GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: FERTILIZER TECHNOLOGY
(COURSE CODE: 3360501)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Indian economy is dominated by agriculture sector. Synthetic fertilizers are must for producing good crops. Hence it is needed to provide comprehensive and balanced understanding of essential link between chemistry and the synthetic fertilizer industry. It is therefore vital for chemical engineers to understand for each fertilizer product, its flow diagram for Industry production. For this purpose chemical engineers should have skills for arranging treatment, reaction and separation steps in a flow diagram for variety of fertilizers including Nitrogenous fertilizers, Phosphatic fertilizer, Potash Fertilizer, Complex fertilizer and Bio fertilizers is essential. Hence this course is designed to achieve this objective.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire the following competencies:

- **Supervise the different stages in fertiliser production.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practicals should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain:

i. Use reactions and unit operations steps in manufacturing of various fertilizers
ii. Characterize fertilizers on the basis of different properties.
iii. Identify engineering problems in fertilizer manufacturing.
iv. Handle the fertilizers.
v. Select appropriate synthesis fertilizer.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**ESE**	**PA**	**ESE**	**PA**	**150**
4	0	2	06	70	30	20	30	

Legends: L – Lecture, **T** -Tutorial/Teacher Guided Student Activity, **P –** Practical, **C –** Credit, **ESE** - End Semester Examination, **PA** -Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Overview of Fertilizers	1a. Justify the need for synthetic fertilizer 1b. Categorize fertilizers 1c. Explain role of essential elements for plant growth	1.1 Synthetic fertilizers, Classification of fertilizers 1.2 Role of essential Elements in plant Growth, 1.3 Macro elements and Micro elements
	1d. Select the relevant fertilizers for the different types of crops	1.4 Application of fertilizers considering Nutrient 1.5 Balance and types of crop
Unit – II Nitrogeneous Fertilizers	2a. Describe different properties of Ammonia 2b. Prepare synthesis path for manufacturing synthesis gas 2c. Differentiate various Ammonia converter 2d. Differentiate various Ammonia manufacturing process 2e. Describe the engineering problems of ammonia manufacturing	2.1 Ammonia: Physical, chemical properties and applications 2.2 Synthesis gas by Catalytic partial oxidation Steam Hydrocarbon reforming 2.3 Ammonia converters: Single bed and multi-bed converter 2.4 Manufacturing of ammonia by Linde Ammonia concept process 2.5 M. W. Kellogg process and Haldor Topsoe process 2.6 Storage and Transportation of Ammonia
	2f. Describe various properties of Nitric Acid 2g. Estimate concentration of Nitric acid 2h. Describe the problems in manufacturing of Nitric Acid	2.7 Nitric acid: Chemical, physical properties and applications 2.8 Manufacturing of Nitric Acid by Pressure ammonia oxidation process and Intermediate pressure ammonia oxidation process 2.9 Concentration of Nitric acid by $Mg(NO_3)2$
	2i. Describe various properties of Urea 2j. Describe the major engineering problems of Urea Manufacturing	2.10 Urea : Physical, chemical properties 2.11 Manufacturing of Urea by Stamicarbon's CO_2 stripping process, Montecatini Solution recycle process Toyo-Koatsu total recycle process
	2k. Describe the manufacturing process of Ammonium Nitrate	2.12 Manufacturing of Ammonium nitrate by Prilling process, Ammonium sulphate from Ammonium carbonate and gypsum Ammonium chloride from Ammonium sulphate and sodium chloride

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit –III Phosphatic Fertilizer	3a. Describe various physical and chemical properties Phosphorus and Phosphoric acid 3b. Describe the manufacturing process of Phosphorus by Electric furnace method 3c. Describe the manufacturing process of phosphoric acid by Wet Process 3d. Describe the manufacturing Strong Sulphuric Acid Leaching Hydrochloric Acid Leaching Electric Furnace Process	3.1 Physical, chemical properties and applications of Phosphorus and Phosphoric acid 3.2 Manufacturing of elemental phosphorous by Electric furnace method 3.3 Manufacturing phosphoric acid by Wet Process 3.4 Strong Sulphuric Acid Leaching Hydrochloric Acid Leaching Electric Furnace Process
Unit –IV Potassic Fertilizers	4a. Describe physical and chemical properties 4b. Explain manufacturing of Potassium Chloride from sylvinite 4c. Describe the of Preparation of Potassium nitrate, Potassium sulphate	4.1 Physical, chemical properties and uses of Potassium Chloride, Potassium nitrate, Potassium sulphate 4.2 Manufacturing of potassium chloride from sylvinite 4.3 Preparation of Potassium nitrate, Potassium sulphate
Unit –V Complex Fertilizer and Bio Fertilizer	5a. Explain the manufacturing of complex fertilizers with sketches 6a. Justify the need for biofertilizers and its benefits 6b. Describe the Nitrogen fixing and Phosphate solubilising biofertilizers 6c. Explain preparation a biofertilizers	5.1 Manufacturing of NPK, Ammonium Sulphate Phosphate (ASP), Calcium Ammonium Nitrate(CAN) 6.1 Types of Biofertilizers 6.2 Biofertilizers Nitrogen-fixing biofertilizers Phosphate-solubilizing biofertilizers 6.3 Preparation of a biofertilizers

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (Theory)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
1	Overview of Fertilizers	06	02	04	02	08
2	Nitrogeneous Fertilizers	22	06	09	06	21
3	Phosphatic Fertilizers	10	03	06	03	12
4	Potassic Fertilizers	06	03	05	03	11
5	Complex Fertilizers and Bio Fertilizers	12	06	06	06	18
	TOTAL	56	20	30	20	70

Legends: **R** = Remember**,** **U** = Understand**,** **A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED PRACTICAL / EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of **Course Outcomes** related to affective domain. Thus over all development of **Programme Outcomes (**as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	I	Prepare chart for fertilizer classification with chemical formula and nutrient content	02
2	I	Estimate nutrient content (% N, %P_2O, % K_2O) in different fertilizers from their chemical formula	02
3	II	Estimate percentage of Nitrogen in Ammonium chloride by substitution method	02
4	II	Estimate percentage of Nitrogen in Ammonium sulfate by substitution method	02
5	II	Estimate percentage of Nitrogen in Ammonium chloride by back titration	02
6	II	Estimate percentage of Nitrogen in Ammonium sulphate by back titration	02
7	II	Analysis of Urea by Formaldehyde method	02
8	II	Estimate percentage of Nitrogen in Ammonium Chloride/Sulphate by Kjeldhal's method	02
9	II	Estimate biuret content in Urea sample by colour comparison	02
10	III	Estimate percentage of Nitrogen in DAP by Formaldehyde method	02
11	III	Estimate percentage of Nitrogen in DAP by Kjeldhal's method	02
12	IV	Prepare potassium sulphate	02
13	IV	Prepare potasium chloride	02
14	V	Estimate ratio from Ammonia to Phosphoric acid in DAP	02
15	V	Prepare potassium nitrate	02

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hours Required
16	VI	Prepare bio-fertilizer	02
	Total		**32**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual or group-based.

i. Prepare course/topic based presentations using internet
ii. Make a report on fertiliser plants in India/Gujarat with their capacity of production and technology being used.
iii. Participate in MCQ/Quiz.

9. SPECIAL INSTRUCTIONAL STRATEGY (IF ANY)

i. Show video/animation films about fertilizer production plants.
ii. Arrange Visit to nearby fertilizer production plant
iii. Arrange expert lectures
iv. Arrange MCQ/Quiz arrange in normal term period.

10. SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Book	Author	Publication
1	Dryden's Outlines of Chemical Technology,	M. Gopala Rao Sitting Marshall	Affiliated East West Press (Pvt) Ltd, 3rd Ed., New Delhi
2	Shreve's Chemical Process Industries, 5th edition	Austin G.T.	McGraw Hill publication, New Delhi
3	Chemical Technology -Vol. I and II, 2nd edition	Pandey G.N. and Shukla	Vani Books Company - Hyderabad
4	Biofertilizers in Agriculture, 2nd edition	N. S. Subba Rao	Oxford & IBH Publishing Company, New Delhi 1988

B) Major Equipment / Instrument with Broad Specifications

i. Glassware: Conical flask, burette, pipette, RBF, measuring cylinder, beaker
ii. Glass Assembly: RBF, reaction vessel, condenser, separating vessel
iii. Burner
iv. Weight balance (minimum 0.1gm)
v. Heating and cooling bath
vi. Kjeldhal Assembly

C) Software/Learning Websites

i. http://nptel.ac.in/courses/103107086/4
ii. http://ijset.com/ijset/publication/v1s6/285-291%20IJSET_PK%20JAGA.pdf
iii. www.gses.com/images/pressreleases/Manufacturing-Process-Fertilizer.pdf
iv. http://nzic.org.nz/ChemProcesses/production/1A.pdf
v. http://tnau.ac.in/eagri/eagri50/SSAC222/lec12.pdf
vi. www.fnca.mext.go.jp/bf/bfm/pdf/Biofertilizer_Manual.pdf

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. N. N. Hansalia**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. R. P. Hadiya,** Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof.Rakesh R Vasava,** Lecturer in Chemical Engineering, Shri K. J. Polytechnic, Bharuch
- **Prof. M. R. Aacharya**, Lecturer in Chemical Engineering, Government Polytechnic, Gandhinagar

Coordinator andFaculty Members from NITTTR Bhopal

- **Dr. Abhilash Thakur**. Associate Professor, Department of Applied Sciences
- **Dr. Joshua Earnest**, Professor, Department of Electrical & Electronics Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: CHEMICAL ENGINEERING PLANT ECONOMICS
(COURSE CODE: 3360502)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

A plant-design project moves to completion through a series of stages starting from preliminary evaluation of economics and market to commercial production. Chemical engineering design of a new chemical plant and the expansion or revision of existing one require the use of engineering principles and theories combined with consideration of practical limits imposed by industrial conditions. In this course special emphasis is given on the applied economics and engineering principles involved in the design of chemical plants. Use of these principles is highly required for any successful chemical engineer to work in the area of production, administration, sales, marketing, research, and development of a new chemical project.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Design chemical engineering plants considering principles of economics.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Explain basic concepts of process and plant design
ii. Select appropriate piping and equipment
iii. Select appropriate plant location
iv. Prepare general layout (outline diagram) of proposed plant
v. Evaluate economics of a chemical project
vi. Optimise conditions with one and two variables

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**ESE**	**PA**	**ESE**	**PA**	**100**
4	4	0	8	70	30	00	00	

Legends: L - Lecture; **T -** Tutorial/Teacher Guided Student Activity; **P -** Practical; **C -** Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Basics of Process and Plant Design	1a. Describe role of Chemical Engineer 1b. Justify the need of plant design 1c. Explain components of chemical Engineering Design 1d. Describe criteria for good designs 1e. Explain Process design and its components 1f. Describe plant design factors	1.1 Plant designs: Chemical Engineering Designs,Process Design, Equipment Design, Building Design 1.2 Criteria for good design: Process design Technical factors, Economic factors Legal phases, Selection of a process 1.3 Continuous v/s Batch processing Shift and Operating schedules Types of flow diagrams
	1g. Describe process evolution stages	1.4 Process evolution stages and their importance, Logical evolution stages 1.5 Checklist for pilot plant investigation.
Unit – II Selection of Process Equipment and Piping	2a. Plan for selection of equipment 2b. Differentiate Standard and special equipment 2c. Prepare specification sheet for equipments 2d. Select appropriate equipments	2.1 Selection of process equipment 2.2 Standard v/s Special equipment 2.3 Specification sheet for equipment 2.4 Selection of equipments: Size reduction equipment, Heat transfer equipment, 2.5 Mass transfer equipment, Material handling equipment, Pumps
	2e. Explain piping, layout and insulation 2f. Classify different insulation.	2.6 Piping, Pipe strength and wall thickness 2.7 Piping design problems, Piping layout rules, Ferrous and non-ferrous pipe, Non-metallic Piping and tubing, 2.8 Types of insulation, Factors governing selection of insulation.
Unit – III Plant Layout and Location	3a. Describe principles of plant layout 3b. Compare methods of plant layout 3c. Explain factors affecting plant location	3.1 Principles of plant layout 3.2 Methods of plant layout: Unit area Concept, Two-dimensional layout 3.3 Scale models 3.4 Factors for selection of plant location: Primary factors and specific factors
Unit – IV Economic Evaluation of Projects	4a. Evaluate total capital investment 4b. Estimate equipment cost solve the numerical based on cost indices 4c. Explain depreciation 4d. Calculate depreciation using different methods 4e. Identify components of total product cost	4.1 Total Capital Investment, 4.2 Fixed capital investment, Working capital investment 4.3 Equipment cost estimation, Cost-Size 4.4 relation, Cost-Time relation, 4.5 Numerical based on Cost Indices 4.6 Depreciation and it's types 4.7 Methods for determining depreciations 4.8 Arbitrary methods, Methods with interest on investment, Numerical for depreciation 4.9 Total product cost (TPC)
	4f. Estimate profitability	4.10 Profitability analysis: Net and gross earnings, Methods of profitability, Percent return on investment, Pay-out time period,Present worth, Turn-over ratio

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
	4g. Calculate break-even capacity	4.11 Break-even analysis (Analytical method), 4.12 Break-even chart (Graphical method), 4.13 Numerical of Break-even analysis
Unit – V Optimum Design	5a. Explain procedure to find out optimum condition 5b. Estimate the optimum insulation thickness and pipe diameter 5c. Solve numerical to find optimum design	5.1 General procedure for determining optimum condition: Procedure with one variable (Analytical and graphical), Procedure with two variables (Analytical and graphical) 5.2 Optimum economic design for Insulation Thickness and Pipe diameter 5.3 Numerical for optimum design

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Process and Plant Design	12	5	5	5	15
II	Selection of Process Equipment and Piping	12	5	5	5	15
III	Plant Layout and Location	07	2	5	2	09
IV	Economic Evaluation of a Project	17	7	7	7	21
V	Optimum Design	08	2	3	5	10
Total		**56**	**21**	**25**	**24**	**70**

Legends: **R** = Remember**, U** = Understand**, A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED TUTORIALS

In tutorials numerical or conceptual problems may be given to individual or group of students. Students should be first allowed to struggle on their own to find the solution, and should try their creativity. However, faculty should remain around the students and help them if they are not able to proceed.

It is better if real life problems are case studies are given where different groups of students may come out with different solutions, which can be discussed in a larger group of student to generate more discussions. Following is the suggestive list of exercises; concerned faculty may change/add exercises to this list.

S. No.	Unit No.	Tutorial Exercises	Approx. Hours Required
1	I	Prepare block type and equipment flow diagram for production of desired (quantity and quality) chemical	4
2	I	Prepare block type material balance flow diagram for production of desired (quantity and quality) chemical	8
3	I	Prepare block type energy balance flow diagram for production of desired (quantity and quality) chemical	4

S. No.	Unit No.	Tutorial Exercises	Approx. Hours Required
4	II	Prepare detailed process and instrumentation flow diagram for production of desired (quantity and quality) chemical	4
5	II	Prepare specification sheet for 1-2 shell and tube heat exchanger	4
6	II	Prepare specification sheet for packed type distillation column	4
7	III	Solve given simple problems using cost–size relationship and cost- time relationship (Cost indices)	4
8	III	Calculate depreciation using Straight line method for given plant	2
9	III	Calculate depreciation using Declining balance method for given plant	2
10	III	Calculate depreciation using Sum of the years digits method for given plant	2
11	III	Calculate depreciation using Sinking fund method for given plant	2
12	III	Find-out break-even point Using Analytical and Graphical methods for given plant	8
13	IV	Solve given simple problems to determine optimum value using one variable and two variable methods. (Graphical and Analytical methods)	8
Total Hours			**56**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed chemical production companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Study (in group of four-five) the design of some real chemical plant and identify good features of design and also weaknesses in it, present in class to have a group discussion.

