COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	TRANSPORT PHENOMENA
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	CHL110
6.	**Status** (*category* for *program*)	Core for CH1 & CH7; PL ES for other programs.

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	None
8.3	Supercedes any existing course	None

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem

11.	**Faculty who will teach the course** Faculty of Chemical Engineering Department	
12.	**Will the course require any visiting faculty?**	No

13. Course objective *(about 50 words)*:

The course will deal with flow problems involving Newtonian and non-Newtonian fluids, solid-state heat conduction, forced & free convection, binary diffusion with or without chemical reaction. Course will highlight coupling between three transport phenomena with applications in various disciplines in engineering & science.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Vector and Tensor analysis; Euler/Lagrangian viewpoint of momentum transport, stress tensor and Newton's law of viscosity, shell momentum balances, derivation of equations of change for isothermal, non-isothermal, and multicomponent systems, Solution to 1D flow problems involving Newtonian or non-Newtonian fluids, friction factor, Mechanisms of energy transport, energy flux for conduction, convection & viscous dissipation, Solutions to 1D conduction and convection problems, Mechanisms of mass transport, mass and molar diffusion fluxes, derivation and application of

	continuity equation to mass transfer in binary mixtures, dimensional analysis of equations of change to solve higher dimensional transport problems, unsteady-state momentum, heat, and mass transport.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to the subject of Transport Phenomena	1
2	Vector and Tensor Analysis	6
3	Basics of momentum transport: Euler/Lagrangian viewpoint, laminar and turbulent flows, boundary layers, stress tensor	2
4	Shell momentum balances, equations of change, dimensional analysis, applications to isothermal flow of Newtonian & non-Newtonian fluids.	11
5	Basics of energy transport, conductive, convective & viscous dissipation energy fluxes	2
6	Equations of change for non-isothermal systems, dimensional analysis, and applications to steady-state conduction & convection	8
7	Basics of mass transport, mechanisms, and mass & molar fluxes	2
8	Derivation of equation of continuity for a binary mixture and its application to convection-diffusion problems.	7
9	Unsteady-state momentum, heat and mass transport.	3
10		
11		
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

Tutorial sheets will be provided as homework assignments and will be discussed in the tutorials. This will also provide an opportunity to discuss concepts and solution techniques taught in the lecture. As this is a first course on transport processes for students, tutorials will enhance learning in the course and help this course serve as a platform for advanced concepts discussed in subsequent transport courses.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Book:

i. R. B. Bird, W. E. Stewart, and E. S. Lightfoot. Transport Phenomena, 2nd ed., Wiley India Pvt. Ltd., 2002

Reference Books:
ii. W. M. Deen, Analysis of Transport Phenomena, Oxford University Press, 1998.
iii. J. Welty, C. E. Wicks, R. E. Wilson, and G. L. Rorrer. Fundamentals of Momentum, Heat, and Mass Transfer. 5th ed., Wiley India Pvt. Ltd., 2007.
iv. W. J. Thompson, Introduction to Transport Phenomena, Prentice Hall, 2000.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Microphone, projector and screen.
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	Air-conditioning
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CHEMICAL ENGINEERING
2.	**Course Title** *(< 45 characters)*	MATERIAL AND ENERGY BALANCE
3.	**L-T-P structure**	2-2-0
4.	**Credits**	4
5.	**Course number**	CHL111
6.	**Status** (*category* for *program*)	CORE

7.	**Pre-requisites** (course no./title)	NIL

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	
10.	**Frequency of offering**	Every sem X1st sem 2nd sem Either sem
11.	**Faculty who will teach the course: Chemical Engineering Faculty**	
12.	**Will the course require any visiting faculty?**	NO

13. **Course objective** *(about 50 words)*:
To develop systematic problem solving skills; to learn and apply material and energy balance on chemical process systems as material and energy balance calculations are a prerequisite to all other calculations in the solution of both simple and complex chemical engineering problems ; to provide information on units and measurement of physical properties

14. **Course contents** *(about 100 words) (Include laboratory/design activities)*: Mathematics and engineering calculations, Dimensional groups and constants, Vapour Pressure; Clausius Clapeyron equation, Cox Chart, During's plot, Raoult's law, Humidity and Saturation, Humid heat, humid volume, dew point, humidity chart and its use,

	Crystallization, dissolution, Ideal gas behavior, Material balance; solving material balance problems with and without chemical reaction; recycle, bypass and purge calculations, aid of computer in solving material balance problems; Energy balance: closed and open systems, heat capacity, calculation of enthalpy changes, energy balances with chemical reaction, heat of vaporization, heat of formation, heat of combination, heat of reaction

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Dimensional groups and units, Mathematics and engineering calculations	2
2	Vapour pressure, Clausius Clapeyron equation, Cox chart, During's plot	2
3	Raoult's law, Humidity and Saturation, humid heat, humid volume, dew point, humidity chart and its use, ideal gases	3
4	Crystallization, Dissolution	2
5	Material Balance; solving material balance problems with and without chemical reaction; recycle, bypass and purge calculations	9
6	Energy balance: open and closed system, heat capacity, calculation of enthalpy changes; energy balances with chemical reaction#	5
7	Heat of vaporization, heat of formation, heat of reaction, heat of combination	5
8		
9	#	
10		
11		
12		
COURSE TOTAL *(14 times 'L')*		28

16. Brief description of tutorial activities

To introduce principles and calculation techniques used in chemical engineering ; Formulate and solve material and energy balance using flowsheeting software and spreadsheets; efficient and consistent methods to solve problems on the topics discussed in the class

17. Brief description of laboratory activities Not Applicable

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Book:

1. Himmelblau, David M., Riggs, James B. Basic Principles and Calculations in Chemical Engineering, Seventh Ed., Prentice Hall of India, 2011
2. Felder, Richard M.; Rousseau, Ronald W.; Elementary Principles of Chemical Processes, Third Edition, John Wiley & Sons, 2000

Reference Book:

