with logic gates	Use of Logic Gates to implement any Logic in Digital	Lecture	EC1101.5 (CO 5)	Class Quiz, End Term
43	SOP, POS forms	Understanding of various forms to represent a Logic	Lecture	EC1101.5 (CO 5)	Class Quiz, End Term
44	K-Map for minimization of Boolean expressions	A systematic way to minimize the given logic	Lecture	EC1101.5 (CO 5)	Class Quiz, End Term
45	Combinational Circuits: Half and Full adders	Understanding of Basic Combinational Circuits	Lecture	EC1101.5 (CO 5)	Class Quiz
46	Half and Full Subtractors	Understanding of Basic Combinational Circuits	Lecture	EC1101.5 (CO 5)	Class Quiz
47	S-R Flip Flop	Understanding of Basic Sequential Circuits	Lecture	EC1101.5 (CO 5)	Class Quiz
48	Tutorial				
49	Introduction to communication system	Basic concept of Communication	Lecture	EC1101.6 (CO 6)	Class Quiz
50	Analog and Digital communication	Understanding of different Communication Systems	Lecture	EC1101.6 (CO 6)	Class Quiz
51	Modulation techniques, Need for modulation	Understanding the importance of a Carrier and its Modulation	Lecture	EC1101.6 (CO 6)	Class Quiz
52	Types of Modulations.	Understanding the different ways to modulate a carrier	Lecture	EC1101.6 (CO 6)	Class Quiz, End Term
53	Tutorial		Quiz 4		

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[EC1101.1]	Apply principles of physics to describe and analyse the working of semiconductor devices and integrated circuits their impacts and hence develop employability skills.	3	2	3	1			1					1			
[EC1101.2]	Analyse different biasing configurations of bipolar junction transistor and hence result in scope of entrepreneurship.	3	2	1	2	1							**1**			
[EC1101.3]	Analyse inverting or non-inverting amplifier structures comprising of operational amplifiers for lifelong learning and encouraging entrepreneurship.	3	3	3	2	**2**							1			
[EC1101.4]	Demonstrate interconversion on different number systems	3	2	3	2	**2**		1					1			
[EC1101.5]	Demonstrate minimization of Boolean expressions	**3**	3	1	**2**	**2**							1			
[EC1101.6]	Identify different parameters pertaining to analog modulation techniques	**3**	2	**2**	2		1						2			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Civil Engineering
Course Hand-Out

Mechanics of Solids | ES1102|4 Credits |4 0 0 4

Session: Jul–Nov, 2018 | Faculty: Prof K. J. Sharma | Class: Core Subject

A. Introduction: This course is offered by Dept. of Civil Engineering as a Core Course for first year students. Mechanics of solids includes important topics from Engineering Mechanics and Strength of Materials. The subject offers a basic understanding of different types of forces acting on rigid bodies at rest and in stage of motion. Most of the fundamentals needed to learn the basics of Engineering Mechanics and strength of materials are discussed in this subject. Strength of materials is a basic course essential for students of all branches of engineering. Modern research and advancement in field of stability, strength and design of structure and machines, dynamic effects. robotics, missiles. Aeroplane and aircraft design, automobiles and automatic control. fluid flow, engine performance, electrical machines, transmission tower, superstructure, heavy earthmoving machines, locomotives, metro railway, supersonic aircrafts, atomic and subatomic behaviour etc are highly dependent on basic principle of Mechanics of Solids In this coursework, students will be trained about methods of analysing forces, determination of centroid and moment of inertia of geometrical figures, determination of various stresses and strains, longitudinal and circumferential stresses and strains due to direct forces , thermal stresses; strains in metallic materials and stresses due to fluid pressures.. Also they will develop skill for testing various building and machinery materials such as- mild steel, cast iron etc. as per Indian standards guidelines. The course will include activities such as- assignments, quizzes, class tests, site visits, projects, focusing on the knowledge of students for lifelong learning and making them employable.

B. Course Outcomes: At the end of the course, students will be able to:

[ES1102.1] Develop the skill to evaluate forces in various engineering elements

[ES1102.2] To locate the centroid and determine the Moment of inertia of various bodies

[ES1102.3] Analysis of dynamics forces to be used in machinery and building component

[ES1102.4] To assess the engineering properties of material subjected to normal, shear and temperature stresses

[ES1102.5] To examine the stress and strain in thin cylinders and pipes along the longitudinal and circumferential direction

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

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

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes, Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Mechanics of Rigid Bodies: Introduction, basic principles and concepts, Force systems, resultant of concurrent and non- concurrent coplanar force systems; Equilibrium of concurrent and non-concurrent coplanar force systems. Centroid and Moment of Inertia of simple and composite areas, **Kinetics**:- Applications of D'Alembert's principle, work-energy and Impulse-Momentum principles. **Mechanics of Deformable Bodies**:- Mechanical properties of materials, normal stress and strain, Hooke's law, modulus of elasticity, tension test on ductile and brittle materials, factor of safety, allowable stress, Poisson's ratio, shear stress and shear strain, modulus of rigidity, relation between modulus of elasticity, modulus of rigidity and bulk modulus. Stresses and deformations in tapering bars, stepped bars, thermal stresses, statically indeterminate problems, Stresses on inclined planes, stresses in thin cylindrical pressure-vesse

F. TEXT BOOKS

1. *S.S.Bhavikatti, Engineering Mechanics 6th Edition2018,New Age International Publishers.*

2. *S.S. Bhavikatti, 3rd edition2010, Vikash Publishing HouseEngineering Mechanics*

G. REFERENCE BOOKS

3. *Beer and Johnson; Engineering Mechanics*
4. *R.K.Bansal; Engineering Mechanics, 3rd edition 2013., Laxmi Publication*
5. *Timoshenko; Strength of Materials*
6. *R.K.Rajput; Strength of Materials , 6th edition2o15 , S. Chand Publishing*

H. Lecture Plan:

Lecture No.	Topics to be covered
	PART-I MECHANICS OF RIGID BODIES
1	**Resultant of concurrent and non-concurrent forces:-** Definition of mechanics, force, principle of transmissibility
2	Classification of force system, resultant of concurrent coplanar forced, parallelogram and triangle law of forces, component of a force, resolution of a force, rectangular component of force and oblique components of a force
3	Illustrative Problems
4	Illustrative Problems
5	Illustrative Problems
6	Resultant of coplanar non –concurrent force system, moment of a force, couple, force and couple system, Varignon's theorem, types of loads on beams
7	Illustrative Problems
8	Illustrative Problems
9	**Equilibrium of concurrent and non con-current coplanar force system:** Definition, condition of equilibrium, Lami's theorem , space diagram and Free Body Diagram, types of supports, types of beams and types of loading
10	Problems on equilibrium of coplanar concurrent force system
11	Problems on equilibrium of coplanar concurrent force system
12	Problems on equilibrium of coplanar concurrent force system
13	Problems on resultant of coplanar non-concurrent force system
14	Problems on resultant of coplanar non-concurrent force system
15	Problems on resultant of coplanar non-concurrent force system
16	Tutorials based on L1-L15
17	**Centroid of plane area :-** Definition, derivation of Centroid of rectangle, circle,
18	Semi-circle, quarter circle, triangle, determination of centroid of composite area
19	Problems on determination of centroid of composite area
20	Problems on determination of centroid of composite area
21	Problems on determination of centroid of composite area
22	**Moment of Inertia:-- Definition,** Theorem of parallel and perpendicular axes, Radius of gyration, M. I. of standard plane lamina like rectangle, triangle and quarter circle
23-24	Problems on determination of M.I. for composite areas
25	**Kinetics of rectilinear motion:-** Newton's second law of motion, work energy principle and impulse momentum principle, D' Alembert's principle
26	Problems on kinetics using above methods
27	Problems on kinetics using above methods
	Part –II MECHANICS OF DEFORMABLE BODIES
28	**Simple Stresses and Strains:-** Introduction to mechanics of deformable, normal stress and strains, Hooke's law, modulus of elasticity

29	Tension test on ductile and brittle materials, factor of safety, allowable stress Tapering Problem:------Illustrative problems
30	Tapering bars, Illustrative problems
31	Stepped bars Illustrative problems
32	Shear stress, shear strain single and double shear, modulus of rigidity
33	Poisson's ratio, bulk modulus, relationship between volumetric strain and linear strain
34	Relationship between modulus of elasticity, modulus of rigidity and bulk modulus
35	Illustrative Problems
36	**Statically indeterminate members and thermal stresses:-** Compound bars subjected to external loads
37	Illustrative problems
38	Illustrative problems
39	Illustrative problems
40	Temperature stresses, compound bar subjected to temperature stresses, illustrative problems
41	Illustrative Problems
42	Illustrative Problems
43	**Stresses on inclined plane:-** equation of stresses on inclined planes, condition for maximum and normal stresses on a plane, concept of principal plane and principal stresses, condition for maximum shear stress on plane and plane of maximum shear stress, resultant stress on a plane
44	Illustrative examples
45	Illustrative problems
46	**Stresses in thin cylinder** due to fluid pressure :-Analysis of thin cylinders subjected to fluid pressure- hoop stress, longitudinal stress and strain, joint efficiencies
47	Illustrative problems
48	Illustrative problems and doubt clarification.

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES				
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4	
[ES1102.1]	Develop the skill to evaluate forces in various engineering elements	3	2	2	1	1	1	2	1			1	1					
[ES1102.2]	To locate the centroid and determine the Moment of inertia of various bodies	3	3	2	3	3	2	1	1			1	1					
[ES1102.3]	Analysis of dynamics forces to be used in machinery and building component	3	2	3	3	3	1		1	2	3	1	1					
[ES1102.4]	To assess the engineering properties of material subjected to normal, shear and temperature stresses	3	2	2	2	2	2			2	2		1					
[ES1102.5]	To examine the stress and strain in thin cylinders and pipes along the longitudinal and circumferential direction.	3	2	2	2	2	2		1	2	2	1	1					

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Automobile Engineering
Course Hand-out

Engineering Chemistry | CY1101 | 4 Credits | 2 1 1 4

Session: July - Nov 18 | Coordinator: Arunava Agarwala | Class: B.Tech. (I and II Sem)

A. Introduction: This course is offered by Dept. of Chemistry for all 1st year B.Tech. students. The objective of the course is to acquaint the students with the basic concepts of chemistry relevant to engineering field. The students with the knowledge of basic chemistry, will understand and explain scientifically the various chemistry related problems in the industry/engineering field.

B. Course Objectives: At the end of the course, students will be able to

[1101.1]. Understand and apply concepts of various types of fuel technology
[1101.2]. Develop new methods to produce soft water for industrial use.
[1101.3]. Understand the synthesis and applications of polymer science and polymer technology.
[1101.4]. Develop skills to synthesis, analysis and use of composite materials.
[1101.5]. Understand and apply the concepts in electrochemistry and corrosion science in protecting metallic objects.
[1101.6]. Acquire basic knowledge of Nanochemistry to appreciate its applications in the fields like medicine, opto-electronics, and electronics.

C. Program Outcomes and Program Specific Outcomes

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

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public healthand safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal,health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineeringpractice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions insocietal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of theengineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverseteams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projectsand in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	Quizz tests (Accumulated and Averaged)	10
	Laboratory Sessions	20
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Chemical Fuels: Classification; Calorific value and its determination; Analysis of solid fuel;Liquid Fuel: Distillation of petroleum, Petroleum cracking, Reforming of petrol, Octane numberand Cetane value, Synthetic petrol, Combustion based numerical; **Water Technology**: Hardnessof water; Units of hardness; Ion exchange water softening technique; Boiler feed water: scale &sludge, priming and foaming; **Polymers & Composites**: Molecular weight determination; Glasstransition temperature; Methods of polymerization; Mechanism of polymerization reactions;Compounding of plastics; Vulcanization; Conducting polymers; Synthesis, properties andapplications of some polymers; Composition and characteristic properties of composites; **Nano Chemistry:** Synthesis, properties and applications of selected nanomaterials; **Corrosion and its Control**: Theories alrd Mechanism of Corrosion; Types of corrosion; Factors affecting corrosion,Protection against gorrosion, Paints and Coatings: Antifouling Coating, Fire retardant paintsand Case studies.

F. Text Books

T1. Jain P.C. and Jain M., Engineering Chemistry, Dhanpat Rai and Sons, Delhi, Revised, 15th Edn. 2006.

T2. Kuriacose J.C., Raja R. J., Chemistry in Engineering and Technology, Vol. I/II TMH 1988

G. Reference Books

R1. None

H. Lecture Plan:

Lec No	**Topics**	**Session Outcome**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1.	**Chemical fuels:** Introduction, Classification, Units of heat, Calorific value: Gross calorific value and Net calorific value.	To acquaint and clear teachers expectations and understand student expectations	Lecture	1101.1	Class Quiz End Term
2.	Description of working of Bomb calorimeter for detection of caloric value of solid /non-volatile liquid fuel; Discussion about all corrections.	Recall working of the calorimeter	Lecture	1101.1	Class Quiz Mid Term I
3.	Numerical problems based on Bomb calorimeter.	Analyze and solve numerical problems	Activity	1101.1	Class Quiz End Term
4.	Description of working of Boy's calorimeter for detection of caloric value of gaseous fuel; Numerical problems based on Boy's calorimeter.	Describe calorimeter and its working principle	Lecture	1101.1	Home Assignment End Term
5.	Dulong's Formula; Numerical problems based on Dulong's Formula; Coal analysis: Proximate analysis.	Analyze and solve numerical problems	Lecture, Activity	1101.1	Class Quiz End Term
6.	Coal analysis: Ultimate analysis; Numerical problems related to Proximate and Ultimate analysis.	Analyze and solve numerical problems	Lecture, Activity	1101.1	Class Quiz Mid Term I End Term
7.	Liquid Fuels: Fractional Distillation, Petroleum Cracking - Fixed Bed catalytic cracking.	Recall principles of distillation, cracking	Lecture	1101.1	Class Quiz Mid Term I End term
8.	Moving bed Catalytic Cracking; Knocking, Octane number, Anti-knocking agents, Unleaded petrol and power alcohol, Cetane number.	Recall principles of cracking, knocking	Lecture	1101.1	Class Quiz Mid Term I End Term
9.	Reforming of Gasoline: Thermal and Catalytic reforming, Synthetic Petrol, Bergius process, Fisher Tropsch method.	Recall basic principles of fuels	Lecture, Activity	1101.1	Class Quiz Mid Term I End Term
10.	Numerical based on Combustion (By Weight Type).	Analyze and solve numerical problems	Activity	1101.1	Class Quiz Mid Term I End Term
11.	Numerical based on Combustion (By Volume Type).	Analyze and solve numerical problems	Activity	1101.1	Class Quiz End Term
12.	**Water Technology:** Introduction, Hardness of water, Important units of hardness.	Describe the properties of water and its aplication	Lecture	1101.2	Class Quiz Mid Term II End Term
13.	Numerical problems based on hardness.	Analyze and solve numerical problems	Lecture, Activity	1101.2	Class Quiz Mid Term II

					End Term
14.	Estimation of hardness: Soap solution method and EDTA method.	Describe working hardness/softness of water	Lecture	1101.2	Class Quiz Mid Term II End Term
15.	Softening of water: cold and hot Lime soda process and numerical problems (calculation of amount of lime and soda).	Analyze and solve numerical problems	Lecture, Activity	1101.2	Class Quiz Mid Term II End Term
16.	Softening of hard water by Ion exchange method and zeolite method.	Describe the conversion of hard water to soft water	Lecture	1101.2	Class Quiz End Term
17.	Internal treatment: Phosphate conditioning and Calgon conditioning.	Recall the conversion of hard water to soft water	Lecture	1101.2	Class Quiz End Term
18.	Boiler problems: scale and sludge formation,priming and foaming and preventive methods.	Recall the conversion of hard water to soft water	Lecture	1101.2	Class Quiz End Term
19.	**Polymers and Composites:** Definition and classification of polymers: based on structure, origin, tacticity, and heating behavior (thermo plastic/ thermosetting).	Describe the working of polymer	Lecture, Activity	1101.3	Class Quiz End Term
20.	Functionality; Degree of polymerization; Co-polymerization: alternating, random, block and graft polymers.	Describe the properties of polymer	Lecture	1101.3	Class Quiz End Term
21.	Molecular weight of polymers: Number average and weight average molecular weights, polydispersity index; Numerical problems based on average molecular weight.	Describe the properties of polymer, Analyze and solve numerical problems	Lecture, Activity	1101.3	Class Quiz End term
22.	Mechanism of free radical polymerization and ionic (both cationic and anionic) polymerization.	Recall the properties of polymer	Lecture, Activity	1101.3	Class Quiz End Term
23.	Mechanism of coordination polymerization (Zieglar Natta Catalyst), Condensation polymerization: definition and examples.	Identify alternative ways to synthesize polymers	Lecture	1101.3	Class Quiz Mid Term II End Term
24.	Polymerization techniques: Bulk, Solution, Suspension and Emulsion.	Identify alternative ways to synthesize polymers	Lecture	1101.3	Class Quiz Mid Term II End Term
25.	Glass transition temperature & factors affecting it.	Identify alternative ways to synthesize polymers	Lecture	1101.3	Class Quiz Mid Term II End Term
26.	Elastomer: Natural rubber, Vulcanization, Synthetic rubbers.	Identify alternative ways to synthesize polymers	Lecture	1101.3	Class Quiz End Term
27.	Preparation, properties and applications ofPolythene (LDPE and HDPE) and Nylon: 6, 6:6, 6:10, 11.	Identify alternative ways to synthesize polymers	Lecture, Activity	1101.3	Class Quiz End Term

28.	Preparation, properties and applications of Phenol Formaldehyde resins (Novolacs / Resols).	Identify alternative ways to synthesize polymers	Lecture	1101.3	Class Quiz End Term
29.	Composites and its Classification.	Describe the properties of composites	Lecture	1101.4	Class Quiz End Term
30.	Characteristic Properties of Composites.	Describe the properties of composites	Lecture	1101.4	Class Quiz End Term
31.	Corrosion and its Control:Introduction, Significance, Chemical Corrosion, Pilling Bedworth Rule (Pilling–Bedworth ratio (P–B ratio).	Describe corrosion and its preventions	Lecture, Activity	1101.4	Class Quiz End Term
32	Electrochemical Corrosion.	Describe corrosion	Lecture	1101.5	Class Quiz End Term
33	Types of corrosion: Galvanic corrosion, Pitting corrosion.	Recall properties of corrosion	Lecture	1101.5	Class Quiz End Term
34	Water line Corrosion; Drop Corrosion; Stress corrosion (caustic embrittlement).	Recall properties of corrosion	Lecture	1101.5	Class Quiz End Term Practical End Term Theory
35	Factors affecting corrosion: the nature of the metal and environment.	Describe corrosion and its reasons	Lecture	1101.5	Class Quiz
36	Corrosion prevention by material selection and design; Protection against corrosion: Sacrificial anodic protection, Impressed current method, anodic protection; Corrosion inhibitors (cathodic/anodic).	Describe corrosion and its preventions	Lecture	1101.5	
37	Electroplating, galvanization, tinning and other metal coating methods.	Describe corrossion prevention	Lecture, Activity	1101.5	Class Quiz
38	Paints and Coatings: Antifouling Coating, Fire Retardants Paints.	Describe corrossion prevention	Lecture	1101.5	Class Quiz
39	**Nano-Chemistry**: Introduction, Synthesis of Nano Materials: Top down and Bottom up approach.	Describe nanochemistry	Lecture	1101.6	Class Quiz End Term Theory
40	Synthesis, properties and applications of Fullerenes and Carbon Nano tube.	Recall basics of nanochemistry	Lecture	1101.6	Class Quiz
41	General Properties of Nano Materials.	Recall nanomaterials	Lecture	1101.6	Class Quiz End Term Theory
42	Revision.	Recall and recap the lessons learnt during the semester	Activity	1101.1-6	Class Quiz Mid Term I Mid Term II End Term Theory
LAB SESSIONS	Lab sessions based on Alternative Fuel Synthesis, testing and fabrication of after exhaust device	Experiment and test different fuels on engines and analyse their impact on pollution reduction	Lab Sessions	1101.1-6	End Term Practical

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CY 1101.1	Understand and apply concepts of various types of fuel technology.	2						1			1		1			
CY 1101.2	Develop new methods to produce soft water for industrial.			1					1				1			
CY 1101.3	Understand the synthesis and applications of polymer science and polymer technology.	2				1					1		1			
CY 1101.4	Develop skills to synthesis, analysis and use of composite materials.						1		1				1			
CY 1101.5	Understand and apply the concepts in electrochemistry and corrosion science in protecting metallic objects.		1		1	1			1				1			
CY 1101.6	Acquire basic knowledge of Nanochemistry to appreciate its applications in the fields likemedicine, opto-electronics, and electronics.	2				1			1				1			

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Basic Sciences

First Year B. Tech.

Engineering Mathematics-II| MA1201 | 4 Credits | 3 1 0 4

Session: January 2019 – May 2019 | Faculty: Dr. Giriraj Methi & Dr. M.Rizwan | Class: First Year B. Tech. II Semester

A. Introduction: An engineering student needs to have some basic mathematical tools and technique which emphasizes the development of rigorous logical thinking and logical skills. Based on this, the course aims at giving adequate exposure to the theory and applications. The course is aimed at developing the basic mathematical skills of engineering students that are imperative for understanding the engineering subjects.

B. Course Outcomes (Cos): At the end of the course, students will be able to

[MA1201.1]: Demonstrate the understanding of First order and First Degree differential Equations

[MA1201.2]: Apply and solve higher order linear differential equations and simultaneous differential equations

[MA1201.3]: Develop the skill to use Beta Gamma function in mathematical problems

[MA1201.4]: Able to change order of double integration and double integral in Cartesian form to polar form and vice versa

[MA1201.5]: Solve triple integral find area and volume of solids using double integral

[**MA1201.6]:** Understand and can handle solid coordinate figure Sphere, Right circular cone and Right Circular Cylinder

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations

[PO.6]. Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes	30
End Term Exam (Summative)	End Term Exam (Only Handwritten class notes)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	

Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal.

E. Syllabus

MA1201 Engineering Mathematics-II

Ordinary Differential Equations: Solutions of first order and first degree differential equations, separable of variables, homogeneous and reducible to homogeneous equations, linear equations & Bernoulli equation, exact equations, reducible to exact. **Linear Higher Order Differential Equations:** Linear homogeneous equations with constant coefficients, inverse differential operators and method of variation of parameters, Solution of Cauchy's and Legendre's differential equations, solution of simple simultaneous linear differential equations. **Multiple Integrals:** Beta and Gamma Functions: elementary properties. Double and Triple integrals, area and volume by double integration, change of order of integration, change of variables from Cartesian to polar form and vice versa. **Analytical Solid Geometry:** Sphere, right circular cone, right circular cylinder.

A. TEXT BOOKS

1. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, Delhi, 2006.
2. E. Kreyszig, "Adianced Engineering Mathematics", Wiley India Edition, 2006.

B. REFERENCE BOOKS

1. B. Ram, “Engineering Mathematics", Vol. I and II, Pearson, 2012.
2. S. Pal & S. C. Bhunia, "Engineering Mathematics", Oxford University Press, 2015

F. Lecture Plan

Lecture No.	Topics	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome

1.	Introduction of Ordinary differential equations-Definition, order & degree of a differential equation	Lecture	[1201.1]	Mid Term - I End Term
2.	Solution of first order and first degree differential equations using Variable separable method	Lecture	[1201.1]	Mid Term - I End Term
3.	Solution of Homogeneous differential equations	Lecture	[1201.1]	Mid Term - I End Term
4.	Equations reducible to homogeneous form	Lecture	[1201.1]	Mid Term - I End Term
5.	Problems of equations reducible to homogeneous form	Lecture	[1201.1]	Mid Term - I End Term
6.	Problem Solving	Tutorial	[1201.1]	Mid Term - I End Term
7.	Solution of Linear differential equations	Lecture	[1201.1]	Mid Term - I End Term
8.	Solution of Bernoulli's equation	Lecture	[1201.1]	Mid Term - I End Term
9.	Solution of Exact differential equations	Lecture	[1201.1]	Mid Term - I End Term

10.	Equations reducible to exact differetnial equations	Lecture	[1201.1]	Mid Term - I End Term
11.	Problems and different IF for reducible Exact differential equations	Lecture	[1201.1]	Mid Term - I End Term
12.	Problem Solving	Tutorial	[1201.]	Mid Term - I End Term
13.	Applications of first order and first degree differential equations in real world problems	Lecture	[1201.1]	Mid Term - I End Term
14.	Introduction and develop theory for CF	Lecture	[1201.2]	Mid Term - I End Term
15.	ways for finding CF	Lecture	[1201.2]	Mid Term - I End Term
16.	Linear homogenous higher order differential equations with constant coefficients	Lecture	[1201.2]	Mid Term - I End Term
17.	Problem Solving	Tutorial	[1201.2]	Mid Term - I End Term
18.	Inverse differential operator	Lecture	[1201.2]	Mid Term - I End Term
19.	Rules for finding Particular integral for	Lecture	[1201.2]	Mid Term - I End Term

	exponential and trigonometrical cases			
20.	Rules for finding Particular integral for remaining cases	Lecture	[1201.2]	Mid Term - I End Term
21.	Develop Method of variation of parameters	Lecture	[1201.2]	Mid Term – II End Term
22.	Problems related to method of varation of parameter	Lecture	[1201.2]	Mid Term – II End Term
23.	Solution of Cauchy's equation	Lecture	[1201.2]	Mid Term – II End Term
24.	Problem Solving	Tutorial	[1201.2]	Mid Term – II End Term
25.	Solution of Legendre's equation	Lecture	[1201.2]	Mid Term – II End Term
26.	Solution of simple simultaneous linear differential equations	Lecture	[1201.2]	Mid Term – II End Term
27.	Problem Solving	Tutorial	[1201.2]	Mid Term – II End Term
28.	Applications of Linear higher order differential equations in real world problems	Lecture	[1201.2]	Mid Term – II End Term

29.	Beta & Gamma functions: Concept and Definitions	Lecture	[1201.3]	Mid Term – II End Term
30.	Properties and problems of beta function	Lecture	[1201.3]	Mid Term – II End Term
31.	Properties and problems of Gamma function	Lecture	[1201.3]	Mid Term – II End Term
32.	Problem Solving	Tutorial	[1201.3]	Mid Term – II End Term
33.	Double Integral & Tripal Integral	Lecture	[1201.4]	Mid Term – II End Term
34.	Area by double integration	Lecture	[1201.4]	Mid Term – II End Term
35.	Volume by double integration	Lecture	[1201.4]	Mid Term – II End Term
36.	Problem Solving	Tutorial	[1201.4]	Mid Term – II End Term
37.	Change of order of integration	Lecture	[1201.4]	Mid Term – II End Term
38.	Change of variables from Cartesian to polar form	Lecture	[1201.5]	Mid Term – II End Term
39.	Change of variables from Polar to Cartesianform	Lecture	[1201.5]	Mid Term – II End Term

40.	Problem Solving	Tutorial	[1201.5]	Mid Term – II End Term
41.	Three D: Basic Concepts	Lecture	[1201.6]	End Term
42.	Introduction to Sphere Equation of sphere with problems	Lecture	[1201.6]	End Term
43.	plane section of sphere	Lecture	[1201.6]	End Term
44.	Problem Solving	Tutorial	[1201.6]	End Term
45.	Right circular cone	Lecture	[1201.6]	End Term
46.	Right circular cylinder	Lecture	[1201.6]	End Term
47.	Problems based on right circular cone & cylinder	Lecture	[1201.6]	End Term
48.	Problem solving	Lecture	[1201.6]	End Term

G. Course Articulation Matrix (Mapping of COs with POs and PSOs) for Data Communications:

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1201.1	Demonstrate the understanding of First order and First Degree differential Equations	3	2	3	1	1		1			1		1				
2101.2	Apply and solve higher order linear differential equations and simultaneous differential equations	3	2	1	2	1		1			1		1				
1201.3	Use Beta Gamma function in mathematical problems	3	3	2	2	1		1			1		1				
1201.4	Able to change order of double integration and double integral in Cartesian form to polar form and vice versa	2	1	2	1	1		1			1		1				
1201.5	Solve triple integral find area and volume of solids using double integral	2	3	1	1	1		1			1		1				
1201.6	Understand and can handle solid coordinate figure Sphere, Right circular cone and Right Circular Cylinder	1	1	1	1	1		1			1		1				

MANIPAL UNIVERSITY JAIPUR

School of Electrical, Electronics and Communication

Department of Electrical Engineering
Course Hand-out

Electrical Engineering | EE 1101 | 4 Credits | 4 0 0

Session: Jan. 19 – May 19 | Faculty: Dr. Sunil Kumar Goyal | Class: First Year (All Branches)

A. Introduction: This course is offered by Dept. of Electrical Engineering as a basic fundamental subject to impart essential knowledge and information of Electrical Technology and their applications. The learning objective would cover the following aspects: -

a) To develop circuit designing skills through general insight of circuit laws and theorems.
b) To analyse the magnetic & electric circuit and calculate different parameters
c) To develop and analyse the single and three phase circuits.
d) To understand the concepts of basic construction & operation of transformer.
e) To understand the fundamentals of DC & Induction motors and measuring Instruments.

B. Course Outcomes: At the end of the course, students will be able to

[1101.1]. Recall basic circuit laws and apply theorems to analyse different types of DC circuits.
[1101.2]. Analyze and illustrate the comparison between linear electric & magnetic circuits.
[1101.3]. Identify and evaluate different configurations of single phase & three phase ac circuits.
[1101.4]. Understand the construction and operating principle of transformer.
[1101.5]. Illustrate the basic operating principles of DC machines & Induction motors and fundamental measuring Instruments

A. Program Outcomes and Program Specific Outcomes

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

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

B. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

C. Syllabus

Introduction to Indian power scenario, Domestic appliances, Basic circuit elements, Source Transformation, Series & parallel resistive circuits, Review of Kirchhoff's laws, Star Delta Transformations, **DC Circuit Analysis:** Mesh and Node voltage analysis, DC Network Theorems-Superposition, Thevenin, Norton, Maximum Power Transfer. Capacitor and Inductor Series & Parallel connections, Charging & Discharging, Energy stored. **Magnetic circuits:** Terminologies, Analysis of series and parallel magnetic circuits, Review of Electromagnetism, Electromagnetic Induction, Fleming's left & right hand rules, Faradays laws, Lenz's law, Induced emf in a conductor & coil, Mutual Inductance, Coupling Coefficient and dot rule. **Single phase AC circuits:** Generation, EMF induced, Average value, RMS value, Peak factor, Form factor, Phasors, Analysis of Pure R, L, C Series and parallel combinations (RL, RC and RLC circuits), Power, Power factor, series and parallel Resonance. **Three phase AC Circuits:** Star and Delta connections, Analysis with balanced loads, Power measurements. **Transformers:** Single phase transformer- types, Construction, working principle, ideal and practical transformers, losses, Efficiency, Regulation. **Electrical Motors:** Introduction of Single & Three phase Induction motors, DC Motors. **Electrical Instruments:** Fundamentals of Electrical Measuring Instruments.

D. TEXT BOOKS

1. Nagasarkar & Sukhija, Basic Electrical Engineering, Oxford University Press, 2006.
2. S.K. Sahdev, Fundamentals of Electrical Engineering & Electronics, Dhanpat Rai & Co, 2010.
3. D. C. Kulsheshtha, Basic Electrical Engineering, McGraw Hill Education India, 2011.

E. REFERENCE BOOKS

1. S. N. Singh, Basic Electrical Engineering, PHI, 2011.
2. D. P. Kothari. & I. J. Nagarath, Basic Electrical Technology, TMH 2004.

F. Lecture Plan:

Lec No	**Topics**	**Session Objective**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
L1	Introduction to the Course	To acquaint students with the outcome based education (OBE) and Course outcome (CO) and program outcome (PO) assessment process	Lecture		NA
L2	Basic circuit elements, Source Transformation	Recall the basic elements of a DC network	Lecture	[1101.1]	Class Quiz
L3	Series & parallel resistive circuits, Review of Kirchhoff's laws	Identify different series and parallel network configurations and their equivalent resistance calculation	Lecture	[1101.1]	Home Assignment Class Quiz
L4-L5	Star-Delta transformation	Explain the need of star-delta transformation and their applications	Lecture	[1101.1]	Home Assignment Class Quiz
T1	L1 – L5	Numerical problems based on L1-L5	Tutorial	[1101.1]	Mid Term Exam
L6 – L7	DC Circuit Analysis – Mesh & Node analysis methods	Recall KVL and KCL and apply them to find solution of different dc network problems using Mesh & Node analysis methods	Lecture	[1101.1]	Mid Term Exam
T2-T3	L6 – L7	Numerical problems based on L6-L7	Tutorial	[1101.1]	Mid Term Exam
L8-L11	DC Network Theorems: Superposition, Thevenin, Norton, Maximum Power Transfer	Analyze and solve different dc network problems using all mentioned theorems	Lecture	[1101.1]	Home Assignment Class Quiz Mid Term Exam
T4-T5	L8-L11	Numerical problems based on L8-L11	Tutorial	[1101.1]	Mid Term Exam
L12	Capacitor, Series & Parallel connections, Charging & Discharging, Energy stored	Recall series and parallel connection of capacitors and energy stored	Lecture	[1101.2]	Class Quiz
L13	Inductor, Series & parallel connections, Growth & Decay of current in inductive circuit, Energy Stored	Recall series and parallel connection of inductors and energy stored	Lecture	[1101.2]	Class Quiz
T6	L12 – L13	Numerical problems based on L12-L13	Tutorial	[1101.2]	Class Quiz
L14– L15	Magnetic circuits, Terminologies, Analysis of series and parallel circuits	Recall the concept of magnetic circuits and their configurations	Lecture	[1101.2]	Class Quiz
L16	Review of Electromagnetism, Electromagnetic Induction, Fleming's left & right hand rules, Lenz's Law	Recall the Fleming's rule, Lenz's law, Faraday's law and review the concept of Electromagnetism	Lecture	[1101.2]	Class Quiz
L17– L18	Induced emf in a conductor & coil, Mutual Inductance, Coupling Coefficient and dot rule	Describe the concept of emf induced in coil, dot rule and Coupling Coefficient	Lecture	[1101.2]	Class Quiz
T7-T8	L14– L18	Numerical problems based on L14-L18	Tutorial		Class Quiz
L19-L20	Single phase circuits: Generation, Emf induced, Average value, RMS value, Peak factor, Form factor	Describe the concept of generation of ac voltage and waveform analysis	Lecture	[1101.3]	Class Quiz

L21 – L24	Phasors, Analysis of pure R, L, C, Series RL, RC and RLC circuits, Impedance, Power, Power factor	Describe the phasor operations and calculation of different quantities pertaining to different combinations of series ac circuits	Lecture	[1101.3]	Mid Term Exam
L25-L26	Analysis of Parallel RL, RC and RLC circuits	Analyze and calculate different quantities pertaining to parallel ac circuits	Lecture	[1101.3]	Mid Term Exam
T9-T10	L19 – L26	Numerical problems based on L19-L26	Tutorial	[1101.3]	Mid Term Exam
L27 – L28	Series & Parallel Resonance, Resonant frequency, Voltage & Current magnification	Recall and examine the series and parallel resonance phenomenon	Lecture	[1101.3]	Class Quiz
T11	L27– L28	Numerical problems based on L27-L28	Tutorial	[1101.3]	Class Quiz
L29-L30	Three phase ac circuits, Advantages, Types of connections, Voltage & Currents, Line & Phase values	Identify and analyse different types of Three phase ac circuits	Lecture	[1101.3]	Class Quiz
L31-L32	Analysis of balanced 3 wire & 4 wire star and delta connected systems, Phasor diagrams	Analyze three phase balanced star and delta connected systems	Lecture	[1101.3]	Mid Term Exam
L33	Measurement of three phase power by two wattmeter method	Examine two wattmeter method for three phase power Measurement	Lecture	[1101.3]	Mid Term Exam
T12-T13	L29 – L33	Numerical problems based on L29-L33	Tutorial	[1101.3]	Class Quiz
L34	Single phase transformer: Introduction, types, Construction, Operating principle, Emf equation	Recall and analyse operating principle of Single phase transformer and their types	Lecture	[1101.4]	Class Quiz
L35 – L36	Ideal & practical transformer, Losses and Efficiency, Voltage regulation	Compare the ideal and practical transformer and analyse different performance parameters	Lecture	[1101.4]	Mid Term Exam
T14	L34 – L36	Numerical problems based on L34-L36	Tutorial	[1101.4]	Class Quiz
L37 - L38	Introduction of single and three phase induction motors	Describe the operating principle of single and three phase induction motors	Lecture	[1101.5]	Class Quiz
L39-L40	DC Machine: Introduction, Construction, Types	Describe the construction and operating principle of DC machine	Lecture	[1101.5]	Class Quiz
L41-L42	Fundamentals of Electrical Measuring Instruments	Describe the construction and operating principle of different Measuring Instruments	Lecture	[1101.5]	Class Quiz

C. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EE 1101.1	Develop circuit designing skills through general insight of circuit laws and theorems.	3	2										2			
EE 1101.2	Analyze and illustrate the comparison between linear electric & magnetic circuits.	2	1										2			
EE 1101.3	Identify and evaluate different configurations of single phase & three phase ac circuits.	1	2										3			
EE 1101.4	Understand the construction and operating principle of transformer and evaluate efficiency.	2	2	1			1	1					2			
EE 1101.5	Illustrate the basic operating principles of DC & Induction motors and fundamental measuring Instruments.						1	1								

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

D. Course Outcome Attainment Level Matrix:

CO	STATEMENT	ATTAINMENT OF PROGRAM OUTCOMES **THRESHOLD VALUE: 40%**											ATTAINMENT OF PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
EE 1101.1	Develop circuit designing skills through general insight of circuit laws and theorems.	3	2										2	3		
EE 1101.2	Analyze and illustrate the comparison between linear electric & magnetic circuits.	2	1										2	1		
EE 1101.3	Identify and evaluate different configurations of single phase & three phase ac circuits.	1	2										3	3	1	
EE 1101.4	Understand the construction and operating principle of transformer and evaluate efficiency.	2	2	1			1	1					2	1	2	
EE 1101.5	Illustrate the basic operating principles of DC & Induction motors and fundamental measuring Instruments.						1	1						1		

0-No Attainment; 1- Low Attainment; 2- Moderate Attainment; 3- Substantial Attainment

MANIPAL UNIVERSITY JAIPUR

School of Computing and Information Technology

First Year B. Tech.

Programming in C | CS 1101 | 4 Credits | 2 1 2 4

Session: January 2019 – May 2019 | Faculty: Dr. Manoj Kumar Sharma | Class: First Year B. Tech. II Semester

A. Introduction:

The main objective of this course is for students to be aware with basic computer fundamentals, number systems and to enhance problem solving and logic design skills through writing set of instructions to solve a real world problem through C programming. Students will spend a significant time on each topic to understand their essential requirements and to use them differently with distinct programmable problems.

B. Course Outcomes (Cos): At the end of the course, students will be able to

[CS1101.1]: Described a deep knowledge of computer for better understanding of devices, basic fundamental of computer comprises in this course.

[CS1101.2]: Design flow chart, Write algorithm and pseudo code parallel with Control Statements to understand flow of program execution.

[CS1101.3]: Understand bitwise operations and conversion of numbers in different representations through Number System.

[CS1101.4]: Developing skills in students to learn memory oriented operation using pointers and understating programming skills by Array, Structure, Union, Enum and String are added.

[CS1101.5]: Students learned the concept of re-usability by means of functions in C and to illustrate the concept of data base using file handling.

C. Program Outcomes and Program Specific Outcomes

[PO.1]. Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems

[PO.2]. Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations

[PO.6]. Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	15
	Sessional Exam II (Close Book)	15
	In class Quizzes and/or Assignments , Activity feedbacks (Accumulated and Averaged)	10
End Term Exam (Summative)	End Term Exam (Open Handwritten Notes)	40
Lab	Practical Lab	20
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

CS1101 PROGRAMMING IN C

Computer Fundamentals: The von Neumann Architecture, flowcharts and algorithms, operating system fundamentals (Linux), programs, assembly language, high level programming languages;

Number System: Binary, decimal, octal, hexadecimal.

C Programming: Data types, variables, operators, expressions, statements, control structures, functions, recursion, arrays and pointers, records (structures), files, input/output, standard library functions and elementary data structures.