9. SPECIAL INSTRUCTIONAL STRATEGY (IF ANY)

i. Use online course material from reputed universities
ii. Show videos related to good economical designs of plants for production of different chemical products.
iii. Show excel spreadsheets from internet about economic evaluation of chemical plants
iv. Show charts and models of different plants and handouts about their design features and specification of equipment
v. Arrange expert lectures
vi. Discuss real life case studies of good and bad design of chemical plants.

10 SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Books	Author	Publication
1	Plant Design and Economics for Chemical Engineers,	Peters, Max and Klaus Timmerhaus	McGraw Hill, New Delhi, 4th edition
2	Chemical Engineering Plant Design.	Vilbrandt, Frank Carl and Dryden,Charles E.	McGraw Hill, New Delhi, 4th edition
3	Chemical Engineering Design	Towler, Gavin and Sinnott, R. K.	Butterworth-Heinemann (2008)
4	Process Engineering Economics	Couper, James R.	Marcel and Dekker

B) Major Equipment/Materials with Broad Specifications

i. Charts and Models
ii. Specification sheets of equipment from fabricator
iii. Commercial project report

C) Software/Learning Websites

i. www.cheresources.com
ii. http://people.clarkson.edu/~wwilcox/Design/refcosts.htm
iii. http://app.knovel.com/web/toc.v/cid:kpCEDPPEP4
iv. https://www.lib.utexas.edu/chem/info/chemengecon.html
v. http://www.mhhe.com/engcs/chemical/peters/data/ce.html

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Kartik R. Desai**, Head, Chemical Engg. Dept., N. G. Patel Polytechnic, Isroli-Afwa
- **Prof. D. H. Joshi**, Lecturer, Chemical Engg. Dept., G. P. Valsad
- **Prof. P. D. Chaudhari**, Lecturer, Chemical Engg. Dept., G. P. Valsad
- **Prof. J. R. Vadher**, Lecturer, Chemical Engg. Dept., Shri BPTI, Bhavnagar

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GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: CHEMICAL REACTION ENGINEERING
(COURSE CODE: 3360503)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Chemical reactor design uses information, knowledge, and experience from a variety of areas like thermodynamics, chemical kinetics, fluid mechanics, heat transfer, mass transfer, and economics. Chemical reaction engineering is the synthesis of all these factors with the aim of properly designing a chemical reactor. The basic concepts of chemical reaction engineering are applied to the design and operation of various commercial reactors performing non catalytic and catalytic reactions. This course enables the diploma engineer to some extent in accomplish the task of selecting, sizing and determining the optimal operating conditions for the reactor.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate and maintain various chemical reactors to produce products of desired quality with minimum cost.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following outcomes:

i. Explain basic concepts to distinguish chemical reactions.
ii. Calculate rate, rate constant, activation energy and order of reaction.
iii. Interpret kinetic data to find order of reactions.
iv. Operate different reactors efficiently using basic knowledge about their functioning
v. Calculate volume, space time and space velocity for Ideal reactors.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	100
3	2	0	5	70	30	00	00	

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Basics of Chemical Reactions	1a. Differentiate between various types of reactions such as chemical reactions Catalytic vs. Non-catalytic and the like 1b. Describe the factors affecting rate of reaction	1.1 Scope and importance of chemical reaction engineering 1.2 Classification of chemical reactions, a. Homogeneous vs. Heterogeneous, b. Catalytic vs. Non-catalytic c. Reversible vs. Irreversible d. By Molecularity e. Exothermic vs. Endothermic f. By order of reaction 1.3 Reaction rate on various basis and variables affecting the rate of reaction.
Unit – II Kinetics of Homogeneous Reactions	2a. Derive the rate law 2b. Calculate rate constant 2c. Estimate Molecularity and order of reaction	2.1 Rate equation/ Rate law 2.2 Concentration dependent term of rate Equation, Rate constant, Elementary and non-elementary reactions 2.3 Molecularity and order of reaction
	2d. Explain temperature dependency from Arrhenius law	2.4 Temperature dependent term of rate Equation, Temperature dependency from Arrhenius law
	2e. Describe the significance of activation energy 2f. Calculate activation energy	2.5 Activation energy
Unit – III Interpretation of batch reactor data	3a. Describe the methods for analysis of kinetic data 3b. Explain the relationships for constant volume batch reaction system	3.1 Methods for analysis of kinetic data Differential vs. Integral method Half life method
		3.2 Relationship for constant volume batch reaction system 3.3 Total pressure of the system and the partial pressure of reacting material Concentration and Conversion
	3c. Derive integrated rate equations	3.4 Integrated rate equation for different order of irreversible reactions: Uni-molecular first order, Bi-molecular, Second order, Tri-molecular third order, nth order, Zero order
Unit – IV Ideal reactors	4a. Describe an ideal reactors 4b. Describe the construction, benefits, limitations and applications of different types of reactors such as batch reactors and others.	4.1 Features of ideal reactors 4.2 Different types of reactors: Batch reactor, Semi batch reactor, Flow reactors, MFR/CSTR, PFR (Tubular), Fixed bed reactors, Fluidised bed reactors

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
	4c. Describe the construction, benefits, limitations and applications of different types of multiphase reactors such as slurry reactor and others	4.3 Multi phase reactors: G-L-S reactor, Slurry reactor, Bubble column reactor, Spray reactor, Trickle bed reactor
Unit – V Design of single Ideal reactor	5a. Explain the performance equation of different types of reactors such as Ideal batch reactor and others	5.1 Performance equation of : Single Ideal reactor for Single reaction Constant density system, Ideal batch reactor, Steady state mixed flow reactor, Steady state plug flow reactor
	5b. Explain space time and space velocity 5c. Differentiate holding time and Space time 5d. Calculate time/volume of reactor.	5.2 Flow reactors: Space time, Space velocity, Holding time Vs. Space time

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Chemical Reactions	6	3	4	3	10
II	Kinetics of Homogeneous reactions	8	4	6	4	14
III	Interpretation of batch reactor data	8	4	6	4	14
IV	Ideal reactors	10	6	6	4	16
V	Design of single Ideal rector	10	4	5	7	16
Total		**42**	**21**	**27**	**22**	**70**

Legends: R = Remember**, U** = Understand**, A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED TUTORIALS

In tutorials numerical or conceptual problems may be given to individual or group of students. Students should be first allowed to struggle on their own to find the solution, and should try their creativity. However, faculty should remain around the students and help them if they are not able to proceed.

It is better if real life problems are case studies are given where different groups of students may come with different solutions, which can be discussed in a larger group of student to

generate more discussions. Following is the suggestive list of exercises; concerned faculty may change/add exercises to this list.

S. No.	Unit No.	Tutorial Exercises	Approx. Hours Required
1	I	Classify chemical reactions and express rate on various basis	2
2	I	Solve the given problems based on rate equation	2
3	II	Solve given problems based on molecularity and order of reaction	2
4	II	Discuss temperature dependency of rate from Arrhenius' Law and solve given problems based on Arrhenius law	4
5	III	Explain various methods of kinetic data analysis	2
6	III	Derive integrated rate equation for different order of reaction	4
7	IV	Explain different Ideal reactors with sketch	2
8	IV	Explain different multiphase reactors with sketch	2
9	V	Derive performance equation of Ideal batch, mixed flow and plug flow reactor	2
10	V	Solve given problems based on performance equation of Ideal batch reactor	2
11	V	Solve given problems based on performance equation of Ideal mixed flow reactor	2
12	V	Solve given problems based on performance equation of Ideal Plug flow reactor	2
		Total	**28**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed chemical production companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Refer books by different authors and solve as many numerical problems (related to above content) as possible. This will improve your understanding of effect of different parameters on functioning of reactors.

9. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

i. Use online course material from reputed universities
ii. Arrange expert lectures
iii. Give as many types of numerical problems to students as many possible and explain one example of each type of problem in detail.

10 SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Books	Author	Publication
1	Chemical Reaction Engineering	Octave Levenspiel	Third Edition, John Wiley and Sons
2	Essentials of Chemical Reaction Engineering	H. Scott Fogler	Fourth Edition, Prentice Hall International
3	The Engineering of Chemical Reactions	Lanny D. Schmidt	Second Edition, Oxford University Press

B) Major Equipment/Materials with Broad Specifications

--Nil--

C) Software/Learning Websites

i. http://nptel.ac.in/courses/103108097/
ii. http://www.umich.edu/~elements/toc/frames.htm
iii. http://ocw.mit.edu/courses/chemical-engineering/10-37-chemical-and-biological-reaction-engineering-spring-2007/lecture-notes/

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Kartik R. Desai**, Head, Chemical Engg. Dept., N. G. Patel Polytechnic, Isroli-Afwa
- **Prof. Mukesh B. Dhangar**, Lecturer, Chemical Engg. Dept., N. G. Patel Polytechnic, Isroli-Afwa
- **Prof. Shilpaben Patel**, Lecturer, Chemical Engg. Dept., Govt. Polytechnic, Gandhinagar

Coordinators andFaculty Members from NITTTR Bhopal

- **Dr. Bashirulla Shaik**, Assistant Professor, Department of Applied Sciences
- **Dr. Joshua Earnest**, Professor of Electrical & Electronics Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PROJECT
(COURSE CODE: 3360508)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	SIXTH

1. RATIONALE

Development of a plant for any chemical product is a big job. It requires preparing a comprehensive report of chemical process and unit operations specific to that product. It is necessary to study the properties of raw materials and product, economic factors, safety features and pollution issues. Calculation of material and energy consumption is very important for designing the plant. Specifications for major equipments, plant layout and location are to be dealt with great care. In view of all these a chemical engineering student must be able to prepare a project report for a particular chemical product including all above aspects to become an entrepreneur. A chemical product can be selected from various chemical sectors like Petrochemicals, Fertilizers, Pharmaceuticals, Pesticides, Natural products, Polymers, Acid and Alkalis, Speciality chemicals, Dyes and pigments etc.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competency:

- To prepare a project report for a particular chemical product including important feature

3. COURSE OUTCOMES

1. Select a chemical product based on market survey
2. Carry out literature survey for selected product
3. Calculate material balance for major equipments
4. Select a suitable site and prepare plant layout
5. Estimate economic evaluation
6. Prepare MSDS and select waste treatment methods

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	200
0	0	8	8	00	00	80	120	

Legends: L - Lecture; **T -** Tutorial/Teacher Guided Student Activity; **P -** Practical; **C -** Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE DETAILS

Unit	Major Learning Outcomes	Topics and Sub-topics
Project Report *of* a selected chemical product	1. Select a chemical product based on market survey	1. Selection of chemical product from various chemical sectors like Petrochemicals, Fertilizers, Pharmaceuticals, Pesticides, Natural products, Polymers, Acid and Alkalis, Speciality chemicals, Dyes and pigments etc.
	2. Describe introduction, history, present status and list of industries manufacturing the product	2. Introduction, history, present status and list of industries manufacturing the product
	3. Discuss Chemical, physical Properties and applications	3. Chemical and physical Properties of raw materials, product and applications of product
	4.1 Explain manufacturing processes with detailed flow diagram 4.2 Select most suitable process	4. Various manufacturing processes with flow diagram and selection of most suitable process
	5. List out and describe major equipments and Instruments	5. Major equipments and Instruments required for selected process
	6. Prepare material balance calculations	6. Material balance of selected process
	7. Describe various utilities	7. Utilities for selected process
	8.1 Explain Site selection parameters 8.2 Select suitable Plant location 8.3 Prepare plant layout	8. Site selection parameters, Plant location and layout
	9. Prepare Economic evaluation of plant	9. Economic evaluation of plant
	10.1 Prepare MSDS of raw materials and product 10.2 Discuss appropriate waste treatment method	10. Important aspects of Safety and Pollution control 10.1 MSDS of raw materials and product 10.2 Gaseous/Liquid/Solid waste treatments

Unit	Major Learning Outcomes	Topics and Sub-topics
Project Report *of* a selected chemical product	1. Select a chemical product based on market survey	1. Selection of chemical product from various chemical sectors like Petrochemicals, Fertilizers, Pharmaceuticals, Pesticides, Natural products, Polymers, Acid and Alkalis, Speciality chemicals, Dyes and pigments etc.
	11. Conclude and prepare list of references	11. Conclusion and references

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
Course contains Practical part only						

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised 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.

7. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of cognitive and practical skills **(Outcomes in cognitive, psychomotor and affective domain)** so that students are able to acquire the competencies. Following is the list of practical exercises for guidance.

***Note**: Here only outcomes in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of **Programme Outcomes/Course Outcomes in affective domain** as given in a common list at the beginning of curriculum document for this programme. Faculty should refer to that common list and should ensure that students also acquire those Programme Outcomes/Course Outcomes related to affective domain*

S. No.	Chapter No.	Practical/Exercise	Apprx. Hrs. Required
1	I	Selection of chemical product from various chemical sectors like Petrochemicals, Fertilizers, Pharmaceuticals, Pesticides, Natural products, Polymers, Acid and Alkalis, Speciality chemicals, Dyes and pigments	4
2	II	Introduction, history, present status and list of industries of product	8
3	III	Chemical and physical Properties of raw materials, product and applications of product	8
4	IV	Various manufacturing processes with flow diagram and	12

S. No.	Chapter No.	Practical/Exercise	Apprx. Hrs. Required
		selection of most suitable process	
5	V	Major equipments and Instruments required for selected process	8
6	VI	Material balance of selected process	20
7	VII	Utilities for selected process	6
8	VIII	Site selection parameters, Plant location and layout	12
9	IX	Economic evaluation	18
10	X	Important aspects of Safety and Pollution control (a) MSDS of raw materials and product (b) Gaseous/Liquid/Solid waste treatments	12
11	XI	Conclusion and references	4
		TOTAL	112

8. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

1. Course/topic based presentation

9. SPECIAL INSTRUCTIONAL STRATEGY (IF ANY)

1. Industrial visit

10 SUGGESTED LEARNING RESOURCES

A. List of Books:

Sr. No.	Title of Books	Author	Publication
1	Encyclopedia of Chemical Processing and Design	Jhon J. McKetta, William A. Cunninghalm	Marcel Dekker Inc., New York and Basel
2	Encyclopedia of Chemical Technology	Kirk and Othmer	John Wiley and Sons, Wiley Interscience
3	Ullman's Encyclopedia of Industrial Chemistry	Ullman	VCH Publishers, Germany
4	Chemical Process Technology Encyclopedia	Coincidine	McGraw-Hill
5	Perry's Chemical Engineers' Handbook	Robbert H. Perry, Down W. Green	McGraw-Hill
6	Plant Design and Economics for Chemical Engineers	Max Peters, Klaus Timmerhaus	McGraw Hill
7	Chemical Engineering Plant Design	Frank C. Vilbrandt, Charles E. Dryden	McGraw Hill
8	Chemical Engineering Design: Principles, Practice and Economics of Plant and Process Design	Gavin Towler, R. K. Sinnott	Butterworth-Heinemann
9	Process Engineering	James R. Couper	Marcel & Dekker