3. Bhatt, B. I., Vora, S. M.; Stoichiometry, Fourth Edition, Tata McGraw Hill Publishing Company Ltd,2004
4. Hougen, O.A., Watson, K. M., Ragatz, R. A., Chemical Process Principles, Part-I Material & Energy Balances, Second Edition, CBS Publishers & Distributors, 2004

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Flowsheeting Software, Spreadsheet
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible) NO*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CHE
2.	**Course Title** *(< 45 characters)*	CHEMICAL ENGINEERING THERMODYNAMICS
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	Currently CHL121
6.	**Status** (*category* for *program*)	Core

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	None
8.2	Overlap with any UG/PG course of other Dept./Centre	MEL140
8.3	Supercedes any existing course	CHL121

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	Every sem 1st sem 2nd sem Either sem

11.	**Faculty who will teach the course:** All ChE faculty	
12.	**Will the course require any visiting faculty?**	None

13.	**Course objective** *(about 50 words)*: Analysis and estimation/description of fluid properties (for pure fluids and mixtures), changes in fluid properties during equilibrium and with changing conditions, thermodynamic analysis of processes. Understanding of states of a system, equilibrium states, and equilibrium processes, of reversible and irreversible processes. How these are applied to design of processes and of materials.

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)*: Review of conservation of energy, mass and introduction to work-energy conversions, and the concept of entropy. Application to closed and open systems; Application in analysis of energy and efficiency of equipment; state and properties of pure fluids under different conditions and in flowing through equipment. Use of equations of states, graphs, correlations and tables to estimate fluid properties, understanding the relationships between fluid properties and changes in properties. Equilibrium properties of materials pure materials and mixtures. Understanding the phase behavior and phase transition of pure fluids. Thermodynamic analysis of fluids in standard fixtures and equipment (piping fixtures, power plants, engines, refrigerators). Equilibrium behavior of mixtures of fluids, the nature of interactions between various fluids and how interactions affect their properties and phase transitions. Introduction to separation processes based on difference in equilibrium thermodynamic properties. Introduction to reaction equilibra

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to Thermodynamics	1
2	Introduction to state of matter, properties, degree of freedom, equilibrium	1
3	Energy, conservation & First Law, Open and closed systems, reversible & irreversible processes, Steady state processes, constant P, V, T processes, Forms of energy	2
4	Phases, phase transitions, PVT behavior; description of materials – Ideal gas description, van der Waals and cubic EOS, Virial EOS, Reduced conditions & corresponding states theories, correlations in description of material properties and behavior	3
5	Efficiency of heat engines, Carnot cycles, temperature scales, entropy as a state property, reversible and irreversible processes, entropy of an ideal gas, Second Law, Losses, Third Law	4
6	Thermodynamic property of fluids, Maxwell relations, 2-phase systems, graphs and tables of thermodynamic properties	4
7	Thermodynamics of flows in ducts, pipes, piping fixtures, nozzles, compressors, pumps. Thermodynamic analysis of steam power plants, combustion engines, and refrigeration cycles.	5
8	Solution Thermodynamics, fundamental property relationships, free energy and chemical potential, partial properties, definition of fugacity and fugacity coefficient of pure species and species in solution, the ideal solution and excess properties, thermodynamic properties of typical solutions and relationship to molecular interactions	6
9	Liquid phase properties from VLE, Gibbs energy, heat effects and property change on mixing Liquid phase properties from VLE, Gibbs energy, heat effects and property change on mixing,#	4
10	VLE at low to moderate pressures, equilibrium, phase rule & Duhem's theorem, graphical understanding of phase behavior of mixtures, activity coefficient and its use in VLE analysis, Raoult's and Henry's Law approximations, Flash calculations, Bubble and Dew point calculations, Properties of fluids from equations of state	6
11	Reviewing Mechanical, & Thermal Equilibra, chemical equilibra, Introduction to reaction equilibra	6
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		

3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times ‘P’)*		

18. Suggested texts and reference materials
STYLE: Author name and initials, Title, Edition, Publisher, Year.

Smith & Van Ness: Introduction to Chemical Engineering Thermodynamics, McGraw Hill, any edition from 4th – 7th.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	C/Fortran/Matlab/some engineering programming language, Spreadsheets, S
19.2	Hardware	None
19.3	Teaching aides (videos, etc.)	None
19.4	Laboratory	None
19.5	Equipment	None
19.6	Classroom infrastructure	Projector
19.7	Site visits	None

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	15% 15%
20.2	Open-ended problems	10%: What if problems on energy efficiency, alternatives to equations of states 10%: What if problems on energy efficiency, alternatives to equations of states
20.3	Project-type activity	15% : Simulating / Modeling energy and material properties in changing conditions 15% : Simulating / Modeling energy and material properties in changing conditions
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	CHEMICAL PROCESS TECHNOLOGY & ECONOMICS
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	XXX
6.	**Status** (*category* for *program*)	DC

7.	**Pre-requisites** (course no./title)	MT-I, CRE-I

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	**Not allowed for** (indicate program names)	Other Departments/centres
10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem
11.	**Faculty who will teach the course** XXX	
12.	**Will the course require any visiting faculty?**	No

13. Course objective *(about 50 words)*:

Introducing the Chemical Engineering undergraduates to Chemical Plant Technologies which encompass all the unit operations of Chemical Engineering and also safety and Hazard operability and chemical plants including refinery, fertilizer and biochemical industries.They will be trained to generate process flow diagrams of Chemical plants, understand the need / way to develop new process technologies.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Introduction to process flow and equipment symbols and Chemical plant sections of a Chemical plant. Generating Process flow diagrams of general chemical plants (gas-liquid handling , liquid-solid, gas-liquid-solid handling plants). Fertilizer Technology- Manufacture of fertilizers including Naphtha reforming and air separation for N2,ammonia synthesis and ammonia converter technology, sulfuric acid, Urea manufacture, Utilities, Safety and HAZOP studies in fertilizer plants. Refining and Petrochemical Technology -

