Rashtrasant Tukadoji Maharaj Nagpur University

Direction No.22 of 2014

Direction issued under section 14(8) of the Maharashtra Universities Act, 1994, relating to B.Tech. V & VI Semester for the award of Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology Full Time in the Faculty of Engineering and Technology.

Whereas, the Maharashtra Universities Act No. XXXV of 1994 has come into force with effect from 22nd July, 1994

AND

Whereas, the amendment to the said Act came to be effected from 12th May, 2000

AND

Whereas, the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology have decided to make amendment related to V & VI Semester B. Tech. in Credit Based Semester Pattern for award of degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology Full time in the Faculty of Engineering and Technology.

AND

Whereas, the Faculty of Engineering and Technology in its meeting held on 28th May 2014 has considered and approved the V & VI Semester Credit Based Scheme of Examination, Syllabus and Absorption Scheme with the recommendations of the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology for its implementation from the academic session 2014-15 and onwards.

AND

Whereas, the recommendations made by the Board of Studies in General Engineering, Chemical Engineering, Chemical Technology and Biotechnology as approved by the Vice Chancellor pertains to Examination leading to the B.Tech. (Semester- V and Semester- VI) for award of degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology.

AND

Whereas, it is expedient to provide an Ordinance for the purposes of describing examination in the Credit Based semester pattern leading to the V and VI Semester for the award of Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology, indicating there in the syllabus and scheme of examination including absorption scheme and C.G.P.A and S.G.P.A.

AND

Now, therefore, I. Anoop Kumar, Vice Chancellor of Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur in exercise of powers vested in me under section 14(8) of the Maharashtra Universities Act, 1994, do hereby issue the following Direction pertaining to the amendment as made for Semester-V and Semester–VI for award of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology.

1. This Direction shall be called “Direction regarding Credit Based Semester Pattern Scheme and Examination leading to B. Tech. Semester-V and Semester – VI to the Degree of Bachelor of Technology in Chemical Engineering, Chemical Technology and Biotechnology in the Faculty of Engineering and Technology Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur.
2. Subject to the compliance with the provisions of this Direction and any other Ordinance which is in force from time to time shall be applicable

3. The Credit Based Scheme of Examination & Absorption Scheme Appendix for Semester–V and Semester-VI shall be as detailed in the following Table-1

TABLE-1

Sr. No.	**B.Tech. (Branch)**	**Board of Studies**	**Credit Based Scheme of Examinations & Absorption Scheme Appendix**
1.	Chemical Engineering	Chemical Engineering	**A**
2.	Chemical Technology	Chemical Technology	**B**
3.	Biotechnology	Biotechnology	**C**

The A.T.K.T. Rules shall be as given in Table – 2, given below:

TABLE – 2

Admission to Semester	**Candidate should have passed in all subject heads of following examination of the university**	**Candidate should have passed in all subject heads except in 1/3 passing subject heads of the following examination taken together**
I	As per eligibility	---
II	----	---
III	----	I and II Semester
IV	----	I and II Semester
V	I and II Semester	III and IV Semester
VI	I and II Semester	III and IV Semester
VII	III and IV Semester	V and VI Semester
VIII	III and IV Semester	V and VI Semester

4. Students falling under old scheme shall be provided maximum five attempts to clear the subject(s), after which they shall be absorbed in the new scheme.

Whereas, any student willing to opt for New Credit Based Semester Scheme shall be absorbed as per the appendices mentioned in **Table-1** at equivalent Credit Based Semester Scheme level. However, student will have to appear for the examinations under Credit Based Semester Scheme for the subjects in which student has not cleared the subject in Yearly Pattern Scheme

5. (i) The Scope of subject shall be as indicated in the syllabus.

(ii) The medium of instruction and examination shall be English.

6. The provisions of Ordinance No. 3 of 2007 relating to the award of grace marks for passing an examination or for securing higher division/class and for securing distinction in subject(s) as updated from time to time shall apply to the examination under this ordinance.

7. An Examinee who does not pass or who fails to present himself/herself for the examination(s) shall be eligible for **reappearing** in the same examination on payment of a fresh fee and as such other fees as may be prescribed from time to time. However, **readmission** to semester should be allowed only when a regular session is running for a particular semester.

8. The computation of Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA) of an examinee shall be implemented progressively as from the academic session 2014-15 onwards.

The marks will be allotted in all examinations which will also include college assessment marks. The total marks for each Theory/Practical subject head shall be converted into Grade points as per **Table - 3.**

SGPA shall be calculated based on Grade Points earned corresponding to percentage of marks as given in **Table - 3** and the Credits allotted to respective Theory/Practical subject head shown in the scheme of examination for respective semester.

9. SGPA shall be computed for every semester and CGPA shall be computed only in VIII semester. The CGPA of VIII semester shall be calculated based on **SGPA** of V to VIII semester as per following computation:-

$$\text{SGPA} = \frac{\sum_{i=1}^{m} Ci.Gi}{\sum_{i=1}^{m} Ci} = \frac{C1.G1 + C2.G2 + \ldots.. + Cm.Gm}{C1 + C2 + \ldots\ldots + Cm}$$

Where, m = Number of subject heads in a given Semester.

$$\text{CGPA} = \frac{\sum_{j=1}^{n} Cj.Gj}{\sum_{j=1}^{n} Cj} = \frac{C1.G1 + C2.G2 + \ldots.. + Cn.Gn}{C1 + C2 + \text{-------} + Cn}$$

Where, n = Number of subject heads from V to VIII Semester taken together.

Ci or Cj = Credit of individual subject head (Theory/Practical).

Gi or Gj = Grade Point earned in individual subject head (Theory/practical).

10. CGPA equal to 6.75 and above shall be considered as equivalent to First Division and CGPA equal to 8.25 and above shall be considered as equivalent to Distinction on Grade Card of VIII Semester as a foot note. Equivalent percentage calculation will be based on the following formula:

$$\text{Equivalent \%} = (\text{CGPA} - 0.75) \times 10$$

TABLE-3

THEORY			PRACTICAL		
Grade	**Percentage of Marks**	**Grade Points**	**Grade**	**Percentage of Marks**	**Grade Points**
AA	80 ≤Marks≤ 100	10	AA	85 ≤Marks≤ 100	10
AB	70 ≤Marks< 80	9	AB	80 ≤Marks< 85	9
BB	60 ≤Marks< 70	8	BB	75 ≤Marks< 80	8
BC	55 ≤Marks< 60	7	BC	70 ≤Marks< 75	7
CC	50 ≤Marks< 55	6	CC	65 ≤Marks< 70	6
CD	45 ≤Marks< 50	5	CD	60 ≤Marks< 65	5
DD	40 ≤Marks< 45	4	DD	50 ≤Marks< 60	4
FF	00 ≤Marks< 40	0	FF	00 ≤Marks< 50	0
ZZ	Absent in Examination	-	ZZ	Absent in Examination	-

11. As Soon as possible, after the examination, the Board of Examinations shall publish a list of successful examinees and the Degree shall be awarded based on V to VIII Semester SGPA and CGPA calculated thereon.

12. I, further directed that the aforesaid Direction shall come into force from the date of issuance and shall remain in force till the relevant Ordinance comes into being in accordance with the provisions of Maharashtra Universities Act, 1994 and the relevant provisions published by this Direction shall be physically repealed from the existing Ordinance.