A. TEXT BOOKS

1. E. Balagurusamy, "Computer Fundamentals & C Programming", TMH, 2008.
2. Y. P. Kanetkar, "Let us C", 12th Edition, BPB Publication, 2014.

B. REFERENCE BOOKS

1. B. W. Kernighan, D. M. Ritchie, "The C Programing Language", 2nd Edition, Prentice Hall of India, 1988.
2. B. Gottfired, "Schaum's Outline Series: Programming with C", 3rd Edition, McGraw Hill Publication, 2004.

F. Lecture Plan

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1.	Awareness with course objectives, outcomes and applications	Basic Terminology, Flow Chart Designing, Algorithm Writing Styles, Applications of an Algorithm	Practical Applications, Real world problems	[1101.1]	Mid Term - I End Term
2.	The von Neumann Architecture		Lecture	[1101.1]	Mid Term - I End Term
3.	Flowcharts and algorithms		Lecture & Activity	[1101.1]	Mid Term - I End Term
4.			Lecture	[1101.1]	Mid Term - I End Term
5.	Operating system fundamentals (Linux)	Basic terminology, examples and commands	Lecture & Problem Solving Practice	[1101.1]	Mid Term - I End Term
6.					
7.	Programs, assembly language, high level programming languages;	Discussion, examples and facts	Lecture & Problem Solving Practice	[1101.1]	Mid Term - I End Term
8.					
9.	Data types	Concept discussion, programming examples	Lecture &	[1101.2]	Mid Term - I End Term

10.	Variables		Problem Solving Practice	[1101.2]	Mid Term - I End Term
11.	Operators			[1101.2]	Mid Term - I End Term
12.	Expressions	Concept discussion, programming examples	Lecture & Problem Solving Practice	[1101.2]	Mid Term - II End Term
13.	Statements		Lecture & Problem Solving Practice	[1101.2]	Mid Term - II End Term
14. 15. 16. 17. 18. 19.	**Number System:** Binary, decimal, octal, hexadecimal	Concept discussion, number system conversion, programming examples	Lecture & Problem Solving Practice	[1101.3]	Mid Term - I End Term
20. 21. 22.	Control structures	Concept discussion, programming examples	Lecture & Problem Solving Practice	[1101.4]	Mid Term - II End Term
23. 24. 25.	Functions	Function writing, parameter passing, types of functions and their flexible use	Lecture & Problem Solving Practice	[1101.4]	Mid Term - II End Term
26. 27. 28.	Recursion, arrays	Recursive functions and parameter passing, array defining and use	Lecture & Problem Solving Practice	[1101.4]	Mid Term - II End Term
29. 30. 31. 32.	Pointers	Dynamic use of memory address, pointer as array, function argument passing through pointers etc.	Lecture & Problem Solving Practice	[1101.4]	Mid Term - II End Term
33. 34. 35. 36.	Records (structures), files, input/output,	Data file creation, different types of file operations etc.	Lecture & Problem Solving Practice	[1101.4]	Mid Term - II End Term
37. 38. 39. 40. 41. 42.	Standard library functions and elementary data structures	Exploration of inbuilt library functions, user define data structures	Lecture & Problem Solving Practice	[1101.4]	Mid Term - II End Term

G. Course Articulation Matrix (Mapping of COs with POs and PSOs) for Data Communications:

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	PSO4
1101.1	Described a deep knowledge of computer for better understanding of devices, basic fundamental of computer comprises in this course.	3	3							1	2		1				
1101.2	Design flow chart, Write algorithm and pseudo code parallel with Control Statements to understand flow of program execution.	2	2	1		1				1	1						
1101.3	Understand bitwise operations and conversion of numbers in different representations through Number System.	3	2	1							1						
1101.4	Developing skills in students to learn memory oriented operation using pointers and understating programming skills by Array, Structure, Union, Enum and String are added.	2	3	3						1	2	2	2				
1101.5	Students learned the concept of re-usability by means of functions in C and to illustrate the concept of data base using file handling.	2		2				1	1				1				

1- Low Correlation : 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Automobile Mechanical and Mechatronics Engineering

Department of Mechanical Engineering
Course Hand-out

Engineering Thermodynamics| ES 1103 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty | Class: Ist Year

A. Introduction: Thermodynamics is a basic science that deals with equilibrium, energy and its transformation, and the laws governing such transformation. These laws are of wide applicability and are used in several branches of engineering and science. Principles and concepts of thermodynamics are important and indispensable tools in the innovation, design, development and improvement of engineering process, equipment and devices which deal with effective utilization of energy. Notable applications of engineering thermodynamics in the field of energy technology are:

power producing devices, e.g., internal combustion engines and gas turbines, steam and nuclear power plant, power consuming devices, e.g., fans, blowers and compressors, refrigeration and air conditioning plants, chemical process plant and direct energy conversion devices. It is essential that every engineer should have a thorough knowledge of thermodynamics and hence thermodynamics has been an essential part of engineering curricula all over the world.

B. Course Outcomes: At the end of the course, students will be able to

[ES1103.1] Understand the fundamental concepts of thermodynamics such as temperature, pressure, system, properties, process, state, cycles and equilibrium in the context of engineering applications.

[ES1103.2] Apply first law of thermodynamics on flow and non-flow processes.

[ES1103.3] Design and analyse the concept of components (compressor, turbine, pump, etc.) with the use of thermodynamic law.

[ES1103.4] Analyse the concept of second law and entropy in the context of thermal applications.

[ES1103.5] Apply the concept of first & second law of thermodynamics to design/utilize the power generating and power consuming devices.

C. Program Outcomes and Program Specific Outcomes

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

[PO.2]. **Problem Analysis:** Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

[PO.3]. Design/ Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal and environmental considerations.

[PO.4]. **Conduct investigations** of complex problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data and synthesis of information to provide valid conclusions.

[PO.5]. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities with an under- standing of the limitations.

[PO.6]. **The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice.

[PO.7]. **Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

[PO.8]. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

[PO.9]. **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions**.**

[PO.11]. Project Management and Finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to owners own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. Life-long Learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	Quizzes (Open Book/Close Book) and Assignments	30
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. A student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Definitions & Concepts: SI Units; System, Thermodynamic Properties of Fluids: Mathematical, Tabular and Graphical representation of data; Ideal gas Van der Waals Equation of state; Compressibility chart; Thermodynamic Diagrams including Mollier diagram; Steam Tables. Zeroth Law of thermodynamics: temperature scale. First Law of Thermodynamics: Applications to Non flow processes, Applications of First Law of Thermodynamics of Flow Processes – Steady State / Transient; Applications of First Law of Thermodynamics to Chemically Reacting Systems. Second Law of Thermodynamics: Applications. Thermodynamic Relations: Thermodynamic Potentials, Maxwell's Relations; Availability. Power Cycles and Refrigeration Cycles, Gas-Vapor Mixtures and Psychrometry.

F. Text Book:

T1. An Introduction to Thermodynamics, YVC Rao, Universities Press (India) Private Limited, Revised Edition, 2004.

G. Reference Book:

R1. Thermodynamics: An Engineering Approach, Y.A. Cengel and M.A. Boles, McGraw Hill (Fifth Edition), 2006.

H. Lecture Plan:

Lec No	**Topics**	**Session Objective**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction to Thermodynamics	Know the basics of the course and understand its applications	Lecture	ES1103.1	Home Assignment and Class Quiz Mid-Term I End-Term
2	Concepts and Definitions- System, Surroundings, Intensive and Extensive Properties, Energy, Equilibrium	Discuss the terms system and surroundings, thermodynamic properties and describe their use	Lecture	ES1103.1	
3	Equilibrium, Stability, Process, Work	Understand the criteria of thermal equilibrium, mechanical equilibrium and chemical equilibrium	Lecture	ES1103.1	
4	Work, Definition of Thermodynamics, Modes of work, Heat	Brief about the thermodynamics definition of work, distinguish between heat and work and identify their effects	Lecture	ES1103.1	Home Assignment and Class Quiz Mid-Term I End-Term
5	Thermodynamic Properties of Fluids- Concepts of phases, Equations of state	Understand a pure substance and a phase and phase transformation	Lecture	ES1103.1	
6	Ideal gas, van der Waals equation, Critical constants	Understand the concept of ideal gas and van der Walls equation of state	Lecture	ES1103.1	
7	Other equations of state, Compressibility chart, Reduced equation of state, Generalized compressibility chart	Use of compressibility chart and generalized compressibility chart and its applications	Lecture	ES1103.1	Home Assignment and Class Quiz Mid-Term I End-Term
8	Graphical representation of data – T-V diagram, P-V diagram, P-T diagram, Mollier diagram	Understand various thermodynamic diagrams like T-v, P-v, P-T, and Mollier diagram	Lecture/Activity	ES1103.1	
9	Tabular representation of data, Steam table	Estimating the properties of steam using steam tables.	Lecture/Activity	ES1103.1	
10	Zeroth law of thermodynamics, First law of thermodynamics-History	Understand the Zeroth law of thermodynamics	Lecture	ES1103.1 ES1103.2	Home Assignment and Class Quiz Mid-Term I End-Term
11	First law of thermodynamics, Consequences, Analysis of elementary processes	Know the genesis of the first law of thermodynamics	Lecture	ES1103.2	
12	Analysis of elementary	Apply the first law of	Lecture	ES1103.1	

	processes, Isothermal processes, Adiabatic processes, Polytropic processes	thermodynamics to analyse different thermodynamics process		ES1103.2	
13	Constant internal energy processes	Apply the first law of thermodynamics to analyse constant internal energy process	Lecture	ES1103.1 ES1103.2	Home Assignment and Class Quiz Mid-Term I End-Term
14	First law analysis of processes – Control mass analysis, Control volume analysis	Explain the control mass and control volume analysis	Lecture	ES1103.2 ES1103.3	
15	Applications of steady state flow processes, Throttling process, Applications of throttling	Analyse the steady flow processes and its applications	Lecture	ES1103.2 ES1103.3	
16	Transient flow processes, Case of an ideal gas	Analyse the transient flow processes.	Lecture	ES1103.1 ES1103.2 ES1103.3	Home Assignment and Class Quiz Mid-Term II End-Term
17 & 18	Second law of thermodynamics- Heat engine, Heat pump or refrigerator, Second law of thermodynamics	Understand the concept of second law and its requirement	Lecture/Lab Visit	ES1103.4	
19	Kelvin, Plank, and Clausius statement, Reversible and Irreversible reactions, Criteria for irreversible processes	Understand the statements of second law of thermodynamics and also discuss the criteria for irreversible process	Lecture	ES1103.4	
20	Carnot cycle, Carnot theorem, Thermodynamic temperature scale	Understand the Carnot cycle and its use in thermodynamics	Lecture	ES1103.4	Home Assignment and Class Quiz Mid-Term II End-Term
21	Clausius inequality, Entropy, Calculation of entropy change	State the Clausius inequality and calculate the entropy change of the system	Lecture	ES1103.4	
22	Principles of entropy increase, Temperature-entropy diagram	Understand the principles of entropy increase and its reason	Lecture	ES1103.4	
23	Available energy, Loss in available energy,	Define the available and unavailable energy through the concept of second law	Lecture	ES1103.4	Home Assignment and Class Quiz Mid-Term II End-Term
24	Availability and Irreversibility	Estimate the loss in available energy in a given process	Lecture	ES1103.4	
25	Thermodynamic relations- Maxwell's relations, Mnemonic diagram, Thermodynamic potentials	Understand the importance the Maxwell's relations	Lecture	ES1103.3 ES1103.4	

26	Thermodynamic potentials, Mathematical preliminaries, Entropy relations	Know the thermodynamic potentials	Self-Study	ES1103.3 ES1103.4	Home Assignment and Class Quiz Mid-Term II End-Term
27	Joule-Thompson coefficient, Clapyeron equation, Gibb's phase rule	Understand the Joule-Thompson coefficient, Clapyeron equation, Gibb's phase rule	Lecture	ES1103.3 ES1103.4	
28	Power and Refrigeration cycles-Classification, Vapor power cycles, Carnot vapor power cycle,	Classify the power cycles into vapour cycles and gas power cycles	Lecture	ES1103.1 ES1103.3 ES1103.5	Home Assignment and Class Quiz End-Term
29	Ideal Rankine cycle and practical Rankine cycle	Explain the basics of Rankine cycle and estimate the thermal efficiency of an Ideal and actual Rankine cycle	Lecture	ES1103.1 ES1103.3 ES1103.5	
30 & 31	Gas power cycles, Otto cycle, Diesel cycle	Analyse the Otto and diesel cycle	Lecture/Lab Visit	ES1103.1 ES1103.3 ES1103.5	
32	Comparison of Otto and Diesel cycle, Air standard dual cycle	Analyse the differences in Otto, Diesel and dual cycle	Lecture	ES1103.1 ES1103.3 ES1103.5	Home Assignment and Class Quiz End-Term
33	Ideal and Actual Brayton cycle	Analyse air standard Brayton cycle	Lecture	ES1103.1 ES1103.3 ES1103.5	
34 & 35	Refrigeration cycle, Vapor compression refrigeration cycle	Understand the practical refrigeration cycle and its components	Lecture/Lab Visit	ES1103.1 ES1103.3 ES1103.5	
36	Refrigerants, Gas refrigeration cycle	Know the criteria in selection of refrigerants and their use	Self-study	ES1103.1 ES1103.3 ES1103.5	Home Assignment and Class Quiz End-Term
37	Gas vapor mixtures and Psychrometry, ideal gas mixtures	Predict the properties of an ideal gas mixture from knowledge of the properties of the constituent species	Lecture	ES1103.1 ES1103.2 ES1103.5	
38	Psychrometer, Psychrometric chart	Use the psychrometric charts in the analysis of process of dealing with air-water vapour mixtures	Activity	ES1103.1 ES1103.5	

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
ES1103.1	Understand the fundamental concepts of thermodynamics such as temperature, pressure, system, properties, process, state, cycles and equilibrium in the context of engineering applications.	3													1	
ES1103.2	Apply first law of thermodynamics on flow and non-flow processes.	3	2													
ES1103.3	Design and analyse the concept of components (compressor, turbine, pump, etc.) with the use of thermodynamic law.	3		3	2										1	
ES1103.4	Analyse the concept of second law and entropy in the context of thermal applications	3	2	3	2		2	2							1	
ES1103.5	Apply the concept of first & second law of thermodynamics to design/utilize the power generating and power consuming devices.	3	3	3			2	2							1	

MANIPAL UNIVERSITY JAIPUR

B.Tech 1st Year

Course Hand-out

History of Indian Science & Technology | HS1102| 2 Credits | 2 0 0 2

Session: JAN-MAY 2019 | Faculty Coordinator- Dr Arun Kumar Poonia| Class: B.Tech 1st Year

Introduction: The course is designed to enable students to know and to develop an understanding about the history of Indian science & technology and the contribution of India in the field of science & technology.

A. Course Objectives: At the end of the course, students will be able to

HS1102.1 Identify the contribution of India in the field of science and technology.

HS1102.2 Understand the contribution of ancient Indians in the field of science and technology for answering general knowledge questions during interviews for future employment

HS1102.3 Analyse ancient Indian education system and reasons for its going into oblivion.

HS1102.4 Examine the growth of Indian science and technology in the 20th century A.D.

B. Program Outcomes

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

D. Assessment Rubrics:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I	15
	Sessional Exam II	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

An introduction and need to learn History of Indian science and technology; Early civilizations and their impact on development of science and technology; Contribution of Indian science and technology in the fields of mathematics, astronomy, medical science, architecture, metallurgy, agriculture, yoga; Discoveries and inventions; Indian education system; Possible reasons of oblivion; Effect of historical developments (pre and post-independence era), Policy measures; Case studies.

F. TEXT BOOKS

1. Lecture notes

G. REFERENCE BOOKS

1. Indian Science and Technology in Eighteenth century, Dharampal, reprint of first edition (1983), Academy of Gandhian Studies, Hyderabad.

2. The Beautiful Tree: Indigenous Indian Education in the Eighteenth century, Dharampal, second edition (1995) Keerthi Publishing house, Coimbatore

3. India's Glorious Scientific Tradition, Suresh Soni, first edition (2008) Prabhat Prakashan

H. Lecture Plan:

Lecture No	**Topics**	**Session Objective**	**Mode of Delivery**	**Corresponding CO**	**Mode of Assessing the Outcome**
1	Introduction to the subject	To acquaint and clear teacher's expectations and understand students' expectations.	Lecture, Discussion	1102.1	Quizzes, 1st Sessional, End Term Examination
2	Why History to Engineers?	To ascertain the interest and the understanding of the students with focus on the need of this subject for them and its connection with the existing knowledge.	Lecture, Discussion	1102.1	Quizzes, 1st Sessional, End Term Examination
3	A Brief overview of India's contribution in Various Fields of Studies- I	To know about the scientific developments of the period. To know about the concepts of science, maths, technology, etc. used in the ancient times. To know about the major works of ancient Indians in the field of Science and Maths.	Discussion, Video	1102.1	Quizzes, 1st Sessional, End Term Examination
4	A Brief overview of India's contribution in Various Fields of Studies – II	To know about the scientific developments of the period. To know about the concepts of science, maths, technology, medicine, surgery, language, etc. in the ancient times. To know about the major works of ancient Indians in various fields of studies.	Lecture, PPT, Discussion	1102.1	Quizzes, 1st Sessional, End Term Examination
5	Ancient Civilizations and Science & Technology- With focus on Indus Valley Civilization	To know about the development and extent of Indus Valley Civilization. To know about the use of concepts of science & technology in Indus Valley Civilization.	PPT, Videos	1102.1	Quizzes, 1st Sessional, End Term Examination

6	Detailed Study about some aspects of Indus Valley Civilization	To know about the town planning/buildings/structures of Indus Valley Civilization. To know and study in detail about the city of Lothal and Harappa.	Lecture, PPT, Discussion	1102.2	Quizzes, 1st Sessional, End Term Examination
7	Ancient Indian Education System-1	To know about the educational system of ancient India. To know about the major fields of studies.	Lecture, PPT	1102.3	Quizzes, 1st Sessional, End Term Examination
8	Ancient Indian Education System-2	To know more about the educational system of ancient India. To know about the major fields of studies.	Discussion	1102.3	Quizzes, 1st Sessional, End Term Examination
9	Our ancient Universities- Nalanda and Takshila	To know about the educational system followed at these Universities and the scholars of those times. To know about the major fields of studies offered in these Universities.	PPT, Video	1102.3	Quizzes, 1st Sessional, End Term Examination
10	Probable Reasons for oblivion	To know about the probable reasons that led to the decline/fall of Indian education system.	Discussion	1102.3	Quizzes, 1st Sessional, End Term Examination
11	Contribution of India in the field of mathematics- 1	Significant contributions and achievements of ancient Indian mathematicians in comparison to the rest of the world.	Videos, PPTs	1102.2	Quizzes, 2 Sessional, End Term Examination
12	Contribution of India in the field of mathematics- 2	Significant contributions and achievements of ancient Indian mathematicians in comparison to the rest of the world.	Discussion	1102.2	Quizzes, 2 Sessional, End Term Examination
13	Contribution of India in the field of Astronomy- 1	Significant contributions and achievements of ancient Indian in the field of astronomy.	Videos, PPTs	1102.1	Quizzes, 2 Sessional, End Term Examination
14	Contribution of India in the field of Astronomy- 2	Significant contributions and achievements of ancient Indian in the field of astronomy.	Discussion	1102.1	Quizzes, 2 Sessional, End Term Examination

15	Contribution of India in the field of Architecture- 1	To look into the architectural heritage of India.	Videos and PPTs	1102.2	Quizzes, 2 Sessional, End Term Examination
16	Contribution of India in the field of Architecture- 2	To look into the architectural heritage of India.	Discussion	1102.2	Quizzes, 2 Sessional, End Term Examination
17	Contribution of India in the field of Metallurgy- 1	Significant contributions and achievements of ancient Indian metallurgists in comparison to the rest of the world.	Lecture	1102.1	Quizzes, 2 Sessional, End Term Examination
18	Contribution of India in the field of Metallurgy- 2, with special reference about Wootz steel.	A discussion on pioneering steel alloy matrix developed in India called Wootz steel and achievements of India in Zinc smelting by distillation process, first in the world	Lecture	1102.1	Quizzes, 2 Sessional, End Term Examination
19	Contribution of India in the field of Yoga and medicine- 1	Contribution of Indian scientists in plastic surgery and cataract surgery with reference to Sushruta Samhita, Jabamukhi Salaka etc.,	Lecture	1102.2	Quizzes, End Term Examination
20	Contribution of India in the field of Yoga and medicine- 2	Discussion on father of Indian medicine, Charkha and his contributions to ancient science of Ayurveda (Charakhasamhita)	Lecture	1102.2	Quizzes, End Term Examination
21	Indian Science & Technology in 20th Century- Major achievements	Major developments and achievements by indian scientists and researchers.	Lecture	1102.1, 1102.4	Quizzes, End Term Examination
22	Indian Science & Technology in 20th Century- Institutionalization of science	To understand the establishment of the scientific and technological institutes and the gradual proliferation of the scientific bodies and societies.	Lecture	1102.4	Quizzes, End Term Examination
23	Indian Science & Technology after Independence- Scientific internationalism and the Institute that Bhabha built	Understand the robust internationalism and mapping out colonial structures and institutional history of the Tata Institute of Fundamental Research.	Lecture	1102.4	Quizzes, End Term Examination
24	Indian Science & Technology after Independence- Biotechnology in India	Realising the adoption of modern biology and biotechnology including early phase	Lecture	1102.4	Quizzes, End Term Examination

		of Department of Biotechnology (DBT), established in 1986.			
25	Case Study- Jantar-Mantar (Jaipur)			1102.2	End Term Examination
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I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	Correlation with Program Outcomes (POs)											
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
HS1102.1	Identify the contribution of India in the field of science and technology.	2	-	-	-	2	2	-	-	-	-	-	1
HS1102.2	Understand the contribution of ancient Indians in the field of science and technology.	2	-	-	-	2	1	-	-	-	-	-	-
HS1102.3	Analyse ancient Indian education system and reasons for its going into oblivion.	2	-	2	-	-	1	-	-	-	-	-	-
HS1102.4	Examine the growth of Indian science and technology in the 20th century A.D.	1	2	-	-	-	1	-	-	-	-	-	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Humanities and Social Sciences

DEPARTMENT OF LANGUAGES

Course Hand-out

TECHNCAL COMMUNICATION | EN1111 | 3 Credits | 2 1 0 3

Session: Jan 19 – May 19 | Faculty: Dr Richa Arora | Class: B. TECH. I YEAR

A. Introduction: This course is offered by Department of Languages as a compulsory course to the students of B.Tech in I and II Semester. The course offers in-depth knowledge of fundamental principles of effective communication skills. The course aims to develop critical and creative thinking abilities for communicative competence. It aims to organize and express ideas clearly in speech.

B. Course Outcomes: At the end of the course, students will be able to-

[1111.1] Review communication as a process with greater awareness

[1111.2] Display enhanced competence in oral and written communication

[1111.3] Use appropriate communication skills in specific contexts and for specific purposes

[1111.4] Demonstrate meaningful group communication exchanges

[1111.5] Frame questions to elicit the desired response and respond appropriately to questions which will lead them towards employability.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science, and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions**: Design a component, system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	15
	Sessional Exam II (Open Book)	15
	In class Quizzes	30
End Term Exam (Summative)	End Term Exam (Open Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work at home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Communication and Communication Skills (LSRW)- Definition, Process, Features, Types, Barriers, Verbal and Non-verbal communication, General and Technical communication; **Applied Grammar and Usage-** Subject-Verb

agreement, Common errors and misappropriations in English, Voice, Determiners, Modals, Jumbled up sentences; **Listening Comprehension**- Hearing and Listening, Types of Listening, Barriers to effective listening, Comprehending conversations and lectures. Role of pronunciation, accent, intonation and voice modulation; **Reading Comprehension**- Skimming and Scanning, Lexical and contextual meaning, Advanced Vocabulary; **Writing Skills**- Précis, Technical reports, Formal letters and Emails, Job Applications - Resumes and Covering Letters, Content writing (for brochures and websites), Bio-Sketch and Statement of Purpose (SoP); **Using Communication Effectively-** Presentations, Group Discussions and Mock interviews; **Case Studies on Communication** (Two/Semester)

F. Reference Books

1. C Tickoo and J Sasikumar. *Writing with a Purpose.* New Delhi: Oxford University Press, 2000.
2. D Green. *Contemporary English Grammar, Structures and Composition*. Delhi: Macmillan Publications, 2000.
3. D Jones. *English Pronouncing Dictionary*. London: ELBS, 2003.
4. L Bauer. *An Introduction to International Varieties of English*. Edinburgh: Edinburgh University Press, 2002.
5. M M McCarthy. *English Idioms in Use*. London: Cambridge University Press, 2002.
6. M Raman and S Sharma. *Technical Communication: Principles and Practice 2/e*. New Delhi: Oxford University Press, 2013.
7. N D Burton and J B Heaton. *Longman Dictionary of Common Errors*. Harlow: Longman, 1998.
8. N Ezekiel. *Collected Poems*. New Delhi: OUP, 2006.
9. N Krishnaswamy. *Modern English: A Book of Grammar Usage and Composition*. Delhi: Macmillan India, 2000.
10. R Parthasarthy (ed.). *Ten Twentieth Century Indian Poets*. New Delhi: OUP, 2009.
11. S Mishra and C Muralikrishna. *Communication Skills for Engineers*. New Delhi: Pearson Education, 2010.

F. Lecture Plan:

DAY	TOPICS	Programme objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
Day 1	Introduction to Communication Skills- LSRW; Definition and process of Communication	Communicate Effectively & Life long learning	Lecture, PPT, Discussion	1111.1	Quizzes, 2 Sessional, End Term Examination
Day 2	Types of Communication features of Communication;	Communicate Effectively& Lifelong learning	Lecture, PPT, Discussion	1111.1	Quizzes, 2 Sessional, End Term Examination
Day 3	Barriers to Communication	Communicate Effectively& Lifelong learning	Lecture, PPT, Discussion	1111.1	Quizzes, 2 Sessional, End Term Examination
Day 4	Verbal and Non-verbal communication	Communicate Effectively& Lifelong learning	Lecture, PPT, Discussion	1111.1	Quizzes, 2 Sessional, End Term Examination
Day 5-6	Difference between General and Technical communication; Revision and Recapitulation of Communication Theory with practical specimens	Communicate Effectively& Lifelong learning	Lecture, PPT, Discussion and problem solving	1111.3	Quizzes, 2 Sessional, End Term Examination

Day 6	Introduction to the basics of English Grammar; Subject-Verb Agreement	Communicate Effectively& Lifelong learning	Lecture, PPT,	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 7	Common errors and misappropriations in English	Communicate Effectively& Lifelong learning	Lecture	1111.4	Quizzes, 2 Sessional, End Term Examination
Day 8	Change of Voice	Communicate Effectively& Lifelong learning	Lecture, PPT, Discussion, Exercise	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 9	Determiners and Modals	Communicate Effectively& Lifelong learning	Lecture, PPT, Exercise	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 10-12	Jumbled up sentences and Grammar Practice	Communicate Effectively& Lifelong learning	Lecture, PPT, Exercise	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 13	Distinction between hearing and listening; Types of Listening	Communicate Effectively& Lifelong learning	Exercise	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 14	Barriers to effective listening	Communicate Effectively& Lifelong learning	Lecture, PPT, Exercise with audio files	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 15	Skills to comprehend conversations and lectures	Communicate Effectively& Lifelong learning	Lecture, PPT, Discussion	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 16-18	Role of pronunciation, accent, intonation and voice modulation	Communicate Effectively& Lifelong learning	Videos	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 19-20	Practical specimens of correct pronunciation, accent, intonation and voice modulation	Communicate Effectively& Lifelong learning	Practice with video files	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 21	Reading Comprehension- An Introduction	Communicate Effectively& Lifelong learning	Lecture, PPT	1111.2,	Quizzes, 2 Sessional, End Term Examination
Day 22	Skimming and Scanning for Reading Comprehension	Communicate Effectively&	Lecture, PPT, Practice with texts	1111.2	Quizzes, 2 Sessional, End

		Lifelong learning			Term Examination
Day 23-24	Lexical and Contextual Meaning in Reading Comprehension	Communicate Effectively& Lifelong learning	Lecture, PPT, practice with texts	1111.2	Quizzes, 2 Sessional, End Term Examination
Day 25	Learning Advanced Vocabulary	Communicate Effectively& Lifelong learning	Worksheet & Exercise	1111.3,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 26	Learning profession specific advance vocabulary	Communicate Effectively& Lifelong learning	Worksheet & Exercise	1111.3,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 27	Introduction to Writing Skills	Communicate Effectively& Lifelong learning	Lecture, PPT,	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 28-29	Précis writing- Theory and practice	Communicate Effectively& Lifelong learning	Lecture, PPT, Exercise	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 30-31	Writing of Technical Reports- Theory	Communicate Effectively& Lifelong learning	Lecture, PPT,	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 32	Formal letter writing- Basics and Practice	Communicate Effectively& Lifelong learning	Lecture, PPT, Home Assignments	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 33	Email Writing- Theory, Practice and etiquette	Communicate Effectively& Lifelong learning	Lecture, PPT, GD	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 34	Resume writing- Theory and Practice	Communicate Effectively& Lifelong learning	Lecture, PPT, Exercise	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 35	Job application & Cover letters- Practice	Communicate Effectively& Lifelong learning	Lecture, Exercise	1111.5	Quizzes, 2 Sessional, End Term Examination
Day 36	Content writing for brochures and websites; Writing Biographical Sketch; Writing Statement of Purpose	Communicate Effectively& Lifelong learning	Lecture, PPT, Exercise	1111.3,1111.5	Quizzes, 2 Sessional, End Term Examination

Day 37	Group Discussion- Theory and Types; Practice	Communicate Effectively& Lifelong learning	Exercise	1111.2,1111.4	Quizzes, 2 Sessional, End Term Examination
Day 38-39	Interview Types, Questions and Etiquettes; Mock Interviews	Communicate Effectively& Lifelong learning	PPT, GD	1111.3	Quizzes, 2 Sessional, End Term Examination
Day 40	Analysing Case Study and its Practice	contextual knowledge to assess societal, health, safety, legal, and cultural issues	PPT, GD	1111.2	Quizzes, 2 Sessional, End Term Examination
Day 41	PowerPoint Presentations	Communicate Effectively	PPT, GD	1111.2	Quizzes, 2 Sessional, End Term Examination
Day 42	PowerPoint Presentations	Communicate Effectively	PPT, GD	1111.2	Quizzes, 2 Sessional, End Term Examination

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	Correlation with Program Outcomes (POs)												Correlation with Program Specific Outcomes (PSOs)		
		PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO3**
[1111.1]	**Review communication as a process with greater awareness**	**2**	**3**							**1**	**1**					
[1111.2]	**Display enhanced competence in oral and written communication**									**3**	**3**					
[1111.3]	**Use appropriate communication skills in specific contexts and for specific purposes**		**3**					**2**		**3**	**3**					
[1111.4]	**Demonstrate meaningful group communication exchanges**								**1**	**3**	**2**	**2**				
[1111.5]	**Write well organized self-introduction, CV, Resume etc. as required in profession**			**1**									**3**			

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil & Chemical Engineering (SCCE)

Department of Chemical Engineering

Course Hand-out

Value, Ethics & Governance BB1101 [2 Credits] [2 0 0 2]

Session: July-Nov, 2018 | Faculty: Dr. Anjalee Narayan | Class: B.Tech–Chemical Engg–3rd SEM

Introduction: The course is offered to understand Moral Values and Ethics in personal as well as professional life. It is basic requirement of every human to be a good human being and a good citizen. It further imparts him basics of corporate governance so as to empower him to work technically and professionally in any organization with confidence and conviction and at the same time with honesty & integrity.

A. **Course Objectives:** At the end of the course, students will be able to

BB1101.1	Define the meaning and relevance of Value and Ethics and apply in personal & professional life.
BB1101.2	Describe the importance of three Gunas for self-development, lifelong learning & growth.
BB1101.3	Find issues and identify solutions related to Public & Private Governance systems.
BB1101.4	Explain the relevance of Company's Act 2013 with reference to corporate world.
BB1101.5	Explain the role and key objectives of organizational governance in relation to ethics and law.
BB1101.6	Demonstrate the social & environmental responsibilities of corporate for sustainability, harmony and growth.

B. **Program Outcomes and Program Specific Outcomes**

PROGRAM OUTCOMES

[PO.1]. **Engineering knowledge**: Demonstrate and apply knowledge of Mathematics, Science and Engineering to classical and recent problems of electronic design & communication system.

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design a component system, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environment.

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

PROGRAM SPECIFIC OUTCOMES

[PSO.1]. An ability to understand the concepts of basic Electronics & Communication Engineering and to apply them to various areas like signal processing, VLSI, Embedded systems, Communication Systems, Digital & Analog Devices, etc.

[PSO.2]. An ability to solve complex Electronics Communication Engineering problems, using latest hardware and software tools, along with analytical skills to arrive cost effective and appropriate solutions.

[PSO.3]. Wisdom of social and environmental awareness along with ethical responsibility to have a successful career and to sustain passion and zeal for real applications using optimal resources as an Entrepreneur.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Mid Sem Exam I (Close Book)	15
	Mid Sem Exam II (Close Book)	15
	In class Quizzes/ Assignments Students' Presentations	20(Min 5 each) 10
End Term Exam (Summative)	End Term Exam (Close Book)	40
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	

Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

D: **Syllabus:**

Values: Relevance of Value Education in day-to-day life. Mantra for success - Value, Moral and Ethics. Determinants of human nature (Three Gunas) and its impact on human life.

Relevance of traits like Personality, Attitude, Behaviour, Ego, Character, introspection, Motivation, Leadership and 4 Qs with relevant Case Studies*.

Governance: Understanding of Public and Private sector Governance systems; Courts & CAG.

Public Sector Governance: Need, relevance, stakeholders.

Private Sector Governance: Proprietary, Partnership, Company (Pvt Ltd & Ltd), Company' Act 2013, Board of Directors; its Roles and Responsivities. Regulatory bodies; its role in ethical governance.

Projects on PPP mode-relevance & prospects.

CSR: Relationship with Society, Philanthropy and Business strategy, CSR Policy, Triple Bottom Line

Text / Reference Books:

1. Professional Module of ICSI.
2. Ghosh B.N., Business Ethics & Corporate Governance, McGraw Hill.
3. Mandal S.K., Ethics in Business & Corporate Governance, McGraw Hill .
4. Ray C.K., Corporate Governance, Value & Ethics, Vaya Education of India
5. Chatterjee Abha, Professional Ethics, Oxford Publications.

***Suggestive Case Studies:**

1) Uphar Theatre Tragedy- Engineering Ethics
2) Bhopal Gas Tragedy- Operational Engineering Ethics
3) Satyam Case- Financial Reporting Ethics
4) Enron Case- Business Ethics
5) Neerav Modi Case- Financial Fraudulence *cases*

D. **Lecture Plan:**

Lec No	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	**Introduction: Values:** Meaning & Relevance of value education	To acquaint and clear teacher's expectations and understand student expectations. Basics of Value Education	Lecture	BB 1101.1	In class Quiz Mid Term I End Term Exam
2	Success: Meaning in perspective of morals & ethics	To understand the concept of success achieved with or without morals / ethics/ values	Lecture, case study	BB 1101.1	In class Quiz Mid Term I End Term Exam

3,4	Professional Ethics & ethical dilemmas Case study-Neerav Modi	To understand the role of professional ethics in the life & deal with dilemmas	Lecture	BB 1101.1	In class Quiz, assignment Mid Term I End Term Exam
5	Three Gunas and their relevance, Nature and kinds of value with examples	Understand basic traits in one's personality, its causes and relevance with value based living.	Lecture	BB 1101.2	In Class Quiz, Mid Term I End Term
6,7	Relevance of traits of individual like Personality, Attitude, Behaviour	To acquaint & develop positive traits of personality in oneself	Short stories, Lecture	BB 1101.2	Class Quiz assignment Mid Term I End Term
8.9	Ego, Character, introspection, Motivation	To acquaint & develop positive traits of personality in oneself and understand negative traits	Lecture Short stories	BB 1101.2	In Class Quiz Mid Term I End Term
10,11	Leadership traits & 4Qs (PQ, IQ, EQ, SQ)	To realize importance of leadership and to imbibe in life	Lecture Short stories	BB 1101.2	In Class Quiz assignment Mid Term I End Term
12,13	Governance & its relevance Case studies- Bhopal Gas & Uphar Cinema	To acquaint with the concept of Governance	Lecture	BB 1101.3	In Class Quiz Mid Term II End Term
14	Public Sector Governance: Need, relevance, stakeholders	Understand various aspects of public sector governance	Lecture	BB 1101.3	Class Quiz, Mid Term II End Term
15	Public Finance, Audit & Control	Understand basics of Public Finance, Check & balance	Lecture Case study	BB 1101.3	Class Quiz, assignment Mid Term II End Term
16,17	Private Sector Governance, proprietary & partnership firms and corporate, PPP mode projects	Understand meaning of proprietary & partnership in a firm / company and perspective in PPP mode	Lecture Short stories	BB 1101.3 & 1101.4	Class Quiz Mid Term II End term
18, 19	Company' Act 2013 : Roles & Responsibilities of Directors & regulatory authorities	Explain various Regulations and practices of Corporate Governance internationally & understand key role of directors	Lecture	BB 1101.4	Class Quiz Mid Term II End Term
20,21	Role of Ethics in Governance Case studies- Satyam & Enron	Recognize the necessity of ethics & transparency in Governance	Movie : Gandhi	BB 1101.5	Class Quiz, assignment Mid Term II End Term
22,23	CSR: Relationship with Society, Philanthropy and Business strategy	To understand the relevance of giving back to society by a corporate & its importance in society	Lecture, case study	BB 1101.6	Class Quiz, End Term
24	CSR Policy, Triple Bottom Line	Understand the concept of TBL in organizational frameworks	Lecture case study	BB 1101.6	Class Quiz assignment End Term
25,26	Students' Presentation	Recall contents and their importance through case studies.	Flipped Class	ALL	Class Quiz End Term

Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
BB1101.1	Define the meaning and relevance of Value and Ethics and apply in personal & professional life.						1		2							
BB1101.2	Describe the importance of three Gunas for self-development, lifelong learning & growth.						1		2	1	1		2			1
BB1101.3	Find issues and identify solutions related to Public & Private Governance systems.						1	1		1	2					
BB1101.4	Explain the relevance of Company's Act 2013 with reference to corporate world.						1		1	1						
BB1101.5	Explain the role and key objectives of organizational governance in relation to ethics and law.						1		2	1			1			1
BB1101.6	Demonstrate the social & environmental responsibilities of corporate for sustainability, harmony and growth.						1	3				1	1			3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Engineering Mathematics III | MA1310 | 3 Credits | 3 0 0 3

Session: Aug18 – Dec 18 | Faculty: Dr. Giriraj Methi | Class: Core course

A. INTRODUCTION: Mathematics is the backbone of engineering to develop analytical skills and capacity and to apply their knowledge to a wide range of problems relevant to modern industry. This course is a carefully selected blend of theory and real-world applications which prepares engineers for specialist professional employment.

B. Course Outcomes: At the end of the course, students will be able to

[MA1310.1] Apply knowledge of Laplace Transform, Fourier Transform, Z transform to solve real world problems.
[MA1310.2] Understand and use concept of probability theory and vector calculus in decision making and industry problems
[MA1310.3] Use of tensor and vector calculus to real world systems.
[MA1310.4] Develop analytical and logical thinking.
[MA1310.5] Recall and recognize the application of mathematics in engineering

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	15
	Sessional Exam II (Closed Book)	15
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Vector Calculus: Gradient, divergence and curl, vector integrals, related theorems, introduction of tensors, Laplace Transforms: Transforms of elementary functions, inverse transforms, convolution theorem .Application of Laplace in solutions of differential equations Fourier series, Fourier Transform: Fourier sine and cosine transforms, Fourier integrals, study of heat and wave equations, Z Transform, Bessel and Legendre differential equations, Rodrigues formula, orthogonal properties of Bessel and Legendre polynomials, Problems: Probability, regression, least square principle of curve fitting, distributions – binomial, Poisson, normal.