	Crude occurrence, properties, Distillation, Refinery Processes and technology, Petrochemical Technologies, Semi conductor Chip Manufacture/ Food technology/ Chloralkali, Introduction to Safety and HAZOP and debottlenecking in Chemical plants, Introduction to Process Engineering economics, Introduction to ASPEN PLUS and flow sheeting using ASPEN PLUS.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to process flow and equipment symbols and Chemical plant sections of a Chemical plant	1
2	Generating Process flow diagrams of general chemical plants (gas-liquid handling , liquid-solid, gas-liquid-solid handling plants)	2
3	Introduction to ASPEN PLUS and flow sheeting using ASPEN PLUS	3
4	Refining and Petrochemical Technology - Crude occurrence, properties, Distillation, Refinery Processes and technology, Petrochemical Technologies.	9
5	Fertilizer Technology- Manufacture of fertilizers including Naphtha reforming and air separation for N2,ammonia synthesis and ammonia converter technology, sulfuric acid, Urea manufacture, Utilities.	8
6	Biochemical plant processes/ Food processing/ Semi-conductor chip manufacture/ Optical fiber manufacture- Introduction, Process flow of the manufacturing plant, Reactor technologies with a single industry example	8
7	Process Engineering Economics - Introduction, Analysis of cost estimation, Interest, Time Value of Money, Taxes and Fixed charges, Profitabolity, Alternative Investments, and replacements	6
8	Safety and HAZOP- Introduction	3
9	[illegible]	2
10		
11		
12		
	COURSE TOTAL *(14 times 'L')*	42

16. Brief description of tutorial activities

Course is structured to include tutorial @ every sixth lecture hour as whole class (7 tutorials in the semester)

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	N/A	
2		
3		
4		
5		
6		
7		
8		
9		
10		
	COURSE TOTAL *(14 times 'P')*	

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. George T. Austin,"Shreve's Chemical Process Industries" fifth edition, McGraw Hill International Editions,1984. (SuggestedText)

2. Gopala Rao M., Marshall Sittig "Dryden's Outline of Chemical Process Technology" third Edition, Affliated East-West Press, India 1997. (Suggested Text)
3. Jacob A. Moulijn, Nichiel Makkee, Annelies Van Diepen, "Chemical Process Technology" first Edition, John Wiley & Sons Ltd. 2008. (Suggested Text)
4. Max S. Peters, Klaus Timmerhaus, Ronald E. West, "Plant design and Economics for Chemical Engineers", fifth edition, McGraw-Hill Higher education, 2003. (SuggestedText)
5. Wilbur Lundine Nelson "Petroleum Refinery Engineering", fourth edition McGraw Hill, NY, 1958. (Reference)
6. James G. Speight, Baki Ozum "Petroleum Refining Processes" Marcel Dekker, NY, 2002.(Reference)
7. James H. Gary, Glenn E. Handwerk "Petroleum Refining (Technology and Economics)" , fifth edition, Marcel Dekker, NY, 2007. (Reference)
8. G. Margaret Wells "Handbook of petrochemicals and processes", second edition, Ashgate Publishing Ltd., 1999. (Reference)
9. James E. Bailey, David F. Ollis "Biochemical Engineering fundamentals", second edition, Mc Graw Hill International Editions, 1986. (Reference)
10. Kirk and Othmer "Encyclopedia of Chemical Technology"- 27 Volume set, fifth edition, John Wiley & Sons Ltd. 2004. (Reference)

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	ASPEN PLUS
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	.ppt files projector, Good Audio facilities
19.7	Site visits	1 industrial visit planned

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	Term project during semester break
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	CHEMICAL ENGINEERING
2.	Course Title (< 45 characters)	CHEMICAL REACTION ENGINEERING (CRE) 1
3.	L-T-P structure	3-1-0
4.	Credits	4
5.	Course number	122
6.	Status (category for program)	CORE

7.	Pre-requisites (course no./title)	

8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	CHL103 for DBEB
8.2	Overlap with any UG/PG course of other Dept./Centre	no
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	

10.	Frequency of offering	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem
11.	Faculty who will teach the course	
12.	Will the course require any visiting faculty?	No

13. Course objective (about 50 words):

To educate the students in basic concepts of homogeneous reactions carried out in ideal reactors. The course involves mass and energy balances for single and multiple reactions carried out in batch, mixed flow, plug flow and recycle reactors. The kinetics of the reactions are studied in detail in order to determine the optimal design of the reactors to achieve maximum selective conversion in the lowest possible cost or time. Principles of reaction mechanisms are discussed and a brief introduction to heterogeneous reactions (mainly Michaelis-Menten kinetics for enzymes) is also given. In the end, basics of non-ideal reactors and residence time distribution (RTD) theory are provided.

14. Course contents (about 100 words) (Include laboratory/design activities):

Introduction to rate equations, calculations of extents of reactions for single and multiple reactions, kinetics of homogeneous reactions, derivation of reactor design equations, analysis and sizing of reactors, data collection and

	plotting to determine rate constants, reactor networks (series/parallel), reaction mechanisms, temperature and pressure effects on reactions and reactor design, simultaneous material and energy balances, multiple steady-states, residence time distributions in non ideal reactors

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	Reactions and reaction rates - stoichiometry, extent of rxn, law of def. proportions etc.	2
2	Reaction rates and some important generalizations	2
3	Ideal reactors - generalized material balance, design equations, graphical interpretation	3
4	Sizing and analysis of ideal batch, mixed (CSTR), plug flow and recycle reactors - solving design equations for constant & variable density systems, reactors in series & parallel etc.	6
5	Reaction rate fundamentals - elementary reaction sequences, steady state approximation and rate limiting step theory	4
6	Analysis and correlation of experimental kinetic data - data collection & plotting, linerization of rate eqns, differential and integral method of analysis	3
7	Multiple reactions - conversion, selectivity, yield, series, parallel, independent and mixed series-parallel reactions	4
8	Use of energy balance in reactor design and analysis - macroscopic energy balances, isothermal reactors, adiabatic reactos, simultaneous material and energy balance, multiple steady-states, blow out and hysteresis	10
9	RTD theory and analysis of non ideal reactors	8
10		
11		
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