Sd/-

. (Anoop Kumar)

Vice Chancellor

Nagpur:

Dated::18/6/2014

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APPENDI X – A
SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
FIFTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr.				Credit				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 501T	Fluid Mechanics	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 502T	Chemical Engineering Thermodynamics	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 503T	Mass Transfer	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 504T	Heat Transfer	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 505T	Biochemical Engineering	BCHE	3	-	-	3	3	-	-	3	20	80	-	-	**100**
6.	BTCHE 506P	Fluid Mechanics	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 507P	Mass Transfer	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8.	BTCHE 508P	Heat Transfer	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
			Total	**15**	**9**	**4**	**28**	**15**	**6**	**4**	**25**	**100**	**400**	**75**	**75**	**650**

SCHEME OF EXAMINATION
RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR
SIXTH SEMESTER B.TECH (CHEMICAL ENGINEERING)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Teaching Scheme, hr.				Credit				MARKS				**Total Marks**
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHE 601T	Separation Processes	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
2.	BTCHE 602T	Environmental Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
3.	BTCHE 603T	Process Equipment Design	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
4.	BTCHE 604T	Chemical Reaction Engineering	BCHE	3	-	1	4	3	-	1	4	20	80	-	-	**100**
5.	BTCHE 605T	Elective-I	BCHE	3	-	-	3	3	-	-	3	20	80	-	-	**100**
6.	BTCHE 606P	Environmental Engineering	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
7.	BTCHE 607P	Process Equipment Design	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8	BTCHE 608P	Separation Processes	BCHE	-	3	-	3	-	2	-	2	-	-	25	25	**50**
8.	BTCHE 609P	Minor Project	BCHE	-	2	-	2	-	1	-	1	-	-	50	-	**50**
			Total	**15**	**11**	**4**	**30**	**15**	**7**	**4**	**26**	**100**	**400**	**125**	**75**	**700**

Elective	Subject Name				
	BOARD				
	BTCHE				
Elective-I	1.Human Behavior in Organization	2. Materials Management	3. Marketing Management	4. Advanced Materials	5. Renewable Energy Sources

Scheme of Absorption for Old Pattern to Semester Pattern of 5th Semester B. Tech. (Chemical Engineering)							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme		
Fifth Semester B. Tech (Chemical Engineering)					Fifth Semester B. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	5SCE1 (BChE)	Fluid Mechanics	Theory		BTCHE 501T	Fluid Mechanics	Theory
2	5SCE2 (BChE)	Chemical Engineering Thermodynamics	Theory		BTCHE 502T	Chemical Engineering Thermodynamics	Theory
3	------	------			BTCHE 503T	Mass Transfer*	Theory
4	------	------			BTCHE 504T	Heat Transfer*	Theory
5	5SCE3 (BChE)	Environmental Eng. and Biotechnology	Theory		BTCHE 505T	Biochemical Engineering	Theory
6	5SCE4 (BChE)	Applied Mathematics III	Theory		------	------	
7	5SCE5 (BChE)	Plant Design –I	Theory		------	------	
8		Fluid Mechanics	Practical		BTCHE 506P	Fluid Mechanics	Practical
9		------	------		BTCHE 507P	Mass Transfer**	Practical
10		------	------		BTCHE 508P	Heat Transfer**	Practical
11		Industrial Waste Treatment	Practical		------	------	

*** Students to appear in university theory examination as per the new scheme**

**** Students to appear in university practical examination as per the new scheme**

Scheme of Absorption for Old Pattern to Semester Pattern of 6th Semester B. Tech. (Chemical Engineering)							
As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme		
Sixth Semester B. Tech (Chemical Engineering)					Sixth Semester B. Tech (Chemical Engineering)		
Sr. No.	**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory/ Practical**
1	6SCE1 (BChE)	Organic Chemical Process Industries	Theory		------	------	
2	------	------			BTCHE 601T	Separation Processes*	Theory
3	------	------			BTCHE 602T	Environmental Engineering*	Theory
4	------	------			BTCHE 603T	Process Equipment Design*	Theory
5	6SCE2 (BChE)	Heat Transfer	Theory		------	------	
6	6SCE 3 (BChE)	Mass Transfer – I	Theory		------	------	
7	6SCE4 (BChE)	Chemical Reaction Engineering- I	Theory		BTCHE 604T	Chemical Reaction Engineering	Theory
8	6CSE5 (BChE)	Process Control – I	Theory		------	------	
9	------	********			BTCHE 605T	Elective-I$	Theory
10	------	------			BTCHE 606P	Environmental Engineering**	Practical
11	------	------			BTCHE 607P	Process Equipment Design**	Practical
12	------	------			BTCHE 608P	Minor Project**	Practical
13		Heat Transfer	Practical		------	------	
14		Organic Chemical Technology	Practical		------	------	
15		Instrumental Methods of Analysis	Practical		------	------	

*** Students to appear in university theory examination as per the new scheme**

**** Students to appear in university practical examination as per the new scheme**

$ This subject is exempted

APPENDIX – B
SCHEME OF EXAMINATION
B. TECH (CHEMICAL TECHNOLOGY)
FIFTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No	Code Theory (T) Practical (P)	Subject	Board	Workload				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT501T	Fluid Flow Operation	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT502T	Solid Fluid Operations	BCHT	3	-	-	3	3	-	-	3	20	80	-	-	100
3.	BTCHT503T	Chemical Equipment Design	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
4.	BTCHT 504T	Process Plant Utilities	BGE	3	-	-	3	3	-	-	3	20	80	-	-	100
5.	BTCHT505T	*Special Technolog-III	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
6.	BTCHT506P	Fluid Flow Operation	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
7.	BTCHT507P	Solid Fluid Operations	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
8.	BTCHT508P	Chemical Equipment Design	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
Total				15	9	3	27	15	6	3	24	100	400	75	75	650

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- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

SCHEME OF EXAMINATION
B. TECH (CHEMICAL TECHNOLOGY)
SIXTH SEMESTER B.TECH (CHEMICAL TECHNOLOGY)

Sr. No.	Code Theory (T) Practical (P)	Subject	Board	Workload				Credit				MARKS				Total Marks
												Theory		Practical		
				L	P	T	Total	L	P	T	Total	Sessional	University	Sessional	University	
1.	BTCHT 601T	Process Engineering Thermodynamics	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
2.	BTCHT602T	Heat Transfer Operations	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
3.	BTCHT603T	Chemical Process Control	BCHT	3	-	-	3	3	-	-	3	20	80	-	-	100
4.	BTCHT604T	Environmental Engineering	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
5.	BTCHT605T	*Special Technology IV	BCHT	3	-	1	4	3	-	1	4	20	80	-	-	100
6.	BTCHT606P	Heat Transfer Operations	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
7	BTCHT607P	Environmental Engineering	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
8.	BTCHT608P	*Special Technology II	BCHT	-	3	-	3	-	2	-	2	-	-	25	25	50
9.	BTCHT 609P	Minor Project	BCHT	-	2	-	2	-	1	-	1			50	--	50
Total				15	11	4	30	15	7	4	26	100	400	125	75	700

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- Food Technology
- Technology of Oils, Fats and Surfactants
- Petroleum Refining and Petrochemical Technology
- Pulp & Paper Technology
- Plastics & Polymer Technology
- Surface Coating Technology

Scheme of Absorption for Old Pattern to Semester Pattern of Third Year B. Tech. (Chemical Technology)

As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern) Fifth Semester B. Tech (Chemical Technology)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme Fifth Semester B. Tech (Chemical Technology)		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	5S.CT.1 (BChE)	Fluid Mechanics and Mechanical Operations	Theory		BTCHT 501T (BCHT)	Fluid Flow Operation	Theory
2					BTCHT 502T (BCHT)	Solid Fluid Operations	Theory
3	5S.CT.2 (BChE)	Plant Design	Theory		BTCHT 503T (BCHT)	Chemical Equipment Design	Theory
4	---	-----	---		[1]BTCHT 504T (BGE)	Process Plant Utilities	Theory
5	5S.CT.3 (BChE)	Heat Transfer	Theory		---	-----	---
6	5S.CT.4 (BGE)	Organic Chemical Process Industries	Theory		---	-----	---
7	5S.CT.5 (BCT)	Special Technology III	Theory		BTCHT 505T (BCHT)	Special Technology III	Theory
8	5S.CT.6 (BChE)	Unit Operations	Practical		BTCHT 506P (BCHT)	Fluid Flow Operation	Practical
9					BTCHT507P (BCHT)	Solid Fluid Operations	Practical
10	------	--------	--------		BTCHT508P (BCHT)	Chemical Equipment Design	Practical
11	5S.CT.7 (BChE)	Heat Transfer	Practical		--------	---------	--------
12	5S.CT.8 (BGE)	Organic Chemical Technology	Practical		---------	---------	--------

[1]Subject is covered in Fourth Semester for Old Pattern according to subject (4S.CT.2) Plant Utilities (Theory). They may be exempted.