F. TEXTBOOKS

1. Grewal, B. S., Higher Engineering Mathematics, Khanna Publishers, 2011.
2. Kreyszig, E., Advanced Engineering Mathematics, Wiley Eastern, 2012.

3. Pal and Bhunia, Advanced Engineering Mathematics, Oxford University Press, 2015

G. REFERENCE BOOKS

4. Meyer, P. L., *Introduction to probability and statistical applications*, IBH 2010.

5. Hogg and Craig, *Introduction of Mathematical Statistics*, MacMillan, 2012.

H. LECTURE PLAN

LEC NO	TOPICS	Session outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1-6	Laplace Transforms: Transforms of elementary functions, inverse transforms, convolution theorem .Application of Laplace in solutions of differential equations	Properties and example	Lecture	1310.1	Mid Term-1, End term
6-9	Fourier series,	Solve the problems and basic concept	Lecture + Tutorial	1310.2	Mid Term-1, End term
9-12	Fourier Transform: Fourier sine and cosine transforms, Fourier integrals, study of heat and wave equations,	Solve the problems and basic concept	Lecture + Tutorial	1310.3	Mid Term-1, End term, Assignment-1
12-15	Probability, distributions – binomial, Poisson,	Solve the problems with basic concept	Lecture + Tutorial	1310.3	Mid Term-2, End term, Assignment-2
15-17	Normal Distribution.	Basic concept and related problems on real life problems	Lecture	1310.3	Mid Term-2, End term
17-22	Vector Calculus: Gradient, divergence, and curl,	Basic concept and related problems on real life problems	Lecture + Tutorial	1310.5	Mid Term-2, End term
22-25	vector integrals,	Brief overview of the concept, Solve the problems and basic concept	Lecture	1310.5	Mid Term-2, End term, Assignment-3
25-29	Gauss Divergence Theorem, Stokes Theorem and Green's Theorem	Solve the problems and basic concept	Lecture	1310.4	End term
29-33	Z Transform,		Lecture	1310.4	End term
33-37	regression, least square principle of curve fitting,	Concept and problems related to industries	Lecture	1310.4	End term
37-39	Bessel and Legendre differential equations, Rodrigues formula, orthogonal properties of Bessel and Legendre polynomials,	Solve the problems and basic concept	Lecture	1310.4	End term
39 - 41	introduction of tensors, Tensor analysis	Basic concept and related problems on real life problems	Lecture + Tutorial	1310.4	End term, Assignment-4

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	*PSO1*	*PSO2*	*PSO3*
MA 1310.1	Apply knowledge of Laplace Transform, Fourier Transform, Z -transform to solve real world problems	2	1		1									1		3
MA 1310.2	Understand and use concept of probability theory and vector calculus in decision making and industry problems	2	1		1	2								1		3
MA 1310.3	Use tensor and vector calculus to real world problems	2	1		1	2								1		3
MA 1310.4	Develop analytical and logical thinking		2	1	1	2	1	1	1					2	1	3
MA 1310.5	Recall and recognize the application of mathematics in engineering		1	1	1	2	1	2	1					2	1	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Organic Chemistry | CY1321 | 4 Credits | 3 1 0 4

Session: July'18 – Nov'18 | Faculty: Dr Nitu Bhatnagar | Class: Core course

A. Introduction: This course is offered by the Department of Chemistry as a core course. The purpose of this course is to provide key knowledge base and laboratory resources to prepare students as professionals in the field of chemistry, chemical industry and related fields. This course explains the behaviour of, and interactions between, matter and energy at both atomic and molecular levels.

B. Course Outcomes: At the end of the course, students will be able to:

[CY1321.1]. Understand the wide range of diversity in Organic Chemistry with the help of knowledge of basic organic chemistry along with practical approach.

[CY1321.2]. Explain various processes involved in understanding the mechanism of reactions.

[CY1321.3]. Impart the knowledge of carbohydrates and proteins.

[CY1321.4]. Identify the problems and applications of organic reactions.

[CY1321.5]. Understand stereochemistry of organic compounds and application of the concept in organic synthesis.

[CY1321.6]. Enhance the scientific skills of students for employability.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
[PO.2]. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments, Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Organic Reaction Mechanism: Reaction intermediates, Inductive effect, Mesomeric effect, Electromeric effect, Hyperconjugation, Types of reactions with mechanism-addition, substitution and elimination, Aromatic and Heterocyclic compounds. Industrially Important Organic reactions: Beckmann Rearrangement, Perkin reaction, Hofmann rearrangement, Reamer-Tiemann reaction, Cannizzaro reaction, Skraup synthesis, Diels-Alder reaction, Aldol condensation etc. Stereochemistry: Constitutional isomerism, Geometric isomerism, Syn-anti, Optical isomerism, Configuration- R,S and E,Z Conformation. Carbohydrates: Monosaccharaides, Disaccharides and Polysaccharides, Sources, Structure and Properties of Glucose, Fructose, Sucrose, Lactose, Starch and Cellulose. Amino acids & Proteins: Amino acids, Peptides, Proteins, Nucleic acids, Enzymes Organic Materials of industrial importance: Dyes-classification–modern theory of colour; Synthesis of methyl orange; Congo red, Malachite green, Indigo and Alizarin. Oils-Fats: Saponification value, Iodine and Acid value of oils, Solvent extraction of oils, Hydrogenation of oils, Soaps and Detergents, Petrochemicals.

F. REFERENCE BOOKS

TEXT BOOKS

1. Morrison B.R. and Boyd L.L., Organic Chemistry 6th Edition, ELBS, New Delhi, 2008.
2. Sykes P, A Guidebook to mechanism in Organic Chemistry, Pearson Education, 6th edition, 1986.
3. Finar I.L., Organic Chemistry Vol. I & II, Pearson Education, 6th edition, 2002.

REFERENCE BOOKS

1. Sharma B.K. Industrial Chemistry, 16th edition, 2011.
2. Modern Analytical Chemistry, David Harvey, McGraw Hill, 1999.

G. Lecture Plan:

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture Interaction	-	NA
2	Organic Reaction Mechanism: General Introduction, Classification of organic compounds, Bond Length, Bond Energy	To ascertain the interest and recapitulate the understanding and the existing knowledge about Organic Compounds	Interaction, Discussion & Question Answer Session	CO 1	In Class Quiz (Not Accounted)
3	Reaction intermediates, Inductive effect, Mesomeric effect	To make them understand the different types of effects	Interaction, Discussion	CO 1	1st Sessional
4	Electromeric effect, Hyperconjugation	To make them understand the different types of effects	Interaction, Discussion	CO 1	1st Sessional
5	Types of reactions with mechanism-Substitution Reactions: Nucleophilic substitution (SN1 & SN2)	To acquaint them with the mechanism of nucleophilic substitution reaction	Interaction, Discussion	CO 1 & CO 2	1st Sessional
6	Electrophilic and Free radical reactions	To make them understand the different types of reactions that involve reactive intermediates	Interaction, Discussion	CO 1	1st Sessional
7	Addition Reactions: Electrophilic, Nucleophilic and Free radical reactions	To make them understand the different types of reactions that involve reactive intermediates	Interaction, Discussion	CO 1	Quiz 1st Sessional
8	Elimination: E1 and E2 Mechanism, Rearrangement Reactions	To make them understand the different types of reactions that involve reactive intermediates	Interaction, Discussion	CO 1	1st Sessional
10	Energy Consideration: Free energy, energy profile diagram, transition state and intermediate	To make them understand the reaction mechanism and the energy profile of the intermediates	Interaction, Discussion	CO 1	Home Assignment
11	Reaction Intermediate: Carbocation, Carbanions,	To give them an understanding of reactive intermediates	Interaction, Discussion	CO 1	1st Sessional
12	Free radicals, carbene and benzynes	To give them an understanding of reactive intermediates	Interaction, Discussion	CO 1	1st Sessional
13	Industrially Important Organic reactions: Introduction, Beckmann Rearrangement	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	1st Sessional
14	Hofmann rearrangement, Perkin reaction	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	1st Sessional
15	Reimer-Tiemann reaction	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	1st Sessional
16	Cannizzaro reaction	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	1st Sessional
	MTE-I				
17	Skraup synthesis	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	2nd Sessional

18	Diels-Alder reaction	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	
19	Aldol condensation	To conceptualize the understanding of reaction mechanisms of Industrially important reactions	Interaction, Discussion	CO 1 & CO 2	2nd Sessional
20	Stereochemistry: Introduction, Classification of Stereoisomerism, Molecular Chirality	To make them understand the concept of chirality/stereochemistry	Interaction, Discussion	CO 5 & CO 6	2nd Sessional
21	Constitutional isomerism, Optical Isomerism: optical activity	To make them understand the concept of optical activity	Interaction, Discussion	CO 5	2nd Sessional
22	Diastereoisomers and meso compounds,	To make them understand the concept of diastereomers and meso compounds	Interaction, Discussion	CO 5	Quiz
23	Fisher projection and Flying Wedge Formulae	To make them understand the Fisher projection and Flying Wedge Formulae	Interaction, Discussion	CO 1 & CO 5	2nd Sessional
24	Optical isomerism in Molecules without Chiral Centers	To make them understand the concept of optical isomerism	Interaction, Discussion	CO 5	2nd Sessional
25	Geometric isomerism, Syn-anti, Configuration- R,S and E,Z,	To make them understand the concept of geometrical isomerism	Interaction, Discussion	CO 5	2nd Sessional
26	Conformational Isomerism, Staggered and Eclipsed Conformations, Difference between Configuration and Conformation	To make them understand the concept of conformational isomerism	Interaction, Discussion	CO 5	2nd Sessional
27	Carbohydrates: Introduction, Classification and nomenclature, Monosaccharides	To recapitulate the understanding and the existing knowledge about carbohydrates	Interaction, Discussion Question Answer Session	CO 3	2nd Sessional
28	Mechanism of osazone formation, interconversion of glucose and fructose, chain lengthening and chain shortening of aldoses	To make them understand the mechanism of osazone formation	Interaction, Discussion	CO 3	2nd Sessional
29	Configuration of monosaccharides, Erythro and threo diastereomers	To make them understand configuration	Interaction, Discussion	CO 3	2nd Sessional
30	Conversion of glucose intro mannose, Formation of glcosides, ethers and esters	To make them understand the conversion of glucose	Interaction, Discussion	CO 3	2nd Sessional
31	Determination of ring size of monosaccharides, Cyclic structure of D (+)-glucose	To make them understand the cyclic structure of glucose	Interaction, Discussion	CO 3	2nd Sessional
	MTE-2				
32	Mechanism of mutarotation, Structures of ribose and deoxyribose	To make them understand the concept of mutarotation	Interaction, Discussion	CO 3	ET exam
33	Disaccharides (maltose, sucrose and lactose)	To give them an understanding of disaccharide	Interaction, Discussion	CO 3	ET exam
34	Polysaccharides (starch and cellulose)	To give them an understanding of polysaccharide	Interaction, Discussion	CO 3	ET exam
35	Amino Acids, Peptides, Proteins and Nucleic Acids: Introduction, Classification, structure and stereochemistry of amino acids, Acid-base behaviour isoelectric point and electrophoresis	To acquaint them with the structure and properties of amino acids	Student presentation, Interaction, Discussion	CO 4	ET exam
36	Preparation and reactions of α-amino acids, Structure and nomenclature of peptides and	To acquaint them with the structure and properties of peptides	Student presentation, Interaction, Discussion	CO 4	ET exam

	proteins, Classification of proteins, peptide structure determination				
37	Peptide Synthesis, Structures of peptides and proteins, Levels of protein structure, Protein denaturation/ renaturation,	To acquaint them with the structure and proteins	Student presentation, Interaction, Discussion	CO 4	ET exam
38	Nucleic acids: Introduction, constituents of nucleic acids, Ribonucleosides and ribonucleotides, The double helical structure of DNA	To acquaint them with the structure and properties of nucleic acids	Student presentation, Interaction, Discussion	CO 4	ET exam
39	Enzymes Definition, classification of enzymes with one example, Mechanism of enzyme action. Lock and key mechanism, induced fit theory, Michaleis-Menten equation. Enzyme inhibition: competitive, uncompetitive and non-competitive, Biological functions of enzymes, Factors affecting enzyme	To acquaint them with the enzyme action	Interaction, Discussion	CO 4	ET exam
40	Organic Materials of industrial importance: Dyes-classification–modern theory of colour	To acquaint them with the basics of dyes and the concept behind the relation of colour and structure	Interaction, Discussion	CO 1 & CO 4	ET exam
41	Synthesis of methyl orange; Congo red, Malachite green, Indigo and Alizarin.	To make them understand the synthesis and working nature of different types of dyes	Interaction, Discussion	CO 1 & CO 4	ET exam
42	Solvent extraction of oils, Hydrogenation of oils, Oils-Fats: Distinction between oil and fat	To make them understand the process involved in the extraction of oil	Interaction, Discussion	CO 1 & CO 4	ET exam
43	Vegetable oil, Saponification value, Iodine and Acid value of oils	To make them understand the concept of different terms associated with the characteristics of fats/oils	Interaction, Discussion	CO 1 & CO 4	ET exam
44	Hydrogenation of oils, Soaps and Detergents, Manufacture of soap, Analysis of oil, fats and waxes, Ecofriendly detergents-zeolite, Principal group of synthetic detergents	To make them understand the difference between soaps and detergents	Interaction, Discussion	CO 1 & CO 4	ET exam
45	Petrochemicals, Manufacture of Petrochemicals, Alkylation, Dealkylation and Hydroalkylation	To make them understand the processes involved during the manufacture of petrochemicals	Interaction, Discussion	CO 1 & CO 4	Home Assignment
46	Pyrolysis, Esterification, Halogenation and Hydrohalogenation	To make them understand the processes involved during the manufacture of petrochemicals	Interaction, Discussion	CO 1 & CO 4	ET exam
47	Nitration, Oxidation, Oxo-hydroformation, Carbonylation, Polymerization	To make them understand the processes involved during the manufacture of petrochemicals	Interaction, Discussion	CO 1 & CO 4	ET exam
	End term Exam				

H. Course Articulation Matrix: (Mapping of COs with POs & PSOs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	*PSO1*	*PSO2*	*PSO3*
CY 1321.1	Master the wide range of diversity in Organic Chemistry with the help of knowledge of basic organic chemistry along with practical approach	2	2	0	2	0	0	0	0	2	0	0	0	0	1	0
CY 1321.2	Explain various processes involved in understanding the mechanism of reactions	3	2	0	0	2	0	0	0	0	0	2	0	0	1	0
CY 1321.3	Impart the knowledge of carbohydrates and proteins	2	0	1	0	0	0	2	0	0	0	0	0	0	0	0
CY 1321.4	Identify the problems and applications of organic reactions	2	2	0	0	0	2	0	0	0	0	2	0	0	0	0
CY 1321.5	Skilled in solving problems of stereochemistry of organic compounds and application of the concept in organic synthesis	2	0	0	0	2	0	0	0	1	1	2	2	0	0	1
CY 1321.6	Enhance the scientific skills of students for employability.	3	2	2	2	3	0	0	1		0	0	0	0	1	1

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR
School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Hand-out
Chemical Process Calculations| CE1305 | 3 Credits | 3 0 0 3
Session: Jul'18 – Dec'18 | Faculty: Dr. Harsh Pandey | Class: Core course

A. INTRODUCTION

This course on Chemical Process Calculations is a core course designed for the undergraduate students of Chemical Engineering. This course is intended to provide clear overview of field of chemical engineering and introduce the elementary principles involved in the analysis of chemical processes. It offers the fundamental knowledge required in solving the material and energy balances related to industrial problems and covers the concepts ranging from basic units and dimensions to simultaneous material and energy balances for reacting and non-reacting systems.

B. COURSE OUTCOME

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

[CE1305.1] Understand the fundamental concepts and calculations in chemical processes

[CE1305.2] Develop the skills to perform mass balance calculations on existing systems

[CE1305.3] Develop the skills to perform energy balance calculations

[CE1305.4] Evaluate the bubble point and dew points of multicomponent mixtures

[CE1305.5] Use the psychrometric charts to determine the properties of air required in solving vaporization and condensation problems

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

The Graduates of Chemical Engineering from MUJ will have:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. ASSESSMENT PLAN

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/Quiz (Formative)	All assignments are to be solved and submitted, on/before deadline, on plain A4 size sheets only. Late submissions will not be entertained.	
Make up Assignments (Formative)	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture. However, you may contact the course coordinator for clarification of doubts, if any.	

E. SYLLABUS

Guidelines for Problem Solving; Review of Basic concepts – Process variables & properties, Degree of Freedom, **MATERIAL BALANCES**: Steady State Material Balances – in non-reacting systems and reacting system, Recycle & purge, elemental vs. species balance, combustion of fossil fuels. **MULTIPHASE EQULIBRIUM**: Single component and multicomponent phase equilibrium, Steady State Material balances in Multiphase systems. **ENERGY BALANCES**: Steady State Energy Balances – in non-reacting & reacting systems, De-Coupled & coupled mass & energy balances, Calculations for network of units with recycle & bypass, Process Flow sheeting with sequential modular calculations, Unsteady State Balances. **HUMIDIFICATION**: Terminology of humidity, Humidity charts, heating and cooling problems of moist air.

F. TEXT BOOKS

T1. David M. Himmelblau and James B.Riggs, Basic Principles and Calculations in Chemical Engineering, 8th ed., Pearsons, TN, 2015

G. REFERENCE BOOKS

R1. Richard M. Felder, Ronald W. Rousseau, Elementary Principles of Chemical processes, 3rd ed., Wiley, 2004

R2. B.I Bhatt and S.M Vora, Stoichiometry, 4th ed., Mc Graw Hill, 2004

H. LECTURE PLAN

LEC NO	TOPICS	SESSION OUTCOME	MODE OF DELIVERY	CORRESPONDING CO	MODE OF ASSESSING CO
1	Introduction to course and its significance	-	Lecture	-	
2,3	Dimensions and Units - Units and conversions and its significance, Fundamental and derived units, Conversion factors, Dimensional consistency	Fundamentals of units and conversions	Lecture	CE 1305.1	Mid Term I, Assignment / Quiz & End Term
4,5	Basic chemical calculations	Concept of mole unit and equivalent weight, Definitions and Calculations for density, specific gravity concentration, interconversion of mole fraction and mass fraction, Temperature and pressure	Lecture	CE 1305.1	Mid Term I, Assignment / Quiz & End Term
6, 7	Choosing a basis, Example problems	Choosing a basis	Lecture	CE 1305.1	Mid Term I, Assignment / Quiz & End Term
8,9	Material Balances without chemical reactions -	Concept of open vs closed systems, steady vs unsteady state systems Degrees of freedom	Lecture	CE 1305.2	Mid Term I, Assignment / Quiz & End Term
10,11	Material Balances without chemical reactions -	Material balance for single units	Lecture	CE 1305.2	Mid Term I, Assignment / Quiz & End Term
12-14	Material Balances without chemical reactions -	Material balance for single units involving unit operations such as mixers, dryers, evaporators, crystallizers, absorbers and strippers	Lecture	CE 1305.2	Mid Term I, Assignment / Quiz & End Term
15-17	Material Balances with	Concept of limiting and excess reactants, Extent of	Lecture	CE 1305.2	Mid Term I, Assignment /

	chemical reactions -	reaction, Percentage conversion, yield, selectivity.			Quiz & End Term
18	Material Balances with chemical reactions -	Material balances involving single and multiple reactions using atomic/elementary balances and molecular/species balances	Lecture	CE 1305.2	Mid Term II, Assignment / Quiz & End Term
19 - 22	Material Balances for multiple units –	Material balances with recycle, bypass and purge streams	Lecture	CE 1305.2	Mid Term II, Assignment / Quiz & End Term
22-25	Combustion calculations -	Problems on combustion of coal, calorific value of fuels, Air requirement and flue gas analysis	Lecture	CE 1305.2, CE 1305.3	Mid Term II, Assignment / Quiz & End Term
26-28	Ideal and Real Gases -	Concept of Ideal gas law and Henrys law. Real gas relationships and estimation of gas properties. Compressibility factor	Lecture	CE 1305.3	Mid Term II, Assignment / Quiz & End Term
29,30	Multiphase Equilibrium -	Vapour liquid equilibrium, dew point and bubble point calculations	Lecture	CE 1305.4	Mid Term II, Assignment / Quiz & End Term
31,32	Multiphase Equilibrium -	Use of Psychometric/humidity charts in problem solving	Lecture	CE 1305.4	Mid Term II, Assignment / Quiz & End Term
33,34	Energy Balances without reactions -	First law of thermodynamics, heat capacities of gases and gaseous mixtures, Sensible heat changes in liquids and gases.	Lecture	CE 1305.3	Assignment / Quiz & End Term
35,36	Energy Balances without reactions -	Enthalpy changes during phase transition	Lecture	CE 1305.3	Assignment / Quiz & End Term
37,38	Energy Balances with Chemical Reactions -	Heat of reaction, heat of formation, heat of combustion	Lecture	CE 1305.3	Assignment / Quiz & End Term
39,40	Energy Balances with Chemical Reactions -	enthalpy change associated with systems involving chemical reactions	Lecture	CE 1305.3	Assignment / Quiz & End Term
41,42	Humidity charts and their use	Humidity calculations	Lecture	CE 1305.5	Assignment / Quiz & End Term

I. COURSE ARTICULATION MATRIX (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	*PSO1*	*PSO2*	*PSO3*
CE 1305.1	Understand the fundamental concepts and calculations in chemical processes	3	1	2		1	2		1				3	3	2	
CE 1305.2	Develop the skills to perform mass balance calculations on existing systems	3	2	2		1		1		1			3	3	2	1
CE 1305.3	Develop the skills to perform energy balance calculations	3	2	2		1		1		1			3	3	2	1
CE 1305.4	Evaluate the bubble point and dew points of multicomponent mixtures	3	2	2	2	1	1						1	1		1
CE 1305.5	Use the psychrometric charts to determine the properties of air required in solving vaporization and condensation problems	3	2	2	2		2	1					2	1		1

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Momentum Transfer| CE 1306/CE1302 | 3/4 Credits | 3 0 0 3 / 3 1 0 4

Session: July 18 – Dec 18 | Faculty: Dr. Gaurav Kataria | Class: Core Course

A. Introduction:

This course is one of the fundamental ground stones of Chemical Engineering. As a practicing chemical engineer you will have to deal with fluids that need to be transported from one part of the process plant to another. Therefore, in this course of momentum transfer you will be introduced to what a fluid is and how are they classified based on their flow properties. Following that you will study how to analyse a fluid in static state, kinematic state and dynamic state. This would include you getting to know different ways of measuring fluid flow and pumping of fluids. At the end of the course unit operations of agitation and mixing, flow through packing, filtration, fluidization and centrifugation will be introduced.

B. Course Outcomes:

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

[CE1306.1] Classify fluids based on rheology and calculate as well as correlate different fluid properties.

[CE1306.2] Correlate the concept of pressure with its measurement and use this knowledge to evaluate and design fluid static equipment like storage tanks and decanters.

[CE1306.3] Assess and design fluid flow measurement equipment based on Bernoulli's equation applying them to different flow problems.

[CE1306.4] Design, evaluate and develop the skill to understand the characteristics of different types of pumps/Blowers.

[CE1306.5] Design different fluid-based unit operations like agitation and mixing, flow through packing, filtration, fluidization and centrifugation.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.
PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.
PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments.	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No makeup for missed short quizzes or assignments or exam will be allowed, except in extenuating circumstances with prior permission of the instructor. The decision of the instructor in this regard will be final.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Review of Navier-Stokes' (NS) equations; non-dimensionalization of NS equations; introduction to turbulence; analogies; correlations for fluid flow; Short introduction to non-Newtonian flows, Engineering Bernoulli Equation; f vs. NRe charts; K factors and equivalent lengths for various fittings; hydraulic diameter; Head vs. Q plots of centrifugal pumps; NPSH, cavitation and priming; pipeline system design including pseudo-steady state approximation; flow measurements; compressors and blowers. Compressible flows in conduits. Mixing and Agitation: Power consumption; mixing times; scale-up, Characterization of solids; fundamentals of two-phase flow; flow through packed beds and in fluidized beds (pressure drops, loading and flooding); pneumatic and hydraulic transportation. Filtration, Centrifuges and cyclones.

F. TEXT BOOKS

1. de Nerves, N., "Fluid Mechanics for Chemical Engineers", McGraw Hill International.
2. McCabe, W.L., Smith, J.C., Harriott, P., "Unit operations of Chemical Engineering", McGraw Hill International.

G. REFERENCE BOOKS

1. Foust, A.S., Wenzel, L.A., Clump, C.W., Maus, L., Andersen, L.B., "Principles of Unit Operations", John Wiley & Sons.
2. Coulson, J.M., Richardson J.F, Backhurst, J.R., Harker, J.H., "Coulson and Richardson's Chemical Engineering Volume 1: Fluid Flow, Heat Transfer and Mass Transfer" Butterworth-Heinemann/Elsevier.
3. Streeter, V.L., Wiley, B., "Fluid Mechanics", McGraw Hill International.
4. Bansal, R.K., "A Textbook of Fluid Mechanics and Hydraulic Machine", Khanna Publications.
5. Douglas, J.F., Gasiorek, J.M., Swaffield, J.A., "Fluid Mechanics", Pearson/Prentice Hall
6. Bennett, C.O., Myers, J.E., "Momentum, Heat, and Mass Transfer", McGraw Hill International.
7. Bird, R.B., Stewart, W.E., Lightfoot, E.N., "Transport Phenomena" John Wiley & Sons.
8. Geankoplis, C.J., "Transport Processes and Separation Process Principles", Prentice Hall of India.

H. Lecture Plan

Lecture	Topics	Session Outcome	Mode of Delivery	Correspo-nding CO	Mode Of Assessing CO
1-3	**Introduction to fluid mechanics**	Introduction to Fluid Mechanics, Continuum Hypothesis, Properties of fluids	Lecture	1306.1	Mid Term I, Assignment & End Term
4-7	**Fluid statics**	Hydrostatics, Application of hydrostatics, Buoyancy, Barometers, Manometers, Gravity settling, Centrifugal decanters, Illustration by examples.	Lecture	1306.2	Mid Term I, Assignment & End Term
8-9	**Dimensional analysis**	Raleigh Method, Buckingham π theorem, Introduction of dimensionless numbers	Lecture	1306.1	Mid Term I, Assignment & End Term
10-11	**Introduction to Fluid Dynamics**	The General Balance Equations, Mass Balance, Flow lines, Velocity Distribution, Steady and Unsteady state balance (one dimensional),- illustration by examples	Lecture	1306.3	Mid Term I, Assignment & End Term
12	**Differential analysis of Fluid Flow**	Euler's equation, Navier Stokes Equation	Lecture	1306.3	Mid Term II, Assignment & End Term
13-17	**Energy Balance Equations for Fluid Flow**	Energy and its different forms, First Law of Thermodynamics, Mechanical Energy Equation (Bernoulli's Equation), Correction factors for Bernoulli's Equation, Head form of Bernoulli's Equation	Lecture	1306.3	Mid Term II, Assignment & End Term
18-21	**Flow though Pipes**	Reynold's Experiment, Reynold's number, Laminar and Turbulent flow, Boundary layer theory, Flow through pipes, Friction factor, Moody's diagram- illustration by examples	Lecture	1306.3	Mid Term II, Assignment & End Term
22-24	**Applications of Bernoulli's equation**	Sudden Expansion and Sudden Contraction, Torricelli's Equation, Pitot tube, Venturi meters, Orifice meters, Rotameter, Losses in pipe systems- illustration by examples	Lecture	1306.4	Mid Term II, Assignment & End Term
25-27	**Pumps and Compressors**	Introduction to positive displacement pumps, centrifugal pumps, NPSH, Cavitation, Reciprocating blowers, centrifugal blowers- illustration by examples	Lecture	1306.4	Mid Term II, Assignment & End Term
28-29	**Pipe Networks**	Design of pipe networks- illustration by examples	Lecture	1306.3	Mid Term II, Assignment & End Term
30-32	**Mixing and Agitation**	Need for agitation and mixing, Types of agitation, Vortex and Baffles, Impeller types, Dimensionless numbers related to mixing, Scale up of agitated vessels, Static mixers, Jet mixers	Lecture	1306.5	End Term
33-42	**Solid Liquid Flows**	Concept of Drag & Coefficient of Drag, Stagnation point, Flow through bed of solids, Motion of particles in fluids, Fluidization, Sedimentation, Filtration	Lecture	1306.5	End Term

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1306.1	Classify fluids based on rheology and calculate as well as correlate different fluid properties.	3	3		1								2	1		2
CE 1306.2	Correlate the concept of pressure with its measurement and use this knowledge to evaluate and design fluid static equipment of storage tanks and decanters.	3	3	1			1	2	1		1	1	2			
CE 1306.3	Assess and design fluid flow measurement equipment based on Bernoulli's equation applying them to different flow problems.	3	3	2				1		1	1	1	2			
CE 1306.4	Design, evaluate and develop the skill to understand the characteristics of different types of pumps/Blowers.	3	3	2				2		2	1	1	2	1		
CE 1306.5	Design different fluid-based unit operations like agitation and mixing, flow through packing, filtration, fluidization and centrifugation.	3	3				1	3		2	1	2	2	2	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Process Synthesis | CE 1307 | 3 Credits | 3 0 0 3

Session: July 18 – Dec 18 | Faculty: Ir. Nandana Chakinala | Class: Core Course

A. Introduction:

This course on Process Synthesis is a core course designed for the undergraduate students of Chemical Engineering. This course emphasizes on the principles applied in developing a process from a potential point of view. The course presents heuristics and systematic tools for developing and screening potential process flow sheets. It provides insight in to the concepts of process design and development.

B. Course Outcomes: At the end of the course, students will be able to

[CE1307.1] Synthesize the optimum reaction path from a set of alternatives.

[CE1307.2] Investigate the thermodynamic feasibility of chemical processes

[CE1307.3] Perform material and energy balances and synthesize the block flow and process flow diagrams for new processes.

[CE1307.4] Describe more widely used industrial separation methods and their basis of separations

[CE1307.5] Synthesize heat exchange networks to minimize external heating and cooling requirements

[CE1307.6] Develop the skill to interpret equilibrium data required in solving material balances

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments.	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No makeup for missed short quizzes or assignments or exam will be allowed, except in extenuating circumstances with prior permission of the instructor. The decision of the instructor in this regard will be final.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction to Process Systems Engineering; Strategy of Reaction Synthesis

SYNTHESIS OF REACTION PATHS - Engineering Data on Reaction Paths; Screening of Reaction Paths; Reaction Paths with Recycle; Conservation of Mass; Material Balancing Pathways

SYNTHESIS OF REACTION FLOWSHEETS - Synthesis of Material Flow; Species Allocation

SEPARATIONS SYNTHESIS - Introduction to Separation Technology; Solid-Solid separation methods; Liquid-Liquid separation techniques; Reduction of Separation Load; Selection of Separation Phenomena; Integration of Auxiliary Operations; Energy Balance; Sensible and Latent Heat; Heat of Chemical Reactions

HEAT EXCHANGE NETWORK SYNTHESIS - Heat energy management and Heat-Exchanger Networks; Case studies from chemical and petroleum processing plants

F. TEXT BOOKS

T1 Dale F. Rudd, Gary J. Powers, and Jeffrey J. Siirola, "Process Synthesis", Prentice-Hall international series in the physical and chemical engineering sciences, 1973.

T2 Regina M. Murphy, "Introduction to chemical processes: Principles, Analysis, Synthesis", 1st ed., McGraw Hill education, 2013.

G. REFERENCE BOOKS

R1 Turton, Bailie, Whiting and Shaeiwitz, "Analysis, Synthesis and Design of Chemical Processes", 3rd ed., Prentice Hall India, 2009

R2 Robin Smith, "Chemical Process: Design and Integration", 8th ed., Wiley, January 2005.

R3 Warren D. Seider, J. D. Seader, Daniel R. Lewin, "Product and Process Design Principles: Synthesis, Analysis and Design", 2nd ed., Wiley, 2009

Lecture Plan:

Lecture No.	TOPICS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1	Introduction to process synthesis	To understand the importance of process synthesis	Lecture		
2-3	*The Engineering of process systems* - Elementary concepts of synthesis and analysis, Pattern of process synthesis	To acquaint the basic steps of process synthesis	Lecture	1307.1	Quiz, Mid term I, End Term
4-5	*Reaction path synthesis* – Engineering data on reaction paths, stoichiometric concepts	To acquaint the data required for reactor synthesis	Lecture	1307.1	Quiz, Mid term I, End Term
6-8	*Reaction path synthesis* – Generation consumption analysis, Economic screening of reaction paths, Atom economy, Process economy and associated heuristics	To synthesize the optimum reaction path from a set of alternatives	Lecture & Tutorial	1307.1	Quiz, Assignment, Mid term I & End term
9-11	*Reactor flow sheet synthesis* – Process flow calculations, Synthesis of new technology	To perform basic material balance calculations of reactor	Lecture & Tutorial	1307.3	Assignment, Mid term I & End term
12	*Reactor flow sheet synthesis* – system variables, system and stream specification	To acquaint the process variables and specifications used in flow calculations	Lecture	1307.3	Assignment, Mid term I & End term
13-16	*Reactor flow sheet synthesis* – reactor material balances, Species allocation from raw materials to reaction sites, recycle structure of flowsheet	To develop the recycle structure of flowsheet	Lecture	1307.3	Quiz, Assignment, Mid term I & End term

17-19	*Reactor flow sheet synthesis* - Chemical Equilibrium and kinetics	To estimate the equilibrium conversion of reactors	Lecture	1307.2	Quiz, Mid term II & End term
20-22	Introduction to separation technology, *Solid-solid separation techniques* - solubility differences, Density differences	To acquaint the basic principles of separations & To understand the property differences exploited in S-S separations	Lecture	1307.4	Quiz, Mid term II & End term
23-24	*Liquid-liquid separation techniques* - volatility differences	To acquaint the concept of volatility in distillation	Lecture	1307.4	Assignment, Mid term II & End term
25-26	*Liquid-liquid separation techniques* – solubility differences, *Gas-Gas separations* – Solubility differences	To describe and understand the L-L extraction and absorption process	Lecture	1307.4	Assignment, Quiz, Mid term II & End term
27	*Solid-liquid separations* – Solubility differences	To describe and understand the S-L extraction and absorption process	Lecture	1307.4	Quiz, Mid term II & End term
28	*Separation technology* – Phase equilibrium, equilibrium calculations and graphs	To interpret the equilibrium data used in separator flowsheet synthesis	Lecture & Tutorial	1307.3 & 1307.6	Assignment, Mid term II & End term
29	*Separator selection* – Heuristics, reduction of separation load	To synthesize separator flowsheet based on heuristics	Lecture	1307.3	Mid term II & End term
30	*Separator flowsheet synthesis* – Separator performance, process flow calculations	To perform material balance of separators	Lecture & Tutorial	1307.3	Assignment, Mid term II & End term
31-33	*Task integration* – Economy of processing plan, Preliminary design of equipment to reuse material and energy, industrial procedures for energy management	To develop the preliminary process flowsheet integrating reactions and separations	Lecture	1307.6	Quiz, Mid term II & End term
34-35	*Heat exchange network synthesis* – Process Energy calculations	To perform energy balance calculations of various systems	Lecture	1307.3 & 1307.5	Assignment, Quiz, End term
36-38	*Heat exchange network synthesis* – Preliminary synthesis of heat exchanger networks, industrial procedures for energy management,	To synthesize preliminary heat exchanger network based on heuristics	Case study & Tutorial	1307.5	End term
39-40	Case studies from chemical and petroleum processing plants	To apply the process synthesis principles for case studies	Case study Activity	1307.3	End term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1307.1	Synthesize the optimum reaction path from a set of alternatives	3	1	1	1		3		2		3	2	3	3		
CE 1307.2	Investigate thermodynamic feasibility of chemical processes	3	1	3			2		1	2	3	2	3	3		1
CE 1307.3	Perform material and energy balances and synthesize the block flow, process flow diagrams for new processes	3	2	2			1		2		3	2	3	3	1	2
CE 1307.4	Describe more widely used industrial separation methods and their basis of separations	3	3	1			2		3		3	2	3	3	1	1
CE 1307.5	Synthesize heat exchange networks to minimize external heating and cooling requirements	3	3	2	2		2		2	1	3	2	3	3	2	2
CE 1307.6	Develop the skill to interpret the equilibrium data required in solving material balances	3	2				2		2		3	2	3	3		1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Basic Sciences

Department of Chemistry

Course Hand-out

Engineering Materials | CE 1304 | 3 Credits | 3 0 0 3

Session: July 18 – Nov 18 | Faculty: Dr. Veena Dhayal | Class: B. Tech. (Chemical) III Sem.

A. Introduction: This course is offered by Dept. of Chemical Engineering as a core course, targeting students who wish to pursue research & development in industries or higher studies in field of engineering materials, including structure of material, ferrous and non- ferrous materials, electrical and magnetic properties of materials and gives an introductory level knowledge on classification of materials, crystal structure, properties and treatments of material. Students are expected to have background knowledge on learning of smart & nano-materials and their potential applications.

B. Course Outcomes: At the end of the course, students will be able to

[CE 1304.1] Analyse the materials classification, properties and 3- dimensional crystal structure and its potential applications in daily life.

[CE 1304.2] Determine the various engineering techniques to improve skills for modification of the surface properties of materials to increase their performance.

[CE 1304.3] Analyse the formation of energy band concept of conductor, insulator and semi-conductor and its applications

[CE 1304.4] Recognize different heat treatment techniques and judge the best way to improve physical and mechanical properties of materials

[CE 1304.5] Analyse the properties of smart nano-engineered & composites materials and apply them to solve real-life problems in engineering.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

The graduates of chemical engineering from MUJ will have:

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

[PO.2]. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

[PO.4]. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

[PO.7]. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

[PO.8]. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

[PO.9]. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

[PO.10]. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Degree Specific Outcomes for chemical engineering are as follows:

[PSO.1]. **Concept to Commissioning:** The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[POS.2]. **Process Intensification**: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. **Specialization:** Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

STRUCTURE OF MATERIALS-crystal structure, substructure, microstructure; **MATERIALS CLASSIFICATIONS** –engineering standards, material selection (CES type packages); **MATERIAL PROPERTIES** – mechanical, electrical, physical, corrosion, etc. properties; **MATERIAL TREATMENT** –Heat treatment**,** Various types of heat treatment such as Annealing, Normalizing, Quenching, Tempering (Austempering, Martempering), and various case hardening processes, surface treatment, etc.; **FERROUS MATERIALS**-Various types of carbon steels, alloy steels and cast irons, its properties and uses, effects of different alloying elements, super alloys; **NON-FERROUS METALS AND ALLOYS**-Non-ferrrous metals such as Cu, Al, Zn, Cr, Ni etc. and its applications, Various type of Brass and Bronze, bearing materials, its properties and uses. Aluminum alloys such as Duralumin; **CERAMICS** – classification, characterization, properties; **PLASTICS** – Various types of polymers/plastics and its applications, Mechanical behaviour and processing of plastics, Future of plastics; **COMPOSITE MATERIALS** – structure, properties, classification, processing; **OTHER MATERIALS:** Brief description of other material such as optical and thermal materials, Introduction to Smart materials & Nano-materials and their potential applications; **ELECTRIC PROPERTIES, SEMICONDUCTORS AND SUPER CONDUCTORS**-Energy band concept of conductor, insulator and semi-conductor. Intrinsic & extrinsic semi-conductors. Super conductivity and its applications; **MAGNETIC PROPERTIES**-Concept of magnetism - Dia, para, ferro Hysteresis. Soft and hard magnetic materials; **SURFACE ENGINEERING AND APPLICATIONS** – techniques, coatings, processing and heat treatment.