Tutorials are an ingtegral part of this course. Tuotial activities mainly involve intense problem solving around the concepts developed in class to ensure that the students can apply fundamental principles learnt in class to real life industrial problems.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	N/A	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text books:

1. Elements of Chemical Reaction Engineering by H. Scott Fogler, 2nd Edition, Prentice Hall 2001
2. Chemical Reaction Engineering by Octave Levenspiel, 3rd Edition, John Wiley & Sons 2001

Reference books:

3. The Engineering of Chemical Reactions by Lanny D. Schmidt, 2nd Edition, Oxford University Press, 1998
4. Applied Mathematics and Modeling for Chemical Engineers by R. G. Rice and D. D. Do, John Wiley & Sons, 1995

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	No
19.2	Hardware	No
19.3	Teaching aides (videos, etc.)	No
19.4	Laboratory	No
19.5	Equipment	Biometric attendance monitor
19.6	Classroom infrastructure	Overhead projector
19.7	Site visits	No

20. Design content of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	N/A
20.2	Open-ended problems	N/A
20.3	Project-type activity	N/A
20.4	Open-ended laboratory work	N/A
20.5	Others (please specify)	N/A

Date: June 2013, 2013 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	CRE-II
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CHL 221
6.	**Status** (*category* for *program*)	

7.	**Pre-requisites** (course no./title)	CORE

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	10%
8.2	Overlap with any UG/PG course of other Dept./Centre	no
8.3	Supercedes any existing course	

9.	**Not allowed for** (indicate program names)	
10.	**Frequency of offering**	☐Every sem ☐1st sem ☒2nd sem ☐Either sem
11.	**Faculty who will teach the course**	
12.	**Will the course require any visiting faculty?**	no

13. Course objective *(about 50 words)*:

The objective of the course is to familiarize the students with the fundamentals of heterogeneous catalytic reactions and concept of reactor design. Course will give understanding on catalysts preparation, heterogeneous catalytic reaction kinetics . and provide knowledge on the design of reactors for catalytic reactions. The effect of transport limitations on reactor performance in Catalytic & non-catalytic heterogeneous reactions will also be discussed.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Introduction, Definition of catalysis, homogeneous and heterogeneous catalysis. Adsorption on catalytic surfaces, kinetic models, catalyst preparation, physical characterization of catalysts, supported metal catalysts.

Mass transfer and internal Diffusion effects in catalytic reactions , Thiele Modulus and Effectiveness factor , Catalyst deactivation, Reactor design,

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction ,Definition of catalysis, homogeneous and heterogeneous catalysis. classification, Preparation and characterisation of catalysts,	3
2	Physical and chemical adsorption, Adsorption isotherms, Determination of BET surface area and pore volume of the Catalyst	4
3	Kinetics of solid catalyzed gas phase reaction, Reaction mechanism	5
4	Laboratory reactors for catalytic gas solid reactions. Design concepts	4
5	Mass transfer, Diffusion and Chemical reactions in catalysts. Effects of external mass transfer and heat transfer, Effectiveness factors.	8
6	Fixed bed catalytic reactors, reactor models, concept of heterogeneous models.	4
7	Non-catalytic gas-solid reactions, different model for gas-solid reaction,	4
8	Gas liquid reactions, film and penetration theories, enhance factor in gas-liquid reactions,	4
9	Reactor systems for gas-liquid reactions.	2
10	Design concept for heterogeneous gas -solid catalytic reactor : Reactor design Applications	4
11		
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

Tutorials will be taken in the lecture hours after each module, total 8

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	N/A	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Book
1. Fogler H.S, 'Elements of chemical reaction engineering' Prentice Hall
Reference Book:
. O. Levensipiel ' Chemical Reaction Engineering , Wiley Publisher
• Smith J.M., 'Chemical engineering kinetics', prentice hall, Mcgraw Hill, Gutterfield

- Carberry, ‘Chemical and catalytic reaction engineering’ Mcgraw Hil
- Froment G.F & Bischoff K.B., ‘Chemical reactor analysis and design’ John Wiley
- C.G. Hill, ‘An Introduction to Chemical Engineering Kinetics and Reactor Design’

. Satterfield, “Heterogeneous Catalysis in Practice” McGraw Hill,
M.M.Sharma and L.K. Doraiswami Heterogeneous Reactions Vol1 and Vol II :

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	FLUID MECHANICS FOR CHEMICAL ENGINEERS
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	CHL231
6.	**Status** (*category* for *program*)	Department Core

7.	**Pre-requisites** (course no./title)	CHL110

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	CHL203 (20%)
8.2	Overlap with any UG/PG course of other Dept./Centre	AML160, AML170
8.3	Supercedes any existing course	None

9.	**Not allowed for** (indicate program names)	
10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem
11.	**Faculty who will teach the course** Faculty of Chemical Engineering Department	
12.	**Will the course require any visiting faculty?**	No

13. Course objective *(about 50 words)*:

Course aims to introduce the mechanics of fluids - both statics and dynamics - relevant to Chemical Engineering operations. Basic concepts of fluid motion will be introduced to develop the skills enabling students to analyse the flow problems and design the Chemical Engineering equipments. The course analyzes forces causing the flow motion providing the estimate for the pressure loss and energy requirement for the flow.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Introduction to fluids, Forces on fluids, Fluid statics, Hydrostatic force on submerged bodies, Rigid body motion, Kinematics of flow - Eulerian and Lagrangian descriptions, Flow visualization, Integral analysis - mass and momentum balances, Bernoulli equation, Flow through pipes and ducts, Flow measurement, Flow transportation - pumps, blowers and compressors, Differential analysis of flow, Conservation of mass, linear and angular

