GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3160002
Contributor Personality Development Program

SEMESTER VI

Type of course: Work-Personality Development

For Year: Pre-final year for all Diploma, Degree & Masters programmes over 2 semesters. For e.g. for Bachelors of Pharmacy and Engineering, the course will be conducted in Semesters V & VI.

Rationale: The Contributor Program aims to accomplish the following outcomes in the lives of students–

- Improve the employability of students by giving them the right work ethic and thinking that employers are looking for.
- Build their confidence with which they can go into any job and contribute meaningfully.
- Improve their ability to engage better in the workplace and to be able to handle the challenges that come up there.
- Build their career-worthiness and help them develop into future-ready contributors with ability to navigate a career in a volatile, changing world.
- Widen their choices of career and success, so that they are able to open up more opportunities for themselves and take up unconventional career pathways.
- Enable them to recognize how they, as technical professionals, can participate and make a positive contribution to their communities and to their state.

Towards this goal, the Contributor Program has been designed to awaken and strengthen students from within, in terms of building positive self-esteem, increasing their confidence level and I-can attitude, improving their aspirations, giving them new methods of thinking, building their cognitive capacities, exposing them to the skills and practices associated with being contributors in the workplace (not mere employees).

The Program content is also designed to expose students to real-world workplace scenarios and sensitize them to some of the challenges faced in society around them, especially in the local communities around them and in their own state of Gujarat.

The Contributor Program syllabus has been evolved and fine-tuned over several years, (a) to address the changing need and contemporary challenges being faced by industry and what employers of today are looking for in the people they hire and (b) by working extensively with universities and students building an appreciation of their challenges and concerns. At the core, the program is guided by the higher ideas and principles of practical Vedanta in work.

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	0	2	70	30	30	20	150

COURSE CONTENT :

Sr. No.	Content	Total Hrs
1	**Finding Solutions** The market environment in which organizations are operating, is becoming increasingly dynamic and uncertain. So, employers are increasingly seeking out people who can innovate and figure out solutions in the face of any challenge (unlike in the past when it was the	1.5 hrs Classroom engagement (including self-discovery/ solutioning sessions)

	people who were most efficient and productive, who were valued by organizations). At the heart of innovation lies this way of thinking of "finding solutions" rather than "seeing problems or roadblocks". Students learn how to build this way of thinking, in this topic.	
2	**Creating Value** Companies are also looking for employees who do not just work hard, or work efficiently or productively - but those who will make a valuable difference to the fortunes of the company. This difference may come from innovation, but it may also come from focusing on the right things and identifying what really matters – both to the company and to the customers. In this topic, students learn how to build this capability.	Same as above
3	**Engaging deeply** The environment we live in is becoming increasingly complex because more and more things are getting interconnected, new fields are emerging, technologies are rapidly changing, capabilities and knowledge one is trained in will become fast obsolete. In such a scenario, the student's ability to quickly understand and master what is going on, dive deep, get involved in any area, rapidly learn new capabilities that a job demands, is important. Engaging deeply is a core way of thinking that can help them in this. In this topic, students learn how to engage deeply.	Same as above
4	**Enlightened self-interest & collaboration at work** The changing nature of work in organizations and in the global environment is increasingly demanding that people work more collaboratively towards shared goals and more sustainable goals. A key to working successfully when multiple stakeholders are involved is "thinking in enlightened self-interest". In this topic, students learn how to develop this way of thinking (going beyond "narrow self-interest").	Same as above
5	**Human-centered thinking & Empathy** In this topic, students explore a human-centric approach to work – where the ability to recognize and respond to other people (whether they are users or customers or team members) as a human being with human needs and difficulties, is essential. This is at the heart of user-centric design of products and solutions, at the heart of genuine customer-centricity in services, and of any successful interaction with other people.	Same as above
6	**Trust Conduct** The biggest currency in a sustainable career is "trust" i.e. being trusted by team members, bosses, and customers. When we are trusted, people listen to us, they are willing to give us the chance to grow, give us the space to make mistakes, and work seamlessly with each other without always having to "prove ourselves". In this topic, students learn how to demonstrate conduct that builds the trust of people.	Same as above
Showcase Lab Sessions		3 hrs
Project work		Beyond classroom

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Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**15**	**-**	**20**	**20**

Reference resources:

A. Basic reference for both students and teachers

1. Contributor Personality Program textbook cum workbook developed by Illumine
2. Web-based ActivGuide™ for self-exploration of rich media resources to vividly understand many of the ideas, watch role models, learn from industry people, get reference readings – that help them enrich the understanding they gained in the class published by Illumine Foundation

B. Advanced reference for teachers

1. On Contributors, Srinivas V.; Illumine Ideas, 2011
2. Enlightened Citizenship and Democracy; Swami Ranganathananda, Bharatiya Vidya Bhavan, 1989
3. Eternal Values for a Changing Society – Vol I-IV, Swami Ranganathananda; Bharatiya Vidya Bhavan
4. Karma Yoga, Swami Vivekananda; Advaita Ashrama
5. Vivekananda: His Call to the Nation, Swami Vivekananda; Advaita Ashrama
6. Six Pillars of Self Esteem, Nathaniel Branden; Bantam, 1995
7. Mindset: The New Psychology of Success, Carol S. Dweck; Random House Publishing Group, 2007
8. Lasting Contribution: How to Think, Plan, and Act to Accomplish Meaningful Work, Tad Waddington; Agate Publishing, 2007
9. Why not?: how to use everyday ingenuity to solve problems big and small, Barry Nalebuff, Ian Ayres; Harvard Business School Press, 2003
10. The value mindset: returning to the first principles of capitalist enterprise (Ch 8 & 9); Erik Stern, Mike Hutchinson; John Wiley and Sons, 2004
11. The Power of Full Engagement: Managing Energy, Not Time, is the Key to High Performance and Personal Renewal, Jim Loehr, Tony Schwartz; Simon and Schuster, 2003
12. Creating Shared Value, Michael E. Porter and Mark R. Kramer; Harvard Business Review; Jan/Feb2011, Vol. 89 Issue 1/2
13. The Speed of Trust: The One Thing That Changes Everything, Stephen M. R. Covey, Rebecca R. Merrill, Stephen R. Covey; Free Press, 2008
14. The Courage to Meet the Demands of Reality, Henry Cloud; HarperCollins, 2009
15. Responsibility at work: how leading professionals act (or don't act) responsibly, Howard Gardner; John Wiley & Sons, 2007

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Course Outcomes:

Sr. No.	CO statement	Marks % weightage
Outcome of theory sessions		
CO-1	Students will be able to recognize & appreciate the thinking required to find solutions in the face of any challenge.	10-12%
CO-2	Students will be able to recognize & appreciate different types of value that can be created and the different ways to create value for others.	10-12%
CO-3	Students will be able to recognize & appreciate how to engage deeply, and its need, value, payoffs and consequences in different contexts.	10-12%
CO-4	Students will be able to differentiate between 'enlightened self-interest' and 'narrow self-interest' & appreciate the payoffs/ consequences of both when working with multiple stakeholders.	10-12%
CO-5	Students will be able to recognize & appreciate the human side of situations or interactions or projects that will help them develop a more human-centric approach/ response to work.	10-12%
CO-6	Students will be able to recognize & appreciate conduct which builds trust of people in contrast to conduct which breaks trust of people - in teams / organization & the value of trust conduct in various situations.	10-12%
Outcome of practical sessions		
CO-7	Students complete their 'Contributor Showcase Profile' on the Showcase Platform. This includes (a) completing Illumine's Contributor Mindset Assessment (b) building evidence to demonstrate their functional orientations as contributors.	15%
CO-8	Students learn to apply contributor thinking to think-through and address real-world challenges.	15%

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Bachelor of Engineering
Subject code: 3160003
INTEGRATED PERSONALITY DEVELOPMENT COURSE

SEMESTER VI

TYPE OF COURSE –

- Value-based holistic personality development course for university students.

