GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject code: 3150004
Subject Name: Contributor Personality Development Program
Semester V

Type of course: Work-Personality Development

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 and Examination Scheme per semester:

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

Note:

- Weekly 2 hours of Classroom facilitated sessions are planned which include Solutioning and Self-discovery sessions.

- In addition, there will be individual/ team projects as part of Practicals. Students can do this on their own, with faculty as guide.

Note:
It is the responsibility of the institute heads that marks for PA of theory & ESE and PA of practical for each student are entered online into the GTU Portal at the end of each semester within the dates specified by GTU.

Content:

Sr. No.	Content	Total Hrs
1	**The Contributor Work Ideal** *In this topic, students explore what is their "ideal" of work - is the ideal to be a "worker" or to be a "contributor"? For example, an employee who has the ideal of a "worker" goes to work to pass time, earn a living, get benefits; in contrast to an employee with the ideal of a "contributor" who wants to make a difference, get things done well, create value for the company. This enables students to transform their expectation of themselves in work*	1.5 hrs Classroom engagement *(including self-discovery/ solutioning sessions)*
2	**Identity & Self-esteem** *In this topic, students engage with the question "who am I?" or on what basis do they define themselves. Is their identity defined by what others think of them (extrinsic self-esteem) or by what they think of themselves (intrinsic self-esteem)? Further, they discover positive identities that lead to intrinsic self-esteem, such as an I-can identity based on one's capacity and inner strength. This enables them to build confidence and self-esteem.*	Same as above
3	**Become a Creator of one's destiny** *In a "victim stance", we see the career environment as full of difficulties and hurdles. We feel powerless or blame our circumstances for not having many opportunities. This makes us fearful of uncertainty and makes us settle for jobs where we remain mediocre. In this topic, students discover the "creator of destiny stance" to challenges and situations. This stance frees them to try out new things, open up new possibilities, take on responsibility, see the opportunity hidden in their environment.*	Same as above
4	**Achieving Sustainable Success** *In this topic, students discover how to achieve sustainable or lasting success, by building one's "engine of success", making them success-worthy. Where their focus shifts to building one's "engine of success" rather than being on chasing the "fruits of success". This is important,*	Same as above

	because over a lifetime of work, all people go through ups and downs – where the fruits are not in their control. People who are focused on the fruits of success, fall prey to disappointment, loss in motivation, quitting too early, trying to find shortcuts – when fruits don't come. Whereas people focused on building their engine of success continue to contribute steadily, irrespective of whether fruits come or not. And with a strong engine of success, fruits come to them in time.	
5	**Career Development Models** *In this topic, students explore a range of diverse "career development models" and the possibilities for contribution each opens up to them (e.g. start-up career model, change-maker career model, etc.). This opens their mind to different and even unconventional career models possible, beyond the usual (such as "stable large company career model" where one gets an engineering degree, then MBA, then get a job in a large company). This frees them from a herd mentality when making career choices.*	Same as above
6	**Expanding contribution in every role** *In this topic, students explore the many roles they can play in their life & discover the power they have to expand the contribution possible in any role. (E.g. role of student, role of manager, role of a project site engineer). So, the potential of a role is in the individual's hands. This opens their mind to an alternative way of career growth.*	Same as above

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (for B.Pharma)					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**20**	**-**	**25**	**20**

Distribution of Theory Marks (for B.E., Diploma, MCA)					
R Level	U Level	A Level	N Level	E Level	C Level
-	**15**	**15**	**-**	**20**	**20**

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

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

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
Outcome of theory sessions		
CO-1	Students will be able to recognize & appreciate two alternative ideals of work – ideal of a "worker" and ideal of a "contributor". And why organizations of today expect people they employ to be contributors and not just workers.	10-12%
CO-2	Students will be able to recognize & appreciate alternative ways in which they could define themselves or "who am I" (their identity) – and which are positive identities that will lead to building intrinsic self-esteem and confidence in oneself; in contrast to identities that will lead to extrinsic self-esteem that makes them	10-12%

	more dependent on their environment.	
CO-3	Students will be able to recognize & appreciate a "victim" stance as distinct from a "creator of destiny" stance in the way people approach challenges and situations; and how the latter frees individuals to take on challenges and open up opportunities.	10-12%
CO-4	Students will be able to differentiate between two alternative approaches to success - 'building one's engine of success' and 'chasing the fruits of success'; they also appreciate the payoffs/ consequences of both and which is more likely to lead to sustainable or lasting success in the long run.	10-12%
CO-5	Students will be able to recognize & appreciate different career models and their value; to help them make more informed career-related choices.	10-12%
CO-6	Students will be able to recognize & appreciate how one can expand the contribution possible in any role, thereby opening up an alternative way of career growth to them.	10-12%
Outcome of practical sessions		
CO-7	Students learn to re-interpret their life and college experiences to showcase their contribution affinities which are relevant for employers.	15%
CO-8	Students learn to apply contributor thinking to real-world or career relevant challenges.	15%

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150005
Semester – V
Subject Name: INTEGRATED PERSONALITY DEVELOPMENT COURSE

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.