	momentum, Navier-Stokes equation, Unidirectional flows, Viscous flows, Skin friction and form friction, Lubrication approximation, Potential flows, Boundary layer theory, Blasius equation for flow over a flat plate, Boundary layer separation, Drag and lift force on immersed bodies, Similitude analysis, Turbulent flows.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to fluids, Continuum hypothesis, Forces on fluids, Normal and shear stresses	2
2	Fluid statics - pressure distribution, Manometry, Forces on submerged bodies (planar and curved),Buoyancy, Rigid body motion (translation and rotation)	5
3	Kinematics of fluid flow- Eulerian and Lagrangian descriptions, Flow visualization, Stream function, Vorticity and Circulation, Kinematic decomposition of flow motion	5
4	System and control volume approaches, Reynolds transport theorem, Integral balances - mass and momentum, Euler's equation of motion, Bernoulli equation and applications, Turbulent flow, Head loss in pipe flow, Moody diagram	6
5	Flow measurement, Transportation of fluids - pumps, selection and design of pumps	3
6	Differential analysis - mass and momentum balances, Navier-Stokes equation, Unidirectional flow, Viscous flow, Stokes law, Skin drag and pressure drag	4
7	Potential flow, Potential function, Solution of Laplace equation	3
8	Boundary layer theory, Blasius solution, Boundary layer separation, Drag and lift force on immersed body	5
9	Similitude analysis, Lubrication approximation	2
10	Compressible flows, Blowers and compressors	2
11	Fluid dynamics in sports, Introduction to turbulence modelling	3
12	Applications of fluid mechanics in Chemical Engineering operations	2
	COURSE TOTAL *(14 times 'L')*	42

16. Brief description of tutorial activities

Tutorial sheet will be provided in advance for weekly tutorial. Problem solving on concepts covered in the lecutres. Tutorials also aim to address the doubts and encourage discussion on difficult concepts.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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	COURSE TOTAL *(14 times 'P')*	

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Books:

F. M. White, Fluid Mechanics, 7th Edition, Tata-McGraw Hill, 2011.

R. W. Fox, P. J. Pritchard and A. T. McDonald, Introduction to Fluid Mechanics, 7th Edition, Wiley-India 2010.

Reference Books:

B. R. Munson, D. F. Young, T. H. Okiishi and W. W. Huebsch, 6th Edition, Wiley-India 2010.

V. Gupta and S. K. Gupta, Fundamentals of Fluid Mechanics, 2nd Edition, New Age International 2011.

R. L. Panton, Incompressible Flow, 3rd Edition, Wiley-India 2005.

R. B. Bird, W. E. Stewart and E. N. Lightfoot, Transport Phenomena, 2nd Edition, Wiley-India 2002.

W. L. McCabe, J. C. Smith and P. Harriot, Unit Operations of Chemical Engineering, 7th Edition, McGraw-Hill International Edition 2005.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Microphone, Projector and Screen
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	Air-conditioning
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CHEMICAL ENGINEERING
2.	**Course Title** *(< 45 characters)*	HEAT TRANSFER FOR CHEMICAL ENGINEERS
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	CHLXXX
6.	**Status** (*category* for *program*)	CORE

7.	**Pre-requisites** (course no./title)	CHL110

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	CHL110 - 10%
8.2	Overlap with any UG/PG course of other Dept./Centre	MEL242 - 70%
8.3	Supercedes any existing course	

9.	**Not allowed for** (indicate program names)	ME
10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem
11.	**Faculty who will teach the course** All faculty in the Department.	
12.	**Will the course require any visiting faculty?**	NO

13. Course objective *(about 50 words)***:**

The objective of the course is exposure to fundamentals of heat transfer, primarily convective heat transfer. Design calculations /procedures for important heat transfer equioment such as heat exchangers and evaporators are to be covered.

14. Course contents *(about 100 words) (Include laboratory/design activities)***:**

Modes of heat transfer - conduction, convection, radiation; Heat transfer coefficients in natural and forced convection; Basic conservation equations; Heat transfer with phase change; Design of double pipe heat exchangers, shell and tube heat exchangers and evaporators; Introduction to radiation

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Modes of heat transfer - conduction, convection, radiation; notion of thermal conductivity, thermal diffuvity and heat transfer coefficient; relationship of thermodynamics and heat transfer	2
2	Differential equations of heat transfer; special forms; commonly encountered boundary conditions	3
3	Conduction heat transfer - one dimensional problems, heat transfer from extended surfaces, two and three dimensional problems	3
4	Convective heat transfer - natural and forced convection; Dimensional analysis; Thermal boundary layer; Reynolds analogy and Colburn analogy	7
5	Correlations - Importance, correlations for natural convection and forced convection	2
6	Introduction to Radiative Heat Transfer, Furnaces	3
7	Heat transfer with phase change - Introduction to boiling, Introduction to condensation	3
8	Design of heat transfer equipment - double pipe heat exchanger, concept of LMTD, DPHE sizing; shell and tube heat exchanger - Kern's method for design, effectiveness-NTU method, construction aspects in brief	9
9	Evaporators - single stage evaporation, boiling point elevation, multiple effect evaporators: forward feed and backward feed contacting; construction aspects in brief, overall material and energy balances	4
10	Introduction to radiation - nature of radiation, radiation intensity, Planck's law, concept of black body and gray body, radiant heat exchange	3
11	Two-dimensional problems in heat transfer	3
12		
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

Homework assignments based on principles and solution techniques covered in lectures will be provided beforehand and will be discussed in the tutorials. Both hand calculations and implimentantion of calculations on spreadsheet will be emphasised. A small part will be dedicated to exposure of using flowsheeting software and heat exchange equipment design software for simulating heat transfer equipments covered in the course

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
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COURSE TOTAL *(14 times 'P')*	

18. Suggested texts and reference materials
STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. J. R. Welty, C. E. Wicks, R. E. Wilson, G. Rorrer, Fundamentals of Momentum, Heat and Mass Transfer, 4th Ed.,Wiley (2007).
2. W. J. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, Sixth Edition, McGRaw Hill (2005).
3. Holman, J. P., S. Bhattacharya, Heat Transfer, 10th Ed., Tata McGraw-Hill (2011).
4. D. Q. Kern, Process Heat Transfer, Tata-McGraw Hill (1997).