Scheme of Absorption for Old Pattern to Semester Pattern of Third Year B. Tech. (Chemical Technology)

As Per Rashtrasant Tukadoji Maharaj Nagpur University (Old Pattern) Sixth Semester B. Tech (Chemical Technology)					As Per Rashtrasant Tukadoji Maharaj Nagpur University Credit Based Semester Pattern Scheme Sixth Semester B. Tech (Chemical Technology)		
Sr. No	**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**		**Sub Code Theory/ Practical**	**Subject**	**Theory Practical**
1	6S.CT.1 (BGE)	Applied Mathematics III	Theory		---	-----	---
2	6S.CT.2 (BChE)	Mass Transfer	Theory		---	-----	---
3	6S.CT.3 (BChE)	Environmental Engineering and BioTechnology	Theory		BTCHT 604T (BCHT)	Environmental Engineering	Theory
4	6S.CT.4 (BChE)	Chemical Engineering Thermodynamics	Theory		BTCHT 601T (BCHT)	Process Engineering Thermodynamics	Theory
5	6S.CT.5 (BCT)	Special Technology IV	Theory		BTCHT 605T (BCHT)	Special Technology IV	Theory
6	6S.CT.6 (BChE)	Mass Transfer	Practical		---	-----	---
7	6S.CT.7 (BGE)	Industrial Waste Treatment	Practical		---	-----	---
8	6S.CT.8 (BCT)	Special Technology II	Practical		BTCHT 608P (BCHT)	Special Technology II	Practical
9	---	-----	---		BTCHT 603T (BCHT)	Chemical Process Control	Theory
10	---	-----	---		[1]BTCHT 602T (BCHT)	Heat Transfer Operations	Theory
11	---	-----	---		[2]BTCHT 606P (BCHT)	Heat Transfer Operations	Practical
					BTCHT607P (BCHT)	Environmental Engineering	Practical
12	---	-----	---		BTCHT 609P (BCHT)	Minor Project	Practical

[1]Subject is covered in Fifth Semester for Old Pattern according to subject (5S.CT.3) Heat Transfer (Theory). They may be exempted.

[2]Subject is covered in Fifth Semester for Old Pattern according to subject (5S.CT.7) Heat Transfer (Practical). They may be exempted

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for

Fifth Semester B.Tech. Chemical Engineering

Subject : BTCHE 501T (BCHE) **Fluid Mechanics (Theory)**
Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

UNIT 1: Classification of fluid mechanics, Properties of fluids, Classification of fluids, Shearing and flow, characteristics of Newtonian and Non-Newtonian fluids, Shear stress distribution of fluids, Pressure measurement, U-tube, Inverted U-tube, Differential and Inclined manometers, Reynolds number, Friction factor

UNIT 2 : Bernoulli`s equation, Frictional loss in pipe, Continuity equation, Velocity distribution for, laminar flow and turbulent flow, Hydraulic mean diameter, losses due to enlargement and contraction of pipe cross - section.

UNIT 3 : Equivalent length of pipe, Pipe fittings, Gate , Globe, Check and Butterfly valves, Boundary layer development, Two-phase flow, Flow patterns in two phase flow. The Baker diagram, Erosion in two phase flow.

UNIT 4 : Flow rate measurement, Working principle and expressions for flowrate through Pitot tube, Orifice meter, Venturimeter, Nozzle, Rotameter, Notch and Weir, Coefficient of discharge, Wet gas flowmeter, Pressure recovery in Orificemeter, Venturimeter and Nozzle.

UNIT 5 : Pumping of fluids, Classification of pumps, Positive displacement pumps, Reciprocating, Pump, Plunger pump, Diaphragm pump, Metering pump, Rotary gear pump, Rotary lobe Pump, Rotary vane pump, Flexible vane pump, Mono pump, Cetrifugal pump, Volute pump, Volute pump with vortex chamber and diffuser vanes, Cavitation, Priming,Net positive suction head ,Multistage centrifugal pumps. Specific speed and operating characteristics of centrifugal pump.

UNIT 6 : Fluid flow in packed column, Classification of packings, Characteristics of packing material, Loading and flooding in packed column,Specific surface of packed column, Permeability coefficient, Modified Reynolds number, Modified friction factor, Kozeny`s,Carman`s, Sawistowski`s and Ergun`s equations for packed column. Characteristics of fluidization, Aggregative and particulate fluidization, Incipient fluidization velocity, equations for pressure drop across fluidized column, Applications of packed and fluidized column.

Books Recommended:

1. R. P. Vyas, Fluid Mechanics, Second edition, Denett & Co. Publication, 2008.
2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier
3. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
4. G.G. Brown, Unit Operations, CBS Publishers Pvt. Ltd, 2005.

5. W.L. Badger, J.T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Education, 1997.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.

Subject : BTCHE 502T (BCHE) **Chemical Engineering Thermodynamics (Theory)**

Lecture	: 3 Hours	Tutorial: 1 Hour	No. of Credits	: 4
University	: 80 Marks		College Assessment	: 20 Marks

Duration of Examination: 3 Hours

Unit I: Basics of Thermodynamics

Review of laws of thermodynamics, Equations of state, Maxwell relationships, homogeneous phases, residual properties, heat effects, two-phase systems, Clausius- Clapeyron equation

Unit II: Compression of Fluid

Flow of compressible fluids, measurement of flow of compressible fluids, convergent-divergent nozzles, supersonic flow, Compression of fluids, single and multistage compression, centrifugal and reciprocating compressors-construction and working

Unit III: Refrigeration

Review of refrigeration cycles, Joule-Thomson expansion, compression and absorption refrigeration, refrigerants and their properties, estimation of power requirements of refrigeration systems, heat pumps.

Unit IV: Solution Thermodynamics

Fundamental property relations, chemical potential, criteria for phase equilibrium, partial properties, ideal gas mixtures, fugacity and fugacity coefficients for pure species, for species in solution, ideal solutions, Excess properties, VLE data- fugacity, Activity coefficients, Excess Gibb's energy, Margules and Van Laar equation, Property changes of mixing

Unit V: Phase Equilibria

Vapour – liquid equilibrium: The nature of equilibrium, criteria of equilibrium, phase rule, Duham's theorem, Raoult's law, VLE by modified Raoult's law, dew point and bubble point calculations, Flash calculations, Determine whether azeotrope exist**,** Equilibrium and stability, liquid -liquid equilibrium, solid-liquid equilibrium, VLL equilibrium

Unit VI: Chemical Reaction Equilibria

Criteria for equilibrium to chemical reactions, the standard Gibbs free energy change and the equilibrium constant. Effect of temperature on equilibrium constant, evaluation of the equilibrium constant, relation of equilibrium constant to composition, calculation of equilibrium conversion for single reaction, The phase rule and Duhem's theorem for reacting systems, multireaction Equilibria

Books Recommended:

1) J.M. Smith, H.C. Van Ness, M.M. Abbott, Introduction to Chemical Engineering Thermodynamics, 6th Edition, McGraw Hill, 2001.
2) K.V. Narayanan, Chemical Engineering Thermodynamics, Prentice-Hall India, 2006.
3) Y.V.C. Rao, Chemical Engineering Thermodynamics, Universities Press, 1997.
4) B.G. Kyle, Chemical & Process Thermodynamics, 3rd Edition, Prentice Hall, New Jersey, 1999.
5) O.A. Hougen, K.M. Watson, and R.A. Ragatz, Chemical Process Principles Part II, Thermodynamics, John Wiley, 1970.
6) R. Reid, J. Praunitz, T. Sherwood, The Properties of Gases and Liquids, 3rd Edition, McGraw-Hill, New York, 1977.