Today 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 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)	
2	0	0	2	70	30	30	20	150

Content:

Lecture No.	Content	Hours
	IPDC-1 (Semester-1)	
1	**Remaking Yourself** - Restructuring Yourself	2
2	**Remaking Yourself** - Power of Habit	2
3	**Learning from Legends** - Tendulkar & Tata	2
4	**Mass Management** - Project Management	2
5	**From House to Home** - Affectionate Relationships	2
6	**Facing Failures** - Factors Affecting Failures	2
7	**Facing Failures** - Failures are not Always Bad	2

8	**Remaking Yourself** - Being Addiction-Free	2
9	**Soft Skills** - Teamwork & Harmony	2
10	**Remaking Yourself** - Handling the Devil - Social Media	2
11	**From House to Home** - Forgive & Forget	2
12	**From House to Home** - Listening & Understanding	2
13	**Financial Wisdom** - Basics of Financial Planning	2
14	**Soft Skills** - Networking - Decision Making - Leadership	2
15	**Review Lecture** - Student Voice-1	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
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
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: 3150501
Semester –V
Subject Name: Mass Transfer Operations -I

Type of course: Professional Core course

Prerequisite: Basics of fluid dynamics, heat transfer and thermodynamics

Rationale: The objective of this course is to study the principles of mass transfer and their applications to separation and purification processes in chemical industry. This course is intended to explain detailed fundamentals of mass transfer operations such as diffusion, mass transfer coefficient, inter phase mass transfer etc.. and its application for in depth study and for solving problems pertaining to some mass transfer operations such as in detail. This course also enables the students to understand principal and working of various mass transfer equipments like gas absorption columns, crystallizers, and extractors 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)	
4	0	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs
1	**Introduction:** Definition and aim of mass transfer operations, Classification of mass transfer operation with examples, Direct Vs Indirect Mass transfer operations, choice of separation method, Methods of conducting mass transfer operations, Design principles	4
2	**Molecular Diffusion in Fluids:** Definition of molecular and eddy diffusion, Ficks law, Concept of N & J Flux, Steady state molecular diffusion in fluids at rest and in laminar flow, concept of effective diffusivity. Diffusivity of gases, Diffusivity of liquids.	10
3	**Mass Transfer Coefficients:** Mass transfer in laminar and turbulent regions, F and k type mass transfer coefficients, Film, Penetration and surface renewal theories, Analogies between momentum, heat and mass transfer, Dimensionless numbers	6
4	**Inter Phase Mass Transfer:** Concept of equilibrium, diffusion between phases, Two resistance theory, Local overall mass transfer coefficient, controlling mass transfer resistances.	4
5	**Gas Absorption:** Equilibrium Solubility of gases in liquids, Ideal and non-ideal solutions, Choice of solvent for absorption, Material balance and liquid to gas ratio for absorption, Counter current multi stage operation (isothermal), Absorption factor, Continuous contact	8

	equipments, Overall coefficient and Transfer units, Concept of HETP and HTU, NTU and jH factor, Industrial absorbers. Dilute solutions, Absorption with chemical reaction	
6	**Equipments for Gas Liquid Operations:** *Gas Dispersed*: Sparged vessels, Mechanically agitated vessels, Gas-Liquid contact, Tray Tower, Tray tower internals, Different types of trays, Weirs, Downcomers and criteria of their selection, Flooding, Loading, Coning, Weeping & dumping in tray tower *Liquid Dispersed*: Ventury scrubber, Wetted wall towers, spray towers, Packed Towers, Packed tower internals, Different types of packings and their selection criteria, mass transfer coefficient for packed towers, Co-current flow of gas & liquid, End effects and axial mixing, Tray tower vs. Packed tower.	8
7	**Liquid-Liquid Extraction:** Ternary liquid- liquid equilibrium and tie line data, system of three liquids-one pair partially soluble, two partially soluble, two partially soluble liquids and one solid, multi-component system, stage wise contact, Single stage & multistage extraction, Co-current and cross current extraction, Continuous counter current multistage extraction with and without reflux, Theory & performance of continuous contact equipments, Single stage & multistage equipments, Applications of liquid-liquid extraction.	10
8	**Leaching:** Steady state and unsteady state leaching operations, Single stage leaching, Multistage cross current and counter current leaching, Rate of leaching, Recovery of solvent vapors, Application of leaching, Leaching equipments	6
9	**Crystallization:** Saturation, Nucleation, Principle of crystallization, Crystallization rate, Equilibria and yields, Nucleation, Crystal growth, Caking of crystals, Application of crystallization, Crystallization equipments	4

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10	30	20	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, Volume-2, 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, 6th edition Mc-Graw Hill international, 2001.
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	Describe fundamentals of diffusion; inter phase mass transfer and mass transfer coefficients.	40
CO-2	Explain various mass transfer operations and their equipments used in chemical industries.	20
CO-3	Apply theoretical and analytical aspects of mass transfer operations to deal with complex problems of separations.	20
CO-4	Solve problems pertaining to various mass transfer operations like gas absorption, liquid-liquid extraction, crystallization and leaching	20

List of Experiments:

1. To determine the diffusion co-efficient of CCl_4 in air & it's variation with temperature.
2. Determine mass transfer co-efficient of liquid (water) evaporation to atmospheric air at elevated temperature.
3. To find out the liquid side mass transfer coefficient K_{La} for the absorption of CO_2 in NaOH in the packed column.
4. To prepare ternary diagram for a system of three liquid –one pair partially soluble.
5. To determine the % extraction for the benzoic acid from dilute aqueous solution using toluene as solvent.
6. To study multistage (cross current) liquid-liquid extraction for extracting acetic acid from benzene using water as solvent.
7. To determine the stage efficiency and the overall recovery of NaOH for multistage cross current leaching operation for leaching of NaOH from mixture of NaOH and $CaCO_3$ using water as a solvent.
8. To find out crystal yield with & without seeding

Major Equipments:

Gas Absorption column, batch crystallizer, Diffusion assembly, Packed column etc.