RATIONALE -

- This course aims to help a person understand and know his / her purpose in life, get a positive thought pattern, gain confidence, improve behaviour, learn better communication and develop a healthy physique with morality and ethics in its core.

- Todays youth lack the guidance to face insecurity about their health and career, premature relationships and family breakdown, addictions and substance abuse, negative impact of internet and social media etc. This course includes such topics that will cover all aspects and provide solution to the current challenges through creative and interactive activities.

- This course will allow students to enjoy, understand and practice invaluable lessons preparing them for a successful future.

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
2	0	0	2	70	30	30	20	150

COURSE CONTENT :

Lecture No.	Content	Hours
1	**Facing Failures** - Insignificance of Failures	2
2	**Facing Failures** - Power of Faith	2
3	**Facing Failures** - Practicing Faith	2
4	**From House to Home** - Bonding the Family	2
5	**Learning from Legends** - Leading without Leading (Pramukh Swami Maharaj)	2
6	**Review Lecture** – Words of Wisdom	2
7	**My India My Pride** - Glorius Past - Part 1	2
8	**My India My Pride** - Glorius Past - Part 2	2

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9	**My India My Pride** - Present Scenario	2
10	**Remaking Yourself** - Begin with the End in Mind	2
11	**My India My Pride** - An Ideal Citizen - 1 (Accountability - Responsibility - Honesty - Integrity)	2
12	**My India My Pride** - An Ideal Citizen - 2 (Loyalty - Sincerity - Punctuality)	2
13	**My India My Pride** - An Ideal Cititzen - 3 (Ethical & Moral Values/Practices)	2
14	**Financial Wisdom** - Financial Planning Process	2
15	**Review Lecture** - Student Voice-2	2

BASIC STUDY MATERIAL / MAIN COURSE WORK-BOOK -

1. IPDC Workbook-I
2. IPDC Workbook-II

IPDC REFERENCES –

- *These are the reference material for each lectures of IPDC.*

Module No.	Module/ Course Topics	Lectures	References
1	Facing Failures	Factors Affecting Failures Failures are not Always Bad Insignificance of Failures Power of Faith Practicing Faith	1. Thomas Edison's factory burns down, New York Times Archives, Page 1, 10/12/1914 2. Lincoln Financial Foundation, Abraham Lincoln's "Failures": Critiques, Forgotten Books, 2017 3. J.K. Rowling Harvard Commencement Speech | Harvard University Commencement, 2008 4. Born Again on the Mountain: A Story of Losing Everything and Finding It Back, Arunima Sinha, Penguin, 2014 5. Failing Forward: Turning Mistakes Into Stepping Stones for Success, John C. Maxwell, Thomas Nelson, 2007 6. Steve Jobs: The Exclusive Biography Paperback, Walter Isaacson, Abacus, 2015

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2	Learning from Legends	Tendulkar & Tata Leading Without Leading	1. Chase Your Dreams: My Autobiography, Sachin Tendulkar, Hachette India, 2017 2. Playing It My Way: My Autobiography, Sachin Tendulkar, Hodder & Stoughton, 2014 3. The Wit and Wisdom of Ratan Tata, Ratan Tata, Hay House, 2018 4. The Tata Group: From Torchbearers to Trailblazers, Shashank Shah, Penguin Portfolio, 2018 5. The Leader Who Had No Title, Robin Sharma, Jaico Publishing House, 2010 6. In the Joy of Others: A Life Sketch of Pramukh Swami Maharaj, Mohanlal Patel and BAPS Sadhus, Swaminarayan Aksharpith, 2013
3	Mass Management	Project Management	1. Project Management Absolute Beginner's Guide, Gregory Horine, Que Publishing, 2017 2. The Fast Forward MBA in Project Management, Eric Verzuh, Wiley, 2011 3. Guide to Project Management: Getting it right and achieving lasting benefit, Paul Roberts, Wiley, 2013
4	My India My Pride	Glorious Past - Part 1 Glorious Past - Part 2 Present Scenario An Ideal Citizen - 1 An Ideal Citizen - 2 An Ideal Citizen - 3	1. Hidden Horizons, Dr. David Frawley and Dr. Navaratna S. Rajaram, 2006 2. Rishis, Mystics and Heroes of India, Sadhu Mukundcharandas, Swaminarayan Aksharpith, 2011 3. Physics in Ancient India, Narayan Dongre, Shankar Nene, National Book Trust, 2016 4. The Rise of Civilization in India and Pakistan, Raymond Allchin, Bridget Allchin, Cambridge University Press, 1982 5. The Āryabhaṭīya of Āryabhaṭa: An Ancient Indian Work on Mathematics and Astronomy (1930), Walter Eugene Clark, University of Chicago Press, reprint, Kessinger Publishing, 2006
5	Remaking Yourself	Restructuring Yourself Power of Habit Being Addiction-Free Begin with the End in Mind Handling the Devil – Social Media	1. Power of Habit, Charles Duhigg, Random House Trade Paperbacks, 2014 2. Change Your Habit, Change Your Life, Tom Corley, North Loop Books, 2016 3. The Seven Habits of Highly Effective People, Stephen Covey, Simon & Schuster, 2013 4. Seven Habits of Highly Effective Teens, Sean Covey, Simon & Schuster, 2012 5. Atomic Habits, James Clear, Random House, 2018 6. How a handful of tech companies control billions of minds every day, Tristan Harris, TED Talk, 2017

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6	Financial Wisdom	Basics of Financial Planning Financial Planning Process	1. Rich Dad Poor Dad, Robert Kiyosaki, Plata Publishing, 2017 2. The Warren Buffett Way, Robert Hagstrom, Wiley, 2013 3. The Intelligent Investor, Benjamin Graham, Harper Business, 2006 4. Yogic Wealth: The Wealth That Gives Bliss, Gaurav Mashruwala, TV18 Broadcast Ltd, 2016
7	From House to Home	Affectionate Relationships Forgive & Forget Listening & Understanding Bonding the Family	1. "What Makes a Good Life? Lessons from the Longest Study on Happiness", R. Waldinger, Ted Talks, 2015 2. Long Walk To Freedom, Nelson Mandela, Back Bay Books, 1995 3. Outliers, Malcolm Gladwell, Back Bay Books, 2011
8	Soft Skills	Teamwork & Harmony Networking - Decision Making - Leadership	1. The 17 Indisputable Laws of Teamwork, John Maxwell, HarperCollins, 2013 2. Team of Teams: New Rules of Engagement for a Complex World, Stanley McChrystal, Portfolio, 2015 3. Predictably Irrational, Revised and Expanded Edition: The Hidden Forces That Shape Our Decisions, Harper Perennial, Dan Ariely, 2010
9	Review	Student Voice – 1 Student Voice – 2 Words of Wim	

COURSE OUTCOMES –

- To provide students with a holistic education – focused on increasing their intelligence quotient, physical quotient, emotional quotient and spiritual quotient.
- To provide students with hard and soft skills, making them more marketable when entering the workforce.
- To educate students on their social responsibilities as citizens of India and have a greater sense of social responsibility.
- To provide students with a value-based education which will enable them to be successful in their family, professional, and social relationships by improving their moral and ethical values.
- To teach self-analysis and self-improvement exercises to enhance the potential of the participants.
- To have a broader sense of self-confidence and a defined identity.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160501
Semester –VI
Subject Name: Mass Transfer Operations II

