GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT
Course Curriculum
CHEMICAL ENGINEERING MATERIALS
(Code: 3330501)

Diploma Programme in which this course is offered	Semester in which offered
Diploma in Chemical Engineering	3rd Semester

1 RATIONALE

For working in the industries related to chemical manufacturing, students requires the knowledge of various classes of material like metals and alloys, ceramics, polymers, composites, coatings, insulating materials, adhesives and lubricants for different applications. Study of Chemical Engineering Materials also has importance towards the understanding of properties of materials for construction of various equipments and piping systems. Properties of materials affect the life and performance of equipments to the large extent. Thus information of properties of these materials is important for students to ensure the minimum cost of products and safety in the plants.

2 COMPETENCY (Programme Outcome according to NBA Terminology):

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

- **Identify appropriate materials for chemical plant equipments, piping, insulation and lining.**

3 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

4 COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit-I **Properties Of Materials**	Describe scope of material science Explain important properties of materials . Select materials	Scope of material science Definition and explanation of : Melting point, Boiling point, Specific heat, Thermal conductivity, Thermal expansion, Thermal insulation, Stresses, Strain, Yield stress, Fatigue,Creep Principles of selection of materials
Unit-II **Corrosion and Its Prevention**	Define corrosion and describe it's types Control and prevent corrosion	1 Definition of corrosion 2 Types of corrosion: Direct corrosion, Electro-chemical corrosion, Galvanic corrosion, High temperature corrosion 3 Factors affecting corrosion rate 4 Methods for control and prevention of corrosion
Unit– III **Metals and Alloys**	Describe and compare ferrous metals and alloys Describe non-Ferrous metals and alloys Explain furnaces	1 Properties and uses of Cast iron, Wrought iron, Mild steel, Stainless steel 2 Comparison of ferrous metals and alloys 3 Properties and uses of metals: Aluminium, Zinc, Chromium, Nickel, Tin, Copper, Titanium, Tungsten, Platinum and Silver 4 Properties and uses of alloys : Duralumin, Brass, Bronze, Inconel, Hastalloy B and C, Invar,

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit– IV **Ceramic Materials**	. Describe ceramic materials . Compare ceramic material	Y alloy 5 Purification of metals using Blast furnace and Arc furnace Ceramic materials Composition, properties and uses of china clay, fire clay, bentonite Classification, properties and uses of refractories Composition, properties and uses of Soda lime glass, borosilicate glass, high silica glass, fibre glass, glass wool, form glass Composition, properties and uses of Porcelain
Unit-V **Organic Materials**	Describe polymers Compare types of polymerization Describe and classify plastics, rubbers Explain vulcanizing of rubber	Definition and importance of Polymer Addition and condensation Polymerization Plastics : definition, classification, general properties and uses Rubbers : definition, classification, general properties and uses Compare natural and synthetic rubber Vulcanizing of rubber
Unit-VI **Protective Coatings and Insulations**	6a. Describe and classify paints 6b. Describe and classify Varnishes 6c. Describe and Classify insulations	Paints: classification and uses Ingredients of paints: their properties and importance Special types of paints and their applications Varnishes: classification and uses Ingredients of Varnishes Types of insulations Properties and applications of different :(i) Electric insulation (ii)Thermal insulation
Unit-VII **Composites, Lubricants**	. Describe and classify composites . Describe and classify lubricants . Describe and classify adhesives	List of composite materials Properties and uses of Fiber reinforced plastics(FRP), Metal

and Adhesives	matrix composites(MMC), Ceramic matrix composites(CMC) Classification, properties and uses of Synthetic lubricants, Semisolid lubricants Adhesives: classification, properties and uses

5 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	Properties of Materials	4	2	3	2	07
II	Corrosion and its Prevention	6	2	4	4	10
III	Metals and Alloys	7	5	4	3	12
IV	Ceramic Materials	6	4	4	2	10
V	Organic Materials	5	3	3	2	08
VI	Protective coatings and Insulations	6	4	4	2	10
VII	Composites, Lubricants and adhesives	8	4	5	4	13
	Total	**42**	**24**	**27**	**19**	**70**

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.

6 SUGGESTED LIST OF PRACTICAL/EXERCISES
(Not Applicable)

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like: course/topic based presentations, internet based assignments, and teacher guided self learning activities, MCQ/Quiz. These could be individual or group-based.

8. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

1. Collecting and demonstrating samples of different materials
2. Following Tutorials exercises may be given to the students

S. No.	Unit No.	Topic on which Tutorial Exercises may be given	Approx. Hrs. Required
1	I	Principles of selection of materials	04
2	II	Control and prevention of corrosion	04
3	III	Comparison of properties of Ferrous metals and alloys	04
4	III	Comparison of properties of important Non-Ferrous metals and alloys	04

S. No.	Unit No.	Topic on which Tutorial Exercises may be given	Approx. Hrs. Required
5	IV	Comparison of properties of Refractories	04
6	V	Compounding of Plastic and Rubber	02
7	VI	Ingredients of Paints and varnishes	02
8	VI	Thermal insulations	02
9	VII	FRP	02
		Total	**28**

9. SUGGESTED LEARNING RESOURCES

A. List of Books:

S. No.	Title of Books	Author	Publication
1	Material science and processes	Hazarachaudhary S. K.	Indian book distribution co.
2	Engineering Materials	Rangwala S C, Rangwala K. S.	Charotar publishing house pvt. limited
3	Engineering Materials	Rajput R. K.	S.Chand and Co., New Delhi