Subject : BTCHE 503T (BCHE) **Mass Transfer (Theory)**
Lecture : 3 Hours Tutorial:1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I: Introduction to Mass Transfer and Molecular Diffusion

Introduction to mass transfer, concept of diffusivity, Molecular diffusion in gases, liquids and solids, diffusivities of gases and liquids, types of diffusion, Fick's and Maxwell law of diffusion, Eddy diffusion, Steady state molecular diffusion. Empirical equations used to determine diffusivity through gas and liquid

Unit II: Mass Transfer Coefficient and Interphase Mass Transfer

Concept of mass transfer coefficients, their relationship, mass transfer under laminar and turbulent flow past solids, boundary layers, mass transfer at fluids surfaces correlation of mass transfer coefficients, J_D, HTU, and NTU concepts, theories of mass transfer, interphase mass transfer and overall mass transfer coefficients, application to gas-liquid and liquid-liquid systems.

Unit III: Humidification and Dehumidification

General principles, vapour-liquid equilibria, enthalpy of pure substances, wet bulb temperature relation, psychrometric chart, Lewis relation, methods of humidification and dehumidification, cooling towers & calculation of height of cooling tower – HTU, NTU concept,.

Unit IV: Drying

Introduction and Principles of drying, equilibrium in drying, type of moisture binding, mechanism of drying, continuous drying, time required for drying, mechanism of moisture movement in solid, heat & mass balance in drying, drying equipments and their design principles.

Unit V: Adsorption and Ion Exchange

Basic principle and equilibria in adsorption. Types of adsorption – Physical and chemical, adsorption isotherms- Langmuir and Freundlich, Single gases and vapors, Introduction to pressure Swing Adsorption (PSA), and Temperature Swing Adsorption (TSA), Equipments: Continuous Contact: steady state– moving bed Absorbers. Ion Exchange- Principles of Ion Exchange, Techniques and applications, Equilibria and rate of ion exchange, equipments

Unit VI: Crystallisation

Crystallization fundamentals, solubility and saturation, Miers theory of crystallization, crystal nucleation, crystal growth, population balance and size distribution, material and energy balances, crystallization equipments, fractional crystallization, freeze crystallization, , calculations of yield.

Books Recommended:

1. R.E. Treybal, Mass Transfer Operations, 3rd Edition, McGraw Hill, 1980.
2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier
3. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier.
4. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003.

5. B.K. Dutta, Principles of Mass transfer and separation processes. PHI Learning, 2013.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.

Subject : BTCHE 504T (BCHE) **Heat Transfer (Theory)**
Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I: Concept of Heat Transfer

Introduction & mechanism of heat transfer. Development and use of general differential equation for heat transfer rate & temperature distribution for steady state heat conduction for various shapes & geometries of solids with various boundary conditions, with & without heat generation.

Unit II: Unsteady State Heat Transfer, Fins & Insulation

Use of lumped capacitance, Heisler charts and error function methods for unsteady state heat transfer. Classification of fins. Fin efficiency and overall effectiveness. Classification and selection of various types of thermal insulations. The concept of critical and economical thickness of insulation and its evaluation for cylindrical and spherical heat transfer equipment.

Unit III: Natural & Forced Convection: Heat Transfer without Phase Change

Introduction to natural and forced convection in laminar and turbulent flow over flat plate, over cylinder & sphere and through closed channels. Concept and use of thermal & hydrodynamic boundary layer and its significance. Prediction of heat transfer coefficient using theoretical, empirical and analogies concepts.

Unit IV: Condensation & Boiling : Convection Heat Transfer with Phase Change

Mechanism of condensation: Nusselt's approach and its extension. Heat transfer in saturated pool & forced convection boiling of liquids. Study of Boiling curve : Its significance and relevance in constant wall temperature & constant heat flux boiling with specific reference to critical (Maximum) heat flux and minimum heat flux (Ladenfrost point).

Unit V: Heat Exchangers & Evaporators

Concept of fouling resistance & overall heat transfer coefficient in heat exchangers. Classification of heat exchangers. Design and rating of double pipe, shell and tube heat exchangers by LMTD and ε-NTU methods. Compact heat exchangers: Plate heat exchangers, helical coil heat exchangers, spiral heat exchangers, regenerators. Classification of evaporators. Steam economy and capacity of multiple effect evaporators. Design considerations of evaporators..

Unit VI: Radiation & Special Cases of Heat Transfer

Radiation fundamentals, properties of materials and heat exchange. Use of solar energy & thermic fluids. Heat transfer in furnaces, agitated vessels, fluidized beds, packed beds, jacketed vessels, immersed helical and spiral coil equipment.

Books Recommended:

1. B.K. Dutta, Heat transfer Principles and Applications, PHI Private Limited, 2001.
2. S.D. Dawande, Principles of Heat Transfer and Mass Transfer, Denett & Co, 2009.
3. R.K. Rajput, Heat and Mass Transfer, S. Chand & Company Ltd., 2007.
4. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003
5. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier

6. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
7. J. M. Coulson, J. F. Richardson, R. K. Sinnott, Chemical Engineering Vol. 6 - Design, Pergamon Press, 1983
8. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.
9. D.S. Kumar, Basics of Heat & Mass Transfer, Eight Edition, S.K. Kataria & Sons, 2010.
10. W.L. Badger, J.T. Banchero, Introduction to Chemical Engineering, Tata McGraw Hill Education, 1997.

Subject : BTCHE 505T (BCHE) **Biochemical Engineering (Theory)**
Lecture : 3 Hours No. of Credits : 3
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I: Introduction to bio-processing fundamentals, overview of microbiology, importance of microbiology, introduction to biochemistry

Unit II: Classification of enzymes, immobilization of enzymes, industrial applications of enzymes, requirement of fermentation process, media design for fermentation, aerobic and anaerobic fermentation processes, solid state fermentation and submerged fermentation.

Unit III: Kinetics of microbial growth, kinetic models, substrate and product inhibition and cell growth, design equations based on biochemical reactions, design of ideal reactors, multiple reactors, related examples etc.

Unit IV: Bioreactors and Fermenters, monitory and control of fermentation processes, various accessories, cultivation and media optimization, product recovery by various unit operations

Unit V: Rheology and mixing in fermentation broths, evolution of rheological data, heat and mass transfer in bioprocessing

Unit VI: Importance of sterilization, thermal death kinetics, batch and continuous sterilization, design and analysis of bioreactor, chemical and biological methods of effluent treatment

Books Recommended:

1. D.G. Rao, Introduction to Biochemical Engineering, Tata McGraw Hill Education, 2010.
2. M. L Shuler, F. Kargi, Bioprocess Engineering – Basic Concepts, 2nd Edition, Prentice Hall Publication, 2003.
3. J.E. Bailey, D.E. Ollis, Biochemical Engineering Fundamentals, 2nd Edition, McGraw-Hill, Inc., 1986.
4. A. Whitekar, P. F. Stanbury, S. J. Hall, Principles of Fermentation Technology, 2nd Edition, Butterworth-Heinemann, 1999.
5. S. Aiba, A. E. Humphrey and N. F. Millis, Biochemical Engineering, 2nd Edition, Academic Press, New York, 1973.
6. B. Atkinson, Biochemical reactors, Pion Limited, London, 1974.