F. TEXT BOOKS

1. W. D. Callister, Fundamentls of Materials Science and Engineering, Wiley (2007), 9th Edition
2. V. Raghvan, Materials Science and Engineering, 5th Edition, Phi Learning (2013)
3. C. Kittle, Introductin to Solid State Physics, Wiley (2007)

G. REFERENCE BOOKS

1. Structure and Bonding in Crystalline Materials, Cambridge University Press (2001)
2. V. Gerold Materials Science and Technology, Volume 1, VCH Publication (1992)

INSPIRED BY LIFE

H. Lecture Plan:

LEC NO	TOPICS	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Introduction to Engineering materials and their applications in real life	To acquaint and clear teachers expectations and understand student expectations	Interaction, discussion	-	NA
2	Materials classifications: engineering standards, material selection (CES type packages)	Analyse the materials classification and its potential applications in daily life.	Lecture, Interaction, Discussion	CO 1	1st Sessional, ET Exam, Home Assignment
3	Structure of materials- crystal structure, substructure, microstructure materials	Thorough understanding of 3- dimensional crystal structure at microlevel	Interaction, Discussion & Question Answer Session	CO 1	1st Sessional, ET Exam, Home Assignment
4, 5	Material treatment –Heat treatment, various types of heat treatment such as Annealing, Normalizing,	Recognize different heat treatment techniques, Annealing, Normalizing	Lecture, Interaction, Question Answer Session	CO 4	1st Sessional, ET Exam, Home Assignment
6	Quenching, Tempering (Austempering, Martempering),	Recognize heat treatments, Quenching, Tempering (Austempering, Martempering	Lecture, Interaction, Question Answer Session	CO 4	1st Sessional, ET Exam, Home Assignment
7	Various case hardening processes, surface treatment, etc.;	Judge the best way to improve surface properties of materials	Lecture, Interaction, Question Answer Session	CO 2	1st Sessional, ET Exam, Home Assignment
8	Ferrous materials: Various types of carbon steels, alloy steels and cast irons	Classification of steel based on their compositions	Lecture, Interaction, Question Answer Session	CO 1, CO 2	1st Sessional, ET Exam, Home Assignment
9, 10	Properties of Ferrous materials: mechanical, electrical, physical, corrosion	Properties of ferrous materials based on their compositions	Lecture, Interaction, Question Answer Session	CO 1, CO 3	1st Sessional, ET Exam
11, 12	Applications of Ferrous materials, effects of different alloying elements, super alloys;	Effect of alloying elements on the properties of materials and their applications.	Lecture, Interaction, Question Answer Session	CO 1	1st Sessional, ET Exam,

13	Non-Ferrous metals such as Cu, Al, Zn, Cr, Ni etc. and its applications and alloys	Classification of non-ferous metals based on their compositions	Lecture, Interaction, Question Answer Session	CO 1	1st Sessional, ET Exam,
14	Revision				
Ist Sessional Exam					
15, 16	Various type of Brass and Bronze bearing materials and its properties and uses, Aluminum alloys such as Duralumin	Compositions of brass and bronze, their properties and applications	Lecture, Interaction, Question Answer Session	CO 1	2nd Sessional, ET Exam, Class test
17	Classification and characterization of ceramics, Properties of Ceramics,	Knowledge about ceramics and their classifications and properties	Lecture, Interaction, Question Answer Session	CO 5	2nd Sessional, ET Exam, Class test
18	Plastics – Various types of polymers/plastics and its applications	Knowledge about polymer. Plastics and its applications	Lecture, Interaction, Question Answer Session	CO 5	2nd Sessional, ET Exam, Class test
19	Mechanical behaviour and processing of plastics, Future of plastics	Mechanical properties of plastics	Lecture, Interaction, Question Answer Session	CO 5	2nd Sessional, ET Exam, Class test
20	Composite materials – classification, processing, structure, properties of Composite materials	Knowledge about composites, its classifications, properties and processing	Lecture, Interaction, Question Answer Session	CO 2, CO 5	2nd Sessional, ET Exam, Class test
21, 22	Other materials: Brief description of other material such as optical and thermal materials,	Knowledge about some important optical and heat resistive materials	Lecture, Interaction, Question Answer Session	CO 3, CO 5	2nd Sessional, ET Exam, Class test
23	Class test				
24, 25	Introduction to Smart materials & nanomaterials, Synthesis and Characterization of nanomaterials	Knowledge about some smart and nano materials, their synthesis and various characterization techniques	Lecture, Interaction, Question Answer Session	CO 5	2nd Sessional, ET Exam
26	Electric properties of nanomaterials,	Major electrical properties of nanomaterials	Lecture, Interaction, Question Answer Session	CO 3	2nd Sessional, ET Exam
27, 28	Potential applications of Nanomaterials	Various applications of nanomaterials	Lecture, Interaction, Question Answer Session	CO 5	2nd Sessional, ET Exam
29, 30	Semiconductors and Super conductors, Energy band concept of conductor,	Knowledge about conductivity and band theory	Lecture, Interaction, Question Answer Session	CO 3	2nd Sessional, ET Exam

31, 32	insulator and semi-conductor, Intrinsic & extrinsic semi-conductors	Classification of conductors	Lecture, Interaction, Question Answer Session	CO 3	2nd Sessional, ET Exam
33	Superconductivity and its applications	Knowledge about superconductivity and its applications	Lecture, Interaction, Question Answer Session	CO 3	2nd Sessional, ET Exam
2nd SESSIONAL EXAMINATION					
34, 35, 36	Magnetic properties-Concept of magnetism, Diamagnetism, Paramagnetism,	Classification of materials based on magnetic properties	Lecture, Interaction, Question Answer Session	CO 1	ET Exam, Quiz
37	Ferromagnetism, Hysteresis	Knowledge about ferromagnetic materials	Lecture, Interaction, Question Answer Session	CO 1	ET Exam, Quiz
38, 39	Soft and hard magnetic materials, Surface engineering of nanomaterials: techniques, coatings	Knowledge about surface engineering of nanomaterials, coating techniques	Lecture, Interaction, Question Answer Session	CO 1, CO 2	ET Exam, Quiz
40	Quiz 1				
41	Surface engineering of nanomaterials: processing and heat treatment.	Surface engineering by heat treatment	Lecture, Interaction, Question Answer Session	CO 2	ET Exam
42	Properties and applications of surface engineering of nanomaterials	Various applications of surface engineering of nanomaterials	Lecture, Interaction, Question Answer Session	CO 2	ET Exam
43	Revision				
	END SEMESTER EXAMINATION				

INSPIRED BY LIFE

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	Statement	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1304.1	Analyse the material classification, properties and 3-dimentional crystal structure and its potential applications in daily life.	1	1	1	1			1	1		1	1		1	1	
CE 1304.2	Determine the various engineering techniques to improve skills for modification of the surface properties of materials to increase their performance.	2	1	2		2		1		1		1	1	1	2	1
CE 1304.3	Analyse the formation of energy band concept of conductor, insulator and semi-conductor and its applications.	2	3		1		1						1	1	1	1
CE 1304.4	Recognize different heat treatment techniques and judge the best way to improve physical and mechanical properties of materials.	1	2	2	1			2			2	1	2		1	1
CE 1304.5	Analyse the properties of smart nano-engineered & composites materials and apply them to solve real life problems in engineering.	2		2	1		1	2	1	1	1		1	1	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

INSPIRED BY LIFE

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Transport Phenomena | CE 1405 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty: Dr Gaurav A. Bhaduri | Class: IV Semester

A. Introduction: This course is an introductory course in Transport Phenomena whereby the student shall be exposed to the various major areas and their applications. The student shall be armed with the basic tools and understanding of the field. The 'premium' in this course shall be on 'thinking' rather than doing things 'mechanically' so that the student is able to apply the various concepts to different situations, other than the ones encountered during the course, as and when the need arises.

B. Course Outcomes: At the end of the course, students will be able to

[1405.1]. Identify transport properties and analyze the mechanisms of momentum, energy and mass transport.

[1405.2]. Develop the skills to select, locate and orient coordinate systems for transport phenomena problems.

[1405.3]. Generate the skills to formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady-state and unsteady flows.

[1405.4]. Develop the skills to identify the analogies between momentum, heat and mass transfer problems.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

PO.1 A thorough knowledge of the basic science, engineering and mathematics and apply that to the underline practice of Chemical Engineering

PO.2 Ability to apply these basic principles to solve real world problems in a broad range of career paths

PO.3 The skills of making smart decisions on process feasibility based in technical and economic evaluation

PO.4 The ability to appreciate the social, ethical, cultural, environmental and safety issues related to chemical engineering profession

PO.5 The ability to develop experimental procedure/protocol to test hypothesis and analysis meaningful interpretation of the generated data

PO.6 The skill to generate sustainable engineering solutions to societal and industrial problems

PO.7 Proficiency to use computational tools for problem solving

PO.8 The ability to communicate effectively (technical and non-technical context) in written and oral form

PO.9 Skills to work effectively and professionally in multi-disciplinary groups

PO.10 The ability to work effectively and professionally on projects both independently and as a part of a group/team

PO.11 The ability to be self-learners and lifelong learners

PO.12 The motivation to develop and lead entrepreneurial projects for societal benefit

Degree Specific Outcomes for chemical engineering are as follows:

PSO.1 Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

POS.2 Process Intensification: graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3 Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home & Class Assignment (Formative)	Home and class assignments are an integral part of this course – you can only learn by doing! Home works will be assigned in between the lectures along with the due date for handing it over. Assignments will also be given during lecture hours where students will be asked to solve open-ended problems/case studies within stipulated time. No late assignments handed after the due date shall be accepted under any circumstance. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. Students are encouraged to discuss problems with their instructor in lecture hours. Students are advised to meet the instructor in case of any difficulty related to assignments and course related matters. Total 10 assignments will be given as a part of home and class assignments.	

E. SYLLABUS

Momentum Transport- Viscosity and mechanisms of momentum transport, shell momentum balances and velocity distribution in laminar flow, the equations of change for isothermal systems, velocity distributions with more than one independent variable, velocity distribution in turbulent flow, interphase transport in isothermal systems, macroscopic balances for isothermal flow systems

Energy Transport- Thermal conductivity and mechanisms of energy transport, shell energy balances and temperature distributions in solids and laminar flow, the equations of change for nonisothermal systems, temperature distributions with more than one independent variable, temperature distribution in turbulent flow, interphase transport in nonisothermal systems, macroscopic balances for nonisothermal systems, energy transport by radiation

Mass Transport- Diffusivity and mechanisms of mass transport, concentration distributions in solids and laminar flow, equations of change for multicomponent systems, interphase transport in nonisothermal mixtures, macroscopic balances for multicomponent systems.

F. TEXT BOOKS

"Transport Phenomena" (Second Edition), R B Bird, W E Stewart, E E Lightfoot, John Wiley & Sons, (2007).

G. REFERENCE BOOKS

"Analysis of Transport Phenomena" (Second Edition), W M Deen, Oxford University Press, (2013).

"Transport Processes and Separation Process Principles: (includes Unit Operations)" (Forth Edition), C Geankoplis, Prentice Hall of India, (2004).

"Introduction to Transport Phenomena" W J Thompson, Prentice Hall, (1999).

H. Lecture Plan:

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1.	Introduction ; Newton's Law of Viscosity	Understand the role of viscosity in the momentum transfer.	Lecture	1504.1	Mid Term I End Term
2.	Non-Newtonian Fluids; Pressure-Temperature Dependence of Viscosity	Distinguishing the types of fluids based on viscosity.	Lecture	1504.1	Mid Term I End Term
3.	Shell Momentum Balances: Boundary Conditions; Flow of a Falling Film	Understand the use of shell momentum balance.	Lecture	1504.1/3	Mid Term I End Term
4.	Flow through a Circular Tube	Understand the use of shell momentum balance.	Lecture	1504.1/2/3	Mid Term I End Term
5.	Flow through an Annulus.	Understand the use of shell momentum balance.	Lecture	1504.1/2/3	Mid Term I End Term
6.	The Equation of Continuity; The Equation of Motion	Generalizing the shell momentum balance equations.	Lecture	1504.1/2/3	Mid Term I End Term
7.	Equations of Change in Curvilnear Coordinates; Uses of Equations of Change to set up Steady Flow Problems	Generalizing the shell momentum balance equations.	Lecture	1504.1/2/3	Mid Term I End Term
8.	Dimensional Analysis of the Equations of Change	Generalizing the shell momentum balance equations.	Lecture	1504.1/2/3	Mid Term I End Term
9.	Unsteady Viscous Flow	Understanding the unsteady flow problems.	Lecture	1504.1	Mid Term I End Term
10.	Fluctuations and Time-Smoothed Quantities; Time-Smoothing of the Equations of Change for an incompressible Fluid	Understanding the solution of unsteady flow problems.	Lecture	1504.2/3	Mid Term I End Term
11.	Definition of Friction Factors; Friction Factors for Flow in Tubes; Friction Factors for Flow Around Spheres	Understanding the role of friction factor in the transport phenomenon.	Lecture	1504.1	Mid Term I End Term
12.	The Macroscopic Mass Balance; The Macroscopic Momentum Balance	Distinguishing the macroscopic and microscopic problems.	Lecture	1504.1/3	Mid Term I End Term
13.	The Macroscopic Mechanical Energy	Distinguishing the macroscopic and	Lecture	1504.1/3/4	Mid Term I End Term

	Balances; Estimation of Friction Loss	microscopic problems.			
14.	Use of the Macroscopic Balance to set up Steady Flow Problems	Distinguishing the macroscopic and microscopic problems.	Lecture	1504.1/3/4	Mid Term I End Term
15.	Review Lecture		Lecture		Mid Term I End Term
MID-TERM I					
16.	Fourier's Law of Heat Conduction; Temperature and Pressure Dependence of Thermal Conductivity in Gases and Liquids	Understand the basic concept of heat transfer.	Lecture	1504.1	Mid Term II End Term
17.	Shell Energy Balances; Boundary Conditions; Heat Conduction with an Electrical Heat Source	Understand the use of shell energy balance.	Lecture	1504.1/3	Mid Term II End Term
18.	Heat Conduction with a Viscous Heat Source	Understand the use of shell energy balance.	Lecture	1504.1/3	Mid Term II End Term
19.	Heat Conduction through Composite Walls: Addition of Resistances	Understand the use of shell energy balance.	Lecture	1504.1/3	Mid Term II End Term
20.	Forced Convection; Free Convection	Distinguishing the solution of forced and free convection.	Lecture	1504.1/3	Mid Term II End Term
21.	The Equations of Energy; The Energy Equation in Curvilinear Coordinates	Generalizing the shell energy balance equations.	Lecture	1504.1/2/3	Mid Term II End Term
22.	Summary of the Equations of Change; Use of the Equations of Change to set up Steady Flow Heat Transfer Problems	Generalizing the shell energy balance equations.	Lecture	1504.1/2/3	Mid Term II End Term
23.	Dimensional Analysis of the Equations of Change	Generalizing the shell energy balance equations.	Lecture	1504.1/2/3	Mid Term II End Term
24.	Unsteady Heat Conduction in Solids	Understanding the unsteady heat flow problems.	Lecture	1504.1/3	Mid Term II End Term
25.	Definition of the Heat Transfer Coefficient; Heat Transfer Coefficients for Forced Convection in Tubes; Heat Transfer Coefficient for Forced Convection around Submerged Objects	Understanding the common terms of heat transfer and their role in the chemical engineering applications.	Lecture	1504.1/3/4	Mid Term II End Term

26.	Heat Transfer Coefficients for Free Convection	Understanding the heat transfer concept in free convection.	Lecture	1504.1/3	Mid Term II End Term
27.	Spectrum of Electromagnetic Radiation; Absorption and Emission at Solid Surfaces; Planck's Law; Wien's Law; Stefan-Boltzmann Law	Understanding the basics of radiation heat transfer.	Lecture	1504.1	Mid Term II End Term
28.	Direct Radiation between Black Bodies in Vacuo at Different Temperatures	Understanding the basics of radiation heat transfer.	Lecture	1504.1/3	Mid Term II End Term
MID-TERM II					
29.	The Macroscopic Energy Balance; The Macroscopic Mechanical Energy Balance (Bernoulli Equation)	Distinguishing the macroscopic and microscopic heat problems.	Lecture	1504.1/3	End Term
30.	Summary of the Balances for Pure Fluids; Use of the Macroscopic Balances for Solving Steady-State Problems (458-460)	Distinguishing the macroscopic and microscopic heat problems.	Lecture	1504.1/2/3	End Term
31.	Definition of Concentrations, Velocities, and Mass Fluxes; Fick's Law of Diffusion; Temperature and Pressure Dependence of Mass Diffusivity	Defining basic terms of mass transfer in transport phenomenon.	Lecture	1504.1/3/4	End Term
32.	Shell Mass Balances; Boundary Conditions; Diffusion through a Stagnant Film	Understand the use of shell mass balance.	Lecture	1504.1/3	End Term
33.	Diffusion with Heterogeneous Chemical Reaction; Diffusion with Homogeneous Chemical Reaction	Understand the use of shell mass balance.	Lecture	1504.1/3	End Term
34.	Diffusion in to a Falling Liquid Film: Forced Convection Mass Transfer	Understand the use of shell mass balance.	Lecture	1504.1/3	End Term
35.	The Equations of Continuity for a Binary Mixture; The Equation of Continuity of A in Curvilinear Coordinates; The Multicomponent Equations of Change in Terms of Fluxes	Generalizing the shell mass balance equations.	Lecture	1504.1/3	End Term

36.	Dimensional Analysis of the Equations of Change for a Binary Isothermal Fluid Mixture	Generalizing the shell mass balance equations.	Lecture	1504.1/2/4	End Term
37.	Definition of Binary Mass Transfer Coefficients in One Phase; Correlations of Binary Mass Transfer Coefficients in One Phase at Low Mass Transfer Rates	Understanding the binary mass transfer terms.	Lecture	1504.1	End Term
38.	Definition of the Transfer Coefficients for High Mass Transfer Rates	Understanding the high mass transfer concepts.	Lecture	1504.1/4	End Term
39.	The Macroscopic Mass / Momentum / Energy Balances for Multicomponent Systems; Use of Macroscopic Balances to Solve Steady State Problems	Distinguishing the macroscopic and microscopic mass transfer problems.	Lecture	1504.1/3	End Term
40.	Use of Macroscopic Balances to Solve Steady State Problems	Solving the macroscopic mass transfer problems.	Lecture	1504.1/3	End Term
END-TERM EXAMINATION					

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1405.1	Identify transport properties and analyze the mechanisms of momentum, energy and mass transport.	3	3			1		1		2		1		3	1	
CE 1405.2	Develop the skills to select, locate and orient coordinate systems for transport phenomena problems.	3	3					1		1		2		2	1	
CE 1405.3	Generate the skills to formulate the differential forms of the equations of change for momentum, heat and mass transfer problems for steady-state and unsteady flows.	3	3			3		2		2		2		3	2	
CE 1405.4	Develop the skills to identify the analogies between momentum, heat and mass transfer problems.	3	2			1		1		2		2		1	2	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Chemical Engineering Thermodynamics | CE 1406 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty: Dr. Abhishek Sharma | Class: B. Tech. (Chemical) IV Semester

A. Introduction: This course intends to present thermodynamics from chemical engineering view point. It covers the laws of thermodynamics, thermodynamic relations, Solution thermodynamics, phase equilibrium and chemical reaction equilibrium. The key elements include the adaptation of thermodynamic laws to different flow processes, description of phase equilibrium and chemical equilibrium and their applications.

B. Course Outcomes: At the end of the course, students will be able to

[1406.1]. Apply the basic laws of thermodynamics to calculate heat and work requirement for industrial processes
[1406.2]. Analyse and evaluate data from PVT behaviour of fluids and ideal gas systems
[1406.3]. Apply mass, energy and entropy balances to flow processes
[1406.4]. Evaluate and apply the concepts of phase equilibrium
[1406.5]. Evaluate and apply the physical and chemical equilibrium
[1406.6]. Apply the knowledge of thermodynamics to the reacting and non-reacting processes

C. Program outcomes and program specific outcomes

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full-scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments, Projects, Case Studies (Accumulated and Averaged)	30
End Term Exam	End Term Exam (Open Book)	30
	Total	100
Attendance	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments	No make-up for missed short quizzes/assignments or exam will be allowed except in extenuating circumstances, with prior permission of the instructor(s), and the decision of the instructor(s) in this regard shall be final.	
Homework/ Home Assignment/ Project	Home works will be assigned in between the lectures along with the due date for handing it over. No late assignments handed after the due date shall be accepted under any circumstance. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. A case study is given which is assessed in form of individual reports submitted.	

E. Syllabus

Review of I and II Laws of Thermodynamics, P–V–T Relations of Pure Fluids - Graphical, Tabular and Mathematical representation; Generalized compressibility chart; Generalized EOS; Thermodynamic Potentials; Maxwell Relations, Thermodynamic Property Relations, Thermodynamic properties of real gases, Multicomponent mixtures, Properties of solutions, Phase Equilibrium (VLE, LLE, VLLE), Review of Thermochemistry; Chemical reaction equilibrium

F. Text books

1) Smith, J. M., Van Ness, H. C., and Abbott, M. M., Introduction to Chemical Engineering Thermodynamics, 6th ed., McGraw-Hill, 2001.

G. Reference books

1) Kyle, B.G., Chemical and Process Thermodynamics, 3rd ed., PHI, New Delhi, 1999.

2) Rao, Y.V.C., Chemical Engineering Thermodynamics, University Press, 1997.

Lecture Plan:

LEC NO	TOPICS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1 – 2	Introduction	Brief overview of the course	Lecture	1406.1	Mid Term -1, End Term
3	Internal Energy, First Law of Thermodynamics, Energy balances for closed systems, Thermodynamics and state function, Equilibrium	Students will be acquainted with these basic concepts	Lecture	1406.1	Mid Term -1, End Term
4 – 6	Phase Rule, Reversible processes, constant V and P processes, Enthalpy, Heat capacity, Mass and energy balances for open systems	Phase rule and other key thermodynamic concepts introduced	Lecture + Tutorial	1406.1; 1406.2	Mid Term -1, End Term

7	PVT behavior of pure substances, Ideal gas	Equations of state are covered	Lecture	1406.1; 1406.2	Mid Term -1, End Term
8	Virial equations of state and its applications, Cubic equation of state	Equations of state are covered	Lecture	1406.1; 1406.2	Mid Term -1, End Term
9	Generalized correlations for gases and liquids	Equations of state are covered	Lecture	1406.1; 1406.3	Mid Term -1, End Term
10 – 11	Heat effects	Heat effects are introduced.	Lecture + Tutorial	1406.1; 1406.3	Mid Term -1, End Term
12 – 14	Second law of thermodynamics, heat engines, entropy and its applications to ideal gas, lost work and ideal work	Second law of thermodynamics is a key concept of this course	Lecture + Tutorial	1406.3	Mid Term -1, End Term, Assignment
15 – 17	Third law of thermodynamics	It is briefly introduced	Lecture + Tutorial	1406.1	Mid Term -1, End Term, Assignment
18 – 19	Property relations for homogeneous phases, residual properties, Two phase systems	Phase equilibria are key components of this course	Lecture + Tutorial	1406.2; 1406.3	Mid Term -2, End Term, Assignment
20	Thermodynamic diagrams, Table of Thermodynamic properties	Students taught about property tables	Lecture	1406.2; 1406.3	Mid Term -2, End Term
21	Generalized property correlations for gases	Students taught about property correlations	Lecture	1406.2; 1406.3	Mid Term -2, End Term
22	Property relationships, partial molar properties, Fugacity and fugacity coefficients, fugacity in ideal solutions	Ideal and real solutions introduced to students	Lecture	1406.2; 1406.3	Mid Term -2, End Term
23 – 25	Property changes of mixing, heat effects of mixing process, excess properties, activity coefficients, gas mixtures	Ideal and real solutions introduced to students	Lecture + Tutorial	1406.2; 1406.3	Mid Term -2, End Term, Assignment
26	Phase equilibria, nature of equilibrium, criteria of equilibrium, phase rule, Duhem's theorem, VLE	Phase equilibria are key components of this course	Lecture	1406.4	Mid Term -2, End Term
27 – 29	Activity coefficients, Gibbs-Duhem equation, coexistence equation, stability	Key concepts of this thermodynamics course	Lecture + Tutorial	1406.4	Mid Term -2, End Term
30 - 33	Systems of limited liquid-phase miscibility	Key concepts of this thermodynamics course	Lecture + Tutorial	1406.4	Mid Term -2, End Term
34	Chemical reaction equilibria, criteria for equilibrium, standard Gibb's free energy change, equilibrium constant, effect of temperature, relations b/w equilibrium constants and compositions, equilibrium	Various kinds of free energy concepts introduced	Lecture + Tutorial	1406.5; 1406.6	End Term, Assignment

	conversions for single reactions				
35	Phase rule, Duhem's theorem for reacting systems	Phase rule is a key concept in thermodynamics	Lecture	1406.5	End Term
36	Multireaction equilibria	Concepts at the confluence of thermodynamics and chemical reactions	Lecture	1406.5; 1406.6	End Term, Assignment
39	Thermodynamics of flow processes, Fundamental equations, flow in pipes, maximum velocity in pipe flow	Thermodyanmics is able to explain the energetics of various mechanical processes	Lecture	1406.6	End Term
41 - 43	Metering and throttling process, Nozzles, compressors, ejectors, temperature measurements at high velocities	Thermodyanmics is able to explain the energetics of various mechanical processes. Practical mechanical devices discussed.	Lecture + Tutorial	1406.6	End Term, Assignment

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE1406.1	Apply the basic laws of thermodynamics to calculate heat and work requirement for industrial processes	3	3	2	1	1	2			3	1	2	1	3	2	2
CE1406.2	Analyze and evaluate data from PVT behavior of fluids and ideal gas systems	3	2			1	2	1	1	2	1	2		3	2	2
CE1406.3	Apply mass, energy and entropy balances to flow processes	3	3	2	1	1	3			3	1	2		3	3	2
CE1406.4	Evaluate and apply the concepts of phase equilibrium	3	2				2			2	1	2		2	1	2
CE1406.5	Evaluate and apply the physical and chemical equilibrium	3	2	1			2			1	1	2		2	2	2
CE1406.6	Apply the knowledge of thermodynamics to the reacting and non-reacting processes	3	3	2		1	2			3	2	2	1	3	2	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Heat Transfer Operations | CE 1407 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty: Dr. Anees A.Y. Khan | Class: Core Course

A. Introduction:

This course on Process Synthesis is a core course designed for the undergraduate students of Chemical Engineering. This course emphasizes on the principle concepts & methods of heat transfer in fluids and solids and their application in various heat transfer equipment in process industries. It provides insight in to the mechanism of heat transfer and design of heat transfer equipment.

B. Course Outcomes:

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

[1407.1]. Understand the basic concepts and laws of the three modes of heat transfer.

[1407.2]. To identify, formulate and solve engineering problems involving conduction, convection and radiation heat transfer

[1407.3]. To identify, formulate and solve engineering problems involving boiling, condensation, evaporation and crystallization

[1407.4]. To design heat exchangers and perform basic calculations of common heat exchangers.

[1407.5]. To develop the problem-solving skills essential to good engineering practice of heat transfer in real world applications thus enhancing the employability

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes and Assignments.	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No makeup for missed short quizzes or assignments or exam will be allowed, except in extenuating circumstances with prior permission of the instructor. The decision of the instructor in this regard will be final.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction – Modes of heat transfer, heat transfer equipment.

Conduction – Steady state conduction in one dimension, Fourier's law, Thermal conductivity, Steady state conduction of heat through composite solid, variable area and in bodies with heat sources.

Convective heat transfer – Overall heat transfer coefficient, heat transfer between fluids separated by plane wall, cylindrical wall, thermal contact resistance, critical insulation thickness; Forced convection – Flow over flat plate, thermal boundary layer, flow across a cylinder, Dimensionless groups in heat transfer, correlations for heat transfer coefficient for both internal and external flows; Free convection – Heat transfer correlations, combined free and forced convection.

Radiation heat transfer – Basic concepts, blackbody radiation, Planck's Law, Wien's displacement law, Stefan-Boltzmann Law, Kirchhoff's Law, Grey body; Radiation intensity of black body, Radiation shield, View factor, combined radiation, conduction and convection.

Heat transfer in boiling and condensation – Boiling phenomena and boiling curve, Mechanism of nucleate boiling, correlations for pool boiling, forced convection boiling; Condensation phenomena, condensation outside horizontal tube or tube bank, inside a horizontal tube, effect of non-condensable gases, drop wise condensation.

Heat exchanger design – Double pipe heat exchanger design using Kern method, Shell and tube heat exchanger design using Kern method and Bell Delaware method, Effectiveness NTU method of heat exchanger analysis. **Evaporators** – Types of evaporators and their construction and operation, Principles of evaporation and evaporators – capacity & economy, boiling point rise, heat transfer coefficient, enthalpy of solution, Evaporator selection and vapor recompression.

Crystallization – Crystal geometry, principles of crystallization- equilibria & yields, nucleation, crystal growth, crystallization equipment

F. TEXT BOOKS

T1 D.Q. Kern, "Process Heat Transfer", Mc Graw Hill, 1997.

T2 B.K. Dutta, "Heat Transfer Principles and Application", PHI India, 2015.

T3 J. P., Holman, "Heat Transfer", McGraw Hill, New York

G. REFERENCE BOOKS

R1 L. Bergman, Theodore, Adrienne S. Lavine, Incropera, Frank P, DeWitt, David P. "Introduction to Heat Transfer", 6th Edition

R2 W.L. McCabe, J.C. Smith, P. Harriot, Unit operations of Chemical engineering, 7th edition, Mc Graw Hill.

R3 A.S. Foust, L.A. Wenzel, C.W. Clump, L. Maus, L.B. Andersen, Principles of Unit Operations, 2nd edition, Wiley India.

R4 J.M. Coulson and J.F. Richardson, Chemical Engineering, Volume 1, 6th edition, Elsevier

Lecture Plan:

Lecture No.	TOPICS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1	Introduction to heat transfer	To understand the importance of heat transfer	Lecture	1407.1	
2-3	*Conduction* - Steady state conduction in one dimension, Fourier's law, Thermal conductivity	To understand the fundamental concepts and laws of heat transfer	Lecture	1407.1	Quiz, Mid term I, End Term
4-6	*Conduction* - Steady state conduction of heat through composite solid, variable area and in bodies with heat sources	To acquire the knowledge required in formulating and solving engineering problems related to conduction	Lecture & Tutorial	1407.1 & 1407.2	Quiz/Assignment, Mid term I, End Term
7-8	*Convective heat transfer* –Overall heat transfer coefficient, heat transfer between fluids separated by plane wall, cylindrical wall, thermal contact resistance, critical insulation thickness	To understand the basic principles of convective heat transfer between fluids	Lecture	1407.1 & 1407.2	Quiz/Assignment, Mid term I & End term

9-11	*Convective heat transfer* – Forced convection	To formulate and solve engineering problems related to convection	Lecture & Tutorial	1407.2 & 1407.5	Quiz/Assignment, Mid term I & End term
12,13	*Convective heat transfer* – Free convection	To identify, formulate and solve engineering problems related to convection	Lecture & Tutorial	1407.2 & 1407.5	Assignment, Mid term I & End term
14-18	*Radiation heat transfer*	To get acquainted with the basic concepts of radiative heat transfer	Lecture	1407.1 & 1407.2	Quiz/Assignment, Mid term II & End term
19-20	*Heat transfer in boiling*	To understand the boiling phenomena and mechanism of heat transfer involved	Lecture	1407.3 & 1407.5	Quiz, Mid term II & End term
21-24	*Heat transfer in condensation*	To acquaint the utility of correlations in estimating heat transfer coefficients in boiling and condensation	Lecture & Tutorial	1407.3 & 1407.5	Quiz, Mid term II & End term
25	*Heat exchanger design* – Double pipe heat exchanger design by Kern method	To acquire the knowledge of various design methods and perform the basic calculations of common heat exchange equipment used in industries	Lecture	1407.1 & 1407.4	Quiz/Assignment, Mid term II & End term
26,27	*Heat exchanger design* – Introduction to Shell and tube heat exchanger	To acquaint different types of heat exchangers used in process industries	Lecture	1407.1 & 1407.4	Assignment, Quiz, Mid term II & End term
28-30	*Heat exchanger design* – Shell and tube heat exchanger design using Kern Method	To perform the basic calculations of common heat exchangers used in industries	Lecture & Tutorial	1407.4 & 1407.5	Quiz/Assignment, Mid term II & End term
30-34	*Heat exchanger design* – Shell and tube heat exchanger design using Bell Delaware Method	To acquire the knowledge of various design methods and perform the basic calculations of common heat exchange equipment used in industries	Lecture & Tutorial	1407.4 & 1407.5	Quiz/Assignment, Mid term II & End term

35-37	*Evaporators*	To understand the mechanism of heat transfer in evaporators	Lecture	1407.1 & 1407.3	Assignment, Mid term II & End term
38-40	*Crystallization*	To acquaint the basic principles of crystallization and related terminology	Lecture & Tutorial	1407.1 & 1407.3	End term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1407.1	Understand the basic concepts and laws of the three modes of heat transfer	3	3		1		2	2				2		2		
CE 1407.2	To identify, formulate and solve engineering problems involving conduction, convection and radiation heat transfer	2	3	1			1							2		
CE 1407.3	To identify, formulate and solve engineering problems involving boiling, condensation, evaporation and crystallization	2	3	1			1						3	2	1	
CE 1407.4	To design heat exchangers and perform basic calculations of common heat exchangers		2				1	2						3	1	
CE 1407.5	To develop the problem-solving skills essential to good engineering practice of heat transfer in real world applications		2				1	2						3	1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Hand-out
Numerical Methods in Chemical Engineering | CE 1408 | 4 Credits | 3 1 0 4
Session: Jan 19 – May 19 | Faculty: Dr. Harsh Pandey | Class: B. Tech. (Chemical) IV Semester

A. Introduction: In chemical engineering, problems related to momentum, heat and mass transfer, chemical reaction engineering, thermodynamics, modeling and simulation, etc. involve linear / nonlinear algebraic equations, ordinary differential equations or partial differential equations. Numerical methods give the solution of applied problems when ordinary analytical methods fail. This course is designed to give an overview of numerical methods for solving a variety of problems encountered by a process engineer. MATLAB will be used as the working environment to solve the problems using step-wise, repeated and iterative solution methods, which would otherwise be tedious or unsolvable by hand-calculations. Since the focus is on the techniques themselves, rather than specific applications, the contents should be relevant to varied fields such as engineering, management, economics, etc.

B. Course Outcomes: At the end of the course, students will be able to:

[CO.1]	Solve the linear and non-linear algebraic equations using direct and iterative numerical techniques
[CO.2]	Approximate the function using appropriate numerical method
[CO.3]	Evaluate the integral using numerical methods
[CO.4]	Solve the ordinary differential equations by an appropriate numerical method
[CO.5]	Solve the partial differential equations by an appropriate numerical method
[CO.6]	Apply the numerical techniques to solve variety of chemical engineering problems, leading to skill enhancement of students

C. Program Outcomes and Program Specific Outcomes

[PO.1].	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems
[PO.2].	**Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences
[PO.3].	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations
[PO.4].	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
[PO.5].	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

[PSO.2]. Process Intensification: graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	Quizzes and Home/Class Assignments/Active Learning Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves. If a student miss a lecture, he himself has to study the topics that have been covered during that particular lecture. The student may contact the course coordinator for clarification of his/her doubts, if any.	
Make up Assignments (Formative)	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture. You may contact the course coordinator for clarification of doubts, if any.	

Active Learning Assignments (Formative)	Students are required to develop MATLAB codes for the Numerical Methods covered in lectures. They can develop their own programs to solve a variety of problems incorporating linear/ non-linear algebraic equations, curve fitting, ordinary and partial differential equations.

E. Syllabus

Finite Differences, Interpolation: Newton's, Stirling's interpolation formulae, Lagrange's Interpolation for unequal intervals. Numerical Integration: Simpson's and Trapezoidal Rule, Solution of Linear Algebraic Equations: Gauss's Elimination method, Gauss's Siedel Method, LU Decomposition Method, Eigen Values and Eigen Vectors: Introduction, Power method, Solutions of Non-Linear Equations, Regula Falsi Method, Newton-Raphson technique, Secant Method, Function Approximation: least square method of curve fitting, Numerical Solutions of Ordinary Differential Equations: Runga-Kutta Method, Pridictor-corrector Methods, Boundary value problems, Shooting Method, Finite difference Technique, Partial Differential Equations, Types of PDE, Finite difference technique(Method of lines), Numerical Solution of Heat, Wave and Laplace Equations.

F. Text Books

1. Gupta, S. K., "Numerical Methods for Engineers," New Age International Ltd., New Delhi, 1995.

G. Reference Books

1. Srimantha Pal, "Numerical Methods", Oxford University Press, 2012.
2. Saumeyen Guha, Rajesh Srivastava, "Numerical Methods for Engineering and Science," Oxford University Press, 2012.
3. Carnahan, B., Luther, H. A., and Wilkes, J.O., "Applied Numerical Methods", John Wiley, New York, 1969.
4. Constantinides, A., and Mostoufi, N., "Numerical Methods for Chemical Engineers with MATLAB Applications," Prentice Hall, 1999.
5. Hanna, O.T. and Sandall,O.C., "Computational Methods in Chemical Engineering," Prentice-Hall, 1995.
6. Sastry, S. S., "Introductory Methods of Numerical Analysis", PHI, 2012.

H. Lecture Plan:

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Introduction to Numerical Methods	To introduce numerical methods to the students	Lecture, Interaction	CE1408.1	NA
2	Linear algebraic equations	To acquaint students to the basics of linear algebraic equations	Interaction, Discussion	CE1408.1	Assignment
3, 4	Gauss Elimination	This key concept for solving equations is introduced	Interaction, Discussion	CE1408.1	Assignment
5,6	LU Decomposition	This key concept for solving equations is introduced	Interaction, Discussion	CE1408.1	Assignment
7,8	Gauss-Jordan Elimination	This key concept for solving equations is introduced	Interaction, Discussion	CE1408.1	Assignment
9,10	Gauss-Siedel Elimination	This key concept for solving equations is introduced	Interaction, Discussion	CE1408.1	Assignment
11,12	Eigen Values and Eigen Vectors: Introduction, Power Method	The significance of these in linear algebra is discussed	Interaction, Discussion	CE1408.1	Assignment
13	Pre-Sessional Review	Review of Syllabus Covered	Discussion	CE1408.1	NA
FIRST SESSIONAL EXAM					
14	Review of First Sessional Exam	Review	Interaction, Discussion	CE1408.1	NA

15, 16	Non-linear algebraic equations, Introduction, Regula Falsi Method	Introducing non-linear equations to the students	Interaction, Discussion	CE1408.1	Assign ment
17,18	Newton-Raphson technique	This key technique for solving non-linear equations is introduced	Discussion, Chalkboard problem solving	CE1408.1	Assign ment, Quiz
19	Secant Method	This key technique for solving non-linear equations is introduced	Discussion, Chalkboard problem solving	CE1408.1	Assign ment
20	Function Evaluation, least square method of curve fitting	Curve fitting is a key concept in this course, and is introduced	Discussion, Chalkboard problem solving	CE1408.2, CE1408.3	Assign ment
21,22	Newton's, Stirling's interpolation formulae	Curve fitting and interpolation is a key concept in this course, and is introduced	Discussion, Chalkboard problem solving	CE1408.2, CE1408.3	Assign ment
23,24	Lagrange's Interpolation for unequal intervals	Curve fitting and interpolation is a key concept in this course, and is introduced	Discussion, Chalkboard problem solving	CE1408.2, CE1408.3	Assign ment
25,26	Numerical Solutions of Ordinary Differential Equations, Predictor-corrector Methods	ODEs form a key backbone of this course, and are introduced here	Discussion, Chalkboard problem solving	CE1408.4	Assign ment
27,28	Runge-Kutta Method	RK method is a key concept in solving ODEs and PDEs numerically, and is covered	Discussion, Chalkboard problem solving	CE1408.4	Assign ment
29	Pre-Sessional Review	Review	Interaction, Discussion	CE1408.1, CE1408.2, CE1408.3, CE1408.4	NA
SECOND SESSIONAL EXAM					
30	Review of Second Sessional Exam	Review	Interaction, Discussion	CE1408.1, CE1408.2, CE1408.3, CE1408.4	NA
31,32	Boundary value problems, Finite difference Technique	Is a key concept in solving ODEs numerically, and is covered	Interaction, Discussion	CE1408.4	Assign ment
33, 34	Shooting Method	Is a key concept in solving ODEs numerically, and is covered	Interaction, Discussion	CE1408.4	Assign ment
35,36	Partial Differential Equations, Types of PDE	PDEs are introduced to the students	Interaction, Discussion	CE1408.5	Assign ment
37,38	Finite difference technique (Method of lines)	Is a key concept in solving PDEs numerically, and is covered	Discussion, Chalkboard problem solving	CE1408.5	Assign ment
39, 41	Numerical Solution of Heat, Wave and Laplace Equations	Extremely useful for Chemical Engineering students, are introduced and solved here	Discussion, Chalkboard problem solving	CE1408.4, CE1408.5, CE1408.6	Assign ment
42	Pre-End Term Exam Review	Review	Interaction, Discussion	CE1408.1, CE1408.2, CE1408.3, CE1408.4,	NA

				CE1408.5, CE1408.6	
END TERM EXAM					

I. Course Articulation Matrix: (Mapping of COs with POs & PSOs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE1408.1	Solve the linear and non-linear algebraic equations using direct and iterative numerical techniques	3	2			2	1	3		2	2	2		2	1	1
CE1408.2	Approximate the function using appropriate numerical method	3	2			2	1	2		2	2	2		1	1	
CE1408.3	Evaluate the integral using numerical methods	3	2			2	1			2	2	2		1	1	1
CE1408.4	Solve the ordinary differential equations by an appropriate numerical method	3	2			2	1	3		2	2	2		2	2	2
CE1408.5	Solve the partial differential equations by an appropriate numerical method	3	2			2	1	2		2	2	2		2	2	2
CE1408.6	Apply the numerical techniques to solve variety of chemical engineering problems, leading to skill enhancement of students	3	3	1			2	2	1	2	2	3	1	3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Basic Sciences

Department of Chemistry
Course Hand-out

Physical and Analytical Chemistry | CY1421| 4 Credits | 3104

Session: Jan 19 – May 19 | Faculty: Dr. Praveen Kumar Surolia | Class: Chemical Engineering 4th Semester B. Tech

A. Introduction: This course is offered by Dept. of Chemistry for 2nd year chemical engineering B. Tech. students. The objective of the course is to acquaint the students with the basic concepts of physical and analytical chemistry. The student with the knowledge of the topics covered such as surface chemistry, colloids, phase rules, photochemistry and various analytical techniques will understand about various physical systems, alloys, surface phenomenon and characterization of reaction products at molecular level, relevant in the industry/engineering field.