B. List of Major Equipment/Materials

---- Nil ----

C List of Software/Learning Websites

i. web.iitd.ac.in/~suniljha/MEL120/L2_Engineering_Materials.pdf
ii. http://engineershandbook.com/Materials
iii. www.engineeringtoolbox.com/engineering-materials-properties-d_1225.html
iv. http://nptel.iitm.ac.in/courses.php

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics:

- **Prof. R. P. Hadiya**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. Kajal J. Sareriya**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. N. N. Hansalia**, Lecturer in Chemical Engineering, Government Polytechnic, Rajkot
- **Prof. Manish R. Nasit**, Lecturer in Chemical Engineering, Shri N. G. Patel Polytechnic, Isroli - Afwa

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof Bashir Shaikh**, Assistant Professor, Department of Applied Sciences.
- **Prof Shashi Kant Gupta,** Professor and Coordinator for State of Gujarat

MECHANICAL OPERATIONS
(Code: 3330502)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	3rd Semester

- **RATIONALE**

The operations of chemical plants require use of material handling and size reduction equipments, screens, agitator, mixers, centrifuges, cyclones, filters and other mechanical separation equipments. Therefore students must have information about the principles, construction and working of these equipments so that they can plan for their efficient use in plants. In this course the students would also learn simple calculations to judge the performance of these equipments.

8. COMPETENCY (Programme Outcome according to NBA Terminology):

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 competencies:

3. **Plan and supervise operation of mechanical operation equipments.**

9. 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
4	0	4	8	70	30	40	60	

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

COURSE DETAILS

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit – I Properties of Particulate Solids	1a. Differentiate Unit operation and Unit process	1.1 Fundamentals of Unit operation and Unit process
	1b. Describe specific properties of solids	1.2 Specific properties of solids : Particle density and Bulk density, diameter, sphericity, equivalent diameter, specific surface area, volume surface mean diameter, mass mean diameter, and shape factor
	1c. Calculate specific property parameters of solids	1.3 Calculation of particle diameter, sphericity, equivalent diameter, specific surface area, volume surface mean diameter, mass mean diameter, and shape factor, numbers of particles in solid
Unit – II	2a. Explain Screen	2.1 Basics of Ideal and actual screen

Screen Analysis	2b. Compare types of screen analysis	2.2 Types of screen analysis
		2.2.1 Cumulative analysis 2.2.2 Differential analysis 2.3 Applications of screen analysis
	2c. Derive formula for effectiveness of screen 2d. Calculate capacity and effectiveness of screen	2.4 Capacity and effectiveness of screen 2.5 Derivation of formula for overall effectiveness of screen 2.6 Calculation of capacity and effectiveness of screen
	2e. Identify faults in screen	2.7 Faults in screening
	2f. Describe types of screening equipment	2.8 Types of screen: Trommel, Grizzlies, Vibrating screen
Unit – III **Size Reduction**	3a. Explain size reduction with applications	3.1 Principles of Size reduction and its application
	3b. Describe working of size reduction equipments	3.2 Classification, comparison and selection of size reduction equipments based on size reduction principle
	3c. Characterise the comminution products	3.3 Characteristics of comminution products
	3d. Explain energy and power requirement in comminution.	3.4 Energy and power required in comminution
	3e. Explain empirical laws of size reduction	3.5 Laws of size reduction: (i) Rittingers law (ii) Bond's law (iii) Kick's law
	3f. Compute the energy and power requirement for size reduction	3.6 Calculation of power required for size reduction using empirical laws
	3g. Calculate work index	3.7 Work index

Unit	Major Learning Outcomes	Topics and Sub-topics
	3h. Explain different size reduction equipment	3.8 Principle, construction and working of Jaw crusher, Gyratory crusher, Fluid Energy mill, Ribbon Blender, Roll crusher, and Ball Mill
	3i. Calculate angle of nip	3.9 Derivation of equation of angle of nip, Calculation of angle of Nip for Roll crusher
	3j. Calculate critical speed	3.10 Derivation of equation of critical speed of Ball mill and its calculations
	3k. Differentiate between open and close circuit grinding	3.11 Difference between open and close circuit grinding
Unit – IV **Sedimentation**	4a. Explain sedimentation 4b. Draw batch sedimentation curve	4.1 Fundamentals of sedimentation 4.2 Batch sedimentation 4.3 Inter phase height Vs time curve for Batch sedimentation
	4c. Describe principle of flocculation and thicker	4.4 Principle of flocculation 4.5 Principle, construction and working of Gravity thicker
	4d. Explain and compare settling	4.6 Fundamentals of free and hindered settling

	4e. Explain Tubular Centrifuge	4.7 Construction and working of Tubular centrifuge
	4f. Describe Cyclone separator 4g. Calculate Cut diameter and efficiency of cyclone	4.8 Principle, construction and working of Cyclone separator 4.9 Cut diameter and efficiency of cyclone
	4h. Explain Terminal settling velocity, Stoke's law, Newton's law	4.10 Terminal settling velocity Stoke's law and Newton's law
Unit –V Filtration	5a. Describe filtration 5b. Classify equipments for liquid-solid separation	5.1 Basics of filtration 5.2 Classification of equipments for liquid-solid separation
	5c. Explain types of filter	5.3 Principle, construction and working of filter press, leaf filter, rotary vacuum filter, cartridge filter
	5d. Characterise filter media	5.4 Filter media and its characteristics
	5e. Explain filter aids 5f. Describe method of application	5.5 Basics of Filter aids 5.6 Method of application
	5g. Differentiate constant rate and constant pressure filtration	5.7 Constant rate filtration and constant pressure filtration