	Economics		
10	Stoichiometry	B. I. Bhatt, S.M. Vora	Tata McGraw Hill
11	Safety and Accident Prevention in Chemical Operation	Faweett, Wood	Interscience Publishers
12	A course in Industrial Safety	K.U. Mistry	N.K.M. Publication
13	Pollution Control in Process Industries	S.P. Mahajan	Tata-McGrawHill
14	Safe Handling of Hazardous Chemicals	A.K. Rohatgi	J.K. Enterprise

B. List of Software/Learning Websites

1. http://www.sbioinformatics.com/design_thesis/design-2520thesis.htm
2. http://npcs.in/projects/
3. http://www.niir.org/books/book/detailed-project-profiles-on-9-selected-chemical-industries
4. http://avogadro.chem.iastate.edu/MSDS/

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. N. N. Hansalia, Lecturer in Chemical engineering, Government Polytechnic, Rajkot**
- **Prof. R. R. Vasava, Lecturer in Chemical engineering, Shri K. J. Polytechnic, Bharuch**
- **Prof. J. R. Vadher, Lecturer in Chemical engineering, Sir B P T I, Bhavnagar**
- **Prof. Ku. P. H. Shukla, Lecturer in Chemical engineering,, Sir B P T I, Bhavnagar**

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Abhilash Thakur. Associate Professor, Department of Applied Sciences NITTTR Bhopal**
- **Dr. Bashirullah Shaikh, Assistant Professor, Department of Applied Sciences NITTTR Bhopal**

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PULP & PAPER TECHNOLOGY
(COURSE CODE: 3360504)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Out of total paper produced in the country, 35% paper is produced in Gujarat. Diploma engineers are responsible for ensuring paper quality, improving the efficiency of production and reducing the environmental impact of the industrial paper making process. Engineers apply their skill while working in laboratory, production, research, sales and marketing. Engineers use chemicals such as sodium hydroxide and sodium sulphide to chemically remove lignin from wood. They ensure that paper is produced uniformly in the same colour. This course is to enable the diploma engineer to some extent in accomplish the task of selecting chemicals, laboratory operations for the Pulp and Paper Technology.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Produce paper of required quality by controlling the process appropriately.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Apply basic concepts of pulp and paper technology to produce paper.
ii. Apply reactions and unit operations steps to manufacture pulp.
iii. Use reactions and unit operations steps appropriately in manufacturing of paper.
iv. Use reactions and unit operations appropriately in manufacturing cellulose and various lignin chemicals.
v. Apply waste disposal techniques.
vi. Perform various chemical tests to monitor quality of raw material, output quality and influent/effluent

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Basics of Pulp and Paper Technology	1a. Describe the consumption pattern of different types of paper	1.1 Pulp and paper industry 1.2 Consumption pattern of paper
	1b. Describe cellulose raw material 1c. Identify problems and scope in India	1.3 Cellulose raw material 1.4 Problems and scope of pulp and paper industries in India
Unit – II Pulp	2a. Explain various raw materials	2.1 Raw materials
	2b. Differentiate the various pulping processes	2.2 Pulping process: Sulphite pulping, Semi-chemical pulping, Mechanical and Thermo-mechanical pulping, Secondary fibber pulping, R.A.G. pulping, Dissolving pulp
	2c. Describe the Kraft pulping process with flow diagram	2.3 Kraft pulping process
	2d. Compare various types of pulps 2e. Explain chemical recovery process	2.4 Comparison of different types of pulps 2.5 Black liquor recovery process
Unit –III Paper	3a. Differentiate the features f various raw materials used in paper manufacture 3b. Describe the Wet process for paper Manufacture with flow diagram	3.1 Types of paper products, Various raw materials: Fibrous and Non-Fibrous 3.2 Wet process for paper Manufacture
	3c. Describe Fourdrinier machine 3d. Describe the economics in paper industry	3.3 Fourdrinier machine 3.4 Economics of paper industry
Unit – IV Cellulose and Lignin Chemicals	4a. Describe the properties of cellulose 4b. Prepare chemical cellulose	4.1 Properties of cellulose 4.2 Preparation of chemical cellulose
	4c. Describe the characteristics of Lignin chemicals 4d. Select cellulose and lignin chemicals	4.3 Lignin chemicals: Types, properties of Di-methyl sulphides and Di- methyl sulfoxide 4.4 Applications of cellulose and Lignin chemicals
Unit – V Waste Disposal Techniques	5a. Analyse pollution potentials of Indian pulp and paper industry	5.1 Pollution potentials of Indian pulp and paper industry
	5b. Interpret the characteristics of industrial Lignin water	5.2 Characteristics of Industrial Lignin water
	5c. Apply bio-technical approach for pollution 5d. Apply Lignin waste treatment.	5.3 Bio-technical approach for pollution 5.4 Enzymology for Lignin waste treatment

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Pulp and Paper Technology	4	3	4	0	7
II	Pulp	12	4	12	4	20
III	Paper	10	4	10	3	17
IV	Cellulose and Lignin Chemicals	8	3	6	4	13
V	Waste Disposal Techniques	8	3	6	4	13
Total		**42**	**17**	**38**	**15**	**70**

Legends: **R** = Remember**, U** = Understand**, A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED PRACTICAL / EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise	Approx. Hours Required
1	II	Undertake qualitative analysis of sodium sulphite	2
2	II	Estimate the amount of lignin by kappa number test	4
3	II	Calculate the moisture content present in wood	2
4	II	Perform pre-hydrolysis of the raw material for pulp	4
5	III	Measure gauge (thickness) of various types of papers	2
6	V	Determine the pH for influent/effluent using different techniques	2
7	V	Determine the COD and DO for influent/effluent	2
8	V	Determine the BOD for influent/effluent	4
9	V	Optimize pH for maximum COD removal for black liquor	4
10	V	Estimate the coagulant dose at optimum pH for maximum COD removal	4

11	V	Determine the total solids and dissolved solids present in influent	2
12	I to V	Prepare the report for pulp and paper production by visiting industry	6
13	I to V	Prepare the model/chart showing different operations and processes involve in pulp and paper industry	2
		Total	**40**
Note: Perform any of the practical exercises from above list for total of minimum 28 hours depending upon the availability of resources so that skills matching with the most of the outcomes of every unit are included.			

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed pulp/paper production companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Study (in group of four-five) the design of some real pulp/paper production plant and identify good features of design and also weaknesses in it, present in class to have a group discussion.
iii. Collect samples of different types of paper from market and identify their specifications, further explore their production processes.

9. SPECIAL INSTRCTIONAL STRATEGY (If Any)

i. Show animations/ videos and drawings/models of pulp and paper production processes
ii. Arrange visit to nearby paper/pulp production industry
iii. Arrange expert lectures.