Type of course: Professional Core course

Prerequisite: Mass Transfer Operations- I

Rationale: The objective of this course is to apply principles of mass transfer operations for detail study and for solving problems pertaining to conventional unit operations such as distillation, humidification, adsorption, drying etc. for separation

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Distillation:** Introduction, Vapor-liquid Equilibria, P-x-y T-x-y diagrams, concept of relative volatility and effect of Pressure and Temperature on equilibrium data, Ideal solutions, Raoult's law as applied to distillation operations, Deviation from ideality, steam distillation, Minimum and maximum boiling azeotropic mixtures, Enthalpy concentration diagrams, Flash distillation, steam distillation, simple distillation, continuous rectification, Binary systems, Batch fractionation etc., Determination of number of stages by Ponchon and Severit method and McCabe-Thiele method, q line, Feed tray location, Concept of minimum, total and optimum reflux ratio, Reboilers, Use of open steam, , Partial condensers, cold reflux, etc., Azeotropic Distillation, Extractive Distillation, Vaccum distillation etc. **Multicomponent distillation :** key components, minimum and total reflux, short cut method: FUG (Fenskey-Underwood-Gilliland) method, Rigorous methods: Lewis-Matheson calculations, Thiele and Geddes method, etc.	26
2	**Humidification Operations:** VLE and Enthalpy for a pure substance, Saturated and unsaturated vapour-gas mixtures and related terminologies such as absolute humidity, dry bulb temperature, dew point, wet bulb temperature, percentage & relative saturation, adiabatic saturation temperature, humid heat, humid volume etc. Psychometric chart & Psychometric relations for air-water system, adiabatic saturation curves, wet bulb temperature theory, Lewis relation, Adiabatic operations, cooling towers.	11
3	**Adsorption and Ion exchange:** **Adsorption:** Definitions and industrial applications, Types of adsorption, nature of	13

	commonly used adsorbents, Adsorption Equilibria, Single gases and vapors, Adsorption hysterises, Effect of temperature on adsorption, Heat of adsorption, Adsorption of solute from dilute liquid solution, Adsorption from concentrated liquid solution, Material balance and application of Freundlich's equation for single stage operation, multistage cross-current operation and multistage countercurrent operation, Equipments for adsorption such as fluidized bed & Teeter beds, steady state moving bed & unsteady state fixed -bed adsorbers, concepts of adsorption wave, break-through curve, Pressure swing adsorber, elution and chromatography etc. **Ion-Exchange** : Principles, Techniques, Applications, Equilibria and Rate of ion exchange	
4	**Drying:** Equilibrium relationship & hysteresis, various types of moisture in drying, Batch drying, rate of batch drying, time of drying, Cross-circulation drying, Through-circulation drying, concept of N_{toG} and H_{toG}, Drying at low temperature, Freeze drying etc. Batch & continuous drying equipments-Tray dryer, Tunnel dryer, Rotary dryers, Spray dryers, Fluidized bed dryer, etc.	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	25	25	10	-	-

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. R. E. Treybal, Mass transfer operations, 3rd edition, Mc-Graw Hill international, New Delhi, 1983.
2. J. F. Richardson, J H Harkar, Coulson and Richardson's Chemical Engineering, Volume2, 5th edition, Butterworth Heinemann, 2002.
3. Binay K. Dutta, Principles of mass transfer and separation processes, 2nd edition, Prentice Hall of India, 2007.
4. W. L. McCabe, J.C .Smith & Harriott, Unit Operations of Chemical Engineering, 7th edition Mc-Graw Hill international, India, 2014.
5. C. J. Geankoplis, Transport processes and unit operations, 3rd edition, Prentice Hall of India, 1993.

Course Outcomes: Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Explain concepts and applications of distillation, humidification, adsorption and drying.	15
CO-2	Describe theories, derivations and equipments of distillation, humidification, adsorption and drying.	35
CO-3	Solve problems of frequently encountered separation systems using	35

	conventional mass transfer operations.	
CO-4	Compare among various mass transfer operations for desired separation.	15

List of Experiments:

1. To measure the vapor pressure of acetone and calculate its latent heat of vaporization.
2. To study the humidification operation and calculate all psychometric parameters for air – water system.
3. To study the characteristics of adsorption of moisture on Silica gel.
4. To study and verify the Freundlich's adsorption isotherm for aqueous oxalic acid – charcoal system.
5. To verify Rayleigh's Equation for Differential Distillation.
6. To find out the critical moisture content of a given material using rate of drying curve.
7. To study the distillation with rectification in bubble cap distillation column
8. To verify the Equilibrium Relationship for n-Butanol-Water System.
9. To validate the basic principles of steam distillation.
10. To determine pressure drop data and values of K_G for various air and liquid velocities in a counter current cooling tower.

Major equipments:

Distillation column, Adsorption column, Cooling tower, dryer etc.

Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual lab by IITs.
3. FOSSEE –DWSIM https://dwsim.fossee.in/

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160506
Semester – VI
Subject Name: Chemical Reaction Engineering 1

Type of course: Professional core

Prerequisite:
Basic knowledge of material and energy balances in chemical engineering applications, laws of thermodynamics.

Rationale:
The course is intended to familiarize the students with concepts of reaction rate, derivation of rate expressions from reaction mechanism, ideal reactor types, integral method of analysis, differential method of analysis, principles of chemical reactor analysis and design, experimental determination of rate equations, design of batch and continuous reactors, how to choose the most appropriate reactor for a given feed, optimization of selectivity in multiple reactions, consideration of temperature and pressure effects, etc.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Overview of chemical reaction engineering**, Classification of reactions, Variables affecting rate, Definition of reaction rate, single and multiple reactions, Elementary and non-elementary reactions, molecularity and order of reaction, extent of reactions, conversion, Selectivity, Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory	7
2	**Kinetics:** Constant volume and variable volume batch, CSTR and PFR reactor data, data collection & plotting, linearization of rate equations. Analysis of total pressure data obtained from a constant-volume batch reactor, Integral and differential methods of analysis of data, Autocatalytic reactions, Reversible reactions, and Bio-chemical reactions.	8
3	**Homogeneous Single Reactions:** Performance equations for ideal batch, Plug flow, Back-mix flow and semi batch reactors for isothermal condition, Size comparison of single reactors, Multiple-reactor systems, Recycle reactor, Optimum recycle operations	8
4.	**Multiple Reactions:** Parallel reactions of different orders, Yield and selectivity, Product distribution and design for single and multiple-reactors, Series reactions: first-order reactions and zero-order reactions, Mixed series parallel complex reactions,	8

5.	**Temperature Effects for Single and Multiple Reactions:** Thermal stability of reactors and optimal temperature progression for first order reversible reactions, Adiabatic and heat regulated reactions, Design of non-isothermal reactors, Effect of temperature on product distribution for series and parallel reactions.	**7**
6.	RTD theory and analysis of non-ideal reactors	**7**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Octave Levenspiel, Chemical Reaction Engineering, 3rd Edition, Wiley-India Pvt. Ltd.
2. H. Scott Fogler, Elements of Chemical Reaction Engineering, 4th Edition, Prentice Hall of India Pvt. Ltd
3. Froment, G.B., and K.B. Bischoff, 1990, Chemical Reactor Analysis and Design, 2nd Ed., Wiley, New York
4. Smith, J.M., 1981, Chemical Engineering Kinetics, 3rd Ed., McGraw-Hill, New York.
5. L. D. Schmidt, the Engineering of Chemical Reactions, Oxford Press.
6. Carberry, J.J., 1976, Chemical and Catalytic Reaction Engineering, McGraw-Hill, New York.