Unit	Major Learning Outcomes	Topics and Sub-topics
	5h. Explain cake resistance, filter media resistance for various conditions	5.8 Brief description of specific cake resistance and filter media resistance for constant rate, constant pressure and vacuum filtration (without numerical)
	5i. Classify centrifugal equipments	5.9 Classification of centrifugal equipments
	5j. Explain batch centrifuge	5.10 Principle, construction and working of batch centrifuge
	5k. Compare centrifuge and filter press	5.11 Advantages and disadvantages of centrifuge over filter press
Unit –VI Separation of Solid Particles	6a. Define solid separation	6.1 Definition and application of solid separation
	6b. Describe factors affecting selection of equipment	6.2 Factors affecting selection of equipment for solid separation
	6c. Explain types of solid separation equipments	6.3 Working principle and construction of a) Jigging b) Elutriation c) Double cone classifier d) Electrostatic precipitator e) Magnetic separator f) Froth flotation cell
	6d. Explain differential settling methods	6.4 Differential settling methods, sink and float method

Unit VII	7a. Describe agitation and mixing	7.1 Define agitation and mixing,
Agitation and Mixing		give their applications
	7b. Classify impellers 7c. Compare various impellers	7.2 Classification of Impellers and brief explanation
	7d. Explain vortex formation and prevention	7.3 Vortex formation and swirling 7.4 Methods of Vortex prevention
	7e. Explain agitation vessel	7.4 Construction and working of agitation vessel
	7f. Derive equation for power consumption	7.5 Derivation of equation for power consumption in agitation vessel
	7g. Calculate power consumption	7.6 Calculations of power consumption in baffled and unbaffled tank
	7h. Describe flow number	7.7 Flow number
	7i. Explain factors affecting agitation	7.8 Factors affecting agitation
	7j. Explain purpose of mixing	7.9 Purpose of mixing solids and pastes
	7k. Describe factors for selection of equipments	7.10 Factors affecting selection of mixing equipments

Unit	Major Learning Outcomes	Topics and Sub-topics
	7l. Explain rate of mixing and mixing index 7m. Compute mixing index	7.11 Rate of mixing and mixing index for pastes & powder 7.12 Calculation of mixing index
	7n. Describe types of mixers	7.12 Construction and working of a) Ribbon blender b) Kneaders c) Pug mill d) Banbury mixer e) Muller mixer

5. 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	Properties of Particulate Solids	07	2	5	2	09
II	Screen Analysis	05	1	2	3	06
III	Size Reduction	10	2	5	5	12
IV	Sedimentation	06	2	3	2	07
V	Filtration	10	2	7	3	12
VI	Separation of Solid Particles	06	2	4	2	08
VII	Agitation and Mixing	12	2	6	8	16
Total		**56**	**13**	**32**	**25**	**70**

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.

6. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course 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 Course 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.

Sr. No.	**Unit No.**	**Practical/Exercise** (Course Outcomes in Psychomotor Domain according to NBA Terminology)	**Apprx. Hrs. Required**
1.	I	Measure volume surface mean diameter, mass mean diameter, number of particles using sieve shaker	4
2.	II	Carry out differential and cumulative screen analysis	4
3.	III	Test Rittinger's law for grinding in ball mill and measure critical speed	4
4.	III	Test Kicks law for crushing in jaw crusher	4
5.	III	Test Bond's law for crushing in roll crusher	4
6.	IV	Measure efficiency of cyclone separator	4
7.	IV	Determine rate of settling by sedimentation	4
8.	V	Measure cake resistance, filter media resistance in filter press.	4
9.	V	Measure rate of filtration, cake resistance, filter media resistance in basket centrifuge	4
10.	V	Measure rate of filtration in gravity filtration	4
11.	V	Measure rate of filtration in vacuum filtration	4
12.	VI	Measure efficiency of separation in froth flotation cell	4
13.	VII	Evaluate mixing index in double cone mixer	4
14.	VII	Measure power consumption in baffled and unbaffled agitation vessel	4
	Total		**56**

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like:

- ---- Assignments
- ---- Technical Quiz/MCQ Test
- ---- Presentation on some course topic
- ---- I-net based assignments

D SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

i. Working of different equipment should be demonstrated using chart and models or with help of video/animation films.
ii. Expert Lecture (by persons working in Industry) may be oragnised.
iii. Visit to nearby industries where such equipment are being used may be arranged.