10 SUGGESTED LEARNING RESOURCES

A) Books

Sr. No.	Title of Books	Author	Publication
1	Dryden's outlines of Chemical Technology	Rao, M.Gopal, Sitting, Marshall	Affilated East-West Press Pvt. Ltd. 3rd Edition
2	Shreves' Chemical Process Industries	Austin, George T.	McGraw-Hill Education India Pvt. Ltd - New Delhi, 5th Edition
3	Environmental Pollution and Control in Chemical Process Industries	Bhatia, S.C.	Second Edition 2011(ISBN**:** 8174091068)
4	Pollution Management in Industries	Trivedi, R.K.	Environmental Publication, Karad, India
5	Handbook of Pulping and Papermaking	Biermann, Christopher J.	ISBN-13: 978-0120973620

B) Major Equipment/Materials with Broad Specification

i. Simple micrometer,
ii. Digital micrometer
iii. Dilute HCl,
iv. Concentrated H_2SO_4, H_2S, Charcoal
v. Laboratory pulping unit/ digester, Digester Volume: 20 Liters, Max Pressure: 20Kg/cm^2, Max Temperature: 200^OC, Pump capacity 20 liters/min
vi. Centrifuge

C) Software/Learning Websites

i. http://www.youtube.com/watch?v=E4C3X26dxbM
ii. https://www.google.co.in/?gfe_rd=crandei=uwn7U4KME6XO8gfW5YGQCQandgws_rd=ssl#q=paper+making+process+pdfandsafe=off
iii. www.unitoperation.com

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Harsh Shukla**, Lecturer in Diploma Chemical engineering, Shri K. J. Polytechnic, Bharuch
- **Prof. (Miss.) Upasana Singh**, Lecturer in Diploma Chemical engineering, Shri K. J. Polytechnic, Bharuch
- **Prof. (Ms.) Parul K. Patel**, Lecturer in Diploma Chemical engineering, G.P. Gandhinagar
- **Prof. (Ms.) Yaminiben Patel**, Lecturer in Diploma Chemical engineering, G.P. Gandhinagar

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- **Dr. Abhilash Thakur**. Associate Professor, Department of Applied Sciences
- **Dr. Joshua Earnest**, Professor of Electrical & Electronics Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: SUGAR & FOOD TECHNOLOGY
(COURSE CODE: 3360505)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Food processing in India is growing as a large production industry covering a very wide range of ready/semi ready to eat foods. The modern food processing and preservation industry was born in 1800s. This course covers the fundamentals of manufacturing sugar and some key food items like dairy products, bakery products and beverages. This technology course enables the student to apply principles of engineering and science to operate food processing facilities for producing foods in large quantities and with narrow tolerances on parameters of standards to deliver the consumers high quality, safe and healthy foods. Diploma engineers may utilize their skills to interpret each steps of manufacturing process flow diagrams and to supervise operation of various equipment/processes involved.

2. COMPETENCY

The course content should be taught and implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Maintain the sugar and food technology processing hygienically**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Characterise sugar and food
ii. Operate raw and refined sugar manufacturing plant
iii. Identify various equipment for sugar production
iv. Produce dairy products
v. Produce bakery products
vi. Produce beverages

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	150
3	0	2	5	70	30	20	30	

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
Unit – I Sugar and Food Industries	1a. Describe the Physical and chemical properties of Sucrose/sugar 1b. Describe the properties and uses of the byproducts of sugar	1.1 Physical and chemical properties of Sucrose/sugar 1.2 Byproducts - molasses, bagasse and filter mud
	1c. Differentiate the different types of food industry 1d. Describe the different types of processing techniques 1e. Describe the storage of different types of food products	1.3 Types of Food Industry 1.4 Food processing techniques 1.5 Food processing equipment 1.6 Food storage
Unit – II Sugar Production Processes	2a. Describe the various stages of the sugar manufacturing process of raw sugar from sugar cane. 2b. Explain refining of sugar 2c. Explain manufacturing of sugar from beet	2.1 Raw sugar from sugarcane 2.2 Milling Operation, Clarification/ Purification, Carbonation process, Suphitation process, Filtration, Concentration/ Saturation, Crystallization, Centrifuging, Drying and Bagging 2.3 Refining of sugar 2.4 Beet sugar manufacturing
Unit – III Equipment For Sugar Production	3a. Distinguish the major equipment involved in sugar production	3.1 Major Equipment for Sugar Production: Crushers, Pressure mills, Shredders, Filter Press, Evaporators, Crystallizers, Centrifuge, Vacuum pump
Unit–IV Dairy Products	4a. Describe the composition of milk 4b. Explain the process of pasteurization 4c. Describe the process of producing milk powder	4.1 Milk and its composition 4.2 Methods of preparation of pasteurized milk 4.3 Preparation of milk powder
	4d. Differentiate cream and butter 4e. Describe the preparation and composition of cheese	4.4 Cream and butter 4.5 composition and preparation of cheese
Unit – V Bakery products and Beverages	5a. Describe the raw materials required for baking products 5b. Describe the function of the different equipment used in the baking industry,	5.1 Baking Industry, raw materials used in baking industries 5.2 Equipment used in baking industries
	5c. Describe manufacturing process of bread	5.3 Manufacturing of bread

Unit	Major Learning Outcomes (in cognitive domain)	Topics and Sub-topics
	5d. Describe preparation of non-alcoholic carbonated beverages 5e. Describe preparation of Wine 5f. Describe preparation of Beer	5.4 Non–alcoholic Beverages, carbonated beverages 5.5 Beverage syrup manufacturing 5.6 Bottling of Carbonated Beverages 5.7 Manufacturing of wine and beer

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (Theory)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Sugar and Food Industries	07	4	4	3	11
II	Sugar Production Processes	12	7	7	7	21
III	Equipment for Sugar Production	07	4	4	4	12
IV	Dairy Products	06	3	4	3	10
V	Bakery products and Beverages	10	4	6	6	16
Total		**42**	**22**	**25**	**23**	**70**

Legends: R = Remember**, U** = Understand**, A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED PRACTICAL / EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes*** *(as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise	Approx. Hours Required
1	I	Determine moisture content in sugar	02
2	I	Determine ash content in sugar	02
3	I	Measure the pH of sugar solution	02
4	I	Determine POL by polarimeter	02

S. No.	Unit No.	Practical/Exercise	Approx. Hours Required
5	II	Determine solid content in juice by brix hydrometer	02
6	II	Analyse baggase	02
7	II	Prepare chart showing unit operations and major equipments used in sugar industries	02
8	II	Prepare the chart showing unit operations and major equipments used in various food industries	02
9	III	Determine specific gravity and fat content of milk sample	02
10	III	Prepare cheese from milk	04
11	III	Prepare butter milk and butter	02
12	IV	Prepare of loaf bread	04
			28

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed sugar/food production companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Study (in group of four-five) the design of some real sugar/food production plant and identify good features of design and also weaknesses in it, present in class to have a group discussion.
iii. Survey market for different types of processed food items available and identify their ingredients/nutrients, further explore their production processes.

9. SPECIAL INSTRCTIONAL STRATEGY (If Any)

i. Show animations/ videos and drawings/models of pulp and paper production processes
ii. Arrange visit to nearby sugar factory, dairy, bakery and a canning factory
iii. Arrange expert lectures.

10 SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Books	Author	Publication
1	Dryden's outlines of Chemical Technology	Rao, M.Gopal, Sitting, Marshall	Affilated East-West Press Pvt. Ltd. - New Delhi, 3rd Edition
2	A Textbook of Chemical technology Vol-1 and Vol-2	Pandey G.N. and Shukla	Vani Books Company Hyderabad 2nd edition
3	Shreves' Chemical Process Industries	Austin, George T.	McGraw-Hill Education India Pvt. Ltd - New Delhi, 5th
4	Handbook of Cane sugar technology	Mathur, R.B.L.	Oxford and IBH publishing , - New Delhi, 2nd edition
5	Hand book of cane sugar engineering	Hugot, E.	Elsevier science, 3rd edition,

C) Major Equipment/Materials with Broad Specifications

i. Double Wedge Polari Meter
ii. Brix Hydrometer
iii. Oven with digital weight Balance
iv. Muffle Furnace
v. Lactometer,

D) Software/Learning Websites

i. www.nzic.org.nz/ChemProcesses/food/6E.pdf
ii. www.emt-india.net/process/sugar/pdf/The%20Sugar%20Industry.pdf
iii. www.journeytoforever.org/farm_library/AD36.pdf
iv. www.smallb.in/sites/default/files/knowledge_base/carbonated_soft_drink.pdf
v. www.eolss.net/sample-chapters/c17/E6-58-05-02.pdf
vi. www.pcij.org/blog/wp-docs/WHO_types_of_alcohol.pdf
vii. www.mssewb.org/scheme/data/S24_Pgs/kasba_bakery.pdf

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Kartik R. Desai**, Head, Chemical Engineering Department, N. G. Patel Polytechnic, Isroli - Ahwa.
- **Prof. Mukesh B. Dhangar**, Lecturer in Chemical Engineering Department, N. G. Patel Polytechnic, Isroli - Ahwa.
- **Prof. Manish R. Nasit**, Lecturer in Chemical Engineering Department, N. G. Patel Polytechnic, Isroli - Ahwa.