Subject : BTCHE 506P (BCHE) **Fluid Mechanics (Practical)**
Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. Verification of Bernoulli's equation
2. To calibrate venturimeter and obtain its coefficient of discharge
3. To calibrate orificemeter and obtain its coefficient of discharge
4. To calibrate rotameter
5. To calibrate notched weir and obtain its coefficient of discharge
6. Friction factor vs. Reynolds number for flow of water in pipe
7. Friction factor vs. Reynolds number for flow of air in pipe
8. To study the relationship between fanning friction factor and Reynolds number for a fluid flowing though coils
9. To obtained equivalent length of pipe for various fitting.
10. Operating characteristics of centrifugal pump
11. To study the hydrodynamic characteristics of a packed bed
12. To study the hydrodynamic characteristics of a fluidized bed
13. Studies in two phase flow

Subject : BTCHE 507P (BCHE) **Mass Transfer (Practical)**
Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. Winkelmann's method – To find the diffusion Coefficient of vapour in still air
2. Liquid Diffusion – To find the Diffusion Coefficient for a liquid –liquid system
3. To calculate rate of Drying.
4. Studies of crystallization phenomena in Batch Crystallization
5. To evaluate the performance of Cooling Tower.
6. To find the mass transfer coefficient in a wetted wall Column
7. Determination of solid-liquid mass transfer coefficient.
8. Evaporation from free surface.
9. Determination of HTU in packed bed.
10. Study of Ion exchange process.
11. Removal of impurities by use of adsorption techniques.

Subject : BTCHE 508P (BCHE) **Heat Transfer (Practical)**
Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To determine total thermal resistance and thermal conductivity of composite wall
2. To determine thermal conductivity of lagging material
3. To determine the air film heat transfer coefficient by natural convection using fin concept.
4. To determine the air film heat transfer coefficient by forced convection using fin concept.
5. To determine Stefan – Boltzman constant for radiation heat transfer
6. To determine convective heat transfer coefficient (while cooling and heating) from the transient response data, with the help of Heisler chart for an infinite cylinder
7. To determine convective heat transfer coefficient (while cooling and heating) from the transient response data, with the help of Heisler chart for Rectangular bar
8. Prediction of thermal conductivity of unknown material using Heisler chart
9. To determine the overall heat transfer coefficient for heating in jacketed enamelled kettle
10. To study boiling phenomenon in a jacketed kettle with and without stirring.
11. To determine overall heat transfer coefficient in shell and tube heat exchanger
12. To determine the overall heat transfer coefficient in CSTR
13. To study the heat transfer in plate type heat exchanger and calculate the overall heat transfer coefficient
14. To verify Dittus- Boelter equation for vertical tube exchanger
15. To determine and verify the relationship between overall heat transfer coefficient and velocity of fluid as suggested by Wilson
16. To determine heat transfer in fin and finless heat exchanger and evaluate fin effectiveness and fin efficiency
17. Verification of Nussult equation for filmwise condensation on the outer surface of inner tube in vertical concentric tube heat exchanger

Rashtrasant Tukadoji Maharaj Nagpur University

Faculty of Engineering & Technology
Syllabus for
Sixth Semester B.Tech. Chemical Engineering

Subject : BTCHE 601T (BCHE) **Separation Processes (Theory)**
Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I & II: Distillation

Vapour – liquid equilibria for ideal and non-ideal systems, positive and negative deviations from ideality, relative volatility. Methods of distillation - differential, flash, low pressure, batch rectification, Continuous rectification for binary system, multistage (tray) towers, Lewis – Sorel, McCabe Thiele Method, Multiple feeds, side streams, tray efficiencies, concept of reflux, Underwood-Fenske equation, Partial and total Condensers, reboilers, Ponchon Savarit method, steam distillation, extractive and azeotropic distillation, Reactive Distillation, Packed towers for distillation, NTU, HTU, HETP concept and calculations, Equipments, Design Aspects

Unit III: Gas Absorption

Mechanism of gas absorption, equilibrium in gas absorption, absorption in wetted wall columns, estimation of transfer coefficient, absorption in packed tower and spray tower, calculation of HETP, HTU, NTU, calculation of height of packed and spray tower. Absorption in tray towers, absorption and stripping factors, tray efficiencies, calculation of number of trays for absorption, Equipments for absorption

Unit IV: Liquid – Liquid Extraction

Liquid-liquid equilibria, single stage extraction, multistage crosscurrent, countercurrent and cocurrent extraction, calculations based on triangular diagrams, stage efficiency, Continuous contact extraction in packed towers, HTU and NTU concept, Equipments for extraction

Unit V: Solid – Liquid Extraction

General principles, continuous leaching, ideal stage equilibrium, Calculation for number of stages, constant and variable underflow, stage efficiencies, right angle triangle diagram, Leaching equipments

Unit VI: Novel Techniques

Introduction and types of membrane separation processes, Membrane separation techniques- microfiltration, ultrafiltration. Nanofiltration, reverse osmosis, dialysis, pervaporation, gas permeation membrane process, molecular sieves. Other advanced separation processes, selection of separation processes for downstream processing.

Books Recommended:

1. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. I: Fluid Flow, Heat Transfer and Mass Transfer, Sixth Edition, Butterworth-Heinemann an imprint of Elsevier

2. J.M. Coulson, J.F. Richardson with J.R. Backhurst, J.H. Harker, Chemical Engineering Vol. II: Particle Technology and Separation Processes, Fifth Edition, Butterworth-Heinemann an imprint of Elsevier
3. R.E. Treybal, Mass Transfer Operations, 3rd edition, McGraw Hill, 1980.
4. C.J. Geankoplis, Transport Processes and Separation Process Principles, 4 Edition, Prentice Hall, 2003
5. S. L. Pandharipande, Principles of Distillation, Dennet and Co.
6. W.L. McCabe, J.C. Smith, P. Harriott, Unit Operations of Chemical Engineering, Seventh Edition, McGraw Hill Publication, 2005.
7. B.K. Dutta, Principles of Mass transfer and separation processes, PHI Learning, 2007.
8. J. D. Seader, E. J. Henley, Separation Process Principles, Wiley, 1998.

Subject : BTCHE 602T (BCHE) **Environmental Engineering (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Environmental Pollutants

Sources & characterization of various pollutants. Concepts of biodegradability, biosorption, biomagnifications. Measurement : COD, BOD, TOD, ThOD, soluble, suspended, volatile solids, ammonical nitrogen. Mathematical model for BOD. Re-oxygenation and de-oxygenation in natural purification process.

Unit II: Natural Process of Water & Air Pollution Control

Mathematical analysis by Streeter-Phelps of oxygen sag curve in natural purification of waste water. Determination of stack height and plume rise. Meteorological parameters and their effects on dilution/dispersion of pollutants present in flue/exhaust gases coming out from stationery and moving sources. Prediction of pollutant concentration downstream of discharge point. Plume behavior.

Unit III: Air Pollution Management

Basic design and operating principles of wet & dry equipments for removal of particulate and gaseous pollutants. Control of air pollution by process changes.

Unit IV: Water Pollution Management

Principles of primary secondary, tertiary and advanced treatment of waste water. Aerobic and anaerobic processes in ponds and lagoons. Basic process design and operating principles of various activated sludge (suspended growth) processes. trickling filter & rotating biological contactor (Attached growth). Special reactors.