E SUGGESTED LEARNING RESOURCES

11. List of Books:

Sr. No.	Title of Books	Author	Publication
1	Unit Operations of Chemical Engineering	McCabe and Smith	McGrawhill Publications, New Delhi
2	Introduction to Chemical Engineering	Badger W. L. and Banchero J. T	McGrawhill Publications, New Delhi
3	Unit Operation –I	Gavhane K. A.	Nirali Prakashan, Pune

- **List of Major Equipment/Materials**

Sieve shaker – Sieve dia – 100 mm to 200 mm, no of sieve – 6-8, Opening – as per requirement (micro or coarse particle)

Laboratory Ball mill - 5kg capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Jaw crusher – 10-50 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Laboratory Roll crusher – 5-25 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Agitation vessel setup – 20-50 liter capacity - Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Cyclone separators – Product Particle as per requirement, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Froth flotation Cell, 5-15 kg/hr capacity, Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Gravity filter

Vacuum Filter

Laboratory filter Press - Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Basket centrifuge - Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

Double cone mixer - Suitable for operation on 415V, 50Hz, 3 Phase, AC supply

C List of Software/Learning Websites

a. www.sciencedirect.com

b. www.cheresources.com

c. http://nptel.iitm.ac.in/courses.php

d. http://engineershandbook.com/unit.operations

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. P. K. Patel**, Lecturer in Chemical Engineering , Govt. Polytechnic Gandhinagar
- **Prof. M. R. Acharya**, Lecturer in Chemical Engineering, Govt. Polytechnic, Gandhinagar
- **Prof. R. P. Hadiya**, Lecturer in Chemical Engineering , Govt. Polytechnic Rajkot.

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof Bashir Shaikh**, Assistant Professor, Department of Applied Sciences.
- **Prof Shashi Kant Gupta,** Professor and Coordinator for State of Gujarat

FLUID FLOW OPERATION
(Code: 3330503)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	3rd Semester

- **RATIONALE**

In almost every chemical plant fluids have to be handled and hence study of fluids at rest and in motion is important. The information about the basic concepts and principles of hydrostatics, hydrodynamics and their applications in handling various fluids like gases, vapors, liquids and slurries are provided in this course which is required for smooth and proper operation of fluid transportations machineries. Using these concepts power requirement for pumps, blowers and compressors can be determined and friction losses through pipes and fittings can also be calculated. Therefore this course is one of the important courses since it attempts to develop these skills in students.

9. COMPETENCY (Programme Outcome according to NBA Terminology):

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

1. **Maintain flow of different fluids in the chemical plants according to the process requirement.**

10. 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**	
4	0	4	8	70	30	40	60	**200**

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

4. COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Fluid Statics and its Applications	1a. Define Ideal fluid and Real fluid 1b. Differentiate between fluid statics and dynamics	1.1. Ideal fluid and Real fluid 1.2. Fundamentals of fluid statics and dynamics
	1c. Classify the types of pressure	1.3. Definitions of pressure concept, Static head, Static pressure, Gauge pressure, Absolute pressure, Dynamic pressure, Total pressure, Vacuum(negative pressure)
	1d. Compare compressible and incompressible fluids	1.4. Compressible and incompressible fluids
	1e. Derive equation of pressure in static fluid	1.5. Derivation of equation of pressure in static fluid
	1f. Explain manometers 1g. Derive equation of pressure difference	1.6. Principle construction and working of Manometers with equation of pressure difference - Simple U tube manometer, Inclined manometer, Piezometer, Two fluid manometer, Micro-manometer
Unit– II Fluid–Flow Phenomena	2a. Explain velocity change across cross section	2.1 Velocity field, velocity gradient, shear stress and rate of shear
	2b. Explain effect of solid boundary	2.2 Boundary layer, it's separation and wake formation
	2c. Define steady state and unsteady state conditions	2.3 Steady state and unsteady state conditions
	2d. Describe types of viscosities	2.4 Viscosity : Absolute, Kinematic and Relative
	2e. Classify fluids	2.5 Classification of fluids : Newtonian and Non-Newtonian with examples
	2f. Describe Reynold's experiment	2.6 Reynold's experiment and Reynolds number, turbulent flow, laminar flow, transition flow
Unit– III Basic Equations of Fluid Flow	3a. Define velocities	3.1 Average velocity and mass velocity
	3b. Derive continuity equation	3.2 Continuity equation for mass balance in steady flow
	3c. Derive Bernoulli's equation and explain corrections	3.3 Bernoulli's equation and corrections in Bernoulli's equation like kinetic energy correction, correction for fluid friction, correction for Pump work
	3d. Use Hagen-Poiseuille's Equation	3.4 Hagen-Poiseuille's Equation
Unit– IV Friction in	4a. Describe roughness of pipe	4.1 Roughness of pipe

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Flowing Fluid	4b. Explain hydraulic radius and equivalent diameter	4.2 Hydraulic radius and equivalent diameter
	4c. Compare skin and form friction	4.3 Skin friction and form friction
	4d. Use friction factor chart	4.4 Friction factor chart
	4e. Calculate friction losses	4.5 Friction from changes in velocity or direction (a) Friction loss from sudden expansion of cross section (b) Friction loss from sudden contraction of cross section 4.6 Friction loss in fittings and valves
Unit– V Transportation of fluid	5a. Compare pipe and tube	5.1 Introduction of pipe and tube
	5b. Describe fittings & joints	5.2 Types and uses of fittings and joints
	5c. Describe valves	5.3 Construction and working of various types of valves like (a) Gate valve (b) Globe valve (c) Check valves (d) Control valve
	5d. Classify pumps	5.4 Classification of pumps
	5e. Explain pumps	5.5 Construction and working of centrifugal, reciprocating and rotary pump
	5f. Explain characteristics of centrifugal pump 5g. Calculate NPSH, head and power	5.6 Developed head and power requirement in centrifugal pump
		5.7 NPSH, Suction lift and Cavitation in centrifugal pump
		5.8 Characteristic curves of Centrifugal pump
		5.9 Numerical based on NPSH, efficiency, head and power
	5h. Explain construction, working and uses of fluid moving machineries	5.10 Construction, working and uses of Compressor, Fan, Blower, Vacuum pump and Jet ejectors
Unit– VI Flow Measurement	6a. Describe methods of flow measurement	6.1 Methods of flow measurement
	6b. Classify flow measuring devices	6.2 Classification of flow measuring devices
	6c. Explain flow meters	6.3 Construction, working principles and application of flow meters like Rotameter, Orifice meter, Venturi meter, Pitot tube, weirs, Coriolis meter, Magnetic meter, Ultrasonic meter
	6d. Derive equation of flow rate	6.4 Derivation of equation of flow rate through Orifice meter, Venturi meter, Pitot tube and weirs
	6e. Solve simple numerical	6.5 Numerical of Orifice meter, Venturi meter