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Bashirulla Shaik**, Assistant Professor, Department of Applied Sciences
- **Dr. Joshua Earnest**, Professor, Department of Electrical & Electronics Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: POLYMER TECHNOLOGY
(COURSE CODE: 3360506)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Polymers account for around 70% of petrochemicals in India. Indian polymer industry is growing at very impressive rate in 21st century. India has become the world's third largest consumer of polymers after China and US. We cannot imagine modern day life without using polymers. The Diploma chemical engineers have to deal with identification and characterization of raw material to ensure the quality of polymer product along with different techniques of processing. The content of this course is designed to enable diploma holders to develop the skills required for working in production, processing, testing, marketing and sales department of plastics, rubbers and fibres manufacturing Industries.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Operate polymer manufacturing plants to produce quality products**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Select appropriate techniques of polymerization
ii. Produce plastics using appropriate reactions and unit operations steps
iii. Produce rubbers using appropriate reactions and unit operations steps
iv. Produce fibres using appropriate reactions and unit operations steps
v. Apply different polymer processing techniques

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Properties of Polymers	1a. Describe techniques of polymerization 1b. Explain impact of properties on polymer	1.1 Techniques of polymerization, Bulk polymerization, Solution polymerization 1.2 Suspension polymerization, Emulsion polymerization 1.3 Molecular weight, Crystallinity and Glass transition temperature
	1c. Describe the salient properties of plastics	1.4 Properties of Plastics: Electrical Resistance, Chemical Resistance, Thermal Stability, Biodegradability
	1d. Describe the salient properties of Rubber	1.5 Properties of Rubbers: Elasticity, Electric Conductivity, Resistance to fatigue
	1e. Describe the salient properties of Fibres	1.6 Properties of Fibres: Resiliency, Elongation, Strength
Unit – II Plastics	2a. Describe the synthesizes various types of plastics	2.1 Properties, applications and manufacturing of: Polyethylene by high pressure ICI process for LDPE, Polyethylene by Ziegler low pressure process for HDPE, Polypropylene, Polystyrene, ABS, Polytetrafluoro Ethylene (PTTE /Teflon), Urea Formaldehyde
Unit – III Rubbers	3a. Describe the properties, applications and manufacturing of various types of rubber	3.1 Properties, Applications and Manufacturing of: Ethylene Propylene Terpolymers, Butyl rubber Polyurethane, Silicone rubber
Unit – IV Fibres	4a. Describe the properties, applications and manufacturing of various types of fibres	4.1 Properties, applications and manufacturing of: Viscose rayon fibres, Cellulose Acetate fibre, Nylon-6, Glass fibres
Unit – V Processing of Polymers	5a. Describe different processing techniques of polymers	5.1 Mastication, Mixing, Moulding, Extrusion, Calendaring, Vulcanization, Compounding Coating

6. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Properties of Polymers	8	5	6	3	14
II	Plastics	12	7	7	6	20
III	Rubbers	8	5	4	4	13
IV	Fibres	8	5	4	4	13
V	Processing of Polymers	6	4	3	3	10
Total		**42**	**26**	**24**	**20**	**70**

Legends: **R** = Remember**,** **U** = Understand**,** **A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED PRACTICAL / EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes (****as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	I	Prepare classification chart based on properties and uses.	2
2	I	Demonstrate thermosetting and thermoplastic properties	2
3	I	Test the effects of solvents on plastic, rubber and fibre	2
4	I	Test the effects of acids and alkalies on plastic, rubber and fibre	2
5	I	Test effects of temperature on plastic, rubber and fibre	2
6	I	Determine the acid value of glyptal resin	2
7	II	Prepare Glyptal resin	2
8	II	Prepare thermo-plastics PMMA(Poly Methyl Methacrylate)	2
9	II	Prepare Polystyrene from styrene	2
10	II	Prepare Phenol Formaldehyde resin from Phenol	2
11	II	Prepare Urea Formaldehyde resin from Urea	2
12	II	Prepare Melamine Formaldehyde	2
13	IV	Prepare primary cellulose acetate from cellulose	2

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hours Required
14	V	Perform Vulcanization of Rubber	2
	Total		**28**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed polymer/plastic/rubber/fibre production companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Study (in group of four-five) the design of some real polymer/plastic/rubber/fibre production plant and identify good features of design and also weaknesses in it, present in class to have a group discussion.
iii. Survey market for different types of polymer/plastic/rubber/fibre items available and identify their composition, further explore their production processes.

9. SPECIAL INSTRCTIONAL STRATEGY (If Any)

i. Show animations/ videos and drawings/models of polymer/plastic/rubber/fiber production processes
ii. Arrange visit to nearby polymer/plastic/rubber/fiber production plants
iii. Arrange expert lectures.

10 SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Books	Author	Publication
1	Outlines of Chemical Technology,	Rao,M. Gopal, Sittig, Marshall	Affiliated East West Press (Pvt) Ltd, New Delhi 3rd Edition
2	Chemical Technology, Vol. I & II	Pandey , G. N. and Shukla	Vani books company, Hyderabad2nd Edition
3	Shreve's Chemical Process Industries,	Austin, G.T.	McGraw Hill publication, New Delhi 5th edition
4	Polymer science	Gowarikar, V, R., Viswanathan, N.V. Sreedhar, Jayadev	New Age International Pvt. Ltd., New Delhi
5	Polymer science and Technology	Joel R.; Fried	PHI Learning, New Delhi, 2007, 2nd Edition
6	Text on etrochemicals	Rao, B. K. Bhaskar	Khanna Publishers, Delhi, 1998, 2nd Edition

B) Major Equipment/Materials with Broad Specifications

i. Glassware: Conical flask, burette, pipette, round bottom flask, measuring cylinder, beaker
ii. Glass Assembly: Round bottom flask, condenser
iii. Burner
iv. Weight balance (minimum 0.1gm)
v. Heating and cooling bath

C) Software/Learning Website

i. www.mossrubber.com/pdfs/Rubber_Prop.pdf
ii. www.ias.ac.in/resonance/Volumes/02/04/0055-0059.pdf
iii. www.unuftp.is/static/fellows/document/ramos99-ff.pdf
iv. www.epa.gov/ttnchie1/ap42/ch06/final/c06s09.pdf
v. www.zorge.com/assets/Documents/Rubber-technology.pdf
vi. www.nzic.org.nz/ChemProcesses/polymers

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnic

- **Prof. N. N. Hansalia**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. (Mrs.) Kajal J. Sareriya**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. R. P. Hadiya**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot

Coordinator and Faculty Members from NITTTR Bhopal

- **Dr. Abhilash Thakur**. Associate Professor, Department of Applied Sciences,
- **Dr. Joshua Earnest**, Professor, Department of Electrical & Electronics Engineering.

GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM
COURSE TITLE: PHARMACEUTICAL TECHNOLOGY
(COURSE CODE: 3360507)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	Sixth

1. RATIONALE

Gujarat is having more than 30 percent of pharmaceutical production capacity of India. Medicinal product manufacturing requires special considerations like sterilization, clean facility development and maintaining strict standards during formulating different dosage. The content of this subject is designed to enable diploma chemical engineers to develop the skills required for working in manufacturing of bulk drugs and formulations in special considerations to comply with standards.