B. Course Outcomes: At the end of the course, students will be able to

[CY1421.1]. Discuss surface chemistry, colligative properties, colloids and apply concepts of adsorption and catalysis.

[CY1421.2]. Explain the basics of phase rule and recognize single and two components systems.

[CY1421.3]. Elaborate photochemical and photophysical processes to explain photochemical energy conversion and other related issues.

[CY1421.4]. Discuss instrumental analysis techniques and skills in advanced methods of separation and analysis.

[CY1421.5]. Illustrate spectroscopic and electrochemical techniques for skill enhancement for the successful chemical analysis.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

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

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change Understand the basic principles of chemistry and to explain them clearly.

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concers.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	Quiz tests and presentations (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Close Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity will help the	

E. SYLLABUS

Surface Chemistry: Ideal and non- ideal solutions, Henry's & Raoult's law, Colligative properties, Colloids, Adsorption and catalysis.

Phase Diagram And Phase Transformations: Phase rule, Single component systems, Binary Phase Diagrams, Lever rule, Typical Phase diagrams for Magnesia-Alumina, Copper-Zinc, Iron-carbon system.

Photochemistry: Jablonski diagram, Laws of photochemistry and quantum yield, Some examples of photochemical reactions, Applications of photochemistry.

Instrumental Analysis: Gas chromatography and High pressure liquid chromatography, Ion exchange separation, Electro analytical techniques, Spectral Techniques and Structural elucidation: UV- Vis, IR, NMR and Mass, Fuel analysis, Food analysis, Drug analysis.

F. TEXT BOOKS

A book or a set of books which covers 60% or more of the syllabus can be written under this category. (Not more than 3)

T.1. Atkins, P., and de Paula, J., Atkin's Physical Chemistry, 9th ed., W. H. Freeman & Co., 2009

T.2. Puri, B.R., Sharma, L.R., and Pathania, M. S., Principles of Physical Chemistry, S.N. Chand and Co. Jalandhar, 31st ed., 1990.

T.3. Adamson, A.W., Physical Chemistry of Surfaces, Inter science Publishers Inc. New York 1997.

G. REFERENCE BOOKS

R.1. Harvey, D., Modern Analytical Chemistry, McGraw Hill, 2000.

R.2. Nelson, W.L., Petroleum Refinery Engineering, Mc Graw-Hill Book Company, 1969.

R.3. Speight, J. G., Fuel Science &Technology Hand Book, Marcel Dekker, New York 1990.

H. Lecture Plan:

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1.	**Surface Chemistry:** Solubility, Henry's law, Different concentration terms	Understanding the concept of solubility and solution	Lecture	CY1421.1	Mid Term I End Term
2.	**Surface Chemistry:** Numerical based on Solubility, Henry's law, Different concentration terms	NA	Interactive/Self study	CY1421.1	Mid Term I End Term
3.	**Surface Chemistry:** Vapour pressure, Raoult's law and its modification, Relative lowering of vapour pressure	Interpretation of vapour pressure and colligative properties	Lecture	CY1421.1	Mid Term I End Term
4.	**Surface Chemistry:** Numerical based on Vapour pressure, Raoult's law and its modification, Relative lowering of vapour pressure	NA	Interactive/Self study	CY1421.1	Mid Term I End Term
5.	**Surface Chemistry:** Ideal solutions and non-ideal solutions, Maximum and minimum boiling solutions	Understanding the concept of solutions and respective boiling point	Lecture	CY1421.1	Mid Term I End Term
6.	**Surface Chemistry:** Numerical	NA	Interactive/Self study	CY1421.1	Mid Term I End Term
7.	**Surface Chemistry:** Colligative Properties, Vapour pressure, Boiling point	Interpretation of vapour pressure and colligative properties	Lecture	CY1421.1	Mid Term I End Term
8.	**Surface Chemistry:** Numerical based on Colligative Properties: Vapour pressure, Boiling point	NA	Interactive/Self study	CY1421.1	Mid Term I End Term
9.	**Surface Chemistry:** Freezing point, Osmotic pressure	Interpretation of colligative properties	Lecture	CY1421.1	Mid Term I End Term
10.	**Surface Chemistry:** Numerical based on Colligative Properties: Freezing point, Osmotic pressure	NA	Interactive/Self study	CY1421.1	Mid Term I End Term
11.	**Surface Chemistry:** Adsorption, Adsorption versus absorption, Types of adsorption: physisorption and chemisorption, Desorption	Understanding the concept of adsorption	Lecture	CY1421.1	Mid Term I End Term

12.	**Surface Chemistry:** Adsorption isotherms: Freundlich and Langmuir, Adsorption isobar	Construct the various adsorption isotherms	Lecture	CY1421.1	Mid Term I End Term
13.	**Surface Chemistry:** Numerical problems based on adsorption	NA	Interactive/Self study	CY1421.1	Mid Term I End Term
14.	**Surface Chemistry:** Colloids, Dispersed Systems and their classification, Size and shape of colloids	Discuss and understand colloidal systems	Lecture	CY1421.1	Mid Term I End Term
15.	**Surface Chemistry:** Purification of colloidal solutions, Applications of colloidal solutions, types of colloids: lyophobic and lyophilic	Elaborate the applications of colloidal systems	Lecture	CY1421.1	Mid Term I End Term
16.	**Surface Chemistry:** Optical Properties, Kinetic Properties, Electric Properties	Recall the properties of colloidal systems	Lecture	CY1421.1	Mid Term I End Term
17.	**Surface Chemistry:** Stability of colloids, Coagulation, Hardy Schulze law, Protective action of lyophilic colloids, Applications of colloids	Discuss the protective action and applications of colloids	Lecture	CY1421.1	Mid Term I End Term
18.	**Surface Chemistry:** Catalytic activity at surfaces, Adsorption and Catalysis, The Langmuir-Hishelwood (LH) mechanism, The Eley-Rideal (ER) mechanism	Elaborate the catalytic activity at surface	Lecture	CY1421.1	Mid Term I End Term
19.	**Surface Chemistry:** Unimolecular Reactions, Bimolecular Reactions	Recall the reactions at surfaces	Lecture	CY1421.1	Mid Term I End Term
20.	**Phase Diagram And Phase Transformations:** Phase rule, Introduction, Definition and examples of phase, component and degrees of freedom	Construct phase diagrams with examples	Lecture	CY1421.2	Mid Term II End Term
21.	**Phase Diagram And Phase Transformations:** One component system, water system, Carbon dioxide System, Sulphur System	Understand and construct phase diagrams with examples	Lecture	CY1421.2	Mid Term II End Term
22.	**Phase Diagram And Phase Transformations:** Problems based on single component systems	Explain one component system	Lecture	CY1421.2	Mid Term II End Term
23.	**Phase Diagram And Phase Transformations:** Binary phase diagrams, Condensed phase rule, Lever rule, Eutectic, Eutectoid, & Peritectic	Explain two component system	Lecture	CY1421.2	Mid Term II End Term
24.	**Phase Diagram And Phase Transformations:** Numerical based on Lever rule	NA	Interactive/Self study	CY1421.2	Mid Term II End Term

25.	**Phase Diagram And Phase Transformations:** Iron-Carbon system	Elaborate Iron-Carbon phase system	Lecture	CY1421.2	Mid Term II End Term
26.	**Phase Diagram And Phase Transformations:** Copper-Zinc system, Magnesia-Alumina system	Elaborate Cu-Zn, MgO_2-Al_2O_3 phase system	Lecture	CY1421.2	Mid Term II End Term
27.	**Photochemistry:** Laws Governing Absorption Of Light, Lambert's Law, Beer's Law	Recall the basics of photochemistry	Lecture	CY1421.3	Mid Term II End Term
28.	**Photochemistry:** Laws Governing Photochemistry, Grotthus-Draper Law, Stark-Einstein's Law (Second Law of Photochemistry), Interpretation Of Einstein's Law, Quantum Yield	Recall the laws of photochemistry	Lecture	CY1421.3	Mid Term II End Term
29.	**Photochemistry:** Luminescence, Chemiluminecence, Fluorescence, Phosphorescence, Jablonski Diagram	Understanding of Jablonski Diagram	Lecture	CY1421.3	Mid Term II End Term
30.	**Photochemistry:** Fluorescence process: Population of energy levels, Stokes shift, Invariance of emission wavelength with excitation wavelength, Mirror image rule, Internal conversion vs. fluorescence emission	Explain radiative and non-radiative processes	Lecture	CY1421.3	Mid Term II End Term
31.	**Photochemistry:** Photosensitization, The Born-Oppenheimer Approximation, Franck-Condon Principle	Explain the Franck-Condon Principle	Lecture	CY1421.3	Mid Term II End Term
32.	**Photochemistry:** Examples of photochemical reactions, Isomerization, Paternò-Büchi Reaction, Norrish reaction	Recall the organic photochemical reactions	Lecture	CY1421.3	Mid Term II End Term
33.	**Photochemistry:** H_2-Cl_2 reaction, H_2-Br_2 reaction	Recall the photochemical chain reactions	Lecture	CY1421.3	Mid Term II End Term
34.	**Photochemistry:** Quenching of Fluorescence, STERN-VOLMER EQUATION	Understand the fundaments of quenching	Lecture	CY1421.3	Mid Term II End Term
35.	**Instrumental Analysis:** Introduction to Chromatography, Types of Chromatography, Number of theoretical plates, Van Deemter equation	Recall the basics of chromatography	Lecture	CY1421.4	End Term
36.	**Instrumental Analysis:** Gas chromatography	Explain gas chromatography	Lecture	CY1421.4	End Term
37.	**Instrumental Analysis:** High performance liquid chromatography	Explain HPLC	Lecture	CY1421.4	End Term
38.	**Instrumental Analysis:** Ion exchange chromatography	Explain ion exchange chromatography	Lecture	CY1421.4	End Term

39.	**Instrumental Analysis:** Introduction to spectroscopy, UV and Visible Spectroscopy, chromophores and auxochromes, Electronic transitions, Orbital Spin States	Recall basics of UV-Vis spectroscopy	Lecture	CY1421.5	End Term
40.	**Instrumental Analysis:** UV and Visible Spectroscopy, Selection Rules of electronic transition, Spectral nomenclature of shifts (Bathochromic shift, Hysochromic shift, Hyperchromism, Hypochromism)	Elaborate principle and application of UV-Vis spectroscopy	Lecture	CY1421.5	End Term
41	**Instrumental Analysis:** UV/VIS of Aromatic compound, unsaturated ketones, Polyenes, and Unsaturated Carbonyl groups, Woodward-Fieser rule-examples and applications	Elaborate principle and application of UV-Vis spectroscopy	Lecture	CY1421.5	End Term
42.	**Instrumental Analysis:** Charge-Transfer Absorption, d → d electronic transitions	Understand charge transfer absorption	Lecture	CY1421.5	End Term
43.	**Instrumental Analysis:** Infrared Spectroscopy, Introduction, Vibrational Modes, Vibrational Frequencies of Bonds, Hooke's Law	Recall basics of IR spectroscopy	Lecture	CY1421.5	End Term
44.	**Instrumental Analysis:** The IR Spectrum – The detection of different bonds, Examples	Elaborate principle and application of IR spectroscopy	Lecture	CY1421.5	End Term
45.	**Instrumental Analysis:** Mass Spectroscopy, Introduction, General Schematic of mass spectrophotometer	Recall basics of mass spectroscopy	Lecture	CY1421.5	End Term
46.	**Instrumental Analysis:** Fragmentation Processes, The Even-Even Rule, The Nitrogen Rule, Rule of Thirteen, Metastable peaks, examples	Elaborate principle and application of mass spectroscopy	Lecture	CY1421.5	End Term
47.	**Instrumental Analysis:** Nuclear Magnetic Resonance Spectroscopy, Introduction, Theory of NMR, Shielding and De-shielding of protons	Recall basics of NMR spectroscopy	Lecture	CY1421.5	End Term
48.	**Instrumental Analysis:** Chemical Shift, Spin-Spin splitting, The N + 1 Rule, Coupling constant, examples	Elaborate principle and application of NMR spectroscopy	Lecture	CY1421.5	End Term

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CY 1421.1	Discuss surface chemistry, colligative properties, colloids and apply concepts of adsorption and catalysis	2						3			2		2	3	1	2
CY 1421.2	Explain the basics of phase rule and recognize single and two components systems			2					2				3	1	0	3
CY 1421.3	Elaborate photochemical and photophysical processes to explain photochemical energy conversion and other related issues	2				3					3		2	2	1	3
CY 1421.4	Discuss instrumental analysis techniques and skills in advanced methods of separation and analysis								2				2	2	1	1
CY 1421.5	Illustrate spectroscopic and electrochemical techniques for the successful chemical analysis		2			2			2				3			2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Process Modelling and Simulation| CE 1505 | 3 Credits | 3 0 0 3

Session: July 18 – Nov 18 | Faculty: Dr Manisha Sharma| Class: B.Tech III Year

A. Introduction: This course is offered by Dept. of Chemical Engineering as a core course. This course focuses on the modelling and simulation of processes involved in chemical engineering operations. In this unit, the students will learn the fundamentals of process synthesis and design using mathematical modelling tools. By the end of this course, the students will have a clear understanding required for analysis of process engineering solutions of real world problems.

B. Course Outcomes: At the end of the course, students will be able to

[1505.1] Understand the basic principles of process modelling and simulation

[1505.2] Carry out the analysis of lumped and distributed models used in process intensive industries

[1505.3] Perform the validation, parametric estimation and optimization of a process model

[1505.4] Develop the skills to generate process flowsheet using different unit operations in a process simulator

[1505.5] Carry out the simulation for generation of material and energy balances for overall system

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PO.1 **Engineering Knowledge:** A thorough knowledge of the basic science, engineering and mathematics and apply that to the underline practice of Chemical Engineering.

PO.2 **Problem Analysis:** Ability to apply these basic principles to solve real world problems in a broad range of career paths.

PO.3 **Project management and finance:** The skills of making smart decisions on process feasibility based in technical and economic evaluation.

PO.4 **Ethics**: The ability to appreciate the social, ethical, cultural, environmental and safety issues related to chemical engineering profession.

PO.5 **Conduct investigations of complex problems**: The ability to develop experimental procedure/protocol to test hypothesis and analysis meaningful interpretation of the generated data.

PO.6 **Environment and sustainability**: The skill to generate sustainable engineering solutions to societal and industrial problems.

PO.7 **Modern tool usage**: Proficiency to use computational tools for problem solving.

PO.8 **Communication**: ability to communicate effectively (technical and non-technical context) in written and oral form.

PO.9 **Design/development of solutions**: Skills to work effectively and professionally in multi-disciplinary groups to solve complex chemical engineering problems.

PO.10 **Individual and team work**: The ability to work effectively and professionally on projects both independently and as a part of a group/team.

PO.11 **Life-long learning**: The ability to be self-learners and lifelong learners.

PO.12 **The engineer and society**: The motivation to develop and lead entrepreneurial projects for societal benefit.

Degree Specific Outcomes for chemical engineering are as follows:

PSO.1 **Concept to Commissioning:** The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

PSO.2 **Process Intensification:** Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3 **Specialization:** students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments, Projects	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No makeup assignments will be given.	
Projects	Each group of 2-3 students will submit a project on a topic relevant to the industrial application of process modelling and simulation. The details of this component will be discussed during the lectures.	

E. SYLLABUS

Pre-requisites: CE1401 and CE1404

Fundamentals and industrial applications of process modeling and simulation, Macroscopic mass, energy and momentum balances, integration of fluid thermodynamics, chemical equilibrium, reaction kinetics and feed/ product property estimation in mathematical models. Steady state lumped systems, modeling of chemical process equipment (reactors, distillation, absorption, extraction columns, evaporators, and heat exchangers). Modelling and simulation of complex industrial systems in petroleum, petrochemicals, polymer, basic chemical industries; Commercial steady state and dynamic simulators; Simulation of process flow sheets.

F. BOOKS

- Luyben, W. L., *Process Modeling, Simulation and Control for Chemical Engineers*, McGraw Hill, 1989.
- Ramirez, W.F., *Computational Methods for Process Simulation*, 2nd ed., Butterworth-Heinemann, 1997.
- Ingham, J., Dunn, I. J., Heinzle, E., Prenosil, J.E., Snape, J.B., *Chemical Engineering Dynamics: An Introduction to Modelling and Computer Simulation*, 3rd ed., Wiley-VCH Verlag GmbH & Co. KGaA, 2007.
- Holland, C. D., *Fundamentals and Modeling of Separation Processes*, Prentice Hall, 1975.
- Himmelblau, D. M., & Bischoff, K. B., *Process analysis and simulation: Deterministic systems*, John Wiley, New York, 1968.

G. Lecture Plan:

LEC NO	TOPICS	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Modelling Overview and Industrial Applications of Process Modelling	Understanding the basic need of modelling and simulation in chemical engineering.	Lecture	CE1505.1	Mid Term I End Term
2	Modelling Process	Understanding the basic 7 step modeling process.	Lecture	CE1505.1	Mid Term I End Term
3	Process Model Characteristics and Introduction to Matlab	Understanding the use of MATLAB in the course.	Lecture	CE1505.4	Mid Term I End Term
4	System Definition; White, Black and Grey Box Models	Understanding the difference between white, black and grey box models.	Lecture	CE1505.1	Mid Term I End Term
5,6	Systematic Modelling Procedure	Applying 7 step modelling process in chemical engineering applications.	Lecture	CE1505.1	Mid Term I End Term
7	Introduction to Matlab Files	Understanding the use of MATLAB in the course.	Lecture	CE1505.4	Mid Term I End Term
8	Fundamental Concepts	Understanding the basic concepts used in the modeling of chemical engineering equipment's.	Lecture	CE1505.1	Mid Term I End Term
9,10,11	Conservation Equations	Understanding the basics of using mass, material and energy balance.	Lecture	CE1505.5	Mid Term I End Term
12,13	Constitutive Relations	Understanding the constitutive relations used in chemical engineering.	Lecture	CE1505.5	Mid Term I End Term
14	Matlab Applications	Apply MATLAB in the chemical engineering applications.	Lecture	CE1505.1/2	Mid Term I End Term
15	Introduction to Lumped Models	Understanding the concept of having variation of variable with time.	Lecture	CE1505.1/2	Mid Term I End Term
16	Solution of Ordinary Differential Equations	Use of Runge Kutta and other ODE solvers.	Lecture	CE1505.1/2	Mid Term I End Term
MID TERM I					
17	Matlab Applications	Use of Runge Kutta and other ODE solvers in MATLAB.	Lecture	CE1505.1/2	Mid Term II End Term
18	Introduction to Distributed Models	Understanding the concept of having variation of variable with time and space.	Lecture	CE1505.1/2	Mid Term II End Term
19	Initial and Boundary Conditions	Understanding the concept of using initial and boundary conditions.	Lecture	CE1505.1/2	Mid Term II End Term
20	Real Time Applications	Use the concepts for real applications of chemical engineering.	Lecture	CE1505.1/2	Mid Term II End Term
21	Partial Differential Equations Solving Methods	Understanding the concept of solving PDEs.	Lecture	CE1505.1/2	Mid Term II End Term

22	Finite Difference Approximation and Boundary Conditions Handling	Understanding the concept of solving PDEs.	Lecture	CE1505.1/2	Mid Term II End Term
23	Matlab Applications	Apply MATLAB to solve PDEs.	Lecture	CE1505.4	Mid Term II End Term
24,25	Model Validation and Verification, Model Calibration	Applying the simulation to validate and verify the model.	Lecture	CE1505.1/2	Mid Term II End Term
26	Model Optimization and Parameter Estimation	Applying the simulation to validate and verify the model.	Lecture	CE1505.1/2	Mid Term II End Term
27	Matlab Applications	Apply MATLAB in the chemical engineering applications	Lecture	CE1505.4	Mid Term II End Term
28,29	Process Synthesis and Design	Applying the simulation to provide the design of the equipment.	Lecture	CE1505.4	Mid Term II End Term
MID TERM II					
30	Aspen Hysys Introduction	Understanding the use of ASPEN in the course.	Lecture	CE1505.4	End Term
31	Convergence Methods	Understand the convergence and divergence of the solution.	Lecture	CE1505.1	End Term
32	Sequential Modular vs Equation Oriented Simulation	Understand the convergence and divergence of the solution.	Lecture	CE1505.1	End Term
33	Aspen Hysys Unit Models	Apply ASPEN in the chemical engineering applications	Lecture	CE1505.4	End Term
34	Reactor Design	Use the balances to design a reactor.	Lecture	CE1505.3/4/5	End Term
35	Thermodynamic Package Selection	Understand the uses of thermodynamic packages in the software's.	Lecture	CE1505.1	End Term
36	Package Selection Recommendations	Understand the uses of thermodynamic packages in the software's.	Lecture	CE1505.1	End Term
38	Types of Heat Exchanger	Use the balances to design a heat exchanger.	Lecture	CE1505.3/4/5	End Term
39	Heat Exchanger Balance	Use the balances to design a reactor.	Lecture	CE1505.3/4/5	End Term
40,41	Heat Exchanger Design	Use the balances to design a reactor.	Lecture	CE1505.3/4/5	End Term
42	Degree of Freedom Analysis, Control Synthesis using Industry Example	Understand the concept of DoF to assume the parameters constant for solving the model.	Lecture	CE1505.3/4/5	End Term
END TERM					

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1505.1	Understand the basic principles of process modelling and simulation	2	1	0	0	2	2	0	0	3	0	0	1	2	0	0
CE 1505.2	Carry out the analysis of lumped and distributed models used in process intensive industries	3	3	0	0	2	1	3	0	3	0	0	0	2	2	1
CE 1505.3	Perform the validation, parametric estimation and optimization of a process model	2	3	0	1	2	0	3	0	3	0	0	0	1	2	1
CE 1505.4	Develop the skills to generate process flowsheet using different unit operations in a process simulator	3	3	0	0	2	0	3	0	3	2	0	0	3	2	1
CE 1505.5	Carry out the simulation for generation of material and energy balances for overall system	3	3	0	0	2	0	3	0	3	1	0	0	3	2	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR
School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Handout
Mass Transfer I | CE1506 | 3 Credits | 3 0 0 3
Session: Jul'18 – Nov'18 | Faculty: Dr. Subhajit Majumder | Class: B. Tech. (Chemical) V Semester

A. INTRODUCTION

This course is offered by Department of Chemical Engineering as a core course. The course focuses on the fundamentals of molecular diffusion, convective mass transfer, and interphase mass transfer. It deals with the design of various mass transfer equipment related to absorption, stripping, adsorption, and humidification.

B. COURSE OUTCOMES

At the end of the course, students will be able to:

[CE1506.1] Understand the basics of diffusional mass transfer

[CE1506.2] Understand the concepts of interphase mass transfer and mass transfer coefficients

[CE1506.3] Understand the mechanism of various mass transfer operations such as absorption, stripping, adsorption, and humidification

[CE1506.4] Develop skills to perform design calculations involved in various mass transfer operations

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. ASSESSMENT PLAN

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	Quizzes and Home Assignments / Class Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Assignments (Formative)	Assignments are an integral part of the course. Home assignments / Class assignments will be provided from time to time. No late submissions will be entertained. It is expected that the students will work on the assignments independently. If any assignment is found copied from any source, marks will be deducted for the same.	
Make up Assignments	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture(s). You may contact the course coordinator for clarification of doubts, if any.	

E. SYLLABUS

Introduction to mass transfer operations. Theory of interphase mass transfer, estimation of mass transfer coefficient, individual and overall mass transfer coefficients for gas-liquid and liquid-liquid operations. Gas Absorption, graphical calculation of number of theoretical stages for absorption and stripping column. Adsorption, adsorption isotherm, batch and continuous stage adsorption, design of adsorption column, and adsorption equipment. Vapor gas mixtures, terminology, Psychometric chart, Water cooling operations, Gas-Liquid contact operations, adiabatic operations, Types of equipment, Design calculations, Cooling towers, design of cooling towers, Recirculating Liquid-gas humidification cooling.

F. TEXT BOOKS

T1. Treybal, R. E., Mass Transfer Operations, 3rd ed., McGraw Hill, 2012.

T2. Seader, J. D. and Henley, E. J., Separation Process Principles, 2nd ed., Wiley, 2010.

G. REFERENCE BOOKS

R1. Geankoplis, C. J., Transport Processes and Unit Operations, 3rd ed., PHI, New Delhi, 2000.

R2. Foust, A.S., Wenzel, L.A., Clump, C.W., Naus, L., and Anderson, L.B., Principles of Unit operations, 2nd ed., John Wiley and Sons, 1980.

R3. McCabe and Smith, Unit Operations in Chemical Engineering, 5th ed., McGraw-Hill, NY, 1993

R4. Hill, G. B., Cooling towers principles and practice, BH, London, 1990.

R5. Sinnott, R. K., Coulson & Richardson's Chemical Engineering Design: Chemical Engineering Design: Vol. 6, 2006.

H. LECTURE PLAN

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode Of Assessing CO
1.	Introduction	Mechanism of mass transfer, Classification of mass transfer operation	Lecture	CE1506.1	Assignment / quiz / Mid Term I
2.	Introduction	Choice of separation method, methods of conducting mass transfer operations, Design principles	Lecture	CE1506.1	Assignment / quiz / Mid Term I
3.	Molecular diffusion in fluids	Basics of steady state molecular diffusion in fluids at rest	Lecture	CE1506.1	Assignment / quiz / Mid Term I
4.	Molecular diffusion in fluids	Basics of steady state molecular diffusion in fluids at rest and in laminar flow	Lecture	CE1506.1	Assignment / quiz / Mid Term I
5.	Molecular diffusion in fluids	Basics of steady state molecular diffusion in fluids in laminar flow	Lecture	CE1506.1	Assignment / quiz / Mid Term I
6.	Mass Transfer coefficients	Significance and Calculation of Mass Transfer Coefficients	Lecture	CE1506.2	Assignment / quiz / Mid Term II
7.	Mass Transfer coefficients	Significance and Calculation of Mass Transfer Coefficients	Lecture	CE1506.2	Assignment / quiz / Mid Term II
8.	Mass Transfer coefficients	Significance and Calculation of Mass Transfer Coefficients	Lecture	CE1506.2	Assignment / quiz / Mid Term II
9.	Mass Transfer coefficients	Significance and Calculation of Mass Transfer Coefficients	Lecture	CE1506.2	Assignment / quiz / Mid Term II
10.	Interphase mass transfer	Basics of Interphase mass transfer and equilibrium conditions	Lecture	CE1506.2	Assignment / quiz / Mid Term II
11.	Interphase mass transfer	Basics of Interphase mass transfer and equilibrium conditions	Lecture	CE1506.2	Assignment / quiz / Mid Term II
12.	Interphase mass transfer	Basics of Interphase mass transfer and equilibrium conditions	Lecture	CE1506.2	Assignment / quiz / Mid Term II
13.	Interphase mass transfer	Material balances and calculation for number of stages	Lecture	CE1506.2	Assignment / quiz / Mid Term II
14.	Interphase mass transfer	Material balances and calculation for number of stages	Lecture	CE1506.2	Assignment / quiz / Mid Term II
15.	Gas-Liquid Operations	Equipment for Gas-Liquid Operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
16.	Gas-Liquid Operations	Equipment for Gas-Liquid Operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
17.	Gas-Liquid Operations	Equipment for Gas-Liquid Operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II

18.	Gas-Liquid Operations	Equipment for Gas-Liquid Operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
19.	Gas-Liquid Operations	Equipment for Gas-Liquid Operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
20.	Gas-Liquid Operations	Equipment for Gas-Liquid Operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
21.	Gas-Liquid Operations	Basics of Humidification operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
22.	Gas-Liquid Operations	Basics of Humidification operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
23.	Gas-Liquid Operations	Basics of Humidification operations	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
24.	Gas-Liquid Operations	Types of Humidification equipment	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
25.	Gas-Liquid Operations	Design of cooling tower	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
26.	Gas-Liquid Operations	Design of cooling tower	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
27.	Gas-Liquid Operations	Design of cooling tower	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
28.	Gas-Liquid Operations	Basic and fundamentals of Gas absorption	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
29.	Gas-Liquid Operations	Basic and fundamentals of Gas absorption	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
30.	Gas-Liquid Operations	Gas absorption equipment	Lecture	CE1506.3 CE1506.4	Assignment / quiz / Mid Term II
31.	Gas-Liquid Operations	Design of Gas absorption towers	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
32.	Gas-Liquid Operations	Design of Gas absorption towers	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
33.	Gas-Liquid Operations	Design of Gas absorption towers	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
34.	Gas-Liquid Operations	Design of Gas absorption towers	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
35.	Gas-Liquid Operations	Design of Gas absorption towers	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
36.	Gas-Liquid Operations	Design of Gas absorption towers	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
37.	Solid-Fluid Operations	Basics of Adsorption and Ion exchange	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
38.	Solid-Fluid Operations	Fundamentals of Adsorption	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
39.	Solid-Fluid Operations	Fundamentals of Adsorption	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
40.	Solid-Fluid Operations	Design of Adsorption equipment	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
41.	Solid-Fluid Operations	Design of Adsorption equipment	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
42.	Solid-Fluid Operations	Design of Adsorption equipment	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term
43.	Solid-Fluid Operations	Design of Adsorption equipment	Lecture	CE1506.3 CE1506.4	Assignment / quiz / End Term

I. COURSE ARTICULATION MATRIX: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[CE1506.1]	Understand the basics of diffusional mass transfer	3	2					1		1			2	3		1
[CE1506.2]	Understand the concepts of interphase mass transfer and mass transfer coefficients	2	2		1			1					1	2	1	
[CE1506.3]	Understand the mechanism of various mass transfer operations such as absorption, stripping, adsorption, and humidification	2	2	1	2			1				1	2	2	1	2
[CE1506.4]	Develop skills to perform design calculations involved in various mass transfer operations	3	1	3		1	2		1	1		1	2	2	1	2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Hand-out
Chemical Reaction Engineering I | CE 1507 | 3 Credits | 3 0 0 3
Session: Jul'18 – Nov'18 | Faculty: Dr. Manisha Sharma | Class: B. Tech. (Chemical) V Semester

A. Introduction: The aim of a chemical engineer is to conduct the chemical reactions at controlled conditions in such a manner so as to achieve maximum selectivity, yield and energy efficiency. This course on chemical reaction engineering combines the knowledge of chemical kinetics and thermodynamics that enables to decide upon the extent of reaction, rate of reaction, and process conditions. It introduces the basic concepts of reactor designing including elucidation of reaction rate and reaction mechanism, principles of chemical reactor design and analysis for homogeneous reactions, multiple reactors and their sequence, temperature and pressure effects, and selection of appropriate reactor and optimizing the reactor conditions.

B. Course Outcomes: At the end of the course, students will be able to:

[1507.1]	Analyze and interpret the reaction systems and reaction kinetics
[1507.2]	Analyze experimental kinetic data to determine reaction mechanisms
[1507.3]	Design the ideal reactors (isothermal Batch, CSTR, and PFR)
[1507.4]	Develop skills to choose the right reactor among single, multiple, recycle reactors
[1507.5]	Understand and apply the concepts of heat capacity and heat of reaction in non-isothermal systems

C. Program Outcomes and Program Specific Outcomes

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

[PO.2]. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

[PSO.2]. Process Intensification: graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	Quizzes/Home and Class Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture. However, you may contact the course coordinator for clarification of doubts, if any.	

E. Syllabus

Kinetics of homogeneous chemical reactions, Rate expressions, Temperature dependence of rate Differential, integral, half-life and total pressure method theories, Elementary and Non elementary reaction kinetics - Pseudo, steady state hypothesis mechanism. Isothermal reactor design. Design of batch, semi-batch, CSTR's and PFR's. Multiple reactor systems, Reactors in series or/and parallel, CSTRs series Performance analysis, Batch, Semi-Batch, Continuous and Recycle reactors. Multiple reaction systems, Series and parallel reactions in flow reactors, Product distribution, Yield and

selectivity. Maximizing the desired product in parallel reactions, Different reactors and schemes for minimizing the unwanted product, maximizing the desired product in series reactions.

F. Books

- Levenspiel, O., Chemical Reaction Engineering, 3rd ed., Wiley India Pvt Ltd
- Fogler, H. S., Elements of Chemical Reaction Engineering, 4th ed., Prentice-Hall of India, Delhi, 2003.

G. Reference Books

- Smith, J. M., Chemical Engineering Kinetics, 3rd ed., McGraw-Hill, 1981.
- Levenspiel, O., The Chemical Reactor Omnibook, OSU Bookstores, Corvallis Oregon, 1993.
- Froment, G. F., and Bischoff, K. B., Chemical Reactor Analysis and Design, 3rd ed., John Wiley and Sons, 2010.
- Richardson, J.F., and Peacock D.G., Coulson and Richardson's Chemical Engineering, vol. 3, 3rd ed., Asian Books Pvt. Ltd., New Delhi, 1998.

H. Lecture Plan

lecture	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode Of Assessing CO
1	Overview of Chemical Reaction Engineering	Acquainted with basic knowledge of chemical reactions	Lecture	1507.1	Mid Term I, Quiz/Assignment & End Term
2	Kinetics of homogeneous chemical reactions, reactor types, rate expressions, Concentration dependent term of a rate equation, kinetic models, testing and validation.	Understanding the fundamentals of chemical rate equations	Lecture	1507.1	Mid Term I, Quiz/Assignment & End Term
3	Temperature dependent term of rate equation and reaction mechanism	Understanding the fundamentals of chemical rate equations	Lecture	1507.1	Mid Term I, Quiz/Assignment & End Term
4	Temperature dependent term of rate equation and reaction mechanism	Understanding the fundamentals of chemical rate equations	Lecture	1507.1	Mid Term I, Quiz/Assignment & End Term
5	Interpretation of Batch reactor data: Constant volume batch reactor, Integral Method of data analysis: Irreversible unimolecular type I order reactions	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term

6	Irreversible bimolecular type II order reactions	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
7	Irreversible trimolecular type III order reactions, empirical nth order reactions	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
8	Irreversible trimolecular type III order reactions, empirical nth order reactions	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
9	Zero-order reactions, Overall order by half-life and fractional-life method	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
10	Irreversible reaction in parallel, homogeneous catalyzed reactions, Autocatalytic reactions	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
11	Irreversible reactions in series, first-order and second-order reversible reactions, reversible reactions in series	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
12	Irreversible reactions in series, first-order and second-order reversible reactions, reversible reactions in series	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
13	Differential method of data analysis, varying volume batch reactor	Acquiring the knowledge of methods for calculating reaction rate parameters	Lecture	1507.2	Mid Term I, Quiz/Assignment & End Term
14	Introduction to reactor design, ideal reactors for a single reactions, ideal batch reactor, space time and space velocity	Grasping the principles for solving chemical	Lecture	1507.3	Mid Term I, Quiz/Assignment & End Term

		reactor design problems			
15	Review I		Lecture		Mid Term I, Quiz/Assignment & End Term
16	Steady-State Mixed flow reactor	Grasping the principles for solving chemical reactor design problems	Lecture	1507.3	Mid Term II, Quiz/Assignment & End Term
17	Steady-State Plug flow reactor	Grasping the principles for solving chemical reactor design problems	Lecture	1507.3	Mid Term II, Quiz/Assignment & End Term
18	Holding time and space time for flow reactors	Grasping the principles for solving chemical reactor design problems	Lecture	1507.3	Mid Term II, Quiz/Assignment & End Term
19	Design for single reactions, Size comparison of single reactors	Grasping the principles for solving chemical reactor design problems	Lecture	1507.3	Mid Term II, Quiz/Assignment & End Term
20	Multiple reactor systems, Plug flow reactor in series	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
21	Mixed flow reactors in series	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
22	Recycle reactors	Developing the fundamental knowledge for solving complex chemical	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term

		reactor design problems			
23	Autocatalytic reactions	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
24	Design for parallel reactions: introduction to multiple reactions	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
25	Quantitative treatment of product distribution and of reactor size	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
26	Quantitative treatment of product distribution and of reactor size	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
27	Multiple reactions: Irreversible first order reaction in series	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
28	First order followed by zero-order reaction, Zero-order followed by first order reaction	Developing the fundamental knowledge for solving complex chemical	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term

		reactor design problems			
29	Reversible reactions	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
30	Irreversible series parallel reactions	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Mid Term II, Quiz/Assignment & End Term
31	Review II		Lecture		Mid Term II, Quiz/Assignment & End Term
32	Temperature and Pressure Effects: Single reactions	Analyzing the effect of operating conditions on Reaction kinetics	Lecture	1507.5	Quiz/Assignment & End Term
33	Equilibrium constants from thermodynamics	Analyzing the effect of operating conditions on Reaction kinetics	Lecture	1507.5	Quiz/Assignment & End Term
34	Multiple reactions	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Quiz/Assignment & End Term
35	Choosing the right kind of reactor	Developing the fundamental knowledge for solving complex chemical reactor design problems	Lecture	1507.4	Quiz/Assignment & End Term

36	Overall Review		Lecture		Quiz/Assignment & End Term

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[1507.1]	Analyze and interpret the reaction systems and reaction kinetics	2	3	1	1		1	1		1	1	1	2	1	1	
[1507.2]	Analyze experimental kinetic data to determine reaction mechanisms	2	2	1	2	1		1		1	2			2		1
[1507.3]	Design the ideal reactors (isothermal Batch, CSTR, and PFR)	2	3		2		1	1		1			2	1	2	
[1507.4]	Develop skills to choose the right reactor among single, multiple, recycle reactors	1	3	1			2	2		2	1		2	2	3	1
[1507.5]	Understand and apply the concepts of heat capacity and heat of reaction in non-isothermal systems	1	1	1		1	1	2		1		1		1	1	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Petroleum Production Technologies | CE 1553 | 3 Credits | 3 0 0 3

Session: Aug 18 – Dec 18 | Faculty: Dr. Anand Chakinala | Class: Program Elective

A. Introduction: This material on Petroleum Production Technologies is a program elective designed for the undergraduate students of Chemical Engineering under petroleum engineering as minors. The objective of the course is to provide a handy guideline to designing, analysing and optimizing petroleum production systems. The students are introduced to the concepts of petroleum production systems, properties of oil, gas and produced water and performance of oil & gas production wells as well as addressing production enhancement techniques such as matrix acidizing, hydraulic fracturing. They are also introduced to the concepts of midstream operations of natural gas processing like acid gas treatment, natural gas compression. This course also addresses designing acidizing jobs, tubing design and separation and dehydration systems.