Reference:

5. Bejan, A., A. D. Kraus, Heat Transfer Handbook, John Wiley (2003).

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	LCD projector, AC
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CHEMICAL ENGINEERING
2.	**Course Title** *(< 45 characters)*	MASS TRANSFER
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	CHLXXX
6.	**Status** (*category* for *program*)	CORE

7.	**Pre-requisites** (course no./title)	Transport Phenomena

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	NO
8.2	Overlap with any UG/PG course of other Dept./Centre	NO
8.3	Supercedes any existing course	CHL251

9.	**Not allowed for** (indicate program names)	NONE

10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem

11.	**Faculty who will teach the course** Chemical Engineering Faculty	
12.	**Will the course require any visiting faculty?**	NO

13.	**Course objective** *(about 50 words)*: After doing the course the students should be able to apply diffusivity, mass transfer coefficient and cascade approaches to analyze mass transfer processes. They should be able to design differential-contact mass-transfer equipment for gas-absorption, adsorption, drying and leaching operations.

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)***:**
	Lattice, Ficks, Stefan-Maxwell, Stokes-Einstein and Irreversible Thermodynamic approaches to diffusivity of binary and multicomponent systems. Film and unsteady state theories, analogy and correlation approaches to mass transfer coefficients in interphase mass transfer. Analysis of cocurrent, counter current and cross flow stage cascades. Design and operating conditions of differential contact equipment such as packed towers for absorption, adsorption, drying and leaching.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Fick's and alternative approaches to diffusion, estimation of diffusivities	8
2	Interphase mass transfer and introduction to mass transfer coefficient	4
3	Film, penetration, surface renewal and boundary layer theories for interphase mass transfer	6
4	Analysis of mass transfer cascades	3
5	Gas-liquid Absorption	3
6	Adsorption	2
7	Drying	2
8	Leaching	2
9	Design and operation of packed towers	12
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
NA		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. W. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, Sixth Edition, McGRaw HIll, 2005
2. R. E. Treybal, Mass Transfer Operations, Third Edition, Tata McGRaw Hill, 2012
3. E. L. Cussler, Diffusion Mass Transfer in Fluid Systems, Third Edition, CUP, 2009

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	LCD projector, AC
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department/Centre proposing the course	CHEMICAL ENGINEERING
2.	Course Title (< 45 characters)	MASS TRANSFER OPERATIONS-II
3.	L-T-P structure	3-1-0
4.	Credits	4
5.	Course number	CHLXXX
6.	Status (category for program)	CORE

7.	Pre-requisites (course no./title)	MT-I

8.	Status vis-à-vis other courses (give course number/title)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	CHL735 - 20%
8.3	Supercedes any existing course	CHL351

9.	Not allowed for (indicate program names)	
10.	Frequency of offering	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem
11.	Faculty who will teach the course	
12.	Will the course require any visiting faculty?	NO

13. Course objective (about 50 words):
The objective of the course is exposure to the design calculations /procedures obtained from a combination of mass conservation and equilibrium considerations for unit operations involving separation of mixture. The operation covered in the course will include flash, distillation, liquid-liquid extraction and adsorption. In addition, calculation pertaining to sizing of the equipments and internals will also be covered.

14. Course contents (about 100 words) (Include laboratory/design activities):
Review of VLE, separation quantification: separation factor, relative volatility, key components; flash: graphical and algebraic (Richford-Rice) method, differential distillation, Binary distialltion: McCabe-Thiele method - minimum reflux, minimum number of stages, open steam, multiple feeds, side streams, packed colums - HETP, HTU method, column pressure, tray efficiency, column sizing, sieve tray design, packed column design

	LLE - equilibrium diagram, selection of solvent; design calculations for single stage, cascade of stages using Hunter & Nash graphical method, McCabe-Thiele method, continuous contacting Multicomponent system: selection of key components, approximate - FUG method, DOF for cascade of stages, MESH formulation; Introduction to azeotropic & extractive distillation, Adsoption equilibrium, breakthrough curve

15. Lecture Outline (with topics and number of lectures)

Module no.	Topic	No. of hours
1	VLE, Ideal Solution, Raoult's law, t-xy and x-y diagram, tie line	2
2	Separation quantification: separation factor, relative volatility, key components; mass separating & energy separating agents, rate based and equilibrium based modeling	2
3	Flash: graphical and algebraic (Richford-Rice) method, isothermal, differential distillation - Rayleigh equation	3
4	Binary distialltion: McCabe-Thiele method - assumptions, operating lines, q-line, stage construction, total & partial condenser, minimum reflux, minimum number of stages, open steam, multiple feeds, side streams, packed colums - HETP, HTU method	10
5	Binary distillation: Operating pressure, tray efficiency, column sizing, sieve tray design, other trays; Packed column design	9
6	LLE-triangular diagram, rectangular coordinates, solvent free basis; selection of solvent; design calculations for single stage, cascase of stages using Hunter & Nash graphical method, McCabe-Thiele method, continuous contacting	9
7	Multicomponent system: selection of key components, approximate - FUG method, DOF for cascade of stages, MESH formulation; Introduction to azeotropic & extractive distillation	4
8	Adsoption equilibrium, breakthrough curve	3
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12		
	COURSE TOTAL *(14 times 'L')*	

16. Brief description of tutorial activities

Homework assignments based on principles and solution techniques covered in lectures will be provided beforehand and will be discussed in the tutorials. Both hand calculations and implimentantion of calculations on spreadsheet will be emphasised. A small part will be dedicated to exposure of using flowsheeting software for simulating mass transfer equipments covered in the course

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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10		
	COURSE TOTAL *(14 times 'P')*	

18. Suggested texts and reference materials
STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. W. McCabe, J. Smith, P. Harriot, Unit Operations of Chemical Engineering, Sixth Edition, McGRaw HIll, 2005
2. R. E. Treybal, Mass Transfer Operations, Third Edition, Tata McGRaw Hill, 2012
3. J. D. Seader and E. J. Henley, Separation Process Principles, Second Edition, Wiley India, 2010
4. R. K. Sinnot, Coulson Richardson's Chemical Engineering Volume 6, Fourth Edition, Cbs Publ Dists, 2005
4. E. L. Cussler, Diffusion Mass Transfer in Fluid Systems, Third Edition, CUP, 2009