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

Sr. No.	CO statement	Marks % weightage
CO-1	To classify reactions based on reaction mechanisms and reaction rates and reactors based on flow patterns	10
CO-2	To determine kinetics of single and multiple homogeneous reactions	20
CO-3	To choose an appropriate reactor type and operating conditions to achieve a desired output such as reactant conversion, selectivity and yield.	25
CO-4	To formulate a set of consistent material and energy balance equations to describe operation of batch, semi-continuous and continuous reactor systems with single or multiple reactions	25
CO-5	To summarize the effect of temperature and pressure on equilibrium conversion and choice of reactors.	10

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Chemical Reaction engineering -1 is covered.

Suggested list of experiments to be performed (8 to 10 experiments are to be given)

The analysis will include various experiments with the objective of sample preparation, measurement of concentration, prediction of kinetics and modeling of kinetics data. Learning outcomes: Students will (a) Familiarize with suitable measurement techniques and devices to measure concentration and temperature (b) Learn to employ various methods to determine the kinetics of reactions. (c) Quantify the effect of non-ideality of flow in chemical reactors. (d) Calculate the effects of mass transfer on chemical reactions, (e) Predict errors in experimentation and compare experimental data with models

1	To determine the activation energy of the reaction between sodium thio-sulphate and HCl using Arrhenius Equation.
2	To determine order of reaction for the reaction between sodium thiosulphate and HCl
3	To measure the kinetics of a reaction between ethyl acetate and sodium hydroxide under condition of excess ethyl acetate at room temperature.
4	To determine the kinetics of the reaction between ethyl acetate and sodium hydroxide at room temperature by the integral method of analysis.
5	To determine the activation energy and frequency factor for reaction between ethyl acetate and sodium hydroxide at room temperature & at different temperature.
6	To determine the kinetics of the reaction between ethyl acetate and sodium hydroxide at room temperature by the differential method of analysis.
7	To determine the kinetics of the reaction between n- butyl acetate and sodium hydroxide at room temperature by the integral method of analysis.
8	To determine the kinetics of the reaction between n- butyl acetate and sodium hydroxide at room temperature by the differential method of analysis
9	To study and analyze Residence Time Distribution (RTD) of a straight tubular flow reactor without helical coils and as a helical coil
10	To study and analyze Residence Time Distribution (RTD) for single tank reactor, two tanks in series and three tanks in series.
11	To analyze Residence Time Distribution (RTD) of packed bed reactor and prediction of extent of dispersion.
12	To study and analyze Kinetics of Dye degradation using Microwaves.

13	To study and interpret Kinetics of Bio-diesel synthesis from vegetable oils by Transesterification
14	To study Multiphase reaction: Effect in mass transfer limited reaction.
15	To study Oscillating reactions, pattern formation and reduced order modeling
16	To conduct Kinetic study of any biochemical reaction

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on the websites including NPTEL, Students can refer to the CDs which are available with some reference books for the solution of problems using software. Students can develop their own programs for the solutions of problems.

Open Source Software/learning website:

1. Students can refer to video lectures available on the websites including NPTEL.
2. Students can perform experiments on Virtual lab by IIT Bombay.
3. FOSSEE –DWSIM https://dwsim.fossee.in/

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160507
Semester – VI
Subject Name: Advanced Separation Processes

Type of course: Professional Elective

Prerequisite: Basic Concepts of unit operations including mass transfer.

Rationale:
The course is intended to familiarize the students of chemical engineering with the new, emerging and non-traditional separation techniques and their potential applications in chemical and allied process industries. The course will provide exposure to membrane based techniques, chromatographic separation, super critical fluid extraction and various other technologies.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Contents	Total Hrs
1	Fundamentals of separation processes, separation factor, chemical potential in interface mass transfer,equilibrium and rate governed separation, drawbacks of the conventional separation processes, need for advanced separation processes. Major areas of applications of advanced separation processes.	5
2	Membrane Separation Processes: Membrane types, materials, synthesis and characterization; Different membrane modules; Working principle, operating parameters, membranes used, transport processes/mechanisms and industrial applications for individual membrane processes such as (i) Reverse osmosis, (ii) nanofiltration, (iii) ultrafiltration,(iv) microfiltration (v) dialysis	8
3	Membrane gas separations, Fundamental mechanism, governing factors, principle of designing of gas separator membrane using complete mixing model. Gas separation membranes, applications of membrane gas separation. Introduction to pervaporation: principle, membranes used and application. Hybrid distillation-pervaporation system, Membrane Reactor: Concept & working, Various types of membrane used for membrane reactor, Membrane bioreactor.	8
4	Reactive and catalytic distillation Concept, advantage & disadvantages, BALE & KATMAX packing Manufacturing of MTBE and ETBE and its comparison with conventional techniques, Concept & working of short path Distillation Unit (SPDU),	6

5	Supercritical extraction: Working Principal, unique properties and solubility behavior of supercritical fluids, Advantages of supercritical extraction, Decaffeination, ROSE process for purification of crude oil, hydrothermal oxidation, and Commercial applications of supercritical extraction.	**6**
6	Chromatographic separation: Principle and operation, Chromatographic column Ion exchange chromatography, Gel filtration and affinity chromatography; Thin layer and paper chromatography Liquid chromatography, Advantages and disadvantages of chromatographic separations.	**6**
7	Electrophoretic separations: Principle of electrophoresis, Factors affecting electrophoresis, Gel membrane and paper electrophoresis, applications of electrophoresis.	**6**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Transport Processes and Separation Process principles, Christie J Geankoplis Prentice-Hall of India Private Ltd, New Delhi, 4th Edition 2006.
2. Membrane Separation Processes, Second Edition, by Kaushik Nath, PHI Learning Pvt. Ltd, New Delhi,2017
3. Munir Cheryan, UF Applications Handbook, Technique Publishing Co, Lancaster, USA (1986).
4. Separation Process Engineering, Philip C. Wankat, Prentice-Hall, 4th Edition, 2016.
5. Introduction to process Engineering & Design" by S.B. Thakore & B.I Bhatt,Tata McGraw-Hill Ltd.,2007
6. Separation Process Principles, J.D. Seader and E.J.Henley, Wiley, 2nd Edition 2004
7. Perry Chemical Engineers Handbook' 7thEdition by R.H Perry and D. Green.
8. Ullman's Encyclopedia of Industrial Chemistry, 7th edition, Wiley-VCH
9. Natural Extracts using supercritical carbon dioxide, M. Mukhopadhyay, CRC Press

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

Sr. No.	CO statement	Marks % weightage
CO-1	Ability to identify an appropriate separation technique for intended problem	20
CO-2	Understand the principle of membrane separation for various aqueous systems	35
CO-3	To conceptualize the reactive and catalytic distillation	20
CO-4	Ability to recognize the selection criteria between advanced separation techniques and conventional separation techniques.	25

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Advanced separation processes is covered.