B. Course Outcomes: At the end of the course, students will be able to

[1553.1]. Understand the basic operations of an upstream & midstream petroleum production process
[1553.2]. Estimate the properties of oil, natural gas and produced water using correlations
[1553.3]. Calculate the reservoir deliverability and well deliverability
[1553.4]. Design equipment's for the upstream and midstream processes thus developing the skills required for employment
[1553.5]. Design acidizing jobs for enhanced oil production

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments, Projects, Case studies (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No make-up for missed short quizzes/assignments or exam will be allowed except in extenuating circumstances, with prior permission of the instructor(s), and the decision of the instructor(s) in this regard shall be final.	
Homework/ Home Assignment/ Project (Formative)	Home works will be assigned in between the lectures along with the due date for handing it over. No late assignments handed after the due date shall be accepted under any circumstance. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. Group projects are assigned which is assessed in the form of individual reports submitted.	

E. SYLLABUS

Introduction to Petroleum production technologies*:* Reservoir, well, separators, pumps and pipelines, compressors, safety controls, **Properties of crude oil, natural gas and produced water**: Review of gas properties, crude oil properties, produced water properties, **Petroleum production from**: *Under saturated oil reservoirs*- Transient flow, pseudo steady state flow, steady state well performance, horizontal well production, effect of water production, *Two-phase reservoirs*- Two phase flow, inflow performance relationship (IPR), Generalized VOGEL IPR, other approximations, *Natural gas reservoirs*- Gas well deliverability, approximations, transient flow, horizontal IPR, **Well bore and choke performance:** Single phase flow of incompressible and compressible, Multiphase flow, Flow through chokes-Single phase liquid flow and gas flow, **Artificial lift methods**: Sucker rod pumping, Gas lift, Plunger lift, Introduction to enhanced oil recovery, **Matrix acidizing:** Acid rock interaction, Carbonate acidizing design, sandstone acidizing design, Hydraulic fracturing,

Midstream operations of natural gas processing: Process modules, Processing objectives, effect of gas type in field processing, Phase separation, Gravity separators, Multistage separation, Centrifugal separators, Slug catchers, gas-liquid coalescers, Acid gas treatment, Batch processes, amine processes, carbonate washing and water washing, Methanol based process, other processes, process selection, Sulfur recovery process, **Natural gas compression:** Thermodynamics of gas compression, Liquefaction processes, types and selection of compressors, Compressor design, control and performance maps, **Equipment design and selection**: Well tubing, separation systems, transportation systems.

F. TEXT BOOKS

1) B.Guo, W.C. Lyons, A. Ghalambor, Petroleum Production Engineering, 3rd ed., Gulf professional publishing, 2007.

G. REFERENCE BOOKS

1) B.Guo, A. Ghalambor, Natural Gas Engineering Handbook, Gulf professional publishing, 2005.

2) Dake L.P., Fundamentals of reservoir engineering, Elsevier, 1978.

3) Smith H.C., Tracy G.W., Farrar R.L., Applied Reservoir Engineering, Vol I and II, OGCL, 1999.

4) Economides, M.J., Daniel Hill, A., Economides, C.E., Petroleum Production Systems, Prentice Hall Inc., 1994.

5) Abdel-Aal, H.K., Aggour, M., Fahim, M.A., Petroleum and Gas Field Processing, Marcel Dekker Inc., 2003.

Lecture Plan:

LEC NO	TOPICS	Session outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1-2	*Introduction to Petroleum production technologies*	*Brief overview of Crude oil production*	Lecture	1553.1	Mid Term-1, End term
3-5	*Properties of crude oil, natural gas and produced water*	*Estimation of the crude properties using empirical equations*	Lecture + Tutorial	1553.2	Mid Term-1, End term
6-10	*Petroleum production from*: Under saturated oil reservoirs, Two-phase reservoirs, Natural gas reservoirs	*Prediction of IPR for different reservoirs*	Lecture + Tutorial	1553.3	Mid Term-1, End term, Assignment-1
11-14	*Well bore and choke performance*	*Prediction of TPR and pressure drop*	Lecture + Tutorial	1553.3	Mid Term-2, End term, Assignment-2
5-9	*Artificial lift methods*	*To acquaint with several lift methods*	Lecture	1553.3	Mid Term-2, End term
10-13	*Matrix acidizing*	*To be able to determine the amount of acid consumption*	Lecture + Tutorial	1553.5	Mid Term-2, End term
14	*Hydraulic fracturing*	*Brief overview of the concept*	Lecture	1553.5	Mid Term-2, End term, Assignment-3
15-19	*Midstream operations of natural gas processing*		Lecture	1553.4	End term
20-23	*Phase separation*		Lecture	1553.4	End term
24-29	*Acid gas treatment*	*To be able to design separation systems*	Lecture	1553.4	End term
30-32	*Natural gas compression*		Lecture	1553.4	End term
33 - 36	*Equipment design and selection*	*To be able to design tubing, separation systems and transportation systems*	Lecture + Tutorial	1553.4	End term, Assignment-4

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	*PSO1*	*PSO2*	*PSO3*
CE1553.1	Understand the basic operations of an upstream & midstream petroleum production process	2	1		1									1		3
CE1553.2	Estimate the properties of oil, natural gas and produced water using correlations	2	1		1	2								1		3
CE1553.3	Calculate the reservoir deliverability and well deliverability	2	1		1	2								1		3
CE1553.4	Design equipment's for the upstream and midstream processes		2	1	1	2	1	1	1					2	1	3
CE1553.5	Design acidizing jobs for enhanced oil production		1	1	1	2	1	2	1					2	1	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Conventional and Non-Conventional Energy Resources | CE 1554 | 3 Credits | 3 0 0 3

Session: July 18 – Nov 18 | Faculty: Dr. Anees Ahmed Yunus Khan| Class: B.Tech III Year

Introduction: This course focuses on the generation of available and derived forms of energy for different industrial applications. In this course, the students will learn about both conventional and non-conventional energy resources such as coal, natural gas, oil, biomass, hydro, wind and solar. By the end of this course, the students will have a better understanding of energy harnessing methods from different sources around the world.

A. Course Outcomes: At the end of the course, students will be able to

[1554.1] List and explain the main sources of energy and their primary applications.

[1554.2] Describe the challenges and problems associated with the use of various energy resources, including fossil fuels, with regard to future supply and the environment.

[1554.3] Develop the skills to explain the principles and outline the technologies to deliver useable energy from conventional and non-conventional energy resources.

[1554.4] Identify issues facing the non-conventional energy industries.

[1554.5] Identify planning and environmental issues related to non-conventional energy systems.

B. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PO.1 **Engineering Knowledge:** A thorough knowledge of the basic science, engineering and mathematics and apply that to the underline practice of Chemical Engineering.

PO.2 **Problem Analysis:** Ability to apply these basic principles to solve real world problems in a broad range of career paths.

PO.3 **Project management and finance:** The skills of making smart decisions on process feasibility based in technical and economic evaluation.

PO.4 **Ethics**: The ability to appreciate the social, ethical, cultural, environmental and safety issues related to chemical engineering profession.

PO.5 **Conduct investigations of complex problems**: The ability to develop experimental procedure/protocol to test hypothesis and analysis meaningful interpretation of the generated data.

PO.6 **Environment and sustainability**: The skill to generate sustainable engineering solutions to societal and industrial problems.

PO.7 **Modern tool usage**: Proficiency to use computational tools for problem solving.

PO.8 **Communication**: ability to communicate effectively (technical and non-technical context) in written and oral form.

PO.9 **Design/development of solutions**: Skills to work effectively and professionally in multi-disciplinary groups to solve complex chemical engineering problems.

PO.10 **Individual and team work**: The ability to work effectively and professionally on projects both independently and as a part of a group/team.

PO.11 **Life-long learning**: The ability to be self-learners and lifelong learners.

PO.12 **The engineer and society**: The motivation to develop and lead entrepreneurial projects for societal benefit.

Degree Specific Outcomes for chemical engineering are as follows:

PSO.1 **Concept to Commissioning:** The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

PSO.2 **Process Intensification:** Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3 **Specialization:** students will be specialized in the areas of petroleum, energy and environment related fields.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes, Assignments AND Projects (Accumulated and Averaged)	15+15
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No makeup assignments will be given.	
Projects	Each group of 2-3 students will submit a project on a topic relevant to relevant to conventional and non-conventional energy production techniques. The details of this component will be discussed during the lectures.	

D. SYLLABUS

Introduction of coal, natural gas and oil as sources of energy. Application of coal in industries. In situ Coal Gasification. Oil and Gas from condensate and oilfields. Scope of Oil and Natural gas industry. Concepts of thermodynamics and system energy in Natural Gas Engineering. Physical properties of natural gas and the associated hydrocarbon liquids. Reservoir aspects of natural gas and oil. Conversion of coal and gas to liquid. Introduction to world energy scenario, Renewable energy resources, Radiation, Solar Geometry, radiation models; Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures, introduction to thermal systems (flat plate collector), Biomass, Biomass resources, wood composition, biogas, biodiesel, ethanol; Wind, types of wind machines, Hydro resources, types of hydro turbine, small hydro systems; Other systems, Geothermal, wave energy, ocean energy.

E. BOOKS

Reference Books:

- Probstein, R. F., and Hicks, R. E., Synthetic Fuels, Dover Publications, 2013.
- S. Rao and B.B. Parulekar, Energy technology, Khanna Publishers, 2017.
- P.C. Jain, Engineering Chemistry, Dhanpat Rai Publishing Company, 2018.
- D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, 1987.
- J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, 1986.
- Sukhatme, S. P., Solar Energy - Principles of Thermal Collection and Storage, 3rd ed., Tata McGraw-Hill, 1996.
- Duffie, J. A., and Beckman, W. A., Solar Engineering of Thermal Processes, 4th ed., John Wiley, 2013.
- Goswami, D. Y., Kreith, F., and Kreider, J. F., Principles of Solar Engineering, Taylor and Francis, 2000.
- Green, Solar Cells, Prentice-Hall, Englewood Cliffs, 1982.

F. Lecture Plan:

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Introduction to World Energy Resources	List and explain the main sources of energy and their primary applications	Lecture and interaction	CO 1	Quiz
2	Introduction of coal, natural gas and oil as sources of energy. Application of coal in industries	List and explain the main sources of energy and their primary applications	Lecture and interaction	CO 1 CO 2	
3	Oil and Gas from condensate and oilfields. Scope of Oil and Natural gas industry.	Describe the challenges and problems associated with the use of various energy resources, including fossil fuels, with regard to future supply and the environment.	Lecture and interaction	CO 1 CO 2	
4	Concepts of thermodynamics and system energy in Natural Gas Engineering.				Quiz
5-6	Physical properties of natural gas and the associated hydrocarbon liquids. Reservoir aspects of natural gas and oil. Conversion of coal and gas to liquid.				1st Sessional ET Exam Home Assignment
7-12	Oil and Natural Gas Production Techniques		Lecture and interaction	CO 1 CO 2	1st Sessional

13-20	Nuclear Processes, Nuclear decay, Nuclear fuel processing, Life cycle of nuclear fuel, Nuclear reactor types and applications.	Explain the principles and outline the technologies to deliver useable energy from conventional and non-conventional energy resources.			ET Exam Home Assignment Quiz Project
	Hydroelectric power: Design considerations for a hydroelectric power plant, classification of hydroelectric power plants, flow duration and power duration curve, Selection of turbine, power load factor.	Identify issues facing the non-conventional energy industries. Identify planning and environmental issues related to non-conventional energy systems.	Lecture and interaction	CO 1 CO 2 CO 3 CO 4	
First sessional exam					
21-23	Biomass, Biomass resources, wood composition, biogas, biodiesel, ethanol.	Identify planning and environmental issues related to non-conventional energy systems.	Lecture and interaction	CO 3 CO 4 CO 5	Quiz II Sessional ET Exam Home Assignment Project
24-26	Wind, types of wind machines, Energy generation from wind.	Identify planning and environmental issues related to non-conventional energy systems.	Lecture and interaction	CO 3 CO 4 CO 5	
27-28	Introduction to world energy scenario, Renewable energy resources, Radiation, Solar Geometry, radiation models	Identify planning and environmental issues related to non-conventional energy systems.	Lecture and interaction	CO 3 CO 4 CO 5	
29-30	Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures,	Identify planning and environmental issues related to non-conventional energy systems.	Lecture and interaction	CO 3 CO 4 CO 5	

Second sessional exam					
30-32	Introduction to solar thermal systems (flat plate collector).	List and explain the main sources of energy and their primary applications	Lecture and interaction	CO 3 CO 4 CO 5	ET Exam Home Assignment Quiz Project
33-40	Other non-conventional energy sources such as Geothermal, wave energy, ocean energy.	List and explain the main sources of energy and their primary applications Identify planning and environmental issues related to non-conventional energy systems.	Lecture and interaction		
End term exam					

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[1554.1]	List and explain the main sources of energy and their primary applications.			1			1	1								3
[1554.2]	Describe the challenges and problems associated with the use of various energy resources, including fossil fuels, with regard to future supply and the environment.			1			2	3			1					3
[1554.3]	Explain the principles and outline the technologies to deliver useable energy from conventional and non-conventional energy resources.			1			2	2								3
[1554.4]	Identify issues facing the non-conventional energy industries.		3		1				1	1						3
[1554.5]	Identify planning and environmental issues related to non-conventional energy systems.					3	1	1					1			3

1- **Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation**

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Process Safety Analysis | CE 1604 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty: Dr. Harsh Pandey | Class: Core course

A. Introduction: This material on Process Safety Analysis is designed for the undergraduate students of Chemical Engineering. This course introduces the basic concepts relating to chemical hazards, risk, and ethics. The interaction and trade-offs of these concepts are stressed in order to establish approaches to the proper selection and evaluation of processes and their implementation into small and large scale plants/laboratories. Quantitative analyses of chemical releases and dispersion using thermodynamic, transport, and reaction/reactor considerations are used to develop an appreciation for and understanding of chemical incidents and the possible consequences to plant facilities, workers, and the general public. Examples of problems that may arise due to inadequate process design, improper process modification, and disregard for ethical decision making are discussed using numerous case studies.

B. Course Outcomes: At the end of the course, students will be able to

[1604.1]	Develop safety culture
[1604.2]	Evaluate effect of toxicants and other hazards
[1604.3]	Quantitatively analyse release and dispersion rates of liquid and vapors
[1604.4]	Analyse fire and explosion hazards
[1604.5]	Integrate safety concepts and ethics into chemical process design
[1604.6]	Perform hazard identification, risk assessment, enhancing employability.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

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

[PO.2]. **Problem analysis**: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. **The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

[PSO.2]. Process Intensification: graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments, Projects, Case Studies (Accumulated and Averaged)	30
End Term Exam	End Term Exam (Open Book)	30
	Total	100
Attendance	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments	No make-up for missed short quizzes/assignments or exam will be allowed except in extenuating circumstances, with prior permission of the instructor(s), and the decision of the instructor(s) in this regard shall be final.	
Homework/ Home Assignment/ Project	Home works will be assigned in between the lectures along with the due date for handing it over. No late assignments handed after the due date shall be accepted under any circumstance. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. A case study is given which is assessed in form of individual reports submitted.	

E. SYLLABUS

Introduction – Accident and loss statistics, inherent safety, safety culture, ethics; **Toxicology**- How toxicants enter and are eliminated from biological organisms, Toxicological studies, Dose vs response, Relative toxicity, threshold limit values; **Industrial Hygiene:** Government regulations, Identification, Evaluation of exposures to volatile toxicants, dusts, noise, toxic vapors, Control; **Source Models:** Flow of liquid through hole, hole in a tank, pipes; Flow of vapor through holes, gases through pipes; Flashing liquids, Liquid pool evaporation or boiling, Toxic Release and dispersion models; **Fires and explosion:** Fire triangle, fire vs explosion, Flammability characteristics of liquid and vapors, TNT equivalency, energy of chemical and mechanical explosions, vapor cloud explosions, BLEVE, Inerting, Static electricity, Explosion proof equipment and instruments, Sprinkler systems; **Relief systems:** Relief concepts, Location of reliefs, Relief scenarios, Relief systems for flares, scrubbers, condensers, knock out drum; **Relief sizing:** Spring operated for liquid/vapor/gas service, Rupture disk relief for liquid/vapor/gas, reliefs for thermal expansion of process fluids; **Hazard Identification:** Surveys, HAZOP, safety reviews **Risk assessment:** Probability theory, event trees, fault trees, QRA, LOPA, **Accident investigations**

F. TEXT BOOKS

1. Crowl, D.A., Louvar, J.F., Chemical Process Safety, Pearson, 3rd edition, 2015.

G. REFERENCE BOOKS

1. Center for Chemical Process Safety (CCPS), Introduction to process safety for undergraduates and engineers, Wiley, 1st Edition, 2016.
2. Sanders, R. E., Chemical Process Safety, Elsevier, 3rd edition, 2006.
3. Klein, J.A., Vaughen, B.K., Process Safety: Key concepts and practical approaches, CRC press, 1st edition, 2017.

H. Lecture Plan:

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Introduction to Safety	To introduce chemical process safety to the students	Lecture, Interaction	CE1604.1	NA
2-4	Toxicology	Introducing concepts related to toxicity and exposure to the students	Interaction, Discussion	CE1604.2	Assignment
5-7	Industrial Hygiene	Introduces industrial hygiene and best practices to the students	Interaction, Discussion	CE1604.2, CE1604.5	Assignment
8-10	Source Models	This key concept for understanding release of hazardous materials is introduced	Interaction, Discussion	CE1604.2, CE1604.3	Assignment
11	Flashing liquids, Liquid pool evaporation or boiling	Students learn about these fire and explosion hazards	Interaction, Discussion	CE1604.4	Assignment
12	Pre-Sessional Review	Review of Syllabus Covered	Discussion	CE1604.1, CE1604.2, CE1604.3, CE1604.4	NA
FIRST SESSIONAL EXAM					
13-16	Toxic Release and dispersion models	This key concept for understanding release and spreading of hazardous materials is introduced	Interaction, Discussion	CE1604.2, CE1604.3	Assignment
17-20	Fires	Students learn about these fire and explosion hazards	Interaction, Discussion	CE1604.4	Assignment

21-23	Explosions	Students learn about these fire and explosion hazards	Interaction, Discussion	CE1604.4	Assignment
24-27	Inerting, Static electricity, Explosion proof equipment and instruments, Sprinkler systems	Students learn about preventing and minimizing damage from fire and explosion hazards	Interaction, Discussion	CE1604.4	Assignment
28	Relief concepts, Location of reliefs, Relief scenarios	Students learn about preventing and minimizing damage from fire and explosion, toxicity, and other hazards	Interaction, Discussion	CE1604.1, CE1604.2, CE1604.3, CE1604.4, CE1604.5	Assignment
29	Relief systems for flares, scrubbers, condensers, knock out drum	Students learn about preventing and minimizing damage from fire and explosion, toxicity, and other hazards	Interaction, Discussion	CE1604.1, CE1604.2, CE1604.3, CE1604.4, CE1604.5	Assignment
30-34	Relief sizing	Students learn about preventing and minimizing damage from fire and explosion, toxicity, and other hazards	Interaction, Discussion	CE1604.1, CE1604.2, CE1604.3, CE1604.4, CE1604.5	Assignment
35	Pre-Sessional Review	Review of Syllabus Covered	Discussion	CE1604.1, CE1604.2, CE1604.3, CE1604.4, CE1604.5	NA
SECOND SESSIONAL EXAM					
36-39	Hazard Identification and Risk Assessment	Students learn about the formal approaches to Hazard Identification and Risk Assessment standardized by Industry	Interaction, Discussion	CE1604.6	NA
40-42	Accident investigations	Students learn about some major industrial disasters, what went wrong, and the lessons learnt from them	Discussion, Class Participation	CE1604.1, CE1604.2, CE1604.3, CE1604.4, CE1604.5, CE1604.6	Miniproject Report
END TERM EXAM					

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	*PSO1*	*PSO2*	*PSO3*
CE 1604.1	Develop safety culture				3									2		1
CE 1604.2	Evaluate effect of toxicants and other hazards	1			2			1						2		
CE 1604.3	Quantitatively analyse release and dispersion rates of liquid and vapors	1			2			2						2	1	
CE 1604.4	Analyse fire and explosion hazards	1			2			2						2		1
CE 1604.5	Integrate safety concepts and ethics into chemical process design			1	2									2		1
CE 1604.6	Perform hazard identification, risk assessment, enhancing employability.			2										2		1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR
School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Handout
Mass Transfer II | CE1605 | 3 Credits | 3 0 0 3
Session: Jan'19 – May'19 | Faculty: Dr. Subhajit Majumder | Class: B. Tech. (Chemical) VI Semester

A. INTRODUCTION

This course on Mass Transfer II is a core course designed for the undergraduate students of Chemical Engineering. This course continues further on the concepts learned in Mass Transfer-I which describes interphase mass transfer involved in design of separation systems. It covers the concepts of vapour-liquid, liquid-liquid, solid-liquid equilibrium involved in mass transfer operations with emphasis on design and performance calculations of rate based and equilibrium-based separations. Separation processes covered in detail in this course are distillation, extraction, leaching and drying.

B. COURSE OUTCOMES

At the end of the course, students will be able to:

[CE1605.1]	Interpret the equilibrium data required in design of separation processes
[CE1605.2]	Illustrate the mass transfer fundamentals involved in design calculations
[CE1605.3]	Use the design methods for solving problems related to mass transfer operations in industries
[CE1605.4]	Perform process design calculations of various mass transfer equipment such as distillation columns, extraction columns and dryers enhancing employability

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

The Graduates of Chemical Engineering from MUJ will have:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. ASSESSMENT PLAN

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	Quizzes and Home Assignments / Class Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Assignments (Formative)	Assignments are an integral part of the course. Home assignments / Class assignments will be provided from time to time. No late submissions will be entertained. It is expected that the students will work on the assignments independently. If any assignment is found copied from any source, marks will be deducted for the same.	
Make up Assignments	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture(s). You may contact the course coordinator for clarification of doubts, if any.	

E. SYLLABUS

Distillation, concept of vapour liquid equilibrium, Raoult's law, deviations from ideal law, azeotropic distillation and steam distillation. Enthalpy concentration diagrams, binary and multi component systems, dew and bubble point calculations, flash vaporization, simple distillation, binary component distillation, Ponchan Savarit method: minimum reflux ratio, optimum reflux

ratio- total reflux ratio, partial condenser, total condenser, McCabe Thiele method: concept of q line, optimum reflux ratio- total reflux ratio, partial condenser, total condenser. Multi component distillation: azeotropic, extractive, molecular distillation. Liquid-Liquid Extraction: liquid-liquid-equilibria, ternary systems triangular and rectangular coordinates-choice of solvent-single stage and multi stage cross current, equipment's such as mixer settler, packed and tray towers. Leaching, Drying and design criteria, Design of rotary dryers.

F. TEXT BOOKS

T1. Treybal R. E, Mass Transfer Operations, 3rd ed., McGraw Hill, 2012

G. REFERENCE BOOKS

R1. Seader, J.D., Henley, E.J., Roper D.K., "Separation Process Principles," 3rd ed., (International Edition), John Wiley & Sons.

R2. McCabe and Smith, Unit Operations in Chemical Engineering, 5th ed., McGraw-Hill.

R3. Coulson, J.M., Richardson, J.F., Chemical Engineering Volume-2, 5th ed., Butterworth-Heinemann.

R4. Geankoplis, C. J., Transport Processes and Unit Operations, 3rd ed., PHI, New Delhi.

R5. Robert H. Perry and Don W. Green, Perry's Chemical Engineers hand book, 8th ed., McGraw Hill.

R6. King, C. J., Separation Processes, 2nd ed., Tata McGraw Hill, New Delhi.

H. LECTURE PLAN

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode Of Assessing CO
1.	Introduction	Understand the basics of Mass Transfer Operations	Lecture	-	Assignment / quiz / Mid Term I
2.	Introduction	Understand the basics of Mass Transfer Operations	Lecture	-	Assignment / quiz / Mid Term I
3.	Distillation	Vapor liquid equilibrium, concept of relative volatility	Lecture	CE1605.1	Assignment / quiz / Mid Term I
4.	Distillation	Effect of P and T on equilibrium data, P-x-y and T-x-y diagrams, y vs x diagrams	Lecture	CE1605.1	Assignment / quiz / Mid Term I
5.	Distillation	Ideal Solutions, Raoult's law, Deviations from ideality, Maximum and minimum boiling azeotrope	Lecture	CE1605.1	Assignment / quiz / Mid Term I
6.	Distillation	Bubble and dew point calculations	Lecture	CE1605.1	Assignment / quiz / Mid Term I
7.	Distillation	Bubble and dew point calculations	Lecture	CE1605.1	Assignment / quiz / Mid Term I
8.	Distillation	Enthalpy concentration diagrams	Lecture	CE1605.1	Assignment / quiz / Mid Term I
9.	Distillation	Single stage flash distillation	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term I
10.	Distillation	Steam distillation	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term I
11.	Distillation	Simple distillation binary and multicomponent mixtures	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term I
12.	Distillation	Continuous rectification of binary systems	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term I
13.	Distillation	Determination of number of stages by Ponchon Savarit method, case study	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term I
14.	Distillation	Determination of number of stages by Ponchon Savarit method, case study	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term I

15.	Distillation	Determination of number of stages by Ponchon Savarit method, case study	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term I
16.	Distillation	Determination of number of stages by Mc-Cabe Thiele method, Case study	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
17.	Distillation	Determination of number of stages by Mc-Cabe Thiele method, Case study	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
18.	Distillation	Partial and total condenser, Concept of minimum, total and optimum reflux ratio	Lecture	CE1605.2; CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
19.	Distillation	Partial and total condenser, Concept of minimum, total and optimum reflux ratio	Lecture	CE1605.2; CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
20.	Distillation	Partial and total condenser, Concept of minimum, total and optimum reflux ratio	Lecture	CE1605.2; CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
21.	Distillation	Use of open steam	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term II
22.	Distillation	Azeotropic distillation, extractive distillation	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term II
23.	Distillation	Concept of multi-component distillation	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term II
24.	Extraction	Liquid-Liquid equilibrium, Choice of solvent	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term II
25.	Extraction	Ternary diagrams	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term II
26.	Extraction	Design calculations for miscible solvents (co-current and counter current)	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
27.	Extraction	Design calculations for miscible solvents (co-current and counter current)	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
28.	Extraction	Design calculations for miscible solvents (co-current and counter current)	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
29.	Extraction	Design calculations for immiscible solvents (co-current and counter current)	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
30.	Extraction	Design calculations for immiscible solvents (co-current and counter current)	Lecture	CE1605.3; CE1605.4	Assignment / quiz / Mid Term II
31.	Extraction	Types of extractors	Lecture	CE1605.1; CE1605.2	Assignment / quiz / Mid Term II
32.	Leaching	Solid liquid equilibrium	Lecture	CE1605.1; CE1605.2	Assignment / quiz / End Term
33.	Leaching	Leaching equipment	Lecture	CE1605.1; CE1605.2	Assignment / quiz / End Term
34.	Leaching	Single and multistage operation	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term
35.	Leaching	Single and multistage operation	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term
36.	Leaching	Single and multistage operation	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term
37.	Drying	Equilibrium relationship and hysteresis, types of moisture	Lecture	CE1605.1; CE1605.2	Assignment / quiz / End Term
38.	Drying	Mechanism of drying, rate of drying	Lecture	CE1605.1; CE1605.2	Assignment / quiz / End Term
39.	Drying	Drying equipment	Lecture	CE1605.1; CE1605.2	Assignment / quiz / End Term
40.	Drying	Drying equipment	Lecture	CE1605.1; CE1605.2	Assignment / quiz / End Term
41.	Drying	Design of Batch, continuous dryers	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term
42.	Drying	Design of Batch, continuous dryers	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term
43.	Drying	Cross-circulation drying, Freeze drying	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term
44.	Drying	Cross-circulation drying, Freeze drying	Lecture	CE1605.3; CE1605.4	Assignment / quiz / End Term

I. COURSE ARTICULATION MATRIX: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[CE1605.1]	Interpret the equilibrium data required in design of separation processes	3	3					2				1		3		2
[CE1605.2]	Illustrate the mass transfer fundamentals involved in design calculations	3	1					2			1		1	3		2
[CE1605.3]	Use the design methods for solving problems related to mass transfer operations in industries	3	3			2		2		2		1		3		2
[CE1605.4]	Perform process design calculations of various mass transfer equipment such as distillation columns, extraction columns and dryers enhancing employability	3	3	1		2		2		2	2	1		3		2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Chemical Reaction Engineering II| CE 1606 | 3 Credits | 3 0 0 3

Session: Jan' 19 – May' 19 | Faculty: Dr Manisha Sharma| Class: B. Tech. (Chemical) VI Semester

Introduction: This course is offered by Dept. of Chemical Engineering as a core course. This course focuses on the design of chemical reacting systems. In this unit, the students will learn the basics of non-ideal reactors, heterogeneously reacting systems and application of real reactors available in process plants and industries. By the end of this course, the students will have a clear understanding required for troubleshooting the design related problems of chemical reactors in real world.

A. Course Outcomes: At the end of the course, students will be able to

[1606.1] Understand the fundamentals of Residence Time Distribution in chemical reactors

[1606.2] Utilize different Flow Models to understand non-ideal reactor behaviour

[1606.3] Analyze the heterogeneous and solid catalysed reactions for industrial applications

[1606.4] Evaluate the performance of different industrial reactors such as packed bed, fluidized bed, and three phase reactors

[1606.5] Apply the detailed kinetics for design of fluid-fluid and fluid-particle systems

B. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

PO.1 **Engineering Knowledge:** A thorough knowledge of the basic science, engineering and mathematics and apply that to the underline practice of Chemical Engineering.

PO.2 **Problem Analysis:** Ability to apply these basic principles to solve real world problems in a broad range of career paths.

PO.3 **Project management and finance:** The skills of making smart decisions on process feasibility based in technical and economic evaluation.

PO.4 **Ethics**: The ability to appreciate the social, ethical, cultural, environmental and safety issues related to chemical engineering profession.

PO.5 **Conduct investigations of complex problems**: The ability to develop experimental procedure/protocol to test hypothesis and analysis meaningful interpretation of the generated data.

PO.6 **Environment and sustainability**: The skill to generate sustainable engineering solutions to societal and industrial problems.

PO.7 **Modern tool usage**: Proficiency to use computational tools for problem solving.

PO.8 **Communication**: ability to communicate effectively (technical and non-technical context) in written and oral form.

PO.9 **Design/development of solutions**: Skills to work effectively and professionally in multi-disciplinary groups to solve complex chemical engineering problems.

PO.10 **Individual and team work**: The ability to work effectively and professionally on projects both independently and as a part of a group/team.

PO.11 **Life-long learning**: The ability to be self-learners and lifelong learners.

PO.12 **The engineer and society**: The motivation to develop and lead entrepreneurial projects for societal benefit.

Degree Specific Outcomes for chemical engineering are as follows:

PSO.1 **Concept to Commissioning:** The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

PSO.2 **Process Intensification:** Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3 **Specialization:** students will be specialized in the areas of petroleum, energy and environment related fields.

C. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments, Mini-Project (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No makeup assignments will be given.	
Projects	Each group of 2-3 students will submit a project on a topic relevant to the design of chemical reactors applicable in process plants. The details of this component will be discussed during the lectures.	

D. SYLLABUS

Isothermal non-ideal flow reactors, RTD in chemical reactors, distribution functions. Conversion in non-ideal flow reactors, Single and multi-parameter models for non-ideal flow, Concepts of mixing, Micro and macro mixing. Heterogeneous reactions, Rate equation for heterogeneous systems, Contacting patterns for two phase systems, Fluid particle non-catalytic reactions, Different models, Derivation of rate equations, Application to design Fluid-fluid non- catalytic reactions. Introduction to Slurry, Trickle bed reactors, and Fluidized bed reactors.

E. BOOKS

Fogler, H. S., Elements of Chemical Reaction Engineering, 4th ed., Prentice-Hall of India, Delhi, 2003.
Levenspiel, O., Chemical Reaction Engineering, 3rd ed., Wiley India Pvt Ltd., 2010.
Smith, J. M., Chemical Engineering Kinetics, 3rd ed., McGraw-Hill, 1981.
Carberry, J. J., Catalytic Reaction Engineering, McGraw-Hill, 1976.
Levenspiel, O., The Chemical Reactor Omnibook, OSU Bookstores, Corvallis Oregon, 1993.
Froment, G. F., and Bischoff, K. B., Chemical Reactor Analysis and Design, 3rd ed., John Wiley and Sons, 2010.

F. Lecture Plan:

Lec No	Topics	Session Outcomes	Model of Delivery	Corresponding CO	Mode of assessing the outcome
1,2,3	Revision of Chemical Reaction Engineering-I	Revise the fundamentals with applications taught in Chemical Reaction Engineering I Course	Lecture	NA	NA
4	RTD Concept	Introducing the concept of Residence Time Distribution	Lecture	1606.1	Mid-Term I End Term Assignment/Quiz/Mini Project
5	Age Distribution of Fluid	Introducing the experimental methods for calculating age distribution of fluids	Lecture	1606.1	Mid-Term I End Term Assignment/Quiz/Mini Project
6	Step and Pulse Experiments, Convolution Integral	Explaining the applied methods for mean residence time and exit age distribution (E) calculation	Lecture	1606.1	Mid-Term I End Term Assignment/Quiz/Mini Project
7	Non Ideal Reactor Conversion	Calculating the conversion in non-ideal flow reactors	Lecture	1606.1	Mid-Term I End Term Assignment/Quiz/Mini Project
8,9,10	Non Ideal Flow Models- Compartment Model	Explaining the fundamentals of compartment model for E calculations	Lecture	1606.2	Mid-Term I End Term Assignment/Quiz/Mini Project
11,12,13	Non Ideal Flow Models- Dispersion Model	Explaining the fundamentals of dispersion model for E calculations	Lecture	1606.2	Mid-Term I End Term Assignment/Quiz/Mini Project
14,15,16	Non Ideal Flow Models- Tank In Series Model	Explaining the fundamentals of tank in series model for E calculations	Lecture	1606.2	Mid-Term I End Term Assignment/Quiz/Mini Project
17,18,19	Non Ideal Flow Models- Pure Convective Model	Explaining the fundamentals of pure convective model for E calculations	Lecture	1606.2	Mid-Term I End Term Assignment/Quiz/Mini Project
20	Mixing Concepts	Introducing the concepts of degree of segregation and earliness of mixing in RTD calculation	Lecture	1606.2	Mid-Term I End Term Assignment/Quiz/Mini Project

21,22	Heterogeneous Reactions-Introduction	Introducing the heterogeneous chemical engineering systems	Lecture	1606.3	Mid-Term II End Term Assignment/Quiz/Mini Project
22,24,25,26	Solid Catalysed Reactions	Explaining the mechanism of heterogeneous reactions in presence of solid catalysts and evaluating the performance of different flow reactors	Lecture	1606.3	Mid-Term II End Term Assignment/Quiz/Mini Project
27,28	Packed Bed Catalytic Reactors	Describing the basics of packed bed reactors with performance evaluation for different design considerations	Lecture	1606.4	Mid-Term II End Term Assignment/Quiz/Mini Project
29,30,31	Fluidized Bed Catalytic Reactors	Explaining the behaviour and performance of fluidized bed reactors using different hydrodynamic models	Lecture	1606.4	Mid-Term II End Term Assignment/Quiz/Mini Project
32,33	Catalyst Deactivation	Explaining the catalyst decay mechanism and its effect on reactor performance	Lecture	1606.4	Mid-Term II End Term Assignment/Quiz/Mini Project
34,35,36	Three Phase Reactors	Describing the fundamentals of three phase reactors with their performance evaluation	Lecture	1606.4	Mid-Term II End Term Assignment/Quiz/Mini Project
37,38,39	Fluid-Fluid Reactions: Kinetics and Design	Explaining the factors involved in kinetic estimation and designing of fluid-fluid reactions	Lecture	1606.5	End Term Assignment/Quiz/Mini Project
40,41,42	Fluid-Particle Reactions: Kinetics and Design	Explaining the factors involved in kinetic estimation and designing of fluid-particle reactions	Lecture	1606.5	End Term Assignment/Quiz/Mini Project

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1606.1	Understand the fundamentals of Residence Time Distribution in chemical reactors	3	3					1	2	3	2				1	
CE 1606.2	Utilize different Flow Models to understand non-ideal reactor behaviour	3	3					1	2	3	2				1	
CE 1606.3	Analyze the heterogeneous and solid catalysed reactions for industrial applications	3	3					1	2	3	2				1	
CE 1606.4	Evaluate the performance of different industrial reactors such as packed bed, fluidized bed, and three phase reactors	3	3					1	2	3	2				1	
CE 1606.5	Apply the detailed kinetics for design of fluid-fluid and fluid-particle systems	3	3					1	2	3	2				1	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering

Course Hand-out

Petroleum Refining Technology| CE 1653 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty: Dr. Anand Chakinala | Class: Elective course

A. Introduction: Petroleum refining technology is a program elective course offered by chemical engineering department targeting students who wish to acquire enough background to pursue his/her specific area of interest in detail. This course presents the basic concepts of petroleum refining technology in a systematic manner and make the students appreciate the major refining processes. It trains the student to perform complete material and energy balances around the major refinery units.

B. Course Outcomes: At the end of the course, students will be able to

[1653.1]. To estimate the properties and specifications of crude/petroleum products and evaluate the crude oils

[1653.2]. Describe major refinery operations and its significance

[1653.3]. Interpret and illustrate the effect of operating parameters on performance of major refinery operations

[1653.4]. Enhance the problem-solving skills by carrying out material balances around the major refinery units

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No make-up for missed quizzes/assignments shall be allowed except in emergency situations with prior permission of the instructor.	
Homework/ Home Assignment/ Quiz (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded. Un-announced quizzes will be part of the lecture/tutorial.	

E. SYLLABUS

Petroleum resources, petroleum industry in India. Composition and classification of petroleum crude, ASTM, TBP and FEV distillation. Refinery flowsheet-overview, Properties and specifications of petroleum products – LPG, Gasoline, naphtha, kerosene, diesel oil, lubricating oil, wax etc. Crude distillation-Atmospheric and Vacuum, Design and operation of topping and vacuum distillation units. Tube still furnaces. Solvent extraction processes for lubricating oil base stocks and for aromatics from naphtha and kerosene, solvent dewaxing. Thermal and catalytic cracking, vis-breaking and coking processes, reforming, hydro processing, alkylation, polymerization and isomerization, Utilities-Hydrogen production, Product blending, Sulphur recovery. Economics, Safety and pollution considerations in refineries.