19. Resources required for the course (itemized & student access requirements, if any)

19.1	Software	Spreadsheet, MATLAB, Flowsheeting software
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	LCD projector, AC
19.7	Site visits	

20. Design content of the course (Percent of student time with examples, if possible)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Department of Chemical Engineering
2.	**Course Title** *(< 45 characters)*	FLUID PARTICLE MECHANICS
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	CHL331
6.	**Status** (*category* for *program*)	Core

7.	**Pre-requisites** (course no./title)	Transport Phenomena, FM

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	N
8.2	Overlap with any UG/PG course of other Dept./Centre	N
8.3	Supercedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem

11.	**Faculty who will teach the course** S. K. Pattanayek, S.Basu, B. P. Mani, R.Mohan,P.Chowski, S.Roy,V.Buwa	
12.	**Will the course require any visiting faculty?**	N

13. Course objective *(about 50 words)*:

To introduce the various particles encountered in various chemical engineering processes, their handling through various unit operation and to understand hydrodynamic interaction with particles

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Introduction and Industries dealing with the particles (Solid, liquid, gas, soft-materials: Colloids, polymer); Solid particles: Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area; Meauserment of surface area, sizes etc.; Drag coefficient in various regimes; Packed bed;Fludization; Sedimentation: Settling, Hindered settling, design of settling tank; filtration; centrifugal separation; cyclone; mixing (solid-solid, solid-liquid and liquid-liquid); segregation, Size reduction, Size enlargement, Flow properties of slurries, Behavior of Colloidal particles in dispersed condition.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction and Industries dealing with the particles	2
2	Solid particles: Particle size, shape and their distribution; Relationship among shape factors and particle dimensions; Specific surface area; Measurement of surface area, sizes etc.;	3
3	Introduction particle-fluid interaction through drag	2
4	Packed bed: Void fraction, superficial velocity, channeling, Friction factors for packed columns, Ergun equation, Kozney Carman eqn, Darcy's law, Blain apparatus	4
5	Fludization: Fluidized bed, minimu fluidization velocity, pressure drop Geldart plot etc. Types of fluidization: Particulate fludization, Bubbling fluidization, Application of fluidization	4
6	Sedimentation: Free Settling, hindered settling, design of settling tank	5
7	Filtration, centrifugal separation, cyclone	7
8	Size reduction	3
9	Segregation; Size enlargement	3
10	Agitator, Liquid-Liquid Mixing, Solid-Liquid Mixing, Solid-Solid mixing,	3
11	Colloidal particles & Flow properties of slurries	4
12	Design of cyclone, Agitator, slurry handling system	2
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- Rhodes, M. J. , Introduction to particle technology, 2nd edition, John Wiley, Chichester ; New York, 2008 .
- Coulson and Richardson's CHEMICAL ENGINEERING, VOLUME 2, Butterworth-Heinemann, Fifth edition 2002.
- McCabe, W., Smith, J. and Harriott, P. Unit Operations of Chemical Engineering, 6th edition., McGraw Hill
- Terence Allen, Powder Sampling and Particle size Determination, Elsevier, 2003
- Hiroaki Masuda, Ko Higashitani, Hideto Yoshida, Powder Technology Handbook, CRC,

Taylor and Francis, 2006.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	PROCESS DYNAMICS AND CONTROL
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	CHL261
6.	**Status** (*category* for *program*)	Dept core for CH1, CH7

7.	**Pre-requisites** (course no./title)	MAL 110, CHL 111

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	MEL 312, EEL301
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	CHL202, CHL261

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐ Every sem ☒ 1st sem ☐ 2nd sem ☐ Either sem

11.	**Faculty who will teach the course** Munawar A. Shaik, Shantanu Roy, Anurag Rathore	
12.	**Will the course require any visiting faculty?**	No

13. Course objective *(about 50 words)*:

To introduce the fundamentals of process control with applications such as temperature, level, and flow control using classical P, PI, and PID controllers. Development of mathematical models based on transfer function approach for single loop systems, obtaining dynamic response of open loop and closed loop systems, stability analysis in transient and frequency domains, and controller tuning methods.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Introduction to automation, block diagrams; Revision of Laplace transform; Modeling based on transfer function approach; Open-loop systems: dynamic response of first order systems, first order systems in series, second order systems, and transportation lag; Feedback control: P, PI, PID controllers, dynamic response of closed loop systems; Linear stability analysis, Routh stability criterion, root locus diagrams; Frequency response: Bode diagrams, Nyquist diagrams, Bode and Nyquist stability criterion; Controller tuning:

	Zeigler-Nichols and Cohen-Coon methods; Introduction to advanced controllers: feedforward control, cascade control, dead time compensation, ratio control, internal model control. Use of MATLAB for control system analysis.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to automation, block diagrams, control structures (feedback vs. feedforward), process & instrumentation diagrams	5
2	Revision of Laplace transforms, solution of ODEs using Laplace transform	4
3	Transfer function approach, response of first order systems: step, impulse and sinusoidal response, first order systems in series	4
4	Second order systems, higher order systems, transportation lag	3
5	Linear closed loop systems, development of block diagrams, classic feedback controllers	3
6	final control element (control valves), block diagram reduction techniques	3
7	Closed loop response, servo & regulatory problems	2
8	Stability analysis, Routh stability criterion, Root locus diagrams (rule based)	3
9	Introduction to frequency response (substitution method), notion of stability	2
10	Bode diagrams, Nyquist plots, Bode and Nyquist stability criterion	4
11	Controller tuning: Ziegler-Nichols method, Cohen-Coon method	4
12	Introduction to advanced controllers: cascade control, feed forward control, ratio control, Smith-predictor, IMC, Introduction to digital control	5
COURSE TOTAL *(14 times 'L')*		42

16. Brief description of tutorial activities

Emphasis on numerical problem solving: block diagram development, use of matlab for open loop and closed loop response, stability analysis, root locus, Bode diagrams, controller tuning.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
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COURSE TOTAL *(14 times 'P')*		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text Book:

- Coughanowr, D. R., LeBlanc, S. "Process Systems Analysis and Control", 3rd edition, McGrawHill, 2008.