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit– VII Conveying and Fluidization	7a Explain conveying	7.1 Pneumatic and Hydraulic conveying with industrial applications
	7b Explain Fluidization	7.2 Fluidization and its industrial applications
	7c Explain Porosity	7.3 Porosity of static bed, Porosity of fluidized bed, Minimum porosity
	7d Describe minimum fluidization velocity	7.4 Minimum fluidization velocity
	7e Explain relation between bed pressure drop and bed height	7.5 Relation of bed pressure drop and bed height with graph

5. 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	Fluid Statics and its Applications	06	02	03	02	07
II	Fluid–Flow Phenomena	06	02	03	02	07
III	Basic Equations of Fluid Flow	07	02	06	02	10
IV	Friction in Flowing Fluid	07	02	06	02	10
V	Transportation of Fluid	12	04	07	04	15
VI	Flow Measurement	12	03	07	04	14
VII	Conveying and Fluidization	06	02	03	02	07
	Total	**56**	**17**	**35**	**18**	**70**

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.

B. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course 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 Course 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.

Sr. No.	**Unit No.**	**Practical/Exercise** (Course Outcomes in Psychomotor Domain according to NBA Terminology)	**Approx. Hrs Required**
1.	II	Identify types of flow by using Reynolds's apparatus	4
2.	II	Measure absolute and kinematic viscosity using Oswald viscometer	4
3.	III	Use Bernoulli's apparatus for mechanical energy balance	4
4.	III	Estimate viscosity of water using Hagen-Poiseuille's equation	4
5.	IV	Measure friction losses through pipe, fittings and valves	4
6.	IV	Measure friction losses through packed bed	4
7.	V	Measure pressure developed by reciprocating pump	4
8.	V	Measure head developed by centrifugal pump	4
9.	V	Measure friction losses through fittings and valves	4
10.	VI	Measure flow through pipe using venturimeter	4
11.	VI	Measure flow through pipe using orifice meter	4
12.	VI	Measure flow through pipe using rotameter	4
13.	VI	Measure flow through open channel using notches	4
14.	VII	Measure minimum fluidization velocity through fluidized bed	4
		Total	**56**

C. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like: course/topic based presentations, internet based assignments, and teacher guided self learning activities, MCQ/Quiz. These could be individual or group-based.

8. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

i. Working of different equipment and fluid transport systems should be demonstrated using chart and models or with help of video/animation films.
ii. Expert Lecture (by persons working in Industry) may be oragnised.
iii. Visit to nearby industries where such fluid flow operations are in use may be arranged.

9. SUGGESTED LEARNING RESOURCES

(A) List of Books:

Sr. No.	Title of Books	Author	Publication
1	Unit Operations of Chemical Engineering	McCabe, Warren L., Julian C. Smith	McGraw Hill Publication, New York 2004 (Seventh Edition)
2	Introduction to Chemical Engineering	L.Badger, Julius T. Banchero	McGraw Hill Publication, New York 2004 (Seventh Edition)
3	Unit Operations of Chemical Engineering Vol-I	Chattopadhyay, P.	Khanna Prakashan, New Delhi, 1996
4	A text book of Fluid Mechanics	Khurmi, R.S.	S. Chand Publication, New Delhi 2002
5	Unit Operation –I	Gavhane, K.A.	Nirali Prakashan, Pune 2009

12. List of Major Equipment/Materials with Major Specification

Venturimeter assembly for fluid flow measurement(Minimum flow rate – 05 lit/min, mercury manometer)

Orifice meter assembly for fluid flow measurement(Minimum flow rate – 05 lit/min, mercury manometer)

Rota meter assembly for fluid flow measurement(Minimum flow rate – 05 lit/min, minimum 1 in. transparent tube)

V Notch, Rectangular Notch assembly for flow measurement in open channel (Minimum notch size 5 cm)

Reynold's Experiment setup for studying types of flow (Minimum pipe dia. –0.5 in transparent pipe)

Bernoullies experiment setup for mechanical energy balance in flowing fluid with transparent channel of at least 1 in ID.