Suggested list of experiments to be performed (8 to 10 experiments are to be given)

1. Determination of the water permeability of a given polymeric membrane.
2. Determination of permeation flux of a membrane in flat-sheet module (Dye-water solution may be used as feed). (RO/NF/UF membranes can be used)
3. The experiment (2) can be performed with various other modules such as spiral wound or hollow fiber.
4. Study of the effect of trans membrane pressure on permeatetion flux of a given membrane in a given module.
5. To determine rejection coefficient of the given membrane for a particular feed waste-water. (RO/NF/UF membranes can be used)
6. Determination of the swelling/sorption characteristics of a given polymeric membrane in a given pure solvent and its mixture of different concentrations.
7. Determination of permeate flux and separation factor for the separation of a given organic-aqueous mixture using pervaporation module.
8. Determination of membrane permeability, selectivity and diffusivity for the separation of a given organic-aqueous mixture using pervaporation.
9. To separate a mixture of dyes using thin layer chromatography

10. Separation of metallic ions by paper chromatography
11. Separation of plant pigments (chlorophylls and carotenoids) from green leaves by column chromatography.
12. Determination of ion exchange capacity of a given cation or anion exchanger
13. Numerical/design assignment of various membrane processes e.g. Reverse Osmosis, Ultra Filtration, Pervaporation etc.
14. Numerical/design assignment based on reactive and catalytic distillation.

In the beginning of the academic term, students may be allotted at least one Open-ended Project / Study Report /Latest outcome in technology. Literature survey including patents and research papers of fundamental process - Design based small project or - Study report based on latest scientific development or - Technology study report/modeling/ simulation/collection report or - Computer based simulation/web based application/analysis presentations of basic concept field which may help them in chemical engineering. These can be done in a group containing maximum three students in each. 4.

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on various websites including NPTEL. ¬ Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, Chemical and other simulation softwares.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160510
Semester – VI
Subject Name: Petroleum Refining and Petrochemicals

Type of course: Professional Elective Course

Prerequisite: Basics of Chemical Technologies

Rationale: Petroleum refining as well as petrochemical industries constitute a major part of chemical sector. Every chemical engineer has to invariably handle the enormous consumption of petroleum products, their diversity and increasing applications. Chemical engineer has to apply the relevant concepts for operating petroleum refinery or petrochemical plant in a safe manner. Beside this, a chemical engineer must be aware about the various properties of petroleum fractions as well as petrochemicals. Hence, this course has been designed to develop such expertise and skills.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P	C	Theory Marks		Practical Marks		
				ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
	PETROLEUM REFINING	
1	**Basics of Petroleum:** Role of Crude Oil in Global Economy, Present Scenario of Crude Oil Refinery, Origin(Formation), Composition, Classification and Evaluation of Crude Oil, Crude Assay Analysis, Distillation Characteristics such as TBP,ASTM & EFV etc.	04
2	**Properties of Petroleum Products:** Types of Gases and their Composition**,** Types of Gasoline & it's Important Properties and Tests such as ASTM Distillation , RVP, Octane number , Oxidation stability , Sulphur Content etc., Various types of Naphtha and their Important Properties and Application, Important tests and Properties of Kerosene such as Flash & Fire Point , Smoke Point , Aniline Point etc., Types of Diesel & its Important Properties and Tests such as Pour Point, Diesel Index , Cetane Number etc. , Heavy Fractions Like Lube Oil, Bitumen ,Asphalt etc. and their Important Properties Such as Viscosity Index, Carbon Residue, Penetration Index, Softening Point etc.	06
3	**Processing of Petroleum:** Pretreatment of Crude (Dehydration & Desalting), Pumping of Waxy Crude , Heating of Crude , Distillation of Petroleum & Types of Reflux , ADU & VDU etc	05

4	**Treatment Techniques:** Physical Impurities Found in Crude & their Removal, Sweetening Techniques, Production and Treatment of LPG, Gasoline Treatment Such as Lead Doctoring, Merox Sweetening, Catalytic Desulphurization etc. Various Methods of Treatment of Lubes Such as Phenol Extraction , Furfural Extraction, etc.	06
5	**Thermal & Catalytic Cracking :** Necessity and types of cracking **Thermal cracking:** Mechanism of Thermal Cracking, Properties of Cracked Materials, Visbreaking, Dubb's Two Coil Process, Delayed Coking, Naphtha Cracking etc. **Catalytic cracking:** Advantages & Theory of Catalytic Cracking, Fixed Bed, Moving Bed & Fluidized Bed Technology, FCC, Hydrocracking, Catalytic Reforming, Platforming, Continuous Catalyst Regeneration Reforming, Catalytic Polymerization, Catalytic Alkylation, Catalytic Isomerization etc.	09
	PETROCHEMICALS **Properties, Uses, Manufacturing Processes, Flow-Sheets etc. of following Petrochemicals**	
6	**C1 and C2 Petrochemicals:** Methanol, Formaldehyde, Chlorome thane etc. Ethylene, Ethylene Dichloride, Vinyl Chloride, Ethylene Oxide, Ethylene Glycol, Ethanol amines etc.	05
7	**C3, C4, Aromatics and Polymers:** Propylene, Butadiene, etc. BTX Separation, p-xylene, Styrene, p-terephthalic acid, etc. PVC, LDPE, LLDPE, HDPE, Polypropylene , Polypropylene Co-polymers , Polystyrene , SBR ,PBR, Polyesters etc.	10

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
14	28	14	14	0	0

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference books:

1. B. K.Bhaskar Rao, Modern Petroleum Refining Processes, Oxford and IBH 2007.
2. M Gopal Rao, Dryden's Outlines of chemical technology, 3rd Edition East-West press pvt. Ltd, Delhi
3. B.K.Bhaskar Rao, A Text on Petrochemicals, 2ndEdition, Khanna Publishers, Delhi, 1998

4. George Austin, Shreve's Chemical Process Industries, 5th edition McGraw Hill publication –New Delhi.
5. W.L.Nelson, Petroleum Refinery Engineering, McGraw Hill, New York, 1958.
6. James H, Gary & Glenn E. Handwerk, ' Petroleum Refining, Technology & Economics', 4th Edition, Marcel Dekker, Inc, 2001.
7. Speight, J. G., The Chemistry and technology of Petroleum, 5th Edition, M. Dekker, 1991.
8. Watkins, R. N., Petroleum Refinery Distillation, 2nd Edition Gulf Pub. Co., Houston, Tex, 1979.

Course Outcomes:

Students should be able to

Sr. No.	CO statement	Marks % weightage
CO-1	Define various test properties of crude oil and petroleum products and also explain their physical significance.	20
CO-2	Explain crude oil processing, treatment techniques and cracking reactions taking place in a petroleum refinery.	40
CO-3	Apply acquired knowledge of refinery processing and manufacturing technologies of producing petrochemicals for problem solving.	20
CO-4	Compare various routes of production of widely used petrochemicals.	20

List of Experiments:

1.	To determine the carbon residue of given sample by rams bottom apparatus.
2.	To determine the carbon residue of given sample by Conradson apparatus.
3.	To determine the calorific value of given sample by bomb calorimeter.
4.	To determine the viscosity of given sample using Engler viscometer at different temperatures.
5.	To determine the viscosity of given sample using say bolt viscometer at different temperatures.
6.	To determine the flash & Fire point of given oil sample using Cleveland open cup apparatus.
7.	To determine the smoke point of given kerosene (with and without acid treatment) sample using smoke point apparatus.
8.	To determine the percentage of corrosive sulfur in a given petroleum product using constant temperature bath.
9.	To characterize the given petroleum product (Diesel, petrol etc.) by A.S.T.M distillation (To plot ASTM curve)
10.	To find out the flash point of given oil sample using Able's apparatus
11.	To determine the flash and fire point of given sample of oil using Pensky-Martin apparatus.
12.	To determine the softening point and penetration index of Bitumen
13.	To determine the cloud and pour point of a given oil sample
14.	To determine the aniline point of a given sample.