List of 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

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150502
Semester –V
Subject Name:Mechanical Operations

Type of course: Professional elective course

Prerequisite: Chemical engineering consists of several unit operations and unit processes. Before the reaction step, the raw materials should be processed through various unit operations and similarly after the reaction step as well the products are passed through various unit operations either for product separation or for purity. Thus unit operations are very essentially part of the chemical engineering; and hence, basic knowledge about the principles and equipment of solid-solid unit operations and solid-liquid unit operations is mandatory for any professional chemical engineer.

Rationale:
The main objective of this subject is to study the basic mechanical operation (crushing, grinding, screening, filtration, etc.) takes place during the process in chemical industry. It also provides platform to study and analyze various properties associated with the solid when it is in flow condition. This subject provides the fundamental knowledge regarding to particle size reduction and enlargement by various methods and also deals with the detail construction & working of equipment's used for mechanical operations.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	**Solids and Its Flow Properties:** Solids, Characteristics of Solid particles, Properties of particulate masses, Particle size, mixed particle size analysis, Average particle size, Specific surface area of mixture, No of particles in mixture, Screen analysis, Standard screens, Capacity and effectiveness of screen, Ideal and actual screens, Screening Equipment – Grizzly screens, Gyrating screens, Trommels, Shaking screens, Oscillating screens.	8
2	**Size Reduction, Enlargement, Screening:** Principles of comminution,Rittinger's and kick's laws, Bond's crushing law and work index,Size reduction equipments, crushers, grinders, Ultra fine grinders,Dry versus wet grinding, Cutting machines, Open circuit and closed circuit operation,	10

	Screening equipment, Comparison of ideal and actual screens, Screen effectiveness.	
3	**Fluidization and Conveying:** Conditions for Fluidization, Types of fluidization, minimum fluidization velocity and pressure drop in fluidised bed, Equations for Kozeny–Carman, Burke – Plummer, Ergun, liquid – solid and gas solid systems, Applications of batch and continuous fluidization, Slurry and pneumatic transport, mechanical and pneumatic conveying, elevators, storage bins and silos for solid/liquid/gases.	**12**
4	**Filtration and Sedimentation :** Introduction, Cake filters, Filter media, Filter aids, principles of cake filtration,Filter press, Shell and leaf filters, Rotary drum vacuum filters, Centrifuges, Gravity classifiers, clarifying filter, Sink and float method, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Differential settling methods, sedimentation zones in continuous thickeners, Cyclones, Hydrocyclones.	**7**
5	**Mixing and Agitation:** Different types of agitators and their selection criteria,Types of Impellers, flow patterns in un-baffled and baffled tanks, Calculation of power required for agitation, Scale up of agitated vessel. Mixing of pastes/liquid/dry powder, pony mixer, ribbon blender, tumbler mixer, and static mixers.	**8**

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. Foust A. S. & associates, "Principles of Unit Operations" John Wiley and Sons (1980).
2. McCabe Smith, "Unit Operation in Chemical Engineering" 5th ed. McGraw Hill (1985).
3. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book", 7th ed. McGraw hill.
4. Badger and Bencharo, "Introduction to Chemical Engineering". Tata McGraw hill.
5. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth Heinemann Pub
6. Welty, Wicks, Wilson &Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th ed. Wiley Narayanan C.M.& Bhattacharya B.C. "Mechanical Operations for Chemical engineers", Khanna Publishers. 3 rd Ed.1999

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150502

Sr. No.	CO statement	Marks % weightage
CO-1	To characterize particles and perform size reduction and size analysis of particles to meet the need of chemical industries	20
CO-2	To review the practical importance and relevance of unit operations used for crushing, grinding and size separation in chemical industry.	20
CO-3	To understanding fluid flow through fluidized bed	20
CO-4	To evaluate the parameters of various filtration equipment and sedimentation	25
CO-5	To identify the different types of mixing, agitation and conveying of solids and estimating the power requirement	15

List of Experiments: (Minimum 08 experiments need to be performed)

1. To determine the screen efficiency for the given sample by sieve analysis
2. To determine the screen efficiency for the given sample by vibrating screen
3. To determine nip angle, Reduction Ratio, Ribbon Factor, Rittinger's constant, Bond's constant, Kick's constant , Work Index as well as Theoretical & Actual Capacity using roll crusher.
4. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index using jawCrusher
5. To calculate the overall efficiency of the cyclone separator.
6. To carry out the batch sedimentation tests.
7. To carry out gravity filtration test
8. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index for ball mill
9. To study filter press
10. To study size reduction of material by drop weight crusher
11. To determine separation efficiency by using froth flotation cell

Major Equipments

Jaw crusher, Gyratory crusher, Roll crusher, Ball mill, Cyclone separator, Plate & Frame filter press, Sieve shaker apparatus etc.

List of Open Source Software/learning website:

Reference to NPTEL lectures can be made for a better understandingregarding mechanical operation done in industriesunder different conditions.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150504

Semester – V
Subject Name: Instrumentation and Process Control

Type of course: Professional Core Corse

Prerequisite: Material and Energy Balance Calculations, Basics of differential equations.

Rationale: The course is designed to introduce the fundamentals of process control along with instrumentation and its applications. The course will teach the students about mathematical models based on transfer function approach for single loop systems, how to obtain dynamic response of open loop and closed loop systems, stability analysis in transient and frequency domains, and controller tuning methods. The course introduces P, PI, and PID controllers and their applications. The course would end with more advanced concepts like feed-forward control, ratio control, model-predictive control, dead-time compensation, etc. The instrumentation for process control is also focused along with hands-on practical experience. Principles of operation of different measuring devices for temperature, level, pressure, flow, pH, humidity, density, and viscosity. Students will be introduced to transmitters, transducers, converters, control valves, digital and analog components related to PLC, DCS, and SCADA systems.