Reciprocating Pump Assembly with pump & motor of minimum 0.25 HP

Centrifugal Pump Assembly with pump & motor of minimum 0.25 HP

Fluidized bed setup made of glass pipe with minimum 2 in ID

Friction through Pipes, Fittings and Valves setup (0.5 in ID pipe with elbow, Tee, Square, Reducer, Enlarger, Glob valve, Gate valve)

Packed bed setup to measure friction losses with minimum 2 in ID transparent pipe

Oswald viscometer and stopwatch

C List of Software/Learning Websites

i. http://www.nzifst.org.nz/unitoperations/flfltheory.htm

ii. http://books.google.co.in/books?id=K4almhE5BoAC&pg=PP1&lpg=PP4&ots=1XDNGSxMsY&dq=Unit+Operation-1+nirali+Prakashan+published+year

iii. http://www.chemicalprocessing.com/whitepapers/fluid-handling/

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. J. R. Vadher**, Lecturer in Chemical Engineering, Govt. Polytechnic, Gandhinagar
- **Prof. M. R. Acharya**, Lecturer in Chemical Engineering, Govt. Polytechnic, Gandhinagar
- **Prof. P. M. Gadhiya**, Lecturer in Chemical Engineering, Govt. Polytechnic, Rajkot
- **Prof. N. N. Hansalia**, Lecturer in Chemical Engineering, Govt. Polytechnic, Rajkot

Coordinator and Faculty Members from NITTTR Bhopal

- **Prof Bashir Shaikh**, Assistant Professor, Department of Applied Sciences.

Prof Shashi Kant Gupta, Professor and Coordinator for State of Gujarat.

INDUSTRIAL STOICHIOMETRY

(Code: 3330504)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	3rd Semester

- **RATIONALE**

Industrial Stoichiometry provides the fundamental information to determine the material and energy balances for all types of unit operations and unit processes across the equipment and overall chemical plant. Material and energy balance calculations are of prime importance for design and also for conservation of mass and energy to reduce the losses and cost that enhances overall economy of plant. The unit conversions, material and energy balance are the essential part in the practice of other courses such as mechanical operations, fluid flow, heat Transfer, mass transfer etc. Thus this course is a core course for chemical engineers and should be learned sincerely by students.

10. **COMPETENCY (Programme Outcome according to NBA Terminology):**

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

1. **Determine material and energy balance for different unit operations and processes.**

11. 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

4. COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Unit Systems	1a. Explain importance of process calculation	1.1 Introduction to process calculation
	1b. Define different unit systems	1.2 Dimensions and systems of units 1.3 Fundamental quantities of units, Derived quantities
	1c. Explain the importance of physical quantities of Units.	1.4 Definition and units of force, volume, pressure, work, energy, power, heat
	1d. Convert units among different systems	1.5 Unit conversions in FPS, MKS and SI systems
Unit– II Basic Chemical Calculations	2a. Calculate important physical quantities	2.1 Definition and calculations of mole, atomic weight, molecular weight, equivalent weight, specific gravity and API gravity
	2b. Calculate composition of mixtures and solutions	2.2 Composition of solid, liquid by weight % and mole % 2.3 Morality, normality, morality, gm/lit and related simple numericals
Unit– III Ideal Gas Law	3a. Derive ideal gas law. 3b. State reference conditions	3.1 Concept of ideal gas 3.2 Derivation of ideal gas law 3.3 Definition of STP and NTP 3.4 Dalton's law and Amagat's law
	3b. Calculate important quantities for ideal gas mixture	3.5 Derive relation between mole%, volume% and pressure% of ideal gases 3.6 Calculation of average molecular weight, density, mole%, weight% in gas mixture in SI/MKS systems
Unit– IV Material Balance In Processes Without Chemical Reactions	4a. Explain law of conservation of mass	4.1 Law of conversation of mass
	4b. Calculate mass balance of important unit operations at steady state condition	4.2 Brief description and simple material balance calculation of drying, distillation, absorption, mixing, crystallization, evaporation 4.3 Single stage material balance calculation of leaching and extraction
	4c. Describe recycling and by passing operations	4.4 Brief idea regarding recycling and by passing operation
Unit– V Material Balance In Processes Involving Chemical Reactions	5a. Explain basic concepts of material balance with chemical reaction	5.1 Definition: Limiting reactant, Excess reactant, conversion, yield and selectivity
	5b. Calculate mass balance with chemical reaction	5.2 Simple numerical for finding yield, conversion and composition 5.3 Simple calculation of material Balance based on reaction.

Unit– VI Energy Balance	6a. Calculate heat capacity, specific heat, heat capacity of gas mixture and liquid mixture	6.1 Heat capacity and specific heat 6.2 Mean heat capacity of gases 6.3 Heat capacity of gas mixture and liquid mixture 6.4 Calculations of heat capacity by integral equation up to three terms
	6b. Explain concepts of sensible heat and latent heat	6.5 Brief explanation of sensible Heat and latent heat of fusion, sublimation, vaporization
	6c. Calculate standard heat of formation and heat of reaction	6.6 Calculations of standard heat of formation from heat of combustion data 6.7 Calculations for heat of reaction from heat of formation and heat of combustion data
Unit– VII Combustion	7a. Describe combustion	7.1 Introduction of combustion
	7b. Describe calorific values	7.2 Types of fuels 7.3 Calorific values of fuels 7.4 Proximate and ultimate analysis of solid fuel
	7c. Calculate calorific value and air requirement for combustion	7.5 Numericals related to calorific values of fuel from composition 7.6 Numericals related to air Requirement and composition of flue gases.

5. 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	Unit Systems	3	2	2	2	06
II	Basic Chemical Calculations	5	2	2	4	08
III	Ideal Gas Law	5	2	2	4	08
IV	Material Balance in Process without Chemical Reactions	8	0	6	7	13
V	Material Balance in Process Involving Chemical Reactions	7	2	3	7	12
VI	Energy Balance	8	2	4	8	14
VII	Combustion	6	2	2	5	09
Total		**42**	**12**	**21**	**37**	**70**

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.