F. TEXT BOOKS

1) J.H. Gary, G.E. Handwerk and M.J. Kaiser, Petroleum Refining – Technology and Economics, 5th ed., CRC Press, New York, 2007

G. REFERENCE BOOKS

1) Nelson, W. L., Petroleum Refinery Engineering, 4th ed., McGraw Hill, 1987
2) Rao, B.K.B., Modern Petroleum Refining Processes, Oxford, IBH, 2008
3) Watkins, R.N. Petroleum Refinery Distillation, 2nd ed., Gulf Publishing, Houston, TX, 1979
4) API Petroleum Refining Handbook, 1989
5) R.J Hengstebeck, Petroleum Processing, Mc Graw Hill, New York
6) J.G Speight, The Chemistry and Technology of Petroleum, 3rd ed., Marcel-Dekker, 1999
7) J.G Speight and Baki Ozum, Petroleum refining processes (Chemical Industries), CRC Press

Lecture Plan:

LEC NO	TOPICS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1	Introduction to conventional crude oil resources, oil wells, world-wide oil distribution, oil usage	To understand the significance of crude oil in todays economy	Lecture		Quiz, Mid term I, End Term
2	*Refinery process flowsheet* – Major operations	To understand the major unit operations of petroleum refinery	Lecture	1653.2	Quiz/Assignment, Mid term I, End Term
3	*Refinery products* - Physical and Chemical properties	To identify and estimate the specifications of crude and petroleum products	Lecture	1653.1	Quiz/Assignment, Mid term I & End term
4	*Refinery feedstocks* - Crude oil properties and crude oil classification	To estimate the properties of crude /petroleum products and evaluate the crude oils	Lecture	1653.1	Quiz/Assignment, Mid term I & End term
5-6	*Crude distillation* – TBP and gravity mid percent curves	To understand different types of graphs associated with refinery calculations	Lecture	1653.1	Assignment, Mid term I & End term
7-8	*Crude distillation* – Atmospheric and Vacuum distillation, Typical boiling range cut fractions	To understand the fractionation of crude oil and analyse the petroleum cuts	Lecture	1653.2 & 1653.3	Quiz, Mid term II & End term
9	*Coking* – Types, Properties and uses of petroleum coke	To acquire knowledge of various types of cokes and their application	Lecture	1653.2	Quiz, Mid term II & End term
10,11	*Coking* – Delayed coking, Flexi coking and Fluid coking	To acquaint major process operations in refinery and understand its significance	Lecture	1653.2 & 1653.3	Quiz/Assignment, Mid term II & End term
12	*Coking* – Material balance delayed coker	To understand and perform material balance of coking unit	Lecture	1653.4	Assignment, Quiz, Mid term II & End term
13,14	*Fluid Catalytic Cracking* – Process, New designs of FCC-Regenerator system	To acquire knowledge of significant conversion processes of crude to petroleum products	Lecture	1653.2 & 1653.3	Quiz/Assignment, Mid term II & End term

15-17	*Fluid Catalytic Cracking* – Cracking reactions, Process variables, Yield estimation, Case-study	To understand the effect of various process variables on performance of FCC	Lecture	1653.3 & 1653.4	Quiz/Assignment, Mid term II & End term
18, 19	*Catalytic Reforming and Isomerization* – Process, Reactions, Reactor design	To understand the effect of various process variables on performance of reforming unit	Lecture	1653.2 & 1653.3	Assignment, Mid term II & End term
20	*Catalytic Reforming and Isomerization* – Isomerization Yields, Capital and Operating costs, case study	To perform material balance of catalytic reformer and isomerization unit	Lecture	1653.4	Mid term II & End term
21	*Hydrotreating* – Process Variables, Reactions	To understand the effect of various process variables on performance of hydrotreating	Lecture	1653.3	Quiz, Mid term I, End Term
22	*Hydrotreating* - material balance Case study	To understand and perform material balance of coking unit	Case study	1653.4	
23	*Catalytic Hydrocracking* – Process, Process Variables	To understand the effect of various process variables on performance of hydrocracking unit	Lecture	1653.3	Quiz/Assignment, Mid term I, End Term
24	*Catalytic Hydrocracking* – Hydrocracking yields, Material balance case study	To understand and perform material balance of coking unit	Case study	1653.4	Quiz/Assignment, Mid term I & End term
25, 26	*Alkylation and Polymerization* – Feedstocks, Types of Process, Comparison of processes	To understand the significance of alkylation process	Lecture	1653.2	Quiz/Assignment, Mid term I & End term
27, 28	*Alkylation and Polymerization* –Process variables, Reactions, Yields	To understand and perform material balance of coking unit	Lecture	1653.4	Assignment, Mid term I & End term
29	*Supporting processes* – Hydrogen production, Gas processing	To acquire the knowledge of gas processing operations in refinery	Lecture	1653.2	Quiz/Assignment, Mid term II & End term
30	*Supporting processes* – Acid gas removal, Sulfur recovery processes	To acquire the knowledge of various supporting processes in refinery	Lecture	1653.2	Quiz, Mid term II & End term
31, 32	*Product Blending* – Blending for Octane number, Blending for Reid Vapour Pressure, Blending for other properties	To acquire the knowledge of blending operations in refinery	Lecture	1653.4	Quiz, Mid term II & End term
33,34	*Product Blending* – Case studies	To perform blending calculations and enhancing problem solving skills	Case study	1653.4	Quiz/Assignment, Mid term II & End term

35	*Lubricating oil blending stocks* – Propane deasphalting	To understand the Lube oil processing operations	Lecture	1653.2	Assignment, Quiz & End term
36	*Lubricating oil blending stocks* – Viscosity index improvement and solvent extraction	To understand the Lube oil processing operations	Lecture	1653.2	Quiz/Assignment, End term
37	*Lubricating oil blending stocks* – Dewaxing	To understand the Lube oil processing operations	Lecture	1653.2	End term
38,39	Economic Evaluation in refineries	To understand the refining costs and margins and its effect on oil markets	Lecture	1653.4	

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1653.1	To estimate the properties and specifications of crude/petroleum products and evaluate the crude oils	2	2											2		3
CE 1653.2	Describe major refinery operations and its significance	2	2		1				2	3		2		1		3
CE 1653.3	Interpret and illustrate the effect of operating parameters on performance of refinery operations	2	2		1			2	1	1				2		3
CE 1653.4	Enhance the problem-solving skills by carrying out material balances around the major refinery units	2	2				2							2		3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Environmental Systems Engineering | CE 1654/1652 | 4 Credits | 3 1 0 4

Session: January 19 – May 19 | Faculty: Dr. Md. Oayes Midda | Class: VI Semester

A. Introduction: This course is designed to bring together and integrate in a single text the more general subject matter of the three principal areas of environmental engineering-air, water and solid-waste management. In this course, students will be introduced with a unique approach to the overall concept of environmental engineering, an approach that emphasizes the relationship between the principles observed in natural purification processes and those employed in engineered processes.

B. Course Outcomes: At the end of the course, students will be able to

[1654.1]. Define, analyse and quantify the environmental quality in describing physical, chemical, mathematical and biological principles.

[1654.2]. Understand the processes by which the environment assimilates waste material/pollution from human activities and industries.

[1654.3]. Have a clear understanding of engineering principles and practices involved in the design and operation of conventional environmental engineering works.

[1654.4]. Acquire the fundamental knowledge of different treatment technologies to curb environmental pollution-air, water and solid-wastes.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.
[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book + Open Book)	30
	Total	100
Attendance (Formative)	A minimum of **75% Attendance** is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home & Class Assignment (Formative)	Home works will be assigned in between the lectures along with the due date for handing it over. No late assignments handed after the due date shall be accepted under any circumstance. Assignments will also be given during lecture hours. Students will be given open-ended problems/case-studies as a part of assignments. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. Students are encouraged to discuss problems with their instructor in lecture hours. Students are advised to meet the instructor in case of any difficulty related to assignments and course related matters. Total 10 assignments will be given.	

E. SYLLABUS

Air Pollution- fundamentals and standards, effects, origins, fate of pollutants, greenhouse effect, acid rain, ozone, dispersion of pollutants, control of stationary and mobile sources.

Solid Wastes- sources, management, processing, and disposal, Waste to Energy

Hazardous Wastes- definition & classification, sources, management, RCRA, HSWA, CERCLA and SARA- What are these? Treatment technologies and disposal

Water Pollution- water chemistry and water quality, water quality standards, treatment systems: coagulation and flocculation; sedimentation and filtration; disinfection, adsorption; membrane processes, Wastewater Characteristics- water quality, constituents, biochemical oxygen demand, dissolved oxygen sag curve, Analysis and Selection of Wastewater Flowrates and Constituents Loadings, standards, onsite, preliminary, primary, secondary and tertiary treatments, Treatment techniques – Physical unit operations; biological processes; chemical unit processes; sludge and biosolids treatment reuse and disposal. **Water Reuse**

F. TEXT BOOKS

Davis and Cornwell, Introduction to Environmental Engineering, 5th edition, McGraw-Hill, 2014.
Metcalf and Eddy, Wastewater Engineering: Treatment and Reuse, 4th edition, McGraw-Hill, 2002.

G. REFERENCE BOOKS

Masters, Gilbert. M., Ela, Wendell. P., *Introduction to Environmental Engineering and Science,* Pearson Education, Inc., 2015.

Peavy, H. S., Rowe, D. R., Tchobanoglous, G., *Environmental Engineering*, McGraw Hill, 2013.

Bhatia, S.C., *Environmental Pollution and Control in Chemical Process Industries*, Khanna Publishers, Delhi, 2001.

Perkins, Henry. C., *Air Pollution*, McGraw Hill, 1974.

H. Lecture Plan:

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1-2	Introduction to Environmental System Engineering, Environmental acts and rules	Basic understanding of Environmental acts and rules	Lecture and interaction	CO 1	In Class Quiz
3-4	Air Pollution – fundamentals and standards	Define, analyse and quantify the environmental quality in describing physical, chemical, mathematical and biological principles. Acquire the fundamental knowledge of different treatment technologies to curb environmental pollution-air, water and solid-wastes	Lecture and interaction	CO 1 and CO 2	
5-6	Air Pollution –effects, origins, fate of pollutants		Lecture and interaction		
7-8	Air Pollution – greenhouse effect, acid rain, ozone		Lecture and interaction		
9-10	Air Pollution – dispersion of pollutants		Lecture and interaction		1st Sessional Home Assignment
11-13	Air Pollution – control of stationary and mobile sources		Lecture and interaction		1st Sessional ET Exam Home Assignment
14-15	Solid Wastes – sources, management	Understand the processes by which the environment assimilates waste material/pollution from human activities and industries	Lecture and interaction	CO 1 CO 2	
16-18	Solid Wastes – processing, and disposal		Lecture and interaction		
First sessional exam					
19	Waste to Energy		Lecture and interaction		
20	Hazardous Wastes– definition & classification, sources, management		Lecture and interaction		
21	RCRA, HSWA, CERCLA and SARA- What are these?		Lecture and interaction		
22-24	Hazardous Wastes– treatment technologies and disposal		Lecture and interaction		II Sessional Home Assignment
25	Water Pollution – water chemistry and water quality	Acquire the fundamental knowledge of	Lecture and interaction	CO 1 CO 2 CO 3	

26	Water Pollution – water quality standards, treatment systems	different treatment technologies to curb environmental pollution-air, water and solid-wastes	Lecture and interaction		
27	Water Pollution – treatment system: coagulation and flocculation		Lecture and interaction		
28-29	Water Pollution – treatment system: sedimentation and filtration		Lecture and interaction		
30-32	Water Pollution – treatment system: disinfection, adsorption		Lecture and interaction		II Sessional ET Exam Home Assignment
33	Water Pollution – treatment system: membrane processes		Lecture and interaction		
34	Wastewater Characteristics- water quality, constituents		Lecture and interaction		
35	Wastewater – biochemical oxygen demand		Lecture and interaction		II Sessional ET Exam Home Assignment
	Wastewater – dissolved oxygen sag curve		Lecture and interaction		
Second sessional exam					
36-37	Analysis and Selection of Wastewater Flowrates and Constituents Loadings	Have a clear understanding of engineering principles and practices involved in the design and operation of conventional environmental engineering works.	Lecture and interaction	CO 3	ET Exam Home Assignment
38	Wastewater – standards, onsite, preliminary, primary, secondary and tertiary treatments				
39-45	Wastewater treatment techniques – biological processes (selected)		Lecture and interaction	CO 3	
46-48	Wastewater treatment techniques – chemical unit processes (selected)		Lecture and interaction	CO 3	

49-50	Wastewater – sludge and biosolids treatment reuse and disposal		Lecture and interaction	CO 3	ET Exam Home Assignment
End Term exams					

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1654.1	Define, analyse and quantify the environmental quality in describing physical, chemical, mathematical and biological principles	3	3	0	2	1	3	3	3	0	0	2	0	1	1	3
CE 1654.2	Understand the processes by which the environment assimilates waste material/pollution from human activities and industries	2	2	0	0	0	2	2	2	0	0	1	0	2	1	0
CE 1654.3	Have a clear understanding of engineering principles and practices involved in the design and operation of conventional environmental engineering works	3	3	2	3	2	2	3	3	2	0	3	0	3	2	3
CE 1654.4	Acquire the fundamental knowledge of different treatment technologies to curb environmental pollution-air, water and solid-wastes	2	2	2	3	2	2	3	3	2	0	2	1	2	1	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Industrial Psychology | PS 1601 | 3 Credits | 3 0 0 3

Session: Jan 19 – May 19 | Faculty: Dr. Suyesha Singh | Semester: VI

A. **Introduction:** This course is offered by Department of Psychology as an elective course. Industrial Psychology is concerned with the study of human behaviour in those aspects of life that are related to the production, distribution and use of the goods and services in our civilization. "Workplace psychology "refers to the practice of applying psychological principles and practices to a work environment in order to solve problems and make improvements.

B. **Course Objectives:** At the end of the course, students will be able to:

[PS1601.1] Explain the nature, scope and methods of Industrial Psychology.

[PS1601.2] Comprehend principles and techniques of employee Selection and recruitment.

[PS1601.3] Acquire Skills required for conducting effective training and development in industrial setup

[PS1601.4] Understand the process of Job Performance Evaluation and Appraisal

[PS1601.5] Evaluate the implications of Physical working conditions, Work Schedules, Accidents and safety in work place

[PS1601.6] Critically evaluate and apply the theories of motivation, job satisfaction, job involvement

[PS1601.7] Acquire skills and learn techniques to maintain work-life balance and manage work stress

C. **PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES**

Program Outcomes for B. Tech. in Chemical Engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

PO.1 A thorough knowledge of the basic science, engineering and mathematics and apply that to the underline practice of Chemical Engineering

PO.2 Ability to apply these basic principles to solve real world problems in a broad range of career paths

PO.3 The skills of making smart decisions on process feasibility based in technical and economic evaluation

PO.4 The ability to appreciate the social, ethical, cultural, environmental and safety issues related to chemical engineering profession

PO.5 The ability to develop experimental procedure/protocol to test hypothesis and analysis meaningful interpretation of the generated data

PO.6 The skill to generate sustainable engineering solutions to societal and industrial problems

PO.7 Proficiency to use computational tools for problem solving

PO.8 The ability to communicate effectively (technical and non-technical context) in written and oral form
PO.9 Skills to work effectively and professionally in multi-disciplinary groups
PO.10 The ability to work effectively and professionally on projects both independently and as a part of a group/team
PO.11 The ability to be self-learners and lifelong learners
PO.12 The motivation to develop and lead entrepreneurial projects for societal benefit

Degree Specific Outcomes for Chemical Engineering are as follows:

PSO.1 The graduates will possess a working knowledge of fundamental principles such as basic chemistry, material and energy balances, physical and chemical equilibria, transport and rate processes, separation processes, chemical process control, reaction engineering
POS.2 The graduates will be able to design sustainable chemical processes including techno-economic feasibility of the process
PSO.3 The graduates will minor in either Petroleum Engineering or Energy and Environment depending on their choice of interest
PSO.4 The graduates will have an aptitude for learning new innovative technologies in chemical and allied fields of chemical engineering or peruse advanced studies

D. **Assessment Plan:**

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to	

(Formative)	participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.

E. **SYLLABUS**

Introduction to Industrial & Organizational Psychology (I/O): Nature, scope and methods of study; Challenges for I/O psychology, problems for I/O psychologists; Human engineering. **Employee Selection and recruitment:** Principles and techniques. **Training & development:** Principles and techniques. **Job Performance Evaluation and Appraisal:** Meaning and nature, techniques. **Working conditions:** Physical working conditions, Work Schedules; Accidents and safety in work place. **Motivation and Work:** Theories of motivation, job satisfaction, job involvement. **Work stress and management:** Nature and meaning, sources, individual differences, consequences of job stress; Stress management techniques.

TEXT BOOKS

T1: Schultz, S.E & Schultz, D.P., Psychology and Work Today: An introduction to Industrial and Organisational Psychology. Pearson, 2014.

T2: Landy, F.L. & Conte, J.M.2nd Edition, Work in the 21st Century: An Introduction to Industrial and Organizational Psychology**.** Wiley India Private Limited,2009.

REFERENCE BOOKS

R1: Blum, M.L. & Naylor, J.C., Industrial psychology: Its theoretical and social foundations. New Delhi: CBS Publishers & Distributors, 2002.

R2: Riggio, R.R., Introduction to Industrial and Organizational Psychology. Routledge

R3: APA Handbook of industrial and organizational psychology-volumes: I, II& III, New York: American Psychological Association, 2011.

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F. Lecture Plan:

Lec No.	Topics	Session Objective	Mode of Delivery	Corresponding CO	Mode of Assessing the Outcome
1	Introduction and Course Hand-out briefing	To acquaint and clear teachers expectations and understand student expectations	Lecture		NA
2	Introduction to Industrial & Organizational Psychology (I/O)	Define industrial psychology and its goals	Lecture	PS1601.1	Written test, First Sessional and end Sem Exam
4-5	Nature, scope and methods of study	understand various research method used in industrial psychology and scope of the field	Lecture	PS1601.1	
6	Challenges for I/O psychology, problems for I/O psychologists; Human engineering.	Discuss challenges and problems of an Industrial Psychologist	Lecture	PS1601.1	Class test, First Sessional and end Sem Exam
7-8	Employee Selection and recruitment: Principles and techniques.	Understand the principles and process of employee selection	Lecture	PS1601.2	Class test, First Sessional and end Sem Exam
9-10	psychological testing and assessment for employee selection & Job analysis	Explain role of psychological test in employee selection	Lecture	PS1601.2	Class test, First Sessional and end Sem Exam
11	Test of Unit I and Unit II	Nature, scope, goals, methods of industrial psychology. Principles and practices in employee selection and recruitment.			Class test, First Sessional and end Sem Exam
12	Meaning and need of training in an organization	Discuss the importance training and development in an organization	Lecture	PS1601.3	Class test, First Sessional and end Sem Exam
13-15	Steps of Training design	Design and execute a training and development programme	Experiential learning based on group activity	PS1601.3	First Sessional and end Sem Exam

16	Techniques for Training	Apply various techniques of training as part of group task/activity	Group activity	PS1601.3	Class test, First Sessional and end Sem Exam
17	Evaluation of Training Program	Critically evaluate the importance and implications of training programme	Lecture	PS1601.3	Class test, First Sessional and end Sem Exam
18	Case Study				
19-21	Meaning and importance of Job performance evaluation	Discuss the importance and implications of Job performance evaluation	Lecture	PS1601.4	Class test, Second Sessional and end Sem Exam
22-23	Sources of Job performance evaluation	Identify sources of Job Performance evaluation	Lecture	PS1601.4	Class test, Second Sessional and end Sem Exam
24-25	Appraisal rating systems and non-rating evaluation methods	Differentiate between rating and non-rating evaluation methods	Lecture	PS1601.4	Class test, Second Sessional and end Sem Exam
26	Case study				
27	Meaning of working condition	Discuss the major physical conditions that affects the employee health	Lecture	PS1601.5	Class test, Second Sessional and end Sem Exam
28	Concept and types of Work Schedules	Explain how work schedules can affect employee health and well-being.	Lecture	PS1601.5	Class test, Second Sessional and end Sem Exam
29-30	Occupational Health and Safety	Describe the causes of accident and steps that can be taken to prevent them.	Lecture	PS1601.5	Class test, Second Sessional and end Sem Exam
31	Meaning of motivation and factor effecting motivation of employee	Discuss the term motivation and its factor effecting motivation of employee	Flipped classroom	PS1601.6	Home Assignments, Second Sessional and end Sem Exam
32-33	Theories of motivation	Discuss various theory of motivation	Lecture	PS1601.6	Class test, Second Sessional and end Sem Exam

34-35	Job satisfaction and job involvement	Understand the concept of job satisfaction and its relationship with employee growth	Lecture	PS1601.6	Class test Second Sessional and end Sem Exam
36-37	Nature and meaning of stress.	Discuss and describe work related stress and its consequences.	Lecture	PS1601.7	Class test Second Sessional and end Sem Exam
38-40	Consequences of job stress; Stress management techniques	Learn skills and strategies to manage work related stress and maintain work-life balance.	Lecture	PS1601.7	Class test Second Sessional and end Sem Exam
41	Case study				

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G. Course Articulation Matrix: (Mapping of COs with POs and PSOs)

CO	Statement	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES			
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3	PSO 4
[PS1601.1]	Explain the nature, scope and methods of Industrial Psychology			2													
[PS1601.2]	Comprehend principles and techniques of employee Selection and recruitment	1		2													
[PS1601.3]	Acquire Skills required for conducting effective training and development in industrial setup																
[PS1601.4]	Understand the process of Job Performance Evaluation and Appraisal			2								1					
[PS1601.5]	Evaluate the implications of Physical working conditions, Work Schedules, Accidents and safety in work place						3										
[PS1601.6]	Critically evaluate and apply the theories of motivation, job satisfaction, job involvement												3				
[PS1601.7]	Acquire skills and learn techniques to maintain work-life balance and manage work stress		2						1								

H. Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

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MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Process Plant Design | CE 1705/1701 | 3/4 Credits | 3 0 0 3/3 1 0 4

Session: July – Dec 2018 | Faculty: Dr. Subhajit Majumder | Class: VII Semester

A. Introduction: This course on Process Plant Design is a core course designed for the undergraduate students of chemical engineering. This course provides the student an insight into various aspects of process design by coupling chemical engineering principles to the principles of economics. It covers in detail the preliminary process synthesis, developing base case design and use of heuristics for choosing the best from various process alternatives.

B. Course Outcomes: At the end of the course, students will be able to

[1705.1]. Understand concepts of process design and economics.

[1705.2]. Analyse, synthesize and design processes for manufacturing products commercially.

[1705.3]. Develop skills in designing equipment optimally based on economics and process considerations.

[1705.4]. Use commercial flow sheeting software to simulate processes and design process equipment for enhancing employability in industries/consultancy firms.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1 Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

POS.2 Process Intensification: graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3 Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. ASSESSMENT PLAN

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments & Project	30
End Term Exam (Summative)	End Term Exam (Open Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	No make-up for missed quizzes/assignments shall be allowed except in emergency situations with prior permission of the instructor.	

Home and Class Assignments and Project (Formative)	Home and Class assignments are integral part of this course. Mainly design oriented problems will be assigned along with the due date for handing it over. Projects shall be assigned at the beginning of the semester. Students are expected to work in groups. A detail project report and viva voce are part of the grading process for Mini project

E. SYLLABUS

Process Design and Development- The hierarchy of chemical process design, General design considerations, the nature of process synthesis & analysis, engineering economics, economic decision making

Developing a conceptual design and finding the best flowsheet- input information: batch vs continuous input-output structure flowsheet, recycle structure of flowsheet, separation system, heat exchanger networks, cost diagram and quick screening of process alternatives

Plant Design- Process design development and general design considerations

Process Economics- Economic feasibility of project using order-of-magnitude cost estimates, plant and equipment cost estimation, product cost estimation

Design Tools and Application- preliminary process optimization, Application of Aspen Plus in different processes.

F. TEXT BOOKS

T1 James M. Douglas, "Conceptual Design of Chemical Processes", McGraw Hill, New York, International Edition (1988).

T2 Robin Smith, "Chemical Process Design", International Editions, McGraw Hill, Singapore (2000).

T3 Warren D. Seider, J. D. Seader, and Daniel R. Lewin, "Product & Process Design Principles: Synthesis, Analysis, and Evaluation", Wiley-India Edition, India, 2nd Edition (2004).

G. REFERENCE BOOKS

R1 Richard Turton, Richard C. Bailie, Wallace B. Whiting, Joseph A. Shaeiwitz, and Debangsu Bhattacharyya, "Analysis, Synthesis, and Design of Chemical Processes", International Edition, Pearson Education International, New Jersey (2012).

R2 Dale F. Rudd, and Charles C. Watson, "Strategy of Process Engineering", John Wiley & Sons, New York (1968).

R3 Max S. Peters, Klaus D. Timmerhaus and Ronald E. West, "Plant Design and Economics for Chemical Engineers", McGraw Hill India, 5th Edition, (2011).

H. TUTORIALS

Short quizzes will be conducted during lecture hour. No late-comers will be allowed to take the quiz, MAKE SURE YOU ARE ON TIME! No make-up for missed short quizzes will be allowed. Problem discussion and solution shall also be a part of the tutorials.

I. HOME/CLASS ASSIGNMENTS AND PROJECT

Home assignment is an integral part of this course. No late assignments/projects handed after the due date shall be accepted under any circumstance. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. All assignments are to be done in pen, only and are to be handed in on A4 size white paper

Conceptual design oriented problem/case study will be given as mini project. Students need to make use of Aspen Plus/ HYSYS to simulate the process flowsheet and design the major equipments in the process flow sheet. Students need to submit a project report detailing the study carried out, by the last instruction day.

J. NOTICES

All notices concerning this course will be mailed to students. Students are responsible for regularly checking their group email ID.

K. LECTURE PLAN

Lecture No.	Topics to be covered	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing CO
1-2	Introduction to Process Design Decisions: Process Synthesis and Analysis.	To acquaint basic knowledge of synthesis and analysis	Lecture	1705.1	Quiz
3-5	Nature of Process Synthesis and Analysis: Creative aspects, Hierarchical approach to conceptual design, HDA Process. Preliminary Process Synthesis with examples.	To acquaint the basic steps of designing a process with few case studies	Lecture	1705.1	Quiz, Mid Term I, End Term
6-8	Conceptual Design of Chemical Processes: Flowsheet synthesis, Design aspects of Batch vs. Continuous, input/output structure of flowsheet, recycle structure of flowsheet	To perform material balances required in synthesizing a process flow sheet	Lecture	1705.2	Mid Term I, Quiz, End Term
9-11	Flowsheet Synthesis	Hands on calculation for synthesizing a process flow sheet	Tutorial	1705.2	Mid Term I, Assignment, End Term, Mini project
12-14	Basic principles of reactor design, Reactor non ideality, residence time distributions, types of reactors and selection criteria	To assess the reactor performance using design equations	Flipped Class	1705.3	Mid term I, Assignment and End term
15-16	Reactor design and cost estimation	Hands on calculations for reactor design	Tutorial	1705.3	Mid term I, Assignment and End term, Mini Project

17-19	Introduction, types of separations, criteria for selection of separation processes	To acquaint the basic knowledge of industrial separation processes	Lecture & Flipped Class	1705.1	Quiz
20-24	Design of Separation processes: Guidelines, design of distillation columns, energy integration of distillation columns, Tutorials on design of absorption column and distillation columns	To perform design calculations of the conventional separation units	Lecture & Tutorial	1705.3	Mid Term II, Quiz and Assignment, End Term, Mini Project
25-29	Process Heat integration: Concepts and basic principles of heat integration, Identification of area and cost targets, Pinch technology for heat exchanger network design	To synthesize the maximum energy recovery design of a given process	Lecture & Case study	1705.3	Mid Term II, Assignment & End term
30-32	Economic Decision making: Case study of gas absorber	To apply the concepts of process design in a case study & design absorber-stripper flowsheet	Lecture & case study	1705.2	Mid Term II & End Term
33-37	Cost Diagram & quick screening of process alternatives: General concepts and principles, Lumped cost diagram and cost allocation diagram, Case study of HDA	To acquaint the basic knowledge of process economics concepts	Lecture	1705.1	Quiz & End Term
38-42	Chemical Project economics: Selection of project site, project cost estimation, cost model and depreciation, time value of money, measures of profitability, project evaluation, tutorial	To investigate the profitability of a chemical project	Lecture & Tutorial	1705.1	Assignment, Project & End term
43	Simulations: Concept of process simulation, Introduction to aspen plus simulation	To design entire process flow sheet using a commercial flow sheeting software	Flipped Classroom & Activity	1705.4	Mini Project

L. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1701.1	Understand concepts of process design and economics	3	3	3	2	2	3	2					2	3	3	1
CE 1701.2	Analyse, synthesise and design processes for manufacturing products commercially	3	3	3	2	1	2	3		2	2	2	2	3	3	2
CE 1701.3	Develop skills in designing equipment optimally based on economics and process considerations	2	2	2	2	2	2	3		2	2	2	2	3	3	2
CE 1701.4	Use commercial flow sheeting software to simulate processes and design process equipment for enhancing employability in industries/consultancy firms	1	2	1	1	1	2	3			2	2		3	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Hand-out
Chemical Process Industries | CE 1706 | 3 Credits | 3 0 0 3
Session: July – Nov, 2018 | Faculty: Dr. Md Oayes Midda | Class: Core Course

A. **Introduction:** This course is offered by Dept. of Chemical Engineering as a core course. This course will cover the manufacturing of various chemicals and industrial gases related to chemical industry, which is an integral part of chemical sciences and engineering. Every chemical engineer should have knowledge on this content. It mainly covers the synthesis, industrial manufacture, process flow diagrams, properties and uses of various chemicals and industrial gases.

B. **Course Outcomes:** At the end of the course, students will be able to

[CE1706.1]. Identify different types of chemical process industries classified as inorganic, organic and natural product industries and their applications.
[CE 1706.2]. Recall various unit operation techniques and their use to synthesize a particular chemical.
[CE 1706.3]. Understand the process flow diagram and various process parameters for the manufacture of various inorganic, organic and natural chemicals.
[CE 1706.4]. Recognize and solve engineering problems during production, while also developing entrepreneurship skills along relevant lines.
[CE 1706.5]. Interpret and illustrate the material balance involved in process synthesis.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. **Assessment Plan:**

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Close Book)	20
	Sessional Exam II (Close Book)	20
	In class Quizzes, Assignments, Presentation and Mini project	30
End Term Exam (Summative)	End Term Exam (Close Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Student who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Overview of typical chemical processes, unit operations and unit processes, Indian chemical process industries scenario. Study aspects of chemical process industries - raw materials, consumption pattern, chemical reactions, process and block flow diagram, applications and major engineering issues. Uses of industrie 1s for Water conditioning and environmental protection.

F. TEXT BOOKS

1. "*Dryden's Outlines of Chemical Technology – for the 21st Century (3rd Edition)*", M Gopala Rao and Marshall Sitting, East-West Press, New Delhi (India), 1997.
2. "*Shreve's Chemical Process Industries (5th Edition)*", George T Austin, Tata McGraw-Hill Companies Inc, New York, 2012.

G. **REFERENCE BOOKS**

1. *"Unit processes in organic synthesis (5th ed)*", Groggins P H, Mcgraw-Hill, 2004.

H. Lecture Plan:

Lecture	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode Of Assessing CO
1	**Introduction to chemical industries – Facts and figures**	Introduction to chemical industries.	Lecture	1706.1	Mid Term I, Assignment & End Term
2	**Unit operations and unit process concepts**	Introduce concepts of UOPs.	Lecture	1706.2	Mid Term I, Assignment & End Term
3, 4, 5, 6	**Sulfur and Sulfuric acid**	Mining of sulfur, Manufacture of sulfuric acid by contact and DCDA process, its applications, Engineering problems	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term I, Assignment & End Term
7, 8, 9, 10, 11	**Fuels and Industrial gases**	Gases like producer gas, water gas, coke oven gas, natural gas, synthesis gas, hydrogen and acetylene. Different types of gasifiers	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term I, Assignment & End Term
12, 13, 14, 15, 16, 17	**Fertilizer Industry**	Overview of fertilizer, major components of fertilizers. Nitrogen fertilizers – ammonia, nitric acid, urea, ammonium nitrate. Phosphate fertilizers – phosphoric acid, single and triple superphosphate, ammonium phosphate	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term II, Assignment & End Term
18,19	**Cement Industry**	History and overview, scenario in India Portland cement and quick lime	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term II, Assignment & End Term
20, 21	**Chlor-alkali industry**	Manufacturing of soda ash, caustic soda and chlorine by methods of production	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term II, Assignment & End Term
22, 23	**Pulp and Paper Industry**	Kraft process and paper making process	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term II, Assignment & End Term
24, 25, 26, 27, 28, 29, 30, 31, 32, 33	**SYNTHETIC ORGANIC CHEMICAL INDUSTRIES**	Few selected chemicals from C1, C2, C3 and C4 compounds (***power point presentations by students***)	Student In-Class Presentations	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term II, Assignment & End Term

34	**Pyrolysis and Cracking**	Pyrolysis and Cracking	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	Mid Term II, Assignment & End Term
35, 36	**Carbohydrates and fermentation industries**	Manufacturing of sugar or sucrose, ethanol production by fermentation	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	End Term
37, 38	**Edible and essential oils**	Extraction of vegetable oils, hydrogenation of oils	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	End Term
39, 40, 41, 42	**Soaps, Detergents and Glycerine**	Manufacturing of soaps, detergents and glycerine	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	End Term
43, 44	**Water conditioning and environmental protection**	Water conditioning and environmental protection	Lecture	1706.1, 1706.2, 1706.3, 1706.4, 1706.5	End Term

I. COURSE ARTICULATION MATRIX (Matching COs with POs):

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE1706.1	Identify different types of chemical process industries classified as inorganic, organic and natural product industries and their applications	2	3			2			2	1	1	1		1	1	1
CE1706.2	Recall various unit operation techniques and their use to synthesize a particular chemical	3	2	1		1		2	2	2		3		1	2	1
CE1706.3	Understand the process flow diagram and various process parameters for the manufacture of various inorganic, organic and natural chemicals	3	3			3		2	3	2	1	2		3	3	2
CE1706.4	Recognize and solve engineering problems during production, while also developing entrepreneurship skills along relevant lines.	3	2			2		2	1	1		2		2	3	2
CE1706.5	Interpret and illustrate the material balance involved in process synthesis	3	3	1					2			2		3	2	1

1- Low Correlation, 2- Moderate Correlation, 3- Substantial Correlation

School of Civil and Chemical Engineering

Department of Chemical Engineering

Course Hand-out

Process Dynamic and Control | CE1707 | 4 Credits | 3 0 2 4

Session: July 18 – November 18 | Faculty: Anees A. Y. Khan | Class: VII Semester

Introduction: This course introduces the behavior and control of dynamic chemical process systems. Subject covers modeling the static and dynamic behavior of processes; control strategies; design of feedback, feedforward, and other control structures; and applications to process equipments.

A. Course outcome: At the end of the course, the students will be able to:

[1704.1] Develop skills to solve simple linear differential equations using Laplace transforms

[1704.2] Develop skills to identify, formulate, and solve linear chemical process dynamics problems

[1704.3] Design a control system to meet desired needs for a given process and analyze stability of transfer functions.

[1704.4] Develop and analyze a feedback control schemes

[1704.5] Familiarize with advanced control strategies like cascade, smith predictor, feed forward control to implement in operating decisions.

C. Program outcomes and program specific outcomes

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

[PO.2]. Problem analysis: Identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences

[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations

[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice

[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development

[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practices

[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings

[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions

[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Degree Specific Outcomes for chemical engineering are as follows:

PSO.1 Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant.

PSO.2 Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3 Specialization: students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	In class Quizzes and Assignments , Activity feedbacks (Accumulated and Averaged)	15
	Tutorials	15
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. Syllabus

Introduction to process control, Laplace transforms. Linear Open-Loop Systems, First-Order Systems: Transfer function, transient response (step response, impulse response, and sinusoidal response), and response of first-order systems in series: non-interacting systems and interacting systems. Second-Order Systems: Transfer function, step response, impulse response, sinusoidal response, transportation lag. Linear Closed-Loop Systems. Control system: Components of a control system, block diagram, negative feedback and positive feedback, servo problem and regulator problem. Controller and final control

element: Mechanism of control valve and controller, transfer functions (P, PI, PD, PID), Example of a chemical-reactor control system.

F. Textbooks:

1. Process System Analysis and Control, 3rd ed., Donald R. Coughnowr, McGraw-Hill Inc., 2013.

G. Reference Books:

1. George Stephanopoulos, Chemical Process Control: An Introduction to Theory & Practice, Prentice -Hall of India Pvt. Ltd., New Delhi, 1993.
2. Duncan A. Mellichamp, Dale Seborg, Thomas F. Edgar, Process Dynamics and Control, John Wiley & Sons Inc, 3rd ed., 2010.

H. Lecture plan

Class Number	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1	Introductory concepts of control system	Understanding the basic concept of control system	Lecture and discussion	-	NA
2,3	Modeling tools for process dynamics	Develop skills to model simple system related to chemical processes	Lecture and interaction	CO 1	In Class Quiz
4,5	Inversion by partial fractions	Develop skills to solve simple linear differential equations using Laplace transforms	Lecture and interaction	CO 1	
6-10	Linear open loop systems. Firs order systems response to various forcing functions such as step, impulse, ramp and sinusoids.	Develop skills to identify, formulate, and solve linear chemical process dynamics problems	Lecture, interaction and Tutorials	CO 2	In Class Quiz

11	Physical examples of first order system and linearization	Develop skills to identify, formulate, and solve linear chemical process dynamics problems	Lecture, interaction and Tutorials	CO 2	1st Sessional ET Exam Home Assignment
12-14	Response of first order systems in series. Interacting and non-interacting systems	Develop skills to identify, formulate, and solve linear chemical process dynamics problems	Lecture, interaction and Tutorials	CO 2	1st Sessional ET Exam Home Assignment
15-17	Higher order systems: Second order system and transportation lag	Develop skills to identify, formulate, and solve linear chemical process dynamics problems	Lecture, interaction and Tutorials	CO 2	
	Mid term 1 (and revision)				
18-23	Linear closed loop control systems: components of a control systems, development of block diagrams. Controllers and final control elements: mechanism, ideal transfer function	Design a control system to meet desired needs for a given process.	Lecture, interaction and Tutorials	CO 3	In Class Quiz
24-28	Block diagram of a chemical reactor control system: Reactor transfer function, control valve, measuring	Design a control system to meet desired needs for a given process.	Lecture, interaction and Tutorials	CO 2, CO 3	

	element, controller, controller transducer, transportation lag and block diagram. Closed loop transfer functions:				II Sessional ET Exam
29-32	Overall transfer functions for single and multiloop. Transient response of simple control systems: Proportional control for set-point change, load change. Proportional integral for set point change and load change, proportional control of system with measurement lag. Stability: Concept and definition of stability, stability criterion, Routh test for stability. Concept of root locus	Design a control system to meet desired needs for a given process and analyze stability of transfer functions.	Lecture, interaction and Tutorials	CO 2, CO 3	Home Assignment
	Mid-term break				
33-36	Introduction to frequency response: Substitution rule, Bode diagram. Control design by frequency response: Tank temperature control system, The Bode stability criterion, Gain and phase margins, Zeigler-Nicholas Controller settings.	Skill to develop and analyze a feedback control schemes	Lecture, interaction and Tutorials	CO3 CO4	In Class Quiz II Sessional
37-42	Advanced control strategies: Cascade control, Feedforward control, Ratio control, Dead-time compensation, internal model control.	Familiarize with advanced control strategies like cascade, smith predictor, feed forward control to implement in operating decisions.	Lecture, interaction and Tutorials	CO5	ET Exam Home Assignment

	Control tuning and process identification. Control valve: Control valve construction, valve sizing, characteristics and positioner				
	Mid term 2 (and revision)				
43-46	Theoretical analysis of complex processes: Control of a steam jacketed kettle, dynamic response of a gas absorber, distributed parameter model.	Skill to develop and analyze a feedback control schemes	Lecture, interaction and Tutorials	CO3 CO4	ET Exam Home Assignment
47-52	State-space representation of physical systems. Transfer function matrix and multivariable control	Skill to develop and analyze a feedback control schemes	Lecture, interaction and Tutorials	CO3 CO4	Home Assignment

I. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[1704.1]	Solve simple linear differential equations using Laplace transforms	3	2			3								3		
[1704.2]	Identify, formulate, and solve linear chemical process dynamics problems		3	2		3					1		1	3		
[1704.3]	Design a control system to meet desired needs for a given process and analyze stability of transfer functions.		2	3		3	1			2				3		
[1704.4]	Develop and analyze a feedback control schemes			2		3		1						2		
[1704.5]	Familiarize with advanced control strategies like cascade, smith predictor, feed forward control to implement in operating decisions.			3		3									2	

1-Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Hand-out
Engineering Economics and Project Management | CE 1708 | 3 Credits | 3 0 0 3
Session: Jul 18-Dec 18 | Faculty: Dr. Gaurav A. Bhaduri | Class: B. Tech.

A. Introduction: The business of business is making money – regardless of area and scale!

Economic evaluation of investment alternatives that maximize profits is a major goal of any corporate manager – or, even an individual. This requires familiarity with economic evaluation and investment decision methods to provide a sound quantitative basis to scrutinize choose the best among alternative engineering projects and general investment opportunities.

Economic feasibility is a pre-requisite for investing in any engineering or non-engineering investment opportunity.

Project Management

Managing projects for on – time completion is very necessary to avoid cost – overruns. Network techniques, such as CPM / PERT / others, are used to aid in planning, scheduling, monitoring and control of activities that are related to each other, and required, for completion of any project (engineering and non-engineering).