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	**Introduction of Process Control:** Need for control and automation, Steady state and dynamic system, control logic, servo and regulatory, control, block diagrams, control structures (feedback vs. feedforward)	3
2	**Laplace Transforms:** Definition, Transforms of simple functions, Ramp functions, Sine functions, Solutions of differential equations. Inversions of transform function by partial fractions, qualitative nature of solutions, Final value and initial value theorems, Translation of transforms, Transforms of unit impulse functions, Transforms of integral.	4
3	**Response of First Order Systems:** Mercury thermometer, Transient response of step functions, Sinusoidal input, Impulse functions. Physical Examples of First Order Systems: Liquid level, Mixing process, linearization. First Order System in Series: Non-interacting system of liquid level, Generalization of several non-interacting systems in series, Interacting systems.	5
4	**Second Order Systems:** Development of transfer functions, Damped vibrator, Liquid manometer, Thermometer in thermo-pocket, Step response & impulse response,	4

	Overshoot, Decay ratio, Rise time, Response time, Period of oscillation, Natural period of oscillation, Sinusoidal response, Transportation lag.	
5	**The Control Systems:** Block diagram, Standard block diagram symbols, Negative and positive feedback, Servo problem v/s regulator problems, Development of block diagrams, Process measuring element, Controller, Final control element. Closed Loop Transfer Functions: Block diagram reduction, Overall transfer function for single loop system, Overall transfer function for change in load, Overall transfer function for multi loop control system, process and instrumentation diagrams , parts of control system.	**4**
6	**Controllers and Final Control Elements:** Actual v/s Ideal controller, Pneumatic controller mechanism of proportional control, Proportional integral (PI) control, Proportional derivative (PD) control, Proportional integral derivative (PID) control. Control valve, Control valve characteristics. Transfer functions of P, On-off, PI, PD, and PID control, Motivation for addition of integral and derivative modes, Block diagram of chemical reactor control system.	**4**
7	**Transient Response of Simple Control Systems:** Proportional control for Set point change (Servo Problem), Proportional control for load change (Regulator Problem), Proportional integral control for load change, Proportional Integral control for set point change, Proportional control for system with measurement lag.	**3**
8	**Stability:** Concept of stability, Definition of stability (linear system), Stability criterion, Characteristic equation, Routh test for stability, Routh array, Method of Root Locus for stability analysis, Nyquist stability criterion.	**5**
9	**Frequency Response analysis:** Fortunate circumstances, Transportation lag, First order system, First order system in series, Bode diagrams, Bode stability criterion, Graphical rules for Bode diagrams. Transient response phase margin, magnitude ratio, phase shift, open loop bode diagrams of various controllers.	**5**
10	**Controller tuning and advance controllers:** Ziegler-Nichols method, Cohen-Coon method, introduction to cascade control, feed forward control, ratio control, Smith-predictor, IMC, MPC, dead-time compensation, digital control.	**5**
11	**Introduction of Process Measurement:** Elements of instruments, Parts of instruments, Static and dynamic characteristics.	**2**
12	**Temperature Measurement:** Scales, Expansion thermometers like constant volume gas, Mercury in glass, Bimetallic, Filled system thermometer like pressure spring thermometer, Static accuracy of thermometer, Dip effect in thermometer, Errors in thermometer of liquid and gas filled type like cross ambient effect, Head effect, Methods of compensation, Thermoelectric temperature measurement: Thermo couples, Pyrometers: Radiation pyrometer, Photo electric pyrometers, Optical pyrometers, Errors in optical pyrometers.	**4**
13	**Pressure Measurement:** Liquid column manometer, Enlarged leg manometer, Inclined tube manometer, Ring manometer, Tilting U tube manometer, Bourdon gauge, Bellows, Bellows differential pressure gauge, Vacuum Measurement: Ionization gauge, Pirani vacuum gauge, Thermocouple vacuum gauge, McLeod gauge	**3**
14	**Liquid Level Measurement:** Direct measurement, Float and tap, Float and shaft, Hydraulic remote transmission, Bubbler system, Diaphragm & air trap system, Differential pressure manometer, Float and spring pneumatic balance, Displacement float, Magnetic float gauge.	**2**

15	**Flow Measurement:** Head flow meter, Orifice plate, Flow nozzle, Venturi tube, Pitot tube, Differential pressure meter, Electric type head flow meter, Bellows type meter, Rota meter, Piston type area meter and Positive displacement meter, Flow control actuators: different types of valves.	**3**
16	**Humidity measurement & pH Measurement:** Psychometer method, wet bulb and dry bulb thermometer, hygrometer method, dead point method, electrolytic water analyzer. Electrode for pH measurement, calomel reference electrode, measuring circuits.	**2**
17	**Density & Viscosity Measurement:** Liquid level method, displacement meters, hydrometer. Viscosity meter, continuous viscosity meters, capillary type viscometers, rotating bowl type viscometer.	**2**
18	Introduction to advance topics like Electrical and pneumatic signal conditioning and transmission, Computer process control, PLC, DCS, and SCADA.	**4**