Major Equipments:

1. Penskey Martin apparatus
2. Cleaveland Flash and Fire Point Apparatus:

3. Softening point Apparatus
4. Ram's bottom Apparatus
5. Conradson carbon residue Apparatus
6. Cloud and pour point Apparatus
7. ASTM Distillation Apparatus
8. Red wood viscometer:
9. Saybolt Viscometer
10. Engler Viscometer
11. Constant Temperature bath
12. Bomb calorimeter
13. Able's apparatus

Open Source Software/learning website:

- Video lectures available on the websites including NPTEL lecture series
- Open access Literature available for Petroleum Refining
- MIT Open course lecture on Petroleum Refining

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160511
Semester – VI
Subject Name: Polymer Science & Technology

Type of course: Professional elective course

Prerequisite: Basic knowledge of Chemistry.

Rationale: The main theme of the course on Polymer Science and Technology is to focus understanding of polymer science and technology, Polymer synthesis and its characterization. Knowledge of properties of polymers will enable their proper selection for applications in domestic as well as industrial appliances.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Introduction: Basic concepts of Monomer ,Types of Monomer, Functionality of Monomer, Basic concepts of Polymer, Effect of functionality on Polymer Structure, Chemical and geometric structure of polymer, Configuration and conformation, Linear, branched and cross-linked structure, Random, alternating, block and graft polymers, Stereo regular polymer, Classification of Polymer	6
2	Basic concept of polymer: structures, configuration, application, tacticity crystalline, mechanism and kinetics of polymerization, mode of formation, Poly dispersity and molecular weight distribution, Concept of Mn(Number average molecular weight), Mw((Weight average molecular weight), Mv(Viscosity average molecular weight) and Mz(Z average molecular weight) and measurement techniques, effect of molecular weight on polymer end use properities Functionality principle, Theory of polymer solutions: solubility parameter, Mark-Houwink-Sakurda equation.	8
3	Polymerization reactions: 1. Addition Polymerization reactions: a. Free radical polymerization b.Ionic polymerization c.Co-ordination polymerization 2.Condensation Polymerization a.Poly condensation polymerization b.Poly addition polymerization 3.Rearrangements and Stereo Polymerization 4.Co-Polymerization	10
4	Techniques of Polymerization: Bulk polymerization, Solution polymerization, Suspension polymerization, Emulsion polymerization, Comparison of bulk, solution, emulsion and suspension polymerization techniques	7

5	Polymer Degradation : Polymer degradation (chain and random), Methods of degradation of polymers such as mechanical, thermal, photo, oxidative and bio degradation	**6**
6	Polymer processing: Unit operations in polymer industries. Compression molding, transfer molding, injection molding, blow molding, reaction injection molding, extrusion, pultrusion, calendaring, rotational molding, thermoforming, rubber processing in two-roll mill, internal mixer.	**9**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**20**	**15**	**10**	**10**	**0**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Polymer science and technology, Joel R. Fried, Prentice Hall India Pvt. Ltd.
2. Textbook of Polymer Science, Fred W. Billmeyer, John Willy and Sons.
3. Rubber chemistry, Brydson, Elsevier Appl.
4. Principles of polymer system, Ferdinend &Rodrigues, Tata McGraw-Hill Pub.
5. Polymer Science, Gowariker, Eastern Wiley Pub.

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	To Synthesize and characterize polymers based on their properties and applications.	20
CO-2	To know the various types of polymerization reactions.	20
CO-3	To Discuss techniques of polymerization.	25
CO-4	To be able to utilize the knowledge for the processing of polymers.	20
CO-5	To build a bridge between theoretical and practical concept used in industry.	15

List of Experiments: (Minimum 05 experiments need to be performed)

1. Bulk polymerization of styrene.
2. Solution polymerization of acrylonitrile.
3. Emulsion polymerization of methylacrylate.
4. Synthesis of urea - formaldehyde by condensation polymerization.
5. To study injection moulding machine: Different materials and moulds; and optimization of cycle Time.
6. Determination of melt flow index for different materials.
7. Extrusion of strands / film and Pelletization.
8. To study Compression moulding.
9. To synthesis polymer using Bulk, solution, suspension & emulsion polymerization method.

Major Equipment

Extruder, compression molding machine, etc.

List of Open Source Software/learning website:

Reference to NPTEL lectures can be made for a better understanding

Literature available on Polymer technology.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160512
Semester – VI
Subject Name: Biochemical Engineering

Type of course: Professional elective

Prerequisite: Basic Concepts of chemistry and unit operations.

Rationale: This course is intended to familiarize the students of chemical engineering with the key aspects associated with biochemical processes. Students will be exposed to the concepts which constitute biochemical engineering including its scope, applications and advantages over conventional processes. Students will also learn the principles and practice of cell culture including sterilization techniques, bioreactor design, and some of the common unit processes of the downstream processing of biological products.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	Biochemical engineering as an interdisciplinary course, comparison of chemical and biochemical processes, Integrated bioprocess systems, Unit Operations in Bioprocess, microbiology fundamentals, Prokaryotic and Eukaryotic cells and their comparison; important features.	6
2	Chemicals of life: carbohydrates- types and functions, proteins- functions, elemental composition and types of proteins, basic idea about primary, secondary and tertiary structure of proteins, protein denaturation. Lipids- classifications and functions.	7
3	Properties of enzymatic reactions, Various models for enzyme-substrate complex formation, factors affecting enzyme activity, Michaelis-Menten equation: derivation and graphical evaluation of kinetic parameters, Enzyme inhibition, Enzyme immobilization, different methods of immobilization, Industrial enzymes and their applications.	7
4	Sterilization and media preparation, different types of solid media, cell death kinetics, Air sterilization, steam sterilization, batch and continuous sterilization. Stoichiometry of microbial growth and product formation, elemental balances, degree of reduction, yield coefficient, respiratory quotients. Oxygen uptake rate, Biomass production in cell cultures, phases of microbial growth, measurement of microbial growth by various methods, Monod growth kinetics, Evaluation of kinetic parameters, substrate and product	7

	inhibition, maintenance energy, environmental factors affecting microbial growth.	
5	Growth of organisms in batch reactor, continuous culture of organism, comparison between batch and continuous biomass culture, Stirred tank reactor in series and stirred tank reactor with recycle of biomass. Fed batch reactor, plug flow reactor.	**6**
6.	Design of Fermentor, Basic Functions, Body construction, Maintenance of aseptic conditions, Control of parameters, Valves and steam traps, Variants of fermentation vessels, Oxygen requirement in fermentations, Aeration and Agitation, Determination of K_La values, Fluid rheology, Factors affecting K_La values	**6**
7.	Product recovery operations, applications of filtration, cell disruption, centrifugation, liquid-liquid extraction, micro and ultrafiltration, chromatography, electrophoresis, isoelectric focusing in downstream processing.	**6**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
14	26	23	7		

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Bioprocess Engineering: Basic concepts, 2nd Edition, by Michael L Shuler & Fikret Kargi, PHI, New Delhi.
2. Introduction to Biochemical Engineering by D. G. Rao, Tata McGraw-Hill Education, 2005.
3. Biochemical Engineering Fundamentals by James Bailey & David F Oillis, Second Edition, McGraw Hill Publications.
4. Principles of Fermentation Technology, by Whitaker, Peter F Stanbury, S. Hall and A. Whitaker, Publisher: Butterworth-Heinemann; 2nd edition
5. Biochemical Engineering, Harvey W Blanch and Douglas S Clark, CRC Press

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand basic features of a biochemical reaction and its stoichiometry	15

CO-2	To develop an elementary idea of the basic features of common microorganisms and their growth and functions of selected biochemical.	20
CO-3	To identify and explain the basic design features of bioreactors	25
CO-4	To understand the principles of the various downstream processing of bio-products	20
CO-5	To understand the basics of enzyme kinetics and features of enzymes with few applications	20

List of Open Source Software/learning website:

Preparation of power-point slides, which include videos, animations, Pictures, graphics for better understanding theory – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus of Biochemical engineering is covered.