Hence, the methods discussed in this course are equally valid for use by

- Engineers
- Business Managers
- Bankers
- Accountants
- Individuals
- Others

B. Course Outcomes: At the end of the course, students will be able to:

CE1708.1 Present and discuss the 'Economic Evaluation' fundamentals and Project Management techniques (Gantt Chart / Networks (CPM / PERT / Others).
CE1708.2 'Arm' the student with the methodology to evaluate project investment alternatives.
CE1708.3 Develop the employability skills to manage projects and identify bottlenecks for better scheduling and control.
CE1708.4 Develop employment / entrepreneurship skills for economic evaluation and investment decision methods / project management techniques.

C. Program Outcomes

Graduate attributes in the B.Tech. Course in Chemical Engineering include:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

D. Program Specific Outcomes

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

E. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	Quizzes and Home/Class Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture. However, you may contact the course coordinator for clarification of doubts, if any.	

F. Syllabus

Cash Flow Concepts, Present Future and Annual Values, Net Present Value, Present value Ratio, Rate of Return, Breakeven, Depreciation and taxes, Project Definition, Project network, scheduling resource and cost, Managing project risk, Project progress, performance measurement, and evaluation.

G. Text Books

T1. "Economic Evaluation and Investment Decision Methods (14tht Edition)", Franklin J Stermole and Johm M Stermole, Investment Evaluation Corporation, Golden,CO (USA), 2014.

T2. "Operations Research: An Introduction", Hamdy A Taha, Prentice Hall, 1997.

H. Reference Books

R1. Peters M. S., Timmerhaus K. D., and West R. E., Plant Design and Economics for Chemical Engineers, McGraw Hill Higher Education, 5th Edition, 2003.

I. Lecture Plan:

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding Course Outcome	Mode of Assessing the Outcome
1.	Introduction – Making Decisions / Concept of Interest / Minimum Rate of Return / Investment Analysis (1-13)	Understanding the basics of subject that why are they studying this in engineering.	Lecture	1708.1	Mid Term I End Term
2.	Compound Interest Formulae and Equivalence Applications (15-41)	Understanding the interest scenario in industries.	Lecture	1708.1	Mid Term I End Term
3.	Compound Interest Formulae and Equivalent Applications (42-52)	Understanding the interest scenario in industries.	Lecture	1708.1	Mid Term I End Term
4.	Present Worth / Annual Worth / Future Worth / ROR / Break-Even Analysis (64-91)	Relating the time with money	Lecture	1708.2/4	Mid Term I End Term
5.	Present Worth / Annual Worth / Future Worth / ROR / Break-Even Analysis (91-120)	Relating the time with money	Lecture	1708.2/4	Mid Term I End Term
6.	Present Worth / Annual Worth / Future Worth / ROR / Break-Even Analysis (120-157)	Relating the time with money	Lecture	1708.2/4	Mid Term I End Term
7.	Incremental Cost Analysis Methods – Mutually Exclusive Investment Analysis by ROR / Unequal Life Projects / NPV / Future Worth of Cash Flows (183-200)	Understanding how to compare the positive ROR alternative with the negative or infinite ROR alternative.	Lecture	1708.2/4	Mid Term I End Term
8.	Incremental Cost Analysis Methods – Mutually Exclusive Investment Analysis by ROR / Unequal Life Projects / NPV / Future Worth of Cash Flows (201-220)	Understanding how to compare the positive ROR alternative with the negative or infinite ROR alternative.	Lecture	1708.2/4	Mid Term I End Term

9.	Incremental Cost Analysis Methods – Mutually Exclusive Investment Analysis by ROR / Unequal Life Projects / NPV / Future Worth of Cash Flows (220- 256)	Understanding how to compare the positive ROR alternative with the negative or infinite ROR alternative.	Lecture	1708.2/4	Mid Term I End Term
10.	Incremental Cost Analysis Methods – Mutually Exclusive Investment Analysis by ROR / Unequal Life Projects / NPV / Future Worth of Cash Flows (Handout)	Understanding how to compare the positive ROR alternative with the negative or infinite ROR alternative.	Lecture	1708.2/4	Mid Term I End Term
11.	Production Cost Variations / Break-Even Analysis / Min Cost/Max Profit Analysis (64 + Handout)	Understanding the concept of variable cost and fixed cost.	Lecture	1708.2/4	Mid Term I End Term
12.	Production Cost Variations / Break-Even Analysis / Min Cost/Max Profit Analysis (Handout)	Understanding the concept of variable cost and fixed cost	Lecture	1708.2/4	Mid Term I End Term
13.	Sensitivity Analysis / Inflation / Risk Analysis (276-306)	Understanding the sensitivity of the parameters relating to production and marketing.	Lecture	1708.2/4	Mid Term I End Term
14.	Sensitivity Analysis / Inflation / Risk Analysis (313-327)	Understanding the sensitivity of the parameters relating to production and marketing.	Lecture	1708.2/4	Mid Term I End Term
15.	Sensitivity Analysis / Inflation / Risk Analysis (327-351)	Understanding the sensitivity of the parameters relating to production and marketing.	Lecture	1708.2/4	Mid Term I End Term
16.	Review Lecture	Reviewing all the syllabus that has been completed.	Lecture		Mid Term I End Term
MID-TERM I					
17.	Depreciation / Depletion / Amortization (359-366)	Understand the concept of decreasing value of tangible/non tangible things.	Lecture	1708.2	Mid Term II End Term
18.	Depreciation / Depletion / Amortization (366-384)	Understand the concept of decreasing value of tangible/non	Lecture	1708.2	Mid Term II End Term

		tangible things.			
19.	Depreciation / Depletion / Amortization (384-403)	Understand the concept of decreasing value of tangible/non tangible things.	Lecture	1708.2	Mid Term II End Term
20.	Income Tax, Cash Flow, and Discounted Cash Flow Rate of Return (415-435)	Understanding what to include or exclude from the income to save income tax.	Lecture	1708.2/4	Mid Term II End Term
21.	Income Tax, Cash Flow, and Discounted Cash Flow Rate of Return (435-470)	Understanding what to include or exclude from the income to save income tax.	Lecture	1708.2/4	Mid Term II End Term
22.	After-Tax Investment Decision Methods and Applications (487-521)	Understand how to estimate the after tax or actual ROR.	Lecture	1708.2/4	Mid Term II End Term
23.	After-Tax Investment Decision Methods and Applications (521-548)	Understand how to estimate the after tax or actual ROR.	Lecture	1708.2/4	Mid Term II End Term
24.	Replacement Analysis (567-593)	Understand the alternatives of replacing the machinery or other things.	Lecture	1708.2/4	Mid Term II End Term
25.	Replacement Analysis (594-605)	Understand the alternatives of replacing the machinery or other things.	Lecture	1708.2/4	Mid Term II End Term
26.	Leverage Concepts: Evaluations Involving Borrowed Money (616-639)	Compare the alternatives of taking leverage of paying at one go.	Lecture	1708.2/4	Mid Term II End Term
27.	Leverage Concepts: Evaluations Involving Borrowed Money (639-647)	Compare the alternatives of taking leverage of paying at one go.	Lecture	1708.2/4	Mid Term II End Term
28.	Review Lecture	Reviewing all the syllabus that has been completed after Mid Term I.	Lecture		Mid Term II End Term
MID-TERM II					
29.	Introduction to Project Management and Control	Understand the necessity to study project management in chemical	Lecture	1708.1/3	End Term

		engineering.			
30.	Gantt Chart	Understanding how to schedule the project	Lecture	1708.1/3	End Term
31.	Introduction to Networks – Terminology (Handout)	Understanding how to distinguish critical and non critical activities.	Lecture	1708.1/3	End Term
32.	Critical Path Method (CPM) (278-288 + Handout)	Understand how to evaluate the critical path which will not to be violated.	Lecture	1708.1/3	End Term
33.	Project Evaluation and Review Technique (PERT) (288-290 + Handout)	If the project is working on probabilistic timeline than understanding how to evaluate the probability that project will complete in the pre described time.	Lecture	1708.1/3	End Term
34.	PERT (Handout)	If the project is working on probabilistic timeline than understanding how to evaluate the probability that project will complete in the pre described time.	Lecture	1708.1/3	End Term
35.	Other Topics in Networks – Shortest Route Problem	If the project is working on probabilistic timeline than understanding how to evaluate the probability that project will complete in the pre described time.	Lecture	1708.1/3	End Term
36.	Review	Reviewing all the syllabus that has been completed.	Lecture		End Term
END-TERM EXAMINATION					

T3. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE1708.1	Present and discuss the 'Economic Evaluation' fundamentals and Project Management techniques (Gantt Chart / Networks (CPM / PERT / Others).		1		1				1	1	2	3		1	2	
CE1708.2	'Arm' the student with the methodology to evaluate project investment alternatives.		2	1	1				2	1	2	3		1	2	
CE1708.3	Develop the employability skills to manage projects and identify bottlenecks for better scheduling and control.		2	1	1				2	1	2	3		1	2	
CE1708.4	Develop employment / entrepreneurship skills for economic evaluation and investment decision methods / project management techniques.		2	1	1				2	1	2	3		1	2	

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Petrochemical Production Technologies | CE 1753 | 3 Credits | 3 0 0 3

Session: Aug 18 – Nov 18 | Faculty: Anand Chakinala | Class: Program Elective

A. Introduction: This course on petrochemical production technologies is a program elective designed for the undergraduate students of Chemical Engineering. This course introduces the basic overview of petrochemical technologies and discuss upon the general topology of the process technologies.

B. Course Outcomes: At the end of the course, students will be able to

[1753.1]. Discuss the major petrochemicals produced and their economic importance

[1753.2]. Explain the major components of petrochemical plants and come up with alternative routes of production that will enhance their employability as well as entrepreneurship skills.

[1753.3]. Discuss the production processes of C2, C3, C4 and aromatic derived petrochemicals

[1753.4]. Understanding the safety precautions in petrochemical processes

C. Program outcomes and program specific outcomes

Program Outcomes for B.Tech. in chemical engineering are as follows.

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	In class Quizzes, Assignments, Projects, Case Studies (Accumulated and Averaged)	30
End Term Exam	End Term Exam (Open Book)	30
	Total	100
Attendance	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments	No make-up for missed short quizzes/assignments or exam will be allowed except in extenuating circumstances, with prior permission of the instructor(s), and the decision of the instructor(s) in this regard shall be final.	
Homework/ Home Assignment/ Project	Home works will be assigned in between the lectures along with the due date for handing it over. No late assignments handed after the due date shall be accepted under any circumstance. It is expected that the students shall work on the assignments independently and not 'copy' the solutions from each other. A case study is given which is assessed in form of individual reports submitted.	

E. Syllabus

Introduction – Petrochemical industry-Structures of petrochemical complexes-Feedstock for petrochemical-Profile of petrochemical and their end products; **Olefins production:** Steam cracking for production of olefins-Gas sweetening unit-C2/C3 Extraction unit-Steam cracking process engineering and technology-Emerging technologies for production of olefins- Alpha Olefins; **Olefin Production:** Steam cracking for production of olefins-Gas sweetening unit-C2/C3 Extraction unit-Steam cracking process engineering and technology-Emerging technologies for production of olefins-Alpha Olefins; **Methane and synthesis gas derivatives:** Synthesis gas and ammonia-synthesis gas and ammonia manufacture from steam reforming-Synthesis gas and ammonia manufacture from partial oxidation process-Urea processes, Process technology-Carbon monoxide-Fischer-Tropsch syn gas technology-Methanol-Formaldehyde-Acetic acid - Chloromethanes - Dimethyl formamide - Dimethyl acetamide - Acetylene; **Ethylene and ethylene derivatives-I:** Ethylene-Ethylene oxide-Process technology-Process hazards-Ethylene oxide storage-Monoethylene glycol-Vinyl chloride-Vinyl acetate-Acetaldehyde-Ethanol-Acetic anhydride-Ethyl acetate-Ethyl chloride; **Aromatic production:** Petroleum feedstock for aromatic hydrocarbons-Aromatic hydrocarbon production catalytic reforming-Reactions in catalytic reforming-Reforming catalyst-Reforming process-Process variables in catalytic reforming-Pyrolysis gasoline as aromatics feedstock-Aromatic separation from reformate and pyrolysis gasoline- technologies for the production of BTX- Aromatic conversion processes; **Oxo Process**

F. Text books

1) Sami Matar and Lewis F.Hatch, Chemistry of Petrochemical Processes, 2nd Edition, Gulf Publishing Company, Houston, 2000.

2) B. K. Bhaskara Rao, Petrochemicals, Oxford & IBH Publishing, 2002.

G. Reference books

1) I.D. Mall, Petrochemical Process Technology, Macmillan India Ltd., New Delhi. 2007.

2) P. Belov, Fundamentals of Petroleum Chemical Technology, Mir Publishers, 1970.

3) A. Chauvel and G.Lefebvre, Petrochemical Processes, Volume 1 & 2, Gulf Publishing Company, 1989.

4) Robert A. Meyers, Handbook of Petrochemical Production Processes, McGraw-Hill, 2004.

Lecture Plan:

LEC NO	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode of assessing CO
1 – 2	Introduction to petrochemical industry	To acquaint with the chemicals derived from crude	Lecture	1753.1	Mid Term - 1, End Term,
3 – 7	Olefin production	To understand the production of olefins in a refinery	Lecture	1753.2, 1753.4	Mid Term - 1, End Term,
8 – 12	C_1 compounds: Methane and syngas derivatives	To familiarize with production processes/technologies of C1 compounds	Lecture	1753.3, 1753.4	Mid Term - 1, End Term, Assignment
13 – 17	C_2 compounds: Ethylene and its derivatives	To familiarize with production processes/technologies of C2 compounds	Lecture	1753.3, 1753.4	Mid Term - 1, End Term, Assignment
18 – 23	C_3 compounds: Propylene and its derivatives	To familiarize with production processes/technologies of C3 compounds	Lecture	1753.3, 1753.4	Mid Term - 1, End Term, Assignment
24 – 29	C_4 compounds: Butanes and Butenes	To familiarize with production processes/technologies of C4 compounds	Lecture	1753.3, 1753.4	Mid Term - 1, End Term, Assignment
30 – 33	Aromatic compounds: Benzene	To gain the knowledge of production of aromatics in a refinery	Lecture	1753.3, 1753.4	Mid Term - 1, End Term, Assignment
33 – 36	Oxo process/Hydroformylation	To gain knowledge of higher alcohol production.	Lecture	1753.3, 1753.4	Mid Term - 2, End Term

H. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	*PSO1*	*PSO2*	*PSO3*
CE1753.1	Discuss the major petrochemicals produced and their economic importance	1	1											1		2
CE1753.2	Explain the major components of petrochemical plants	1	1	2	1		1	1					1			2
CE1753.3	Discuss the production processes of C2, C3, C4 and aromatic derived petrochemicals	2	1	2	1		1	1					1	1	1	2
CE1753.4	Understanding the safety precautions in petrochemical processes	1	1				3	2	1				1			2

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering

Department of Chemical Engineering
Course Hand-out

Energy and Process Integration | CE 1754 | 3 Credits | 3 0 0 3

Session: July'18 – Nov'18 | Faculty: Dr. Md. Oayes Midda | Class: B. Tech. (Chemical) VII Semester

A. Introduction:

Integration is the process of keeping 'all together' in an optimized way. Chemical process needs to be integrated in an optimized way so that the whole process requires minimum energy as well as the cost. Therefore, we have to be familiar with the fundamental concepts related to process integration, pinch technology, heat exchanger network and energy targeting. The contents discussed in this course will be useful for a chemical engineer working in process & plant design as well as research & development.

B. Course Outcomes: At the end of the course, students will be able to

[1754.1]. Understand the fundamentals of process integration and pinch technology.
[1754.2]. Carry out pinch analysis for heat exchanger networks using chemical engineering skills.
[1754.3]. Identify the energy target, unit target, area target, cost target and supertargeting for a heat exchanger network (HEN).
[1754.4]. Recognize maximum energy recovery (MER) network using pinch design method (PDM).
[1754.5]. Conduct the process optimization of energy and resource analysis using network evolution and evaluation.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

Program Outcomes for B.Tech. in chemical engineering are as follows.

The Graduates of Chemical Engineering from MUJ will have:

[PO.1]. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
[PO.2]. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
[PO.3]. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
[PO.4]. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
[PO.5]. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
[PO.6]. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
[PO.7]. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
[PO.8]. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
[PO.9]. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
[PO.10]. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
[PO.11]. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
[PO.12]. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

[PSO.1]. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

[PSO.2]. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

[PSO.3]. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Open Book)	20
	Sessional Exam II (Open Book)	20
	Project, Quizzes/Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Make up Assignments (Formative)	Students who misses a class will have to report to the teacher about the absence. A makeup assignment on the topic taught on the day of absence will be given which has to be submitted within a week from the date of absence. No extensions will be given on this. The attendance for that particular day of absence will be marked blank, so that the student is not accounted for absence. These assignments are limited to a maximum of 5 throughout the entire semester.	
Homework/ Home Assignment/ Activity Assignment (Formative)	There are situations where a student may have to work in home, especially before a flipped classroom. Although these works are not graded with marks. However, a student is expected to participate and perform these assignments with full zeal since the activity/ flipped classroom participation by a student will be assessed and marks will be awarded.	

E. SYLLABUS

Introduction – Energy Targeting and the Pinch Principle, Problem Table, Cascade Diagram, Composite / Grand Composite Curves, Pinch Point, Utility Pinch; Maximum Energy Recovery Network – Pinch Design Method, Grid\Diagram, Stream Splitting / Matching; Evolution / Evaluation of Networks – Euler's Principle, Identification and Breaking of Loops Using Paths; Capital Cost targeting, Continuous Targeting – Area / Cost Targeting, Vertical Heat Transfer, Threshold Problem, Super targeting; Distillation Column Targeting Principles, Grand Column Composite Curves, Column Composite Curves, Evaluation of Energy Saving Options; Introduction to Heat and Power Systems.

F. BOOKS

1. Shenoy, U.V., *Heat exchanger network synthesis: Process optimization by energy and resource analysis*, Gulf publishing, 1995.
2. Douglas, James. M., *Conceptual design of chemical processes*, McGraw-Hill Inc, 1988.
3. Seider, W. D., Seader, J. D., Lewin, D. R., Widagdo, S., *Product and process design principles: synthesis, analysis and evaluation (3rd Ed)*, John Wiley & Sons, Singapore, 2010.
4. Kemp, I. C., *Pinch analysis and process integration: A user guide on process integration for the efficient use of energy*, Butterworth Heinemann, 2006.
5. Klemes, J. J., Varbanov, P. S., Alwi S. R. W. W., and Manan, Z. A., *Process Integration and Intensification: Saving Energy, Water and Resources*, De Gruyter, 2014.

Lecture Plan:

Lecture	TOPICS	Session Outcome	Mode of Delivery	Corresponding CO	Mode of Assessing CO
1	Introduction and course hand-out briefing	Acquainted with basics of Energy and Process Integration	Lecture	1754.1	Mid Term I, Quiz/Assignment/Project & End Term
2	Process integration, methods and area of application, history and few examples from nature	Acquainted with basics of Energy and Process Integration	Lecture	1754.1	Mid Term I, Quiz/Assignment/Project & End Term
3	Fundamentals concepts related to heat integration (process design hierarchy, onion diagram), energy losses by various industries, The role of thermodynamics in process design	Acquainted with basics of Energy and Process Integration	Lecture	1754.1	Mid Term I, Quiz/Assignment/Project & End Term
4	Key concepts of process integration and pinch analysis and its significance, Composite curves (basic concepts of heat exchange and temp–enthalpy diagram)	Understanding the fundamentals of Energy Exchange in Process	Lecture	1754.2	Mid Term I, Quiz/Assignment/Project & End Term
5	Hot and cold composite curves and their allowability of shifting vertically/horizontally	Understanding the fundamentals of Energy Exchange in Process	Lecture	1754.2	Mid Term I, Quiz/Assignment/Project & End Term
6	Network grid representation	Understanding the fundamentals of Energy Exchange in Process	Lecture	1754.2	Mid Term I, Quiz/Assignment/Project & End Term
7	Temperature intervals and heat cascade diagram	Understanding the fundamentals of Energy Exchange in Process	Lecture	1754.2	Mid Term I, Quiz/Assignment/Project & End Term
8, 9, 10	Energy targeting procedure (problem table algorithm, pinch point and minimum utility requirements)	Understanding the fundamentals of Energy Exchange in Process	Lecture	1754.2	Mid Term I, Quiz/Assignment/Project & End Term
11	Basic pinch design method (understanding the pinch design feasibility and important design criteria), maximum energy recovery (MER) network	Acquiring the Design knowledge of HEN in Process	Lecture	1754.3	Mid Term I, Quiz/Assignment/Project & End Term
12, 13, 14	Case study – MER network drawing (split and without split network), stream split algorithm	Acquiring the Design knowledge of HEN in Process	Lecture	1754.3	Mid Term I, Quiz/Assignment/Project & End Term

15, 16	Concept of balanced composite curves	Acquiring the Design knowledge of HEN in Process	Lecture	1754.3	Mid Term II, Quiz/Assignment/Project & End Term
17	Concept of grand composite curves and use of multiple utilities	Acquiring the Design knowledge of HEN in Process	Lecture	1754.3	Mid Term II, Quiz/Assignment/Project & End Term
18	Concept of vertical heat transfer and Spaghetti network	Acquiring the Design knowledge of HEN in Process	Lecture	1754.3	Mid Term II, Quiz/Assignment/Project & End Term
19	Case Study – number of units targeting	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
20	Euler's network and graph theory for number of units and loop finding. Concept of loops and paths.	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
21, 22	Identification of loops, elimination of loop	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
23	Checking ΔTmin violation and restoration by path relaxation	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
24, 25	Network evolution and evaluation and final MER design after path relaxation	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
26	Case Study – shell targeting	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
27	Case Study – cost targeting (operating cost, capital cost and total annual cost)	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
28	Effect of ΔTmin and supertargeting	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
29	Fundamentals of threshold problems and pseudo pinch problems	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
30	Case study – threshold problem	Grasping the basics of advanced HEN	Lecture	1754.4	Mid Term II, Quiz/Assignment/Project & End Term
31	Continuous targeting and determination of significant curve shift	Developing the knowledge of solving HEN problems in Industries	Lecture	1754.5	Quiz/Assignment/Project & End Term

32	Case study – continuous determination of energy and unit targets	Developing the knowledge of solving HEN problems in Industries	Lecture	1754.5	Quiz/Assignment/Project & End Term
33	Topology trap	Developing the knowledge of solving HEN problems in Industries	Lecture	1754.5	Quiz/Assignment/Project & End Term
34	Fast matching algorithm for threshold problem	Developing the knowledge of solving HEN problems in Industries	Lecture	1754.5	Quiz/Assignment/Project & End Term
35	Retrofitting of final network	Developing the knowledge of solving HEN problems in Industries	Lecture	1754.5	Quiz/Assignment/Project & End Term
36	Basic concepts of designing of multi-pinch problems	Developing the knowledge of solving HEN problems in Industries	Lecture	1754.5	Quiz/Assignment/Project & End Term

G. Course Articulation Matrix: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE 1754.1	Understand the fundamentals of process integration and pinch technology	2	2	1			2	3	1		1			1	2	3
CE 1754.2	Carry out pinch analysis for heat exchanger network network using chemical engineering skills	3	3	3	3		2	3	1	1	2		1	2	3	3
CE 1754.3	Identify the energy target, unit target, area target, cost target and supertargeting for a heat exchanger network	3	3	3	3		1	3	1	1	2	2	1	3	3	3
CE 1754.4	Recognize maximum energy recovery (MER) network using pinch design method	2	3	3	3		2	2			2	2	1	2	2	3
CE 1754.5	Conduct the process optimization of energy and resource analysis using network evolution and evaluation	2	3	3	3		2	3		1	2	2	2	2	3	3

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation

MANIPAL UNIVERSITY JAIPUR

School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Hand-out
Process Intensification | CE 1803 | 3 Credits | 3 0 0 3
Session: Jan 19 – May 19| Faculty: Dr Gaurav A. Bhaduri|
Class: VIII Semester

A. COURSE SUMMARY:

In the modern times, there has been a great focus on the optimal use of energy and cost to get better way of life. However, the chemical and process industry has a delayed response in incorporation of new technologies, because of the high risk involved. In the 1980's, Colin Ramshaw introduced to the world the idea of high gravity (HiGEE) based distillation and paved the way for what is today *Process Intensification*. This topic covers a wide range of unit operations and unit processes that have been reimagined to become highly optimized and efficient. The current course has been designed to introduce to the students the idea of process intensification and give them a feel of its application to unit operations and unit processes.

B. COURSE OUTCOME:

By the end of the course the students will be able to

CE1803.1. Describe the basic principles underlying process intensification.
CE1803.2. Describe with elaboration the design of different physical process intensification equipment.
CE1803.3. Assess the enhancement factors responsible for heat intensification in process industries and their applications.
CE1803.4. Develop skills to assess the design of intensified reactors for different types of reactions.
CE1803.5. Develop skills to assess the enhancement factors responsible for intensification of separation processes related to equipment design and application.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES:

Graduate attributes in the B.Tech. Course in Chemical Engineering include:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2. Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

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

PO9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11. Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes for chemical engineering are as follows:

PSO.1. Concept to Commissioning: The students of the program would be able to envision, synthesize, demonstrate, and design any chemical processes right from conceiving the idea to commissioning of a full scale plant taking into account environmental concerns.

PSO.2. Process Intensification: Graduates would be equipped with the skills of assessing and finding cost effective innovations involving process intensification and integration for sustainable future developments.

PSO.3. Specialization: Students will be specialized in the areas of petroleum, energy and environment related fields.

D. Assessment Plan:

Criteria	Description	Maximum Marks
Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
	Quizzes and Home/Class Assignments (Accumulated and Averaged)	30
End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100

Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.
Make up Assignments (Formative)	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture. However, you may contact the course coordinator for clarification of doubts, if any.

E. SYLLABUS:

Introduction to process intensification (PI): sustainability related issues in process industry; definitions of process intensification; fundamental principles and approaches of PI; design of a sustainable and inherent safer processing plants.

Mechanisms involved in PI: intensified heat transfer, intensified mass transfer, electrically enhanced processes, micro fluidics; compact and micro heat exchangers;

Reactors: Reactor engineering theory, spinning disc reactors, oscillatory baffled reactors, micro reactors, reactive separations, membrane reactors, supercritical operations, Field enhanced reactors, Rotating fluidized beds

Intensification and separation processes: Distillation (reactive, extractive), centrifuges, membranes, drying, precipitation and crystallization; Intensified mixers, PI case study.

F. TEXT BOOKS:

T1. Reay, D.A.; Ramshaw, C.; Harvey, A.P.; "*Process Intensification: engineering for efficiency, sustainability and flexibility*", 1ed, (IChemE) Butterworth Harriman, London, 2008.

T2. Stankiewicz, A.; Moulijn, J.A.; (Eds) "*Re-Engineering the Chemical Processing Plant: Process Intensification*," 1st ed., CRC Press, 2003.

G. REFERENCE BOOKS:

R1. Segovia-Hernandez, J.G.; Bonilla-Petriciolet, A.; (Eds) "*Process Intensification in Chemical Engineering Design Optimization and Control*", 1st ed., Springer, 2016.

R2. Keil, F.J.; (Ed) "*Modelling of Process Intensification*", 1st ed., Wiley International, 2007.

R3. Kiss, A.A; "*Process Intensification Technologies for Biodiesel Production*", 1st ed., Springer, 2014.

R4. Raghavan, K.V; Reddy, B.M.; (Eds) "*Industrial Catalysis and Separations Innovations for Process Intensification*", 1st ed, CRC Press/Apple Academic Press, 2015.

R5. Mothes, H.; "*Process Design Synthesis, Intensification and Integration of Chemical Processes*", 1st ed, Manufective, 2015.

H. LECTURE PLAN:

Lectures	Content	Session Outcome	Mode of Delivery	CO tracking	Assessment
1-3	Introduction to Process Intensification (PI)	Understand the basics and history of Process intensification, unit operation and unit processes, philosophy and opportunity of PI, classification of PI, sustainability of PI	Lecture	CE1803.1	Class Quiz
4-6	Physical methods for PI	Understand the use of Momentum transfer concepts Mixing and flow through packed bed, channel flow, and fluidization, static mixers, spinning disk, oscillatory baffled mixers in PI.	Lecture	CE1803.2 CE1803.5	Class Quiz, Case study essay, Mid Semester exams.
7-14	PI for heat transfer	Understand the use of Heat transfer operations, combined heat and fluid flow, intensification of heat flow, plate heat exchangers, spiral heat exchangers, plate and shell heat exchangers, plate fin heat exchangers, flat tube and fin heat exchangers, microchannel heat exchangers, Matrix heat exchangers, application of heat exchangers, nanofluids in PI.	Lecture	CE1803.2 CE1803.3 CE1803.5	Class quiz, Case study essay, mid semester exam and end semester exam
Mid Term I					
15-22	PI for separation processes	Understand the use of mass transfer concepts, nanofluids, divided walls columns, HiGee distillation, centrifuges, membranes, drying, crystallization, Soxhlet extraction, ultrasound mass transfer in PI.	Lecture	CE1803.5 CE1803.1	Class quiz, case study essay, mid and end semester exams
23-34	PI for reactions and reactors.	Understand the concept of mass transfer with chemical reactions, reactive distillation, reactive adsorption, reactive extraction, supercritical fluids, spinning reactors, ultrasound reactors, cavitation reactors, HEX reactors, Fluidized bed reactors, packed bed reactors, membrane reactors used to intensify the Processes in chemical engineering.	Lecture	CE1803.4 CE1803.5 CE1803.1	Class quiz, case study essay, mid and end semester exams
Mid Term II					
35-40	Application of PI	Follow the case studies of how PI can be applied for all different process industries.	Lecture	CE1803.2 CE 1803.3 CE1803.4 CE1803.5	Class quiz, case study essay, mid and end semester exams
End Term					

I. COURSE ARTICULATION MATRIX (Matching COs with POs):

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CE1803.1	Describe the basic principles underlying process intensification.	3	2			2			1	2		1		1	3	
CE1803.2	Describe with elaboration, design of different physical process intensification equipment.	1	2			1			1	2			1	1	3	
CE1803.3	Assess the enhancement factors responsible for heat intensification in process industries and their applications.	1	2			1			1	2			1		3	1
CE1803.4	Develop skills to assess the design of intensified reactors for different types of reactions.	1	2			1			1	2			1		3	1
CE1803.5	Develop skills to assess the enhancement factors responsible for intensification of separation processes related to equipment design and application.	1	2			1			1	2			1		3	1

1- Low Correlation, 2- Moderate Correlation, 3- High Correlation

MANIPAL UNIVERSITY JAIPUR
School of Civil and Chemical Engineering
Department of Chemical Engineering
Course Handout
Process Optimization | CE1804 | 3 Credits | 3 0 0 3
Session: Jan'19 – May'19 | Faculty: Dr. Subhajit Majumder | Class: B. Tech. (Chemical) VIII Semester

A. INTRODUCTION

Due to the increased cost of energy and stringent environmental regulations, the chemical industry has gone through several developments during the past few years. Optimization is one of the tools to address these issues. With an emphasis on problem formulation, this course introduces the students to the basic concepts of Optimization which has been applied in many fields of science, engineering, as well as business. The various techniques and tools used for optimization have also been discussed in this course.

B. COURSE OUTCOMES

At the end of the course, students will be able to:

[CE1804.1]	Develop a mathematical statement for the objective function and the equality and inequality constraints
[CE1804.2]	Implement the theory and applications of optimization techniques in a comprehensive manner for solving linear and non-linear, geometric, dynamic, integer and stochastic programming techniques
[CE1804.3]	Identify, formulate and solve a practical engineering problem of their interest by applying or modifying an optimization technique to enhance employability skills
[CE1804.4]	Use of commercial software to optimize chemical processes thereby enhancing their skills.

C. PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

The Graduates of Chemical Engineering from MUJ will have:

PO1. Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2. Problem analysis: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

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Internal Assessment (Summative)	Sessional Exam I (Closed Book)	20
	Sessional Exam II (Closed Book)	20
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End Term Exam (Summative)	End Term Exam (Closed Book)	30
	Total	100
Attendance (Formative)	A minimum of 75% Attendance is required to be maintained by a student to be qualified for taking up the End Semester examination. The allowance of 25% includes all types of leaves including medical leaves.	
Assignments (Formative)	Assignments are an integral part of the course. Home assignments / Class assignments will be provided from time to time. No late submissions will be entertained. It is expected that the students will work on the assignments independently. If any assignment is found copied from any source, marks will be deducted for the same.	
Make up Assignments	Students who miss a class will not be provided with any sort of makeup assignment or make up quiz. If you miss a lecture, you yourself have to study the topics that were covered during that particular lecture(s). You may contact the course coordinator for clarification of doubts, if any.	

E. SYLLABUS

Formulation of the objective function. Unconstrained single variable optimization: Newton, Quasi-Newton methods, polynomial approximation methods. Unconstrained multivariable optimization: Direct search method, conjugate search method, steepest descent method, conjugate gradient method, Newton's method. Linear Programming: Formulation of LP problem, graphical solution

of LP problem, simplex method, duality in Linear Programming, two-phase method. Nonlinear programming with constraints: Necessary and sufficiency conditions for a local extremum, Quadratic programming, successive quadratic programming, Generalized reduced gradient (GRG) method. Use of MS-Excel and MATLAB for solving optimization problems. Introduction to global optimization techniques. Applications of optimization in Chemical Engineering.

F. TEXT BOOKS

T1. Edgar, T.F., Himmelblau, D. M., Ladson, L. S., Optimization of Chemical Process, 2nd ed., McGraw-Hill, 2001.

G. REFERENCE BOOKS

R1. Rao, S. S., Optimization Techniques, Wiley Eastern, New Delhi, 1985.

R2. Godfrey, C.O. and Babu, B.V., New Optimization Techniques in Engineering, Springer-Verlag, Germany, 2004.

R3. Beveridge, G. S. and Schechter, R. S., Optimization Theory and Practice, McGraw- Hill, New York, 1975.

R4. Reklaitis, G.V., Ravindran, A. and Ragsdell, K. M., Engineering Optimization-Methods and Applications, Wiley India Pvt Ltd., 2006.

H. LECTURE PLAN

Lecture No.	Topics	Session Outcome	Mode of Delivery	Corresponding CO	Mode Of Assessing CO
1.	Introduction	Understand the nature and organization of optimization problems	Lecture	CE1804.1	Assignment / quiz / Mid Term I
2.	Problem formulation	Develop models for optimization	Lecture	CE1804.1	Assignment / quiz / Mid Term I
3.	Problem formulation	Formulate the objective function	Lecture	CE1804.1	Assignment / quiz / Mid Term I
4.	Optimization theory and methods	Learn the Basics concepts of Optimization	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
5.	Optimization theory and methods	Learn the Basics concepts of Optimization	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
6.	Optimization theory and methods	Learn the Basics concepts of Optimization	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
7.	Optimization theory and methods	To optimize unconstrained functions (one dimensional search)	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
8.	Optimization theory and methods	To optimize unconstrained functions (one dimensional search)	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
9.	Optimization theory and methods	To optimize unconstrained Multivariable functions	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
10.	Optimization theory and methods	To optimize unconstrained Multivariable functions	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
11.	Optimization theory and methods	To optimize unconstrained Multivariable functions	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I

12.	Optimization theory and methods	To optimize unconstrained Multivariable functions	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
13.	Optimization theory and methods	Understand the basics of Linear programming (LP) and its applications	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
14.	Optimization theory and methods	Understand the basics of Linear programming (LP) and its applications	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
15.	Optimization theory and methods	Understand the basics of Linear programming (LP) and its applications	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
16.	Optimization theory and methods	Understand the basics of Linear programming (LP) and its applications	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term I
17.	Optimization theory and methods	Understand the basics of Nonlinear programming (NLP) with constraints	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term II
18.	Optimization theory and methods	Understand the basics of Nonlinear programming (NLP) with constraints	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term II
19.	Optimization theory and methods	Understand the basics of Nonlinear programming (NLP) with constraints	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term II
20.	Optimization theory and methods	Understand the basics of Nonlinear programming (NLP) with constraints	Lecture	CE1804.1; CE1804.2	Assignment / quiz / Mid Term II
21.	Optimization theory and methods	Solution of global optimization problems with continuous and discrete variables	Lecture	CE1804.2	Assignment / quiz / Mid Term II
22.	Optimization theory and methods	Solution of global optimization problems with continuous and discrete variables	Lecture	CE1804.2	Assignment / quiz / Mid Term II
23.	Optimization theory and methods	Solution of global optimization problems with continuous and discrete variables	Lecture	CE1804.2	Assignment / quiz / Mid Term II
24.	Optimization theory and methods	Solution of global optimization problems with continuous and discrete variables	Lecture	CE1804.2	Assignment / quiz / Mid Term II
25.	Applications of optimization in Chemical Engineering	Optimization of Heat transfer and energy conservation problems	Lecture	CE1804.3	Assignment / quiz / Mid Term II
26.	Applications of optimization in Chemical Engineering	Optimization of Heat transfer and energy conservation problems	Lecture	CE1804.3	Assignment / quiz / Mid Term II
27.	Applications of optimization in Chemical Engineering	Optimization of Heat transfer and energy conservation problems	Lecture	CE1804.3	Assignment / quiz / Mid Term II
28.	Applications of optimization in Chemical Engineering	Optimization of Heat transfer and energy conservation problems	Lecture	CE1804.3	Assignment / quiz / Mid Term II
29.	Applications of optimization in Chemical Engineering	Optimization of Separation processes	Lecture	CE1804.3	Assignment / quiz / Mid Term II
30.	Applications of optimization in Chemical Engineering	Optimization of Separation processes	Lecture	CE1804.3	Assignment / quiz / Mid Term II
31.	Applications of optimization in Chemical Engineering	Optimization of Separation processes	Lecture	CE1804.3	Assignment / quiz / End Term
32.	Applications of optimization in Chemical Engineering	Optimization of Separation processes	Lecture	CE1804.3	Assignment / quiz / End Term

33.	Applications of optimization in Chemical Engineering	Optimization of Fluid flow systems	Lecture	CE1804.3	Assignment / quiz / End Term
34.	Applications of optimization in Chemical Engineering	Optimization of Fluid flow systems	Lecture	CE1804.3	Assignment / quiz / End Term
35.	Applications of optimization in Chemical Engineering	Optimization of Fluid flow systems	Lecture	CE1804.3	Assignment / quiz / End Term
36.	Applications of optimization in Chemical Engineering	Optimization of Fluid flow systems	Lecture	CE1804.3	Assignment / quiz / End Term
37.	Applications of optimization in Chemical Engineering	Optimization of Chemical reactor and its operation	Lecture	CE1804.3	Assignment / quiz / End Term
38.	Applications of optimization in Chemical Engineering	Optimization of Chemical reactor and its operation	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term
39.	Applications of optimization in Chemical Engineering	Optimization of Chemical reactor and its operation	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term
40.	Applications of optimization in Chemical Engineering	Optimization of Chemical reactor and its operation	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term
41.	Applications of optimization in Chemical Engineering	Optimization in large-scale plant design and operations	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term
42.	Applications of optimization in Chemical Engineering	Optimization in large-scale plant design and operations	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term
43.	Applications of optimization in Chemical Engineering	Optimization in large-scale plant design and operations	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term
44.	Applications of optimization in Chemical Engineering	Optimization in large-scale plant design and operations	Lecture	CE1804.3; CE1804.4	Assignment / quiz / End Term

I. COURSE ARTICULATION MATRIX: (Mapping of COs with POs)

CO	STATEMENT	CORRELATION WITH PROGRAM OUTCOMES												CORRELATION WITH PROGRAM SPECIFIC OUTCOMES		
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
[CE1804.1]	Develop a mathematical statement for the objective function and the equality and inequality constraints	3	3										1	2		
[CE1804.2]	Implement the theory and applications of optimization techniques in a comprehensive manner for solving linear and non-linear, geometric, dynamic, integer and stochastic programming techniques	3	2				1					1	1			
[CE1804.3]	Identify, formulate and solve a practical engineering problem of their interest by applying or modifying an optimization technique to enhance employability skills	3	2	1				1				1	1	2		2
[CE1804.4]	Use of commercial software to optimize chemical processes thereby enhancing their skills.			1		3				2	1	1	1	2	1	1

1- Low Correlation; 2- Moderate Correlation; 3- Substantial Correlation