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
10	20	15	10	10	**5**

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. Coughanowr, D. R., LeBlanc, S. "Process Systems Analysis and Control", 3rd edition,McGraw-Hill (2008).
2. Stephanopoulos, G. "Chemical Process Control: An Introduction to Theory and Practice", Pearson Education (1984)
3. Seborg, D.E., Edgar, T.F., Mellichamp, D.A. "Process Dynamics and Control", 2nd edition, John Wiley (2003)
4. William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, Mc-GrawHill (2005).
5. S.K. Singh, Industrial Instrumentation and Control, 3rd edition, McGraw-Hill (2008).
6. R. P. Vyas, "Process Control and Instrumentation", Denett & Co.
7. Donald .P. Eckman, "Industrial Instrumentation", John Wiley & Sons Inc, New York.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150504

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

Sr. No.	CO statement	Marks % weightage
CO-1	understand concepts of open and close loop control system	10
CO-2	construct mathematical models of chemical process with its transfer function	25
CO-3	evaluate the performance of control system with controllers and control strategies along with instrumentation	25
CO-4	design control loop with appropriate controllers and control valve	20
CO-5	apply appropriate instruments for various application in chemical plant	20

List of Open Source Software/learning website:

Scilab Xcos open source software can e used for process control modelling and analysis.

Students can refer to video lectures available on the websites including NPTEL

Students can refer website of "*The International Federation of Automatic Control (IFAC)*" https://www.ifac-control.org/ for international conference proceedings.

List of Experiments: (Minimum 10 experiments to be performed)

1. Response of first order system: thermometer
2. Response of first order liquid level system
3. Response of mixing process
4. Reponses of second order system: U-tube manometer or damped vibrator
5. Response of Interacting tanks
6. Response of Non-interacting tanks
7. Calibration of thermos couple test rig
8. Characteristics of flow control valves
9. Temperature and pressure measuring devices
10. Level measuring devices (Bubble system)
11. Viscosity and pH measuring devices (pH Control trainer)
12. Transmitters and transducers
13. Open loop systems: lagged thermometer
14. Temperature, level, flow, and pressure control trainers
15. Flow-level cascade control

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150505
Semester –V
Subject Name: Particle and Fluid Particle Processing

Type of course: Professional elective course

Prerequisite: Basic knowledge of fluid mechanics and particles are required to study the course. However, the course gives insight of both fluid and particles processing in detail.

Rationale:
The main objective of this subject is to study the basic fluid particle processingto understand the basic physical unit operations in a chemical process industry. It also provides platform to study and analyze various properties associated with the solid when it is in flow condition.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs
1	Introduction: Solid- Fluid operations, characterization and classification	6
2	Mixing and agitation: Mixing, Agitation, Different types of agitators and their selection criteria, Calculation of power required for agitation, Scale up of agitated vessel, static mixers, intensive mixers, heating and cooling mixers.	8
3	Fluidization and Transportation: Fluid flow in porous solid beds, Conditions for Fluidization, Types of fluidization, Applications of fluidization Transportation: Mechanic, Slurry, hydraulic and pneumatic transport, conveyors	11
4	Filtration and sedimentation: Cake filters, Constant rate filtration, constant pressure filtration,Filter press, Shell and leaf filters, vacuum filters, Centrifugal filters, Filter media, Filter aids, Clarifying filters, Gravity classifiers, Sink and float method, Clarifiers and thickeners, Batch sedimentation, Rate of sedimentation, Thickeners, Cyclones, Hydrocyclones, Centrifuges.	8
5	Solid- Fluid Mass Transfer: Leaching, Crystallization, Nucleation, Growth of crystals, Drying, Solid- Fluid Reactors: Fluidized bed reactor, moving bed reactor, slurry bed reactor, fixed bed reactor.	12

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150505

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. Foust A. S. & associates, "Principles of Unit Operations" John Wiley and Sons (1980).
2. McCabe Smith, "Unit Operation in Chemical Engineering" 5th ed. McGraw Hill (1985).
3. Perry R.H. & Chilton C.H., "Chemical Engineers Hand Book", 7th ed. McGraw hill.
4. Badger and Bencharo, "Introduction to Chemical Engineering". Tata McGraw hill.
5. Coulson and Richardson: Chemical Engineering, Vol. 2.Butterworth Heinemann Pub
6. Welty, Wicks, Wilson &Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th ed. Wiley Narayanan C.M.& Bhattacharya B.C. "Mechanical Operations for Chemical engineers", Khanna Publishers. 3 rd Ed.1999

Sr. No.	CO statement	Marks % weightage
CO-1	To characterize particles and perform size reduction and size analysis of particles to meet the need of chemical industries	20
CO-2	To understand the performance of solid-fluid reactors	20
CO-3	To understanding fluid flow through fluidized bed	20
CO-4	To evaluate the parameters of various filtration equipment and sedimentation	25
CO-5	To identify the different types of mixing, agitation and conveying of solids and estimating the power requirement	15

List of Experiments: (Minimum 08 experiments need to be performed)

1. To determine the screen efficiency for the given sample by sieve analysis
2. To determine the screen efficiency for the given sample by vibrating screen
3. To determine nip angle, Reduction Ratio, Ribbon Factor, Rittinger's constant, Bond's constant, Kick's constant , Work Index as well as Theoretical & Actual Capacity using roll crusher.
4. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index using jawCrusher
5. To calculate the overall efficiency of the cyclone separator.
6. To carry out the batch sedimentation tests.
7. To carry out gravity filtration test
8. To determine Rittinger's constant, Bond's constant, Kick's constant and Work Index for ball mill
9. To study filter press
10. To study size reduction of material by drop weight crusher
11. To determine separation efficiency by using magnetic separator
12. To determine separation efficiency by using froth flotation cell

Major Equipments

Jaw crusher, Gyratory crusher, Roll crusher, Ball mill, Cyclone separator, Plate & Frame filter press, Sieve shaker apparatus etc.