Unit V: Solid Waste Pollution Management:

Solid waste management by dumping, landfill, incineration, composting, vermiculture; using bioremediation for specific pollutants like chromium. Mercury, ammonia / urea, phenolic sludge. E-waste. Hazardous waste management.

Unit VI: Pollution Control in Selected Process Industries & Major Issues

Pollution in fertilizer industries, petroleum refineries and petrochemical units, pulp and paper industries, Sugar industries, Dairy, Alcohol industries. Radioactive wastes. Case studies. Environmental impact assessment (EIA), Environmental audit, Major disasters, global environmental policies and national strategies.

Books Recommended:

1. Metcalf and Eddy, Wastewater Engineering: Treatment, Disposal and Reuse, Tata McGraw-Hill Pub.Co.Ltd., New Delhi, 1979.
2. S.P. Mahajan, Pollution Control in Process Industry, Tata McGraw Hill Publishers, 1987.
3. G.N. Pandey, G.C. Camey, Environmental Engineering, Tata McGraw-Hill Pub.Co.Ltd., 1992.
4. H.S. Peavy, D.R. Rowe, G. Tchobanoglous, Environmental Engineering, McGraw-Hill, 1986.
5. C.N. Sawyer, P.L. McCarty, G.F. Parkin, Chemistry for Environmental Engineering, Tata-McGraw-Hill Edition, 2003.
6. B.C. Punmia, A.K. Jain, A. K. Jain, Wastewater Engineering, Laxmi Publications, 2005.
7. S.K. Garg , Sewage Disposal and Air Pollution Engineering, Khanna Publishers, 2010.
8. M.N. Rao, H.V. Rao, Air Pollution, McGraw-Hill Europe, 1989.

Subject : BTCHE 603T (BCHE) **Process Equipment Design (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Introduction to Principles of Design

Nature of process equipments, general design procedure, basic considerations in design, standards, codes, and their significance, equipment classification and their selection, design pressure, design temperature, design stress, review of fabrication techniques and environmental considerations in design procedure. Principal stresses, theories of failure . Materials of construction and selection for process equipments, linings and coatings for equipments.

Unit II: Pressure Vessel

Proportioning of pressure vessels, selection of L/D ratio, optimum proportions of vessels. Design of unfired pressure vessels subjected to combined loading, purging of vessels.

Selection and design of various heads such as flat, hemispherical, torispherical, elliptical and conical, Opening/ nozzles, manholes, Nozzle reinforcement design, etc. Flanged joints, classification of flanges, design of non standard flanges, types of Gaskets their selection, and design. Bolt design and selection.

Unit III: Design of Pressure Vessels Subjected To External Pressure and High Pressure Vessels

Pressure vessels subjected to external pressure: Design of shell, heads, nozzles, flanged joint, stiffening rings.

Design of thick cylinder, pre-stressing, Analysis and design of high pressure vessels: monoblock and compound (multilayer), etc.

Unit IV: Vessel Support

Introduction and classification of supports, design of skirt supports, stresses due to dead weight, wind load, seismic load, and period of vibration, design of base plate, skirt, bearing plate, anchor bolts, bolting chairs, design of bracket supports. Design of saddle supports, ring stiffeners, etc.

Unit V: Storage Vessels

Various types of storage vessels and applications, Atmospheric vessels, vessels for storing volatile and nonvolatile liquids, storage of gases, Losses in storage vessels, Various types of roofs used for storage vessels, manholes, nozzles and mountings. Design of cylindrical and spherical storage vessels; should include base plates, shell plates, roof plates, wind girders, curb angles for self supporting and column supported roofs.

Unit VI: Agitators and Reaction Vessels

Types of agitators, their selection, applications, baffling, power consumption which includes twisting moment, equivalent bending moment, design of blades etc.

Reaction vessels- Introduction, classification, heating systems, design of vessels, study and design of various types of jackets like plain, half coil, channel, limpet oil. Study and design of internal coil reaction vessels, Heat transfer coefficients in coils.

Books Recommended:

1. S. D. Dawande, Process Equipment Design, Denett & Co, 2009
2. M.V. Joshi, V. V. Mahajani, Process Equipment Design, Macmillan India.
3. B.C. Bhattacharya, Introduction to Chemical Equipment Design, CBS Publications, 1985.
4. J. M. Coulson, J. F. Richardson, R. K. Sinnott, Chemical Engineering Vol. 6 - Design, Pergamon Press, 1983.
5. E.E. Ludwig, Applied Process Design for Chemical and Petrochemical Plants, Vol. 1 and 2, Gulf Publishing Co., 1997.
6. S. M. Walas, Chemical Process Equipment: Selection and Design, Butterworth-Heinemann, 1990.
7. L. E. Brownell, E. H. Young, Process Equipment Design - Vessel Design, John Wiley and Sons, Inc., 1959.
8. Indian standards Institution, 'Code for unfired pressure vessels', IS – 2825.

Subject : BTCHE 604T (BCHE) **Chemical Reaction Engineering (Theory)**

Lecture : 3 Hours Tutorial: 1 Hour No. of Credits : 4

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Kinetics of homogeneous reactions

Irreversible and reversible reactions, Equilibrium; Order and molecularity of reaction. Elementary and non elementary reactions; Fractional conversion and equilibrium conversion. Rate of reaction based on all components of the reaction and their interrelation. Law of mass action, Rate Constant-Based on thermodynamic activity, Temperature dependency of rate Constant -Arrhenious law, Transition state theory and collision theory. Temperature and conversion profiles for exothermic and endothermic reactions

Unit II: Batch Reactor Data

Batch reactor concept, Constant volume Batch reactor system; Design equation for zero, first, second order irreversible and reversible reactions, graphical interpretation of these equations and their limitations, Variable volume Batch reactors. Design equation for first and second order irreversible and reversible reactions, Graphical interpretation of their limitations, Multiple reactions-stoichiometry and rate equations for series and parallel reactions, Non elementary single reactions Development of rate expression; Chain reactions development of rate expressions, Batch recycle reactors, Semi-batch reactor, related examples etc.

Unit III: Flow Reactors

Types of flow reactors and their differences, space-time and space velocity, Design equation for plug flow reactor and CSTR; Size comparison of single reactors; Different reactor arrangements, optimum size determination; Performance of Recycle reactors, Auto-catalytic (recycle) reactors, Yield and selectivity, Best operating condition for mixed and plug flow reactors, Multiple reactions in CSTR and PFR reactors. Maximization of desired product rate in a plug flow reactor and back mixed reactor, product distribution in multiple reactions, related examples etc.

Unit IV: Temperature and Pressure Effects

Equilibrium Conversion, Optimum temperature progression, Adiabatic and non adiabatic operations, Temperature and conversion profiles for exothermic and endothermic reactions and related examples etc.

Unit V: Residence Time Distribution

Residence time distribution in reactors: E, F and C curve, and their relationship, conversion in reactors having nonideal flow; models for non-ideal flow: Dispersion model, dispersion number, Tank in Series model, Multi parameter model, mixing of fluids: Self-mixing of single fluid. Two parameter models.

Unit VI: Catalysis

Catalysis in homogeneous and heterogeneous reactions, catalyst classification, preparation, poisoning and regeneration, Promoters and inhibitors, Catalyst deactivation, Mechanism of deactivation, catalyst effectiveness, related examples etc.

Books Recommended:

1. O. Levenspeil, Chemical Reaction Engineering, 3rd Edition, John Wiley & Sons, 2001.
2. H. S. Fogler, Elements of Chemical Reaction Engineering, 3rd Edition, PHI, 2002.

3. S.D. Dawande, Chemical Reaction Engineering, 3rd Edition, Denett & Co, 2009.
4. S. M. Walas, Reaction Kinetics for Chemical Engineers, McGraw Hill, 1959.
5. J.M. Smith, Chemical Engineering Kinetics, 3rd Edition, McGraw Hill, 1987.