2. COMPETENCY

The course content should be taught and curriculum should be implemented with the aim to develop required skills in the students so that they are able to acquire following competency:

- **Supervise production of drugs following standards for quality and cleanliness.**

3. COURSE OUTCOMES (COs)

The theory should be taught and practical should be carried out in such a manner that students are able to acquire required learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes:

i. Identify appropriate methods in medicine production.
ii. Apply various methods of sterilization.
iii. Use design parameters for clean facilities
iv. Produce different dosage forms.
v. Identify appropriate packaging materials.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	ESE	PA	ESE	PA	
3	0	2	5	70	30	20	30	150

Legends: L - Lecture; **T** - Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** - Credit; **ESE** - End Semester Examination; **PA** - Progressive Assessment

5. COURSE CONTENT DETAILS

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – I Basics of Pharmaceutical Technology	1a. Describe the characteristics of the Pharmaceutical industries compared to other industries	1.1 Characteristics of Pharmaceutical industries
	1b. Explain the concept of product standards 1c. Distinguish the different methods of production 1d. Compare API and formulation production	1.2 Product Standards: IP, BP, USP 1.3 Methods of production, Chemical synthesis, Isolation from plants, isolation from animals 1.4 Fermentation 1.5 API and Formulation
Unit – II Sterilization	2a. Justify the need for in the sterilization pharmaceutical industry 2b. Compare methods of Sterilization, with their benefits and limitations 2c. Describe the sterile facilities	2.1 sterility and requirement of sterility, Concept of sterilization 2.2 Methods of Sterilization with, applications, , Heat sterilization, (a)Steam sterilization, (b) Dry heat sterilization, Radiation sterilization Gas sterilization, Filtration sterilization 2.3 Sterile facilities : preparation area, compounding area, ware housing
Unit – III Clean Facilities	3a. Describe the important design parameters for various processes	3.1 Design parameters for clean facilities : Air change rate, Pressurization, Temperature control, Humidity control
	3b. Describe Architectural design issues	3.2 Architectural design issues : Facility Layout, Air locks and Pass through, windows, Gowning room
	3c. Select material of construction 3d. Explain the concept of clean construction	3.3 Material of construction for wall, doors, ceilings, floors 3.4 Clean construction
	3e. Describe HEPA filters	3.5 HEPA filters
Unit – IV Dosage forms	4a. Describe features of different types of solid dosage forms 4b. Describe the excipients in solid dosage forms	4.1 Solid dosage forms : Tablets, Coated tablets, Gelatine capsules, Chewable tablets, Gum based tablets 4.2 Excipients in solid dosage forms
	4c. Describe features of the semi-solid dosage forms 4d. Describe the features of different types of Gels 4e. Differentiate between Gels, Commercial Gelling agents	4.3 Semi-Solid dosages : Ointments and creams, 4.4 Bases for ointments and creams, 4.5 Packaging and storage of ointments and creams 4.6 Types of Gels, Commercial Gelling agents
	4e. Distinguish various liquid dosage forms	4.7 Liquid dosage forms: Solutions, Suspensions, Emulsions

Unit	Major Learning Outcomes (In Cognitive Domain)	Topics and Sub-topics
Unit – V Manufacturing and Packaging	5a. Differentiate between the manufacturing of tablets and capsules	5.1 Manufacturing, tablets and capsules
	5b. Describe packaging and storage of ointments and creams	5.2 Packaging and storage of ointments and creams
	5c. Describe the critical aspects of liquid manufacturing 5d. Describe the salient features of different types of packaging materials 5e. Describe the process of maintaining the quality control of packaging materials.	5.3 Critical aspects of liquid manufacturing: particle size of raw materials, parameters of compounding, uniformity, stability problems 5.4 Packaging materials: General considerations, Glass, Plastic and metal 5.5 Quality control of packaging materials

6. SUGGESTED SPECIFICATION TABLE WITH HOURS and MARKS (THEORY)

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Pharmaceutical Technology	06	4	4	2	10
II	Sterilization	07	3	3	6	12
III	Clean Facilities	07	3	3	6	12
IV	Dosage forms	13	7	7	7	21
V	Manufacturing and Packaging	09	5	5	5	15
Total		**42**	**22**	**22**	**26**	**70**

Legends: **R** = Remember**, U** = Understand**, A=** Apply and above Level (Bloom's revised 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.

7. SUGGESTED PRACTICAL / EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills **(outcomes in psychomotor and affective domain)** so that students are able to acquire the competencies/programme outcomes. Following is the list of practical exercises for guidance.

Note*: Here only outcomes mainly in psychomotor domain are listed as practical/exercises. However, if these practical/exercises are completed appropriately, they would also lead to development of certain outcomes in affective domain which would in turn lead to development of* ***Course Outcomes*** *related to affective domain. Thus over all development of* ***Programme Outcomes*** *(as given in a common list at the beginning of curriculum document for this programme) would be assured.*

Faculty should refer to that common list and should ensure that students also acquire outcomes

in affective domain which are required for overall achievement of Programme Outcomes/Course Outcomes.

S. No.	Unit No.	Practical/Exercise (Outcomes in Psychomotor Domain)	Approx. Hours Required
1	I	Separate medicine from plant extract	2
2	I	Synthesise pharmaceutical ingredient in laboratory conditions	2
3	I	Prepare pharmaceutical product by fermentation	4
4	II	Preserve milk by application of heat sterilization	2
5	II	Prepare chart of sterilization techniques	2
6	III	Prepare chart of clean facility development	2
7	IV	Prepare tablets	2
8	IV	Demonstrate some excipients	2
9	IV	Prepare ointment product	2
10	IV	Prepare cream product	2
11	IV	Prepare solution product	2
12	IV	Prepare suspension product	2
13	IV	Prepare an emulsion product	2
14	V	Prepare some packaging materials/Demonstrate packaging process for some drug	2
		Total	**30**

8. SUGGESTED STUDENT ACTIVITIES

Following is the list of proposed student activities. These could be individual and group based.

i. Explore internet, visit websites of reputed pharmaceutical companies and prepare ppt presentations on different topics (in group of four-five) and present in class
ii. Study (in group of four-five) the design of some real pharmaceutical production plant and identify good features of design and also weaknesses in it, present in class to have a group discussion.
iii. Survey market for different types of packaging available for pharmaceutical items and identify their features (commercial as well medicinal), further explore packaging processes required for such type of packaging.

9. SPECIAL INSTRCTIONAL STRATEGY (If Any)

i. Show animations/ videos and drawings/models of pharmaceutical production processes
ii. Arrange visit to nearby API production plants and formulation plants
iii. Arrange expert lectures.

10 SUGGESTED LEARNING RESOURCES

A) Books

S. No.	Title of Books	Author	Publication
1	Pharmaceutical Process Engineering	Hickey, Anthony J.;David Ganderton	Marcel Dekker Inc. USA, 2001
2	Pharmaceutical Manufacturing handbook	Gad, Shayne Cox	John Wiley and Sons, 2008
3	Good pharmaceutical Manufacturing practice	Sharp, John	CRC press, New York, 2005

B) Major Equipment/Materials with Broad Specifications

i. Glassware: Conical flask, burette, pipette, round bottom flask, measuring cylinder, beaker
ii. Glass Assembly: Round bottom flask, condenser, Separating funnel
iii. Burner
iv. Weight balance (minimum 0.1gm)
v. Heating and cooling bath
vi. Refrigerator

C) Software/Learning Websites

i. www.pharmaceuticalonline.com
ii. www.pharmaceutical-technology.com
iii. www.pharmamanufacturing.com
iv. www.worldpharmaceuticals.net

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- **Prof (Smt.) K. J. Sareriya**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof M. R. Aacharya**, Lecturer in Chemical Engineering, Government Polytechnic, Gandhinagar.

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