List of Open Source Software/learning website:

Reference to NPTEL lectures can be made for a better understandingregarding mechanical operation done in industriesunder different conditions.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150506
Semester – V
Subject Name: Chemical Process Plant Design & Economics

Type of course: Humanities and social science

Prerequisite: Basic Concepts of material and energy balance, fluid flow operations and unit process and chemical technology.

Rationale:

This course brings together the concepts of engineering and economics with special reference to chemical process and plant design along with the hierarchy of decisions in synthesis and analysis of a chemical process and its alternatives. This course is intended to challenge chemical engineer to combine basic technical principles learned in other courses in the general curriculum with practical elements of economics, business practices and organization along with principles of safety, environmental and sociological issues to design an integrated chemical process plant.

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
1	**Introduction and Process design aspects:** Basic design, optimization, selection of process-factors affecting process selection. Types of project design, Importance of Laboratory development pilot plant, safety factors, types of flow diagrams.	6
2	**Selection of process equipments:** Standard versus special equipment-material of construction for process equipments, selection criteria, and specification sheets.	4
3	**Process auxiliaries and Process utilities**: Piping design, layout, and supports for piping insulations. Pipe fittings, types of valves, selection of valves, process control and instrumentation control system design. Process water, boiler feed water, water treatment, waste treatment and disposal, disposal, steam, oil heating system, chilling plant, compressed air and vacuum	6
4	**Plant location and layout:** Factors affecting plant location, factors in planning layouts, principles of plant layout, Unit plot plan, vertical and horizontal lay out	4
5	**Cost estimation:** Cash flow and cumulative factors affecting estimation of investment and production cost, breakeven point and its significance, total capital investment, fixed and working capital investment & their estimations, type of estimates, cost indexes, method for	5

	estimating capital investment. Simple and compound interest.	
6	**Estimation of total product cost:** manufacturing cost, general expenses, Manufacturing cost: direct production cost, fixed charges, plant overhead cost.	**5**
7	**Depreciation:** Types of depreciation, Method for determining depreciation: straight line method, decline balance method, sum of the year digit method, shrinking fund method etc, single unit and group depreciation, adjustment of depreciation account, evaluation of depreciation methods	**5**
8	**Profitability, alternative investments and replacement:** Methods for profitability evaluation, Evaluation of Break Even Point, % rate of return, Practical factors in alternative investment and replacement Studies.	**5**
9	**Project management:** Planning of project schedule by BAR CHART, Inventory control scheduling a project using CPM/PERT methods.	**5**

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. Peters, Max S., K.D. Timmerhaus and R.E. West, Plant Design and Economics for Chemical Engineers (5th Ed), McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (2003).

2. Douglas, James M., Conceptual Design of Chemical Processes, McGraw-Hill International Editions (Chemical Engineering Series), New York, USA (1988).

3. Biegler, L.T., I.E. Grossmann and A.W. Westerberg, Systematic Methods of Chemical Process Design,Prentice Hall (Pearson Education), New Jersey, USA (1997).

4. Mahajani,V.V., Chemical Project Economics, Macmillan Indian Ltd., New Delhi, India (2005).

5. Smith, R., Chemical Process: Design and Integration, John Wiley and Sons, West Sussex, UK (2005).

6. Coulson and Richardson's Chemical Engineering, Vol. 6: Chemical Engineering Design. By R.K. Sinnott, Butterworth-Heinemann, Oxford, 3rd, Ed., 1999, 1994

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

Sr. No.	CO statement	Marks % weightage
CO-1	State the basic concepts of economics, selection of equipment, process plant design and project management.	25
CO-2	Discuss Plant auxiliaries, process utilities, plant location and layout	20
CO-3	Calculate capital investment, total product costs, break even analysis and depreciation.	30
CO-4	Explain alternative investment, replacements and profitability analysis.	25

List of Open Source Software/learning website:

NPTEL lecture series Literature available on Plant design and project Economics

Suggested activities/mini-project on plant design and cost estimation:

The plant design project involves a small group of students working as a team to design a nominated chemical manufacturing plant. The tasks include the study of the available processes, process selection, calculation of material and energy balances, preparation of flow sheets, design of selected plant items, an assessment of factors affecting plant safety, sustainability and environmental impact, estimation of plant cost and process economics, preparation of a design report and drawing of the plant layout.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150507
Semester – V
Subject Name: Energy Technology

Type of course: Open elective course

Prerequisite: None

Rationale:
To provide an idea of the challenges in the field of energy management and to provide a perspective on energy technology. Students will learn the systems dimensions of the energy problems and its historical perspective on energy technology and system development. For different types of energy sources utilization in industries, the procedure of power generation, transportation along with conventional and advanced application in different sectors should be known by the student. This subject will guide students in the same direction.