Subject: BTCHE 605T (BCHE) **Elective – I: Human Behavior in Organization (Theory)**

Lecture : 3 Hours
University : 80 Marks
Duration of Examination: 3 Hours
No. of Credits : 3
College Assessment : 20 Marks

Unit I: Fundamentals of Organizational Behavior

The Dynamics of People and Organizations, Models of Organizational Behavior, Managing Communications, Social Systems and Organizational Culture

Unit II: Motivation, Needs, contents and Processes

Motivation, Theories of motivation, Performance Appraising and Rewarding system

Unit III: Leadership and Empowerment

Leadership, Empowerment and Participation

Unit IV: Individual and Interpersonal Behavior

Transactional Analysis

Unit V: Group Behavior and Emerging Aspects of Organizational Behavior

Informal and Formal Groups, Team and Team Building, Organizational Behavior across Cultures

Unit VI: Organisational Change and Its Effects

Forces of change, Resistance to change, Approaches to managing organisational changes, Conflict management, Managing Stress, Stress and Counselling

Books Recommended:

1. J. Newstrom, Organizational Behavior: Human Behavior at Work, 13thEdition. McGraw-Hill. 2010.
2. Dessler, Gary. Human Resource Management, 8th Edition. Prentice-Hall. 2000
3. Kreitner, Robert and Kinicki, Angelo. Organizational Behavior 6th Ed. McGraw Hill 2005
4. Robbins, Stephen. Organizational Behavior, 8th Edition. Prentice-Hall. 1998
5. Subba Rao S.V. Human Resource Management and Industrial Relation. Himalaya Publishing House 1st Edition, 1997.
6. Fred Luthans, Organisational Behaviour, Mc-Graw Hill 8th International Edition 2000.
7. K. Aswathappa, Organizational Behaviour, Himalaya Publishing House, Revised and Enlarged Edition 1998.

Subject : BTCHE 605T (BCHE) **Elective – I: Materials Management (Theory)**
Lecture : 3 Hours No. of Credits : 3
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I: Introduction

Introduction to materials management and productivity, functions of material management, organization structures in material management, role of material management techniques in improved material productivity.

Unit II: Material planning

Objectives, material requirement planning, manufacturing resource planning, JIT production planning, strategic material planning, material control: acceptance, sampling, inspection, make or buy decision, simple cost analysis, economic analysis, break even analysis, break even point theory, whether to add or drop a product line store management and warehousing, product explosion.

Unit III: Purchasing

Importance of good purchasing system, organization of purchasing functions, purchase policy and procedures, responsibility and limitations, purchasing decisions, purchasing role in new product development, role of purchasing in cost reduction, negotiations and purchase, purchasing research: identification of right sources of supply, vendor rating, standardization, vendor certification plans, vendor and supply reliability, developing new source of supply.

Unit IV: Cost reduction

Cost control v/s cost reduction, price analysis, material cost reduction techniques, variety reduction, cost reduction and value improvement, techniques of cost control, standard costing, cost effectiveness, cost analysis for material management, material flow cost control.

Unit V: Inventory management-I

Inventory v/s stores, types of inventory, inventory control, inventory build –up, EOQ, various inventory models, inventory models with quantity discount, exchange curve concept, coverage analysis, optimal stocking and issuing policies

Unit VI: Inventory management-II

Inventory management of perishable commodities, ABC – VED analysis, design of inventory distribution systems, surplus management, information system for inventory management, case studies

Books Recommended:

1. W.R. Stelzer Jr., Materials Management, Prentice-Hall, 1970
2. D.S. Ammer, Materials Management and Purchasing, Richard D. Irwin, Homewood, IL, 1980.
3. A. K. Dutta, Materials Management: Procedures, Texts and Case, Prentice-Hall of India, 2004
4. P. Gopalakrishnan, M. Sundersen, Material management- An integrated approach, Prentice-Hall of India, 1977.
5. K.C. Jain, L.N. Aggrawal, Production Planning Control and industrial Management, Khanna Publishers.

Subject : BTCHE 605T (BCHE) Elective – I: Marketing Management (Theory)

Lecture : 3 Hours No. of Credits : 3
University : 80 Marks College Assessment : 20 Marks
Duration of Examination: 3 Hours

Unit I: Fundamentals of Marketing

Meaning of Marketing & Marketing Management, Core Marketing concepts, Scope of Marketing, Importance / Role of Marketing, Marketing management philosophies, Marketing Mix, Limitation of Marketing Concept

Unit II: Marketing Research & Marketing Information System

Meaning of marketing information system and marketing research, Importance of marketing research, Scope & role of marketing research, Types of marketing research, Steps in marketing research

Unit III: Consumer behavior, Market Segmentation, Targeting and Positioning

Meaning of Consumer Behavior, Factors affecting Consumer Behavior, Types of Buying Decisions, Stages in Buying Decision Process

Market Segmentation, Need for Market Segmentation & Benefits of Market Segmentation, Bases of Segmenting Consumer Market, Target Marketing and Positioning

Unit IV: Product Management, Product Life cycle & New Product Development

Concept of product, Levels of products, Classification of products, Product Line Decision, Product Mix Decision, Meaning of Product Life Cycle (PLC), Stages of P.L.C. and marketing strategies, Meaning of new product, New product development process

Unit V: Strategic Planning and Forecasting

Concept of strategic planning, Factors affecting planning for future.

Unit VI: Distribution & Logistic Management, Promotion strategy

Marketing Channels - Structure, Functions and Significance, Types of intermediaries in distribution channel & their functions, Distributions strategies, Physical distribution, marketing logistics and supply chain management, Importance, Functions of marketing logistics, Promotion Mix, Advertising, Personal Selling & Direct marketing, Sales Promotion, Publicity and public relations

Books Recommended:

1. P. Kotler, K. L. Keller, A. Koshy, M. Jha, Marketing Management: A south Asian Perspective. Pearson Education -Prentice Hall, 13th edition, 2009.
2. A. Kumar, N. Meenakshi, Marketing Management: Comprehensive Text, Best Practices and Corporate Insights, Vikash Publishing House, 1st edition, 2006.
3. K. Kaunakaran, Marketing Management: Text and Cases In Indian Context, Himalaya Publishing House, 2nd & revised, 2008.
4. S.A. Chunawalla, D.R. Patel, Production and Operations Management, Himalaya Publishing House, 2010.
5. S. A. Sherlekar, Marketing Management, Himalaya Publishing House, 13th Revised edition, 2005.
6. S. H. H. Kazmi, Marketing Management: Text and Cases, Excell Books, 1st edition, 2007.

Subject : BTCHE 605T (BCHE) Elective – I: Advanced Materials (Theory)

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Introduction to Advanced Materials

Introduction to materials, Properties of materials, structure-property correlationships, selection of materials, Physics and Chemistry of materials, Need of advance materials**.**

Unit II: Metallic Materials

Introduction and properties of metals and alloys, advanced metallic systems, steels for special applications: such as stainless steels, Ti- alloys, A & Al-Mg and Cu- alloys. Cast Iron, special steels, Superalloys

Unit III: Advanced Polymeric materials

Introduction of basic polymeric materials, properties of polymers, visco-elastic behaviour of polymers. Advanced Polymeric Materials, New polymeric materials such as Kevlar, Nomex, UHMWPE and Fiber Technology, polymer composites, synthetic rubber. Engineering polymers: polyamide, polycarbonates etc. Specialty polymers: liquid-crystal polymers, conductive polymers etc. Applications

Unit IV: Ceramic Materials

Introduction of Ceramic materials, structures of ceramics, Advanced ceramic materials such as Si alloys, toughened ceramics, glasses and glazes, Advances in powder synthesis techniques, Advances in processing methods, Microsrtucutral design and grain boundary engineering, case studies.