References:

- Seborg, D.E., Edgar, T.F., Mellichamp, D.A. “Process Dynamics and Control”, 2nd edition, John Wiley (2003)
- Stephanopoulos, G. “Chemical Process Control: An Introduction to Theory and Practice”, Pearson Education (1984)

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	LCD projector, bio-metric device for attendance
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	CHEMICAL ENGINEERING
2.	**Course Title** *(< 45 characters)*	NUMERICAL METHODS IN CHEMICAL ENGINEERING
3.	**L-T-P structure**	(3-0-2)
4.	**Credits**	4 UNITS
5.	**Course number**	CHL(1--) OR CHL(2--)
6.	**Status** (*category* for *program*)	CORE COURSE FOR CHEMICAL ENGINEERING UNDERGRADUATES

7.	**Pre-requisites** (course no./title)	NONE

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	CHL711/761/773
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem

11.	**Faculty who will teach the course** ALL CHEMICAL ENGINEERING FACULTY	
12.	**Will the course require any visiting faculty?**	NO

13. Course objective *(about 50 words)*:

To introduce students to

* numerical methods used to solve engineering problems with help of computers
* fundamentals of numerical methods/algorithms to solve systems of different mathematical equations (e.g. linear/ non-linear algebraic equations, ordinary /partial differential equations, etc)
* writing their own computer programs using C and also using commerical softwares like MATLAB.
* hands-on experience to apply these computer programs to solve problems in different areas of chemical engineering e.g. fluid flow, heat and mass transfer, chemical reaction engineering etc.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Estimation and round of error calculations. Solution of linear algebraic

	equations via Gauss elimination, LU decomposition, matrix inversion, Gauss-Seidel method etc. Solving non-linear algebraic equations with the help of root finding. Numerical Integration and differentiation. Solution of ordinary differential equations encountered in initial/boundary value problems via implicit and explicit methods. Solution of partial differential equations by numerical methods. Chemical engineering problems where the above mentioned numerical schemes are involved will be illustrated in details.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	INTRODUCTION,APPROXIMATION AND ROUND OFF ERRORS	1
2	LINEAR ALGEBRAIC EQUATIONS 1. Gauss elimination, LU decomposition and matrix inversion 2. Gauss-Seidel and special matrices 3. Chemical engineering problems involving solution of linear algebraic equations	5
3	Eigenvalues	3
4	ROOT FINDING AND SOLUTION OF NON-LINEAR EQUATIONS 1. Root finding methods: Bracketing (Bisection) and Open (Newton-Raphson, Secant) methods 2. Solution of a system of non-linear equations 3. Chemical engineering problems involving solution of non-linear equations	8
5	Functions, interpolation, approximation, regression Interpolation, Newton's polynomials and lagrange polynomials, spline interpolation, linear regression, polynomial regression, least square regression	6
6	NUMERICAL INTEGRATION AND DIFFERENTIATION 1. High-accuracy differentiation formulas, Richardson extrapolation 2. Trapezoidal rule, Simpson’s rule, integration with unequal segments, Romberg integration, quadrature methods, multiple integrals 3.Chemical engineering problems involving numerical differentiation and integration	4
7	ORDINARY DIFFERENTIAL EQUATIONS 1. Euler method, RK methods,adaptive RK method, 2. Solution to a system of ODEs 3. Initial and boundary value problems 4. Chemical engineering problems involving a system of ODEs	8
8	PARTIAL DIFFERENTIAL EQUATIONS 1.Characterization of PDEs 2.Solution to elliptic PDEs 3.The Laplace equation, solution technique, boundary conditions 4. Solution to parabolic PDEs 5. The heat conduction/diffusion equations, explicit, implicit, C-N methods, boundary conditions 6. 2D parabolic equations 7. Chemical engineering problems involving a PDEs	7
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12		
	COURSE TOTAL *(14 times ‘L’)*	42

16. Brief description of tutorial activities

Two hours of lab where students will learn to write their own codes in C to solve numerical problems and will learn to use softwares like MATLAB

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Introduction	2
2	Solution of linear algebraic equations using Gauss elimination	2
3	Solution of linear algebraic equations using Gauss-siedel method	2
4	Solution of a non-linear equation using bracketing and Newton-Raphson method	2
5	Solution of a system of non-linear equations using Newton-Raphson method	2
6	Problem(s) involving interpolation	2
7	Problem(s) involving numerical integration	2
8	Solution to an ODE: Euler vs R-K method	2
9	Solution to a system of ODEs (IVP)	2
10	10 Solution to a system of ODEs (BVP) 11 Solution of 2D parabolic equations 12 Solution of 2D parabolic equations 13 .... 14 Practical examination	2 2 2 2 2
	COURSE TOTAL *(14 times 'P')*	28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Text books:
S.C. Chapra & R.P. Canale, "Numerical Methods for Engineers with Personal Computer Applications", McGraw Hill Book Company, 1985.
R.L. Burden & J. D. Faires, "Numerical Analysis".

Reference books:
Atkinson, K.E., "An Introduction to Numerical Analysis", John Wiley & Sons, 1978.
Gupta, S. K., "Numerical Methods for Engineers, New Academic Science, 2012.
Press, W. H. et al., "Numerical Recipes in C: The Art of Scientific Computing, 3rd Edition, Cambridge University Press, 2007.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	C Compiler/MATLAB
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Projectors
19.4	Laboratory	Computational Lab
19.5	Equipment	
19.6	Classroom infrastructure	####
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	INTRODUCTION TO INDUSTRIAL BIOTECHNOLOGY
3.	**L-T-P structure**	3-1-0
4.	**Credits**	4
5.	**Course number**	CHL XXX
6.	**Status** (*category* for *program*)	Core for CH

7.	**Pre-requisites** (course no./