Teaching and Examination Scheme:

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

Content:

Sr. No.	Content	Total Hrs	%weigh tage
1	**An Introduction to Energy Sources:** Energy consumption, world energy future, energy sources and their availability**,** Conventional and Non-conventional energy, primary and secondary energy resources, energy and environment, energy needs for growing economy, energy sector reforms, energy security, energy audit, energy conservation and its importance	**7**	**15**
2	**Energy Efficiency in Thermal Utilities** **Fuels and Combustion:** Introduction to fuels, properties of fuel oil, coal and gas, storage, handling and preparation of fuels, principles of combustion, proximate and ultimate analysis, calorific values, gasification, composition of coal. **Steam System:** Properties of steam, assessment of steam distribution losses, steam leakages, steam trapping, condensate and flash steam recovery system, identifying opportunities for energy savings. **Insulation andRefractories:** Insulation-types and application, economic thickness of insulation, heat savings and application criteria, Refractory-types, selection and application of refractories, heat loss. **Waste Heat Recovery:** Classification, advantages and applications, commercially viable waste heat recovery devices, saving potential.	**10**	**20**

3	**Solar energy** Solar radiation and related terms, measurement of solar radiation, solar energy collectors-flate plate collector, air collector, concentrating collectors, application and advantages of various collectors, solar energy storage system (thermal, chemical, mechanical), solar pond, application of solar energy	**10**	**15**
4	**Fuel cell** Introduction, hydrogen- oxygen fuel cell, ion exchange membrane cell, fossil fuel cell, molten carbonate cell. Advantages and disadvantages, conversion efficiency, polarization, type of electrodes, application of fuel cell	**07**	**20**
5	**Energy from biomass** Introduction, biomass conversion technology, photosynthesis, biogas generation, factors affecting biogas generation, classification of biogas plants and their comparison, types of biogas plant, biogas from plant wastes, community plants and site selection, digester design consideration, design calculations, methods of maintaining and starting of biogas plant, properties and utilization of biogas, thermal gasification of biomass, pyrolysis	**10**	**15**
6	**Wind energy** Basic principles, power in wind, force on blades and turbines, wind energy conversion, site selection, basic components of wind energy conservation system (WECS), classification of WECS, wind energy collectors, applications of wind energy.	**07**	**15**

Reference Books:

1. Fuels & combustion by Samir Sarkar, Orient Longmans(1974)
2. Solar Energy: Principles of Thermal Collections and Storage, S. P. Sukhatame and J. K. Nayak, Tata McGraw Hill, New Delhi
3. Energy Technology by Rao &Parulaker.
4. Energy Sources 2nd Ed. by G. D. Rai, Khanna Publications, NewDelhi

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 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.

Course Outcomes:

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150507

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the basic knowledge of available energy sources, energy conservation and energy audit	15
CO-2	To Evaluate the energy saving & conservation in different thermal utilities	20
CO-3	To understand the design and applications of power generating devices using solar energy	15
CO-4	To understand the basics of fuel cell and able to design different types of cells	20
CO-5	To classified various biomass conversion methods and able to design/develop biogas plant	15
CO-6	To understand the design and applications of power generating devices using wind energy	15

List of Tutorials: Students can select any type of renewable energy and try to find out the application in chemical or other industries and can suggest modification in the energy production techniques, which can make the surrounding of plant environmental friendly and economical at the same time. Each group of students are expected to create a way to utilize renewable energy 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, Chemical and other simulation softwares.

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150508
Semester – V
Subject Name: Material Science and Engineering

Type of course: Open elective

Prerequisite: Basic Concepts of physics and chemistry.

Rationale: This course is intended to familiarize students with essential concepts in material science with an emphasis on particulate solids, their behavior and processing in various engineering applications. It will briefly cover basic concepts behind the chemistry of organic and inorganic compounds, chemical bonding and structure, and structure-property relationships in different engineering materials.

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
1	**Introduction** : Classification of Engineering Materials; Levels of Structure; Structure–Property Relationships in Materials	5
2	**Atomic structure & Chemical bonding**: Quantum states, Ionization Potential, Electron Affinity and Electronegativity, Types of chemical bonds- Ionic, covalent, metallic and secondary bonding, Bond Energy, Bond Type and Bond Length	7
3	**Structure of solids**: The Crystalline and the Noncrystalline States, ionic solid, covalent solids, metals and alloys, Classification of Polymers, Structure of Long Chain Polymers	6
4	**Crystal defects**: Point Imperfections, The Geometry of Dislocations, Other Properties of Dislocations, Surface Imperfections	6
5	**Phase rule**: Single-component Systems, Binary Phase Diagrams, Some Typical Phase Diagrams and applications, phase transfornmation, nucleation and growth, transformations in steel, precipitation process, solidification and crystallization, glass transition	7
6	**Plastic deformation and creep in crystalline materials:** The Tensile Stress-Strain Curve, Plastic Deformation by Slip, The Shear Strength of Perfect and Real Crystals, The Effect of Temperature on the Stress to Move a Dislocation, mechanism of creep and creep resistant materials	7
7	**Oxidation and corrosion**: Mechanisms of Oxidation, Oxidation Resistant Materials, The Principles of Corrosion, Protection against Corrosion	7
8	**Conductors, resistors and semiconductor materials**, resistivity range, free electron theory, superconducting materials, intrinsic and extrinsic semiconductors, fabrication of	7

	integrated circuits, Magnetic and dielectric materials: Ferromagnetism and Related Phenomena, soft and hard magnetic materials,	

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. Materials Science and Engineering: A first course, by V Raghavan, (5th Edition) PHI learning Centre, New Delhi.

2. Materials Science and Engineering: An Introduction, 10th Edition, William D. Callister Jr., David G. Rethwisch (WILEY)

3. Introduction to Materials Science for Engineers (8th Edition) 8th Edition by James F. Shackelford, Pearson

4. Elements of Materials Science and Engineering, L. H. Van Vlack (Addison-Wesley)

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

Sr. No.	CO statement	Marks % weightage
CO-1	To understand the basic structure of materials at the molecular, microscopic, and macroscopic scales	20
CO-2	To promote an understanding of the relationship between material structure, processing and properties	35
CO-3	To acquire basic knowledge of crystal defects, phase rule, plastic deformation and corrosion in materials	25
CO-4	To Gain a broad perspective on materials chemistry and physics for selection of engineering materials for specific 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 Advanced analytical techniques is covered.