6. SUGGESTED LIST OF PRACTICAL/EXERCISES

Not Applicable

7. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities: Tutorials, group assignments based on mass and energy balance of equipments like heat exchanger, boilers, distillation column, evaporator, dryer, reactors, absorption column, Use of MS-Excel in solving numerical.

C. SPECIAL INSTRUCTIONAL STRATEGY (If Any)

More numerical examples should be discussed in the class to make concepts clear. Home Assignment should given to students on similar type of numerical for more practice.

Video lecture from NPTEL websites may be shown to class for better understanding of the concepts.

Video/animation films may be shown for explaining abstract concepts.

Quizzes may be organised in the class by dividing it into groups to create an environment of competition.

Tutorial sessions may be organised as given in following table

Sr. No.	Unit No.	Topics/Sub Topics on which Numerical may be given during Tutorial Sessions	Approx. Hrs. Required
1	I	Systems of Units and Conversions	02
2	II	Numericals based on composition of mixtures and solutions	03
3	III	Numericals based on Ideal gas law and calculation of composition of gas mixture	03
4	IV	Numericals based on mass balance for important unit operations	06
5	V	Numericals based on mass balance involving chemical reactions	04
6	VI	(a) Numericals based on heat capacity and heat change (b) Numericals based on heat of formation and heat of reaction	06
7	VII	Numericals on calorific values of fuel, theoretical air requirement and composition of flue gases	04
		Total	**28**

9. SUGGESTED LEARNING RESOURCES

F List of Books:

S. No.	Title of Books	Author	Publication
1	Stoichiometry	Bhatt B. I. and Vora S. M.	Tata-McGraw Hill, New Delhi, Year-2007
2	Process Calculation	Gavhane K. A.	Nirali Prakashan, Pune, Year-2012
3	Basic Principles and Calculations in Chemical Engineering	Himmelablau David M.	PHI Learning, New Dehli, Year-2003

B. List of Major Equipment/Materials

Nil.

C. List of Software/Learning Websites

i.Basic Principles & Calculations in Chemical Engg (CD Rom)

ii.www.ocw.mit.edu

10. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnics

- **Prof. Harsh B. Shukla**, Lecturer in Chemical Engineering, Shri K.J. Polytechnic, Bharuch
- **Prof. Rakesh R. Vasava**, Lecturer in Chemical Engineering, Shri K.J. Polytechnic, Bharuch
- **Prof. Mukesh B. Dhangar**, Lecturer in Chemical Engineering, Shri N. G. Patel Polytechnic, Isroli-Afwa

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Coordinator and Faculty Members from NITTTR Bhopal

- **Prof Bashir Shaikh**, Assistant Professor, Department of Applied Sciences.
- **Prof Shashi Kant Gupta,** Professor and Coordinator for State of Gujarat

CHEMICAL PROCESS TECHNOLOGY-I
(Code: 3330505)

Diploma Programme in which this course is offered	Semester in which offered
Chemical Engineering	3rd Semester

- **RATIONALE**

The importance of this subject arises from the need of providing comprehensive and balanced understanding of essential link between chemistry and the chemical industry. It is vital to develop simple but meaningful flow diagram for each chemical product which a student can understand. This course develops skill for arranging and understanding treatment, reaction and separation steps in a flow diagram for variety of chemicals including acids, chloro-alkalies, cement, lime, coal, coal chemicals, plastics, dyes and intermediates, pharmaceutical products, soap and detergents and many other products. Diploma holders utilize this skill to read and recognize each step of process flow diagrams during their job. The area of job may be production, R and D, design, technical services, project development, sales and marketing etc. Thus it is a key course every chemical engineer should develop mastery over it.

11. COMPETENCIES (Programme Outcome according to NBA Terminology):

The course content should be taught and implemented with the aim to develop different types of skills so that student is able to acquire following competencies.

1. **Prepare flow charts for manufacturing important chemicals in plants.**
2. **Prepare important chemicals in laboratory**

12. 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

D. COURSE DETAILS

Unit	Major Learning Outcomes (Course Outcomes in Cognitive Domain according to NBA terminology)	Topics and Sub-topics
Unit – I Acid And Alkali	**1a.** Classify chemical Industries	1.1 Scope and classification of chemical Industries
	1b. Describe properties and uses	1.2 Properties and uses of Sulphuric acid, HCL, soda ash and caustic soda
	1c. Prepare flow diagram and Explain manufacture	1.3 Manufacture of:(i) sulphuric acid by DCDA process (ii) Hydrochloric acid (iii)soda ash by Solvay process (iv)caustic soda byelectrolytic process
	1d. Explain major engineering problems	1.4 Major engineering problems of sulphuric acid and soda ash manufacturing
Unit– II Cement And Lime	2a. Describe cement and lime	2.1 Introduction of cement and lime **2.2** Properties and uses of cement and lime 2.3 Types of cement
	2b. Prepare flow diagram and explain manufacture	**2.4** Manufacture of Portland Cement and lime
	2c. Explain major engineering problems	**2.5** Major Engineering problems of cement industry
Unit– III Metallurgical Industries	3a. Describe various ores	3.1 Iron ores, bauxite and copper pyrites
	3b. Explain manufacture with neat figure	3.2 Production of pig iron by Bessemer process, Aluminum from bauxite; and extraction of copper from copper pyrites
Unit– IV Coal And Coal Chemicals	4a. Describe coal & coal chemicals	4.1. Types of coal and coal chemicals
	4b. 4c. Explain coal processes	4.2. Coking of coal 4.3. Distillation of coal tar 4.4. Gasification of coal 4.5. Hydrogenation of coal
Unit– V Polymers	5a. Classify polymers	5.1 Classification of polymers
	5b. Differentiate thermosetting and thermoplastic polymer	5.2 Thermosetting and thermoplastic polymers
	5c. Prepare flow diagram and	5.3 Manufacture of
	explain manufacture	(i) Polyethylene by Philips process