Suggested list of experiments to be performed (8 to 10 experiments are to be given)

1. Preparation of aqueous culture medium for microbial growth and steam sterilization of the medium in autoclave.
2. Preparation of solid medium (on agar): Slant, stab, petridish and inoculation of microbial culture in laminar hood cabinet.
3. Analytical Estimation of Glucose from aqueous solution by DNS method using spectrophotometer.
4. Estimation of total sugar, reducing and non-reducing sugar from jaggery sample by Cole's Method.
5. Estimation of Protein by Folin-Lowry method
6. To study the Growth kinetic of any microorganism by using Monod Equation
7. Determination of dissolved oxygen concentration from a sample of water.
8. Determination of oxygen transfer rate and $K_l a$ value
9. Determination of iodine value of the given sample of vegetable oil.
10. Determination of free CO_2 in a given sample of tap-water.
11. Determination of BOD-5 for a given sample of waste water
12. To perform column chromatography
13. To perform drying operation on any biomass/biological materials and construct the drying rate plot.

List of Open Source Software/learning website: Software:

Students can refer to video lectures available on the websites including NPTEL, Students can refer to the CDs which are available with some reference books for the solution of problems using software.

Students can develop their own programs for the solutions of problems.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160513
Semester – VI
Subject Name: Wastewater Engineering

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea on the challenges in the field of water management with a perspective on wastewater management. Students will learn about the problems and its solution perspective on waste water treatment methods, sewage and sludge disposal. Different types of primary, secondary and advances treatment methods should be known by the student. This subject will guide students in the same direction. The objectives of this course are to help the students develop the ability to apply the basic understanding of physical, chemical and biological phenomena for successful design, operation and maintenance of sewage treatment plants.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	% weightage
1	**Characterization and treatment of wastewater** Introduction: Wastewater flow and its characteristics, Wastewater collection systems, Estimation and variation of wastewater flows. Problems of industrial wastewaters, sampling protocol, equalization, neutralization, proportioning processes, volume and strength reduction. Preliminary, primary, secondary and tertiary wastewater treatment processes. Theory and design of screens, grit chambers, sedimentation, coagulation, flocculation	**07**	**15**
2	**Activated sludge treatment for wastewater** Physico-chemical and biological treatment strategies and their evaluation, Theory of activated sludge process (ASP), extended aeration systems, trickling filters (TF), aerated lagoons, stabilization ponds, oxidation ditches, sequential batch reactor, rotating biological contactor, etc., Mass balancing in ASP and TF and their design.	**10**	**25**
3	**Anaerobic treatment of wastewater** Anaerobic treatment process, Effects of pH, temperature and other parameters on anaerobic treatment, Concept of anaerobic contact process, anaerobic filter, anaerobic fixed film reactor, fluidized bed and expanded bed reactors and up flow anaerobic sludge blanket (UASB) reactor.	**08**	**15**

4	**Planning for wastewater treatment and its reclamation** Indian standards for disposal of treated wastewaters on land and in natural streams, Agricultural irrigation, Ground water recharge, Treated wastewater reclamation and reuse, Introduction to duckweed pond, vermiculture and root zone technology for wastewater treatment, Special treatments, Recent technologies of treatment.	**10**	**20**
5	**Industrial wastewater treatment** Study on wastewater generation points, wastewater characteristics, process flow sheets, wastewater treatment scheme for sugar, textile, steel, paper/ pulp, oil refinery, pharmaceutical, dyes and intermediates industries.	**10**	**25**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

Legends: R: Remembrance; U: Understanding; A: Application; N: Analyze; E: Evaluate; C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference:

Text Books

1. Economics of Water Resources Planning, James L.D. and Lee R.R., McGraw-Hill, Newyork, 1971.
2. Water Resources Handbook, Mays L.W., McGraw-Hill 1996.
3. Design of Water-Resource Systems, Maass A., Hufschmidt M.M., Dorfman R., Jr. Thomas H.A., Marglin, S.A., Fair G.M., Harvard University Press, 1962.
4. Environmental Engineering (Vol. I) Water Supply Engineering, Garg S.K., Khanna Publishers, 1977.
5. Water Supply and Wastewater Engineering, Raju B.S.N., Tata McGraw-Hill, New Delhi, 1995.
6. Water Supply and Sanitary Engineering, Birdie G.S. and Birdie J.S. Dhanpat Rai Publishing Company Private Ltd. New Delhi, 2014.
7. Wastewater Engineering: Treatment Disposal Reuse, Metcalf & Eddy, McGraw-Hill, 1979
8. Water & Wastewater Engineering Volume II, Fair G.M., Geyer J.C., Okun D.A., John Wiley& Sons Ltd. Newyork, 1968.

Other References:

1. Water Resources Systems Planning and Management, Chaturvedi M.C., Tata McGraw-Hill, India, 1992.
2. Introduction to Hydrology, Viessman W., Thomas Y. Crowell, Harper and Row, NY, 1972.

3. Handbook of Applied Hydrology, Chow V.T., McGraw Hill Book Company, New York, 1964.
4. Engineering Hydrology, Subramanya K., Tata McGraw Hill Company Ltd., New Delhi, 1994.
5. Hydrology and Water Resources Engineering, Patra. K.C., Narosa Publising House, New Delhi, 2008.

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the basic knowledge about the wastewater and its treatment processes	15
CO-2	To understand the activated sludge process for the treatment of wastewater	20
CO-3	To understand the anaerobic process for the treatment of wastewater	15
CO4	To understand the standards for wastewater treatment, disposal and its reclamation	15
CO-5	To study the wastewater treatment scheme for various industries	20

List of Tutorials: Students can select any type of wastewater treatment. Each group of students are expected to create a way to utilize wastewater treatment method and sludge disposal process in innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL. Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, ChemCAD and other simulation softwares.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160514
Semester – VI
Subject Name: Green Technology and Sustainable Development

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea on Green Technology with an approach towards the design, manufacturing and use of chemical products to reduce or eliminate the chemical hazards intentionally. Green Technology is a new and rapidly emerging branch of chemistry. The goal of Green Technology is to create better and safe chemicals while choosing the safest and the most efficient ways to synthesize them. The main goal of Green Technology is to eliminate hazards right at the design stage. The principles of Green Technology demonstrate how chemical production could be achieved without posing hazard to human health and environment.