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 softwares.

Collaborative Open Resource Environment – for Materials

The CORE-Materials repository contains 1670 open educational resources (OERs) in Materials Science and Engineering, freely available under a range of Creative Commons licenses. (Source: CORE webpage)

Suggested topics for tutorials:

The tutorials will be consisting of solving the numerical problems/critical evaluation/higher order thinking problems based on the following topics:

1. Bonding Properties of Atoms
2. Properties of Crystals & Defects
3. Diffusion
4. Mechanical Properties
5. Plastic Deformation & Strengthening
6. Failure, Creep, Fatigue, & Fracture
7.Phases and Phase Diagrams
8. TTT (Time-Temperature-Transformation)Diagrams
9. Ceramics, Polymers, & Electronic Properties

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3150509

Semester – V
Subject Name: Fuels and Combustion

Type of course: Open Elective Corse

Prerequisite: Material and Energy Balance Calculations

Rationale: Fuels and combustion course introduces basic knowledge about solid, liquid and gaseous fuels, their origin, classification, preparation procedure and characterization in terms of physico-chemical properties. Coal being the main solid fossil fuels, its mining, cleaning and combustion processes covered in detail. Petroleum is the liquid fuel which is elaborated in terms of exploration, evaluation, distillation and secondary processing. Different important gaseous fuels are also included. It also covers fundamentals of combustion along with and combustion appliances. Emphasis is given to combustion of various fuels considering thermodynamics. Combustion appliances are discussed in Combustion technology section. Basic knowledge of advance topics like continuous industrial furnaces and oxy-rich combustion is also incorporated for wide exposure and realising importance of the subject.

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	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	**Introduction :** Types of fuels, solid, liquid and gaseous fuels, History of solid liquid and gaseous fuels, production, present scenario and consumption pattern of fuels, fundamental definitions, properties and various measurements, properties of solid liquid fuels and their measurement techniques.	5
2	**Solid fuels :** Coal origin, its classification, composition, and properties. Coal mining, preparation, and washing. Combustion of coal and coke making, different types of coal combustion techniques, coal tar distillation, coal liquefaction: direct and Indirect liquefaction, coal gasification, oxidation and hydrogenation. Efficient use of solid fuels.	7
3	**Liquid Fuels :** Origin and classification of petroleum, refining, properties & testing of petroleum products, various petroleum products, petroleum refining in India, liquid fuels from other sources, storage and handling of liquid fuels.	5

4	**Gaseous Fuels :** Types of gaseous fuels: natural gases, methane from coal mines, manufactured gases, producer gas, water gas, biogas, refinery gas, LPG, hydrogen, acetylene, other fuel gases. Cleaning, purification and quality enhancement of gaseous fuels.	**7**
5	**Manufactured fuels :**Agro fuels, solid fuel handling, properties related to combustion, handling, and storage. bio-Fuels: types of bio-fuels, production processes and technologies, Bio-fuel applications.	**6**
6	**Stoichiometry of combustion :** Estimation of minimum amount of air required for a fuel of known composition, theoretical and actual combustion processes - Air fuel ratio, estimation of dry flue gases for known fuel composition, calculation of the composition of fuel and excess air supplied from exhaust gas analysis, dew point of products. calorific value of fuels, adiabatic flame temperature, mechanism and kinetics of combustion,	**9**
7	**Combustion Technology:** Stoichiometry and thermodynamics of combustion, calculation of heat of formation and heat of combustion, first law analysis of reacting system, combustion of oil, combustion of coal, combustion of gas, flue gas analysis, flame properties, draft system, combustion appliances, gas burners, functional requirement of burners, gas burner classification, stoker firing, pulverized system of firing, fluidized bed combustion process, combustion controls. Introduction to different types of furnaces: heat treatment furnaces, industrial furnaces, process furnaces, and kilns. Applications of batch and continuous furnaces, oxy-rich combustion.	**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
10	25	20	10	5	**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. Irvin Glassman, "Combustion" 2nd ed., Academic Press.
2. John Griswold, "Fuels Combustion and Furnaces" Mc-Graw Hill Book Company Inc.
3. S.P. Sharma & Chander Mohan, "Fuels & Combustion", Tata McGraw Hill Publishing Co. Ltd.
4. Gupta O.P, "Elements of Fuels, Furnaces & Refractories", 3rd ed., Khanna Publishers.
5. Dr. Samir Sarkar, "Fuels & Combustion", 2nd ed., Orient Longman.

6. B. I Bhatt & S. B. Thakore, "Stoichiometry", 5th ed., Tata McGraw Hill Publishing Co. Ltd.
7. James G, "Chemistry and Technology of Petroleum", Marcel Dekker, NY
8. B. K. Sharma, "Fuels and Petroleum Processing" , 1st ed., Goel publishing, Meerut.
9. Blokh A.G, "Heat Transmission in Steam Boiler furnaces", Hemisphere Publishing Corpn.

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

Sr. No.	CO statement	Marks % weightage
CO-1	summaries importance of solid liquid and gaseous fuels	20
CO-2	understand basic processing of fuels	25
CO-3	select appropriate equipment for combustion and fuel	25
CO-4	apply stoichiometry to evaluate combustion performance	30

List of Open Source Software/learning website:

Students can refer to video lectures available on the websites including NPTEL

Students can refer website of FurnXpert "https://www.furnxpert.com/casestudy" for case studies of furnace simulation and analysis.