		(ii)Polyvinyl chloride (iii)Phenol formaldehyde (iv)Nylon 6,6 (v) Polyester Fibre
Unit– VI **Dyes And Intermediates**	**6a** Explain dye	6.1. Definition & applications of dye
		6.2. Classification of dyes
	6b Construct flow diagram	6.3. Manufacture of

Unit	**Major Learning Outcomes** (Course Outcomes in Cognitive Domain according to NBA terminology)	**Topics and Sub-topics**
	and explain manufacture	(i) Aniline by reduction of nitrobenzene, (ii) Anthraquinone 6.4. from phthalic anhydride, 6.5. Vat dye and 6.6. Reactive dye
Unit– VII Miscellaneous	**7a.** Describe soap and Detergent	7.1 Soap and detergent
	7b. Prepare flow diagram and Explain manufacture	7.2 Manufacture of (i) soap by 7.3 continuous hydrolysis and 7.4 saponification (ii) Linear Alkyl 7.5 Benzene(LAB)
	7c. Describe explosives and propellants	7.6 Explosives - Ammonium 7.7 nitrate, TNT and RDX **a.** Important Propellants

5. 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	Acids-Alkali	14	04	09	04	17
II	Cement and Lime	07	02	05	02	09
III	Metallurgical Industries	07	03	04	02	09
IV	Coal and Coal chemicals	05	02	04	01	06
V	Polymers	08	02	05	03	10
VI	Dyes and Intermediates	08	02	05	03	10
VII	Miscellaneous	07	03	04	02	09
	Total	56	18	36	17	70

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.

D. SUGGESTED LIST OF EXERCISES/PRACTICAL

The practical/exercises should be properly designed and implemented with an attempt to develop different types of practical skills **(Course 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 Course 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.	Unit No.	Practical/Exercise (Course Outcomes in Psychomotor Domain according to NBA Terminology)	Apprx. Hrs. Required
1	I	Standardize sulfuric acid solution	02
2	I	Standardize hydrochloric acid solution	02
3	I	Standardize sodium hydroxide solution	02
4	II	Prepare hydrated lime	02
5	III	Beneficiate ores	02
6	IV	Determine calorific value of coal	02
7	V	Prepare phenol formaldehyde	02
8	VI	Identify some polymers using simple tests	02
9	VI	Prepare nitrobenzene	02
10	VI	Prepare indigo dye	02
11	VI	Prepare vat dye	02
12	VI	Prepare reactive dye	02
13	VII	Prepare soap	02
14	VII	Prepare detergent	02
		Total	**28**

10. SUGGESTED LIST OF STUDENT ACTIVITIES

Following is the list of proposed student activities like: course/topic based presentations, internet based assignments, teacher guided self learning activities, and MCQ/Quiz. These could be individual or group-based.

8. SPECIAL INSTRUCTIONAL STRATEGIES (If Any)

i. More examples of Flow Charts should be discussed in the class to make concepts clear. Home Assignment should be given to students on preparing flow charts for more practice.

ii. Video/animation films may be shown for explaining abstract concepts and manufacturing process in industries.

iii. Samples of detailed flow charts from Industries may be collected and students may be asked to interpret them.

9. SUGGESTED LEARNING RESOURCES

11. List of Books:

S. No.	Title of Books	Author	Publication
1	Outlines of Chemical Technology, 3rd edition	M. Gopala Rao, Marshall Sittig	Affiliated East West Press (Pvt) Ltd-New Delhi
2	Shreve's Chemical Process Industries, 5tn edition	Austin G.T.	McGraw Hill publication –New Delhi
3	Chemical Technology -Vol. I and II, 2nd edition	G.N. Pandey and Shukla	Vani Books Company -Hyderabad
4	A Text Book on Petrochemicals, 2nd edition	Rao B. K. B.	Khanna Publishers – New Delhi

B. List of Major Equipment/Materials

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

- **List of Software/Learning Websites**

  - http://www.epa.gov/sectors/sectorinfo/sectorprofiles/chemical.html
  - www.emis.vito.be/sites/default/Bref_**cement**_and_**lime_production**.pdf
  - www.docbrown.info/page04/Mextract.htm
  - http://www.goiit.com/posts/show/0/content-general-principles-of-extraction-of-metals-804401.htm
  - http://www.contentshoppe.com/images/eLearning/sample2.swf
  - http://www.petrochemistry.net/coal-chemicals.html
  - http://www.auroma.in/propertiescoal.pdf

11. COURSE CURRICULUM DEVELOPMENT COMMITTEE

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- **Prof. S K Charola**, Lecturer in Chemical Engineering, Sir BPTI, Bhavnagar
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