Students will learn the concept of sustainable development including different perspectives, consequences of societal resource use and strategies for changing this concept towards a sustainable direction.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	%weightage
1	**Principles of Green Technology and Green Engineering:** To learn to modify the processes and products to make them green safe and economically acceptable to the society, Concepts of green chemistry and Process intensification.	07	15
2	**Green Synthesis and Catalysis:** Green oxidation and photochemical reactions, Microwave and Ultrasound assisted reactions, Synthesis of Green Reagents, Green solvents, Green nanotechnology and Ionic liquids.	07	20
3	**Green Industrial Processes:** Pollution statistics from various industries like polymer, textile, pharmaceutical, dyes, pesticides and wastewater treatment. A greener approach towards all these industries.	07	15
4	**Meaning of Sustainable Development:** Understand the Sustainable Development, three principal dimensions: the ecological, the economic and the social dimension, including intergenerational justice; use a systems perspective, to describe sustainability challenges and possibilities for major technical systems and for their transformation to meet sustainability requirements	07	15
5	**Concepts of Cleaner Technologies:** Cleaner Production (CP), Definition, methodology, Role of CP in Achieving Sustainability, Benefits, Role of Industry, Government and Institutions, Environmental Management	10	20

	Hierarchy, Relation of CP and EMS. CP case studies: Ammonical nitrogen recovery from wastewater, Fluoride removal from wastewater, Reuse of water from sewage treatment plant, Gas quenching process: replacement of oil with nitrogen and Reduction of hydrogen cyanide from process stack. Reuse of liquid industrial waste from several industries.		
6	**Challenges and Practical Implementation:** Responsibilities and potentials of companies for action. Green Productivity and emerging technologies. Implementation of the practical applications of Green emerging technologies and sustainable development. Case studies in Green Technology. Green laws compliance.	**07**	**15**

Reference:

1. Chemistry for Environmental Engineering and Science, Sawyer C.N, McCarty P.L and Parkin G.F. 5th ed. McGraw-Hill Professional, 2003.
2. Environmental Chemistry with Green Chemistry, Das A. K. Books and Allied (P) Ltd., Kolkata, India, 2012.
3. Green Chemistry: Environmentally Benign Reactions, Ahluwalia, V.K. Ane Books India, New Delhi, India, 2006.
4. Green Chemistry: An Introductory Text, Lancaster M. Royal Society of Chemistry, Cambridge, 2002.

Text Books

1. Introduction to Green Chemistry, Matlack A.S. Publisher: Marcel Dekker, Newyork, 2001.
2. Green Chemistry: Theory and Practice, Anastas P.T. and Warner J.C. Oxford University Press, 1998.
3. Pollution Prevention: Fundamentals and Practice, Bishop P. L. McGraw-Hill, Boston, 2000.
4. Cleaner Production Audit Environmental System Reviews, Modak P., Visvanathan C. and Parasnis M. Asian Institute of Technology, Bangkok, 1995.
5. Handbook of Green Chemistry and Technology, Clark J.H. and Macquarrie D.J. Wiley-Blackwell Publishers, 2002

Other references

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

Legends: R: Remembrance, U: Understanding, A: Application, N: Analyze, E: Evaluate, C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160514

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the principles of green chemistry and engineering	15
CO-2	To understand the field of Green Technology and its approach towards the new discovery and innovation	20
CO-3	To gain knowledge on Green industrial processes	15
CO4	To understand the concept of sustainable development and its importance	15
CO-5	Ability to describe Cleaner Production measures applicable to different industries	20
CO-6	Understand and select the different principles of green chemistry and sustainable development for various applications.	15

List of Tutorials: Students can select any type of green technology and sustainable development method. Each group of students is expected to create a way to utilize green technology and sustainable development process of industry in an innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL. Students can refer to the CDs which are available with some reference books for the solutions of problems using software's. Students can develop their own programs for the solutions using excel, ChemCAD and other simulation software's.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160515
Semester – VI
Subject Name: Solid Waste Management

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea on Solid Waste Management is a pressing issue. The course on Solid Waste Management gives the student an overview of municipal solid waste management including collection, transfer, transport and disposal. To make the students conversant with different aspects of the types, sources, generation, storage, collection, transport, processing and disposal of municipal solid waste.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs	% weightage
1	**Introducing Municipal Solid Waste Management its Generation and Characteristics of Waste:** Sources, Types, composition, quantity, sampling and characteristics of waste, factors affecting generation of solid wastes. Overview: problems and issues of solid waste management-Need for solid waste management-Functional elements such as waste generation, storage, collection, transfer and transport, processing, recovery and disposal in the management of solid waste.	08	15
2	**Types of Solid Waste:** Waste products during manufacturing and packing, operation of pollution control facilities, generation and minimization at source, recycling, disposal, Bio medical waste-generation and management system, E-waste-generation and management system.	10	20
3	**Disposal of Solid Waste:** Segregation, volume reduction at source, recovery and recycle; dumping of solid waste-sanitary, landfills-site selection-design and operation of sanitary landfill-leachate, landfill gas management-landfill closure and environmental monitoring-landfill remediation; Municipal solid waste in Indian conditions, legal aspects of solid waste disposal, plastic waste disposal and necessary equipments.	10	20
4	**Waste Collection, Storage and Transport:** Collection: Collection of solid waste–collection services–collection system, equipments–time and frequency of collection–labour requirement–factors affecting	10	20

	collection–analysis of collection system–collection routes–preparation of master schedules. Transfer and Transport: Need for transfer operation–transfer stations–types –transport means and methods–location of transport stations–Manpower requirement–collection routes: Transfer stations–selection of location, types and design requirements, operation and maintenance.		
5	**Risk Assessment and Environmental Legislation** Characterization and site assessment, Waste minimization and resource recovery, Laws for solid waste management	**07**	**15**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
30	**15**	**15**	**5**	**5**	**0**

Legends: R: Remembrance; U: Understanding; A: Application; N: Analyze; E: Evaluate; C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference:

Text Books

1. Integrated solid waste management: Engineering Principles and Management Issues, Tchobanoglous G., Theisen H., Vigil S.A. McGraw-Hill, New York, 1993.
2. Unit Operations in Resource Recovery Engineering, Vesilind P.A. and Rimer A.E., Prentice Hall, 1981.
3. Waste Treatment and Disposal, Willams P. T. John Wiley and Sons, Ltd. 2005.
4. Waste Management, Bilitewski B., Härdtle G., Marek K. Springer-Verlag Berlin Heidelberg, 1997.

Other references

1. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Housing and Urban Affairs, Government of India, New Delhi, 2000.
2. Solid Waste Management: Collection Processing and Disposal, Bhide A.D. and Sundaresan, B.B. NEERI, Nagpur, 2001.
3. Practical Handbook of Processing and Recycling Municipal Waste, Manser A.G.R. and Keeling A.A. Lewis Publishers, CRC Press, 1996.
4. Waste Management Practices: Municipal, Hazardous, and Industrial, Pichtel J. CRC Press, 2014.
5. Hazardous Waste Management, LaGrega M.D., Buckingham P.L., Evans J.C. McGraw-Hill, New York, 1994.
6. Hazardous Wastes: Sources, Pathways, Receptors, Watts R.J. John Wiley and Sons, New York, 1998.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3160515

List of Open Source Software/learning website: www.nptel.iitm.ac.in/courses/

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO1	An understanding of the nature and characteristics of municipal solid wastes	**15**
CO2	Execute an action plan for types of solid waste	**20**
CO3	Select the appropriate method for solid waste disposal	**15**
CO4	Ability to plan waste minimization and design storage, collection, transport, processing and disposal of municipal solid waste	**20**
CO5	To implement risk assessment and laws related to solid waste management	**15**

List of Tutorials: Students can select any type of solid waste management techniques. Each group of students is expected to create a way to utilize industrial methods of waste minimization techniques in innovative way and prepare report of project assigned to his/her group. In addition, each group is expected to give a power point presentation during the semester. The presenter will be selected randomly just prior to the presentation.

List of Open Source Software/learning website: Students can refer to video lectures available on various websites including NPTEL. Students can refer to the CDs which are available with some reference books for the solutions of problems using softwares. Students can develop their own programs for the solutions using excel, ChemCAD and other simulation softwares.