Unit V: Composite and Special Materials

Physics of materials with a focus on applications to electronic and other materials

Electrical conduction, Intrinsic and extrinsic semiconductors, Semiconductor devices, Optical properties of materials, Magnetic properties of materials, Mechanical properties, Superconductive materials.

Introduction to Composite Materials, Factors influencing the properties of composite materials like fiber parameter, matrix, interface and molding methods, Phase selection criteria, Reinforcing mechanisms, Interfaces, advantages and disadvantages, Polymer Composites, Reinforcing and matrix materials, Fiber winding techniques, Fabrication techniques, Laminates, Mechanical behaviour, etc.

Unit VI: Nano and Bio materials

Historical development of nanotechnology, Future trends, Introduction, Characterization, Properties of Individual nanoparticles, Methods of synthesis, Carbon nanostructures, Nanostructured materials, Self-assembly and Catalysis, Biological nanomaterials, Nanoelectronics, Nanomachines and nanodevices, Bio-materials, Implants, devices and sensors, drug delivery systems.

Books Recommended:

1. D. R. Askeland, M. Phule, The Science and Engineering of Materials, 5th Edition, Thomsom Learning, 2005.
2. W. D. Callister, Materials Science and Engineering: An Introduction, 7th Edition, Wiley, 2005.
3. B.S. Narang, Material Science, CBS Publishers & Distributors, 1991.
4. L. H. Van Vlack, Elements of Materials Science and Engineering, 6th Edition, Prentice Hall, 1989.
5. V. Raghavan, Materials Science and Engineering, PHI Learning Pvt. Ltd., 2004.

6. B.S. Murty, P. Shankar, B. Raj, B B Rath, J. Murday, Textbook of Nanoscience and Nano technology, University Press, 2012.
7. O.P. Khana, Materials Science and Metallurgy, Dhnapat Rai Publications, 1995.

Subject : BTCHE 605T (BCHE) Elective–I: Renewable Energy Sources (Theory)

Lecture : 3 Hours No. of Credits : 3

University : 80 Marks College Assessment : 20 Marks

Duration of Examination: 3 Hours

Unit I: Solar-Energy.

Solar radiation its measurements and prediction, solar flat plate thermal collectors concentrating collectors-applications-heating, cooling, desalination, power generation, drying, cooking etc. Principle of photovoltaic conversion of solar energy, types of solar cells and fabrication. Photovoltaic applications: battery charger, domestic lighting, street lighting, and water pumping, power generation schemes.

Unit II: Wind Energy.

Atmospheric circulation- classification, factors influencing-wind shear-turbulence-wind speed monitoring-Aerodynamics of wind turbine rotor-site selection-wind resource assessment-wind energy conversion devices-classification, characteristics and applications. Hybrid systems-safety and environmental aspects.

Unit III: Bio-Energy.

Biomass resources and their classification,- chemical constituents and physicochemical characteristics of biomass- Biomass conversion processes-Thermo chemical conversion: direct combustion, gasification, hydrolysis and liquefaction- biochemical conversion: anaerobic digestion, alcohol production from biomass- chemical conversion process: hydrolysis and hydrogenation. Biogas- generation-types of biogas Plants applications.

Unit IV: Hydrogen and Fuel Cells:

Thermodynamics and electrochemical principles-basic design, types and applications, production methods, Biophotolysis: hydrogen generation from algae biological pathways, storage gaseous, cryogenic and metal hydride an transportation. Fuel cell: principle of working, various types, construction and applications.

Unit V& VI: Other Types of Energy and Energy Audit

Ocean energy resources, principles of ocean thermal energy conversion systems, ocean thermal power plants, principles of ocean wave energy conversion and tidal energy conversion, hydropower, site selection, construction, environmental issues, geothermal energy, types of geothermal energy sites, site selection and geothermal power plants.

Concept of energy of audit, analysis of the cost effectiveness of renewable energy sources, present status, comparison, forecast.

Books Recommended:

1. D. P. Kothari, K.C. Singal, R. Rajan, Renewable Energy Sources and Emerging Technologies, PHI Learning Pvt. Ltd, 2009.
2. G.D. Rai, Non-conventional Energy Sources, Khanna Publishers, 2007
3. J. Twidel, T. Wier, Renewable Energy Sources, Taylor & Francis Publishers, 2005
4. S.P. Sukhatme, Solar Energy, Tata McGraw Hill Publishing Company Limited, 2006
5. K.C. Khandelwal, S.S. Mahdi, Biogas Technology- A Practical Handbook, Tata McGraw Hill, 1986.
6. Y P Abbi, S. Jain, Handbook on Energy Audit and Environment Management, TERI, 2006.

Subject : BTCHE 606P (BCHE) **Environmental Engineering (Practical)**
Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To determine the concentration of CO_2 present in waste water sample
2. Analysis of cation exchange effluents from thermal power plant (Determination of Ca^{2+} & $Mg^{2+)}$
3. To determine the alkalinity of a waste water sample by Warden method
4. Analysis of ferrous and ferric ions from pickling waste effluents
5. Determination of dissolved oxygen (DO) present in water sample
6. To determine the percentage of available chlorine present in bleaching powder
7. Determination of chemical oxygen demand (COD) present in waste water sample
8. Determination biological oxygen demand (BOD) present in waste water sample
9. Analysis of fly ash sample to determine the loss on ignition
10. Measurement of Air quality
11. Water softening using molecular sieves
12. Analysis and removal of TDS from waste water.
13. Removal of suspended particles from waste water.
14. Determination of Monod Kinetic constants
15. Determination of Specific Growth rate and maximum specific growth rate

Subject : BTCHE 607P (BCHE) **Process Equipment Design (Practical)**

Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Minimum 8 sheets related to design and drawing mentioned below should be drawn. Out of 8, two drawing should be performed/demonstrated on AutoCAD.

1. Design of Pressure Vessels
2. Design of Vessel Supports
3. Design of Storage Tanks
4. Design of Heat Exchangers
5. Design of Tray Towers
6. Design of Packed Towers
7. Process Flow Symbols
8. Process Flow Diagram
9. Piping & Instrumentation Diagram
10. Equipment Layout
11. Use of AutoCAD

Subject : BTCHE 608P (BCHE) **Separation Processes (Practical)**

Practical : 3 Hours No. of Credits : 2
University : 25 Marks College Assessment : 25 Marks
Duration of Examination: 6 Hours

LIST OF EXPERIMENTS

Required to perform minimum 8 practical from the list given below:

1. To verify Rayleigh's Equation for Simple Distillation
2. To construct the boiling point diagram for binary – miscible system
3. Distillation using Sieve Plate, Bubble Cap Column
4. To determine the thermal and vaporization efficiencies in Steam Distillation
5. Single/multiple stage extraction studies
6. To prepare the ternary phase diagram.
7. Soxhlet Extraction
8. Absorption studies in packed column
9. Absorption studies in bubble column
10. Batch/ Continuous Leaching
11. Membrane separation

Subject	**: BTCHE 609P** (BCHE)	**Minor Project (Practical)**	
Practical	: 2 Hours	No. of Credits	: 1
University	: Nil	College Assessment	: 50 Marks

The minor project will be for a group of three/four students under the guidance of departmental faculty of the institute and will carry 1 credit. The minor project will involve work based on analytical/experimental/design/industrial/combination of these topics in consultation with guide.

Each group of Students has to submit a typed and bound report (2 copies) at the end of the sixth semester to the respective guides. All students must go for minimum one relevant industry visit during the semester

Internal assessment marks will be awarded after the completion of the said project based on the work and presentation made by them in front of departmental committee.

Teaching load of minor project will be maximum 2 hours per week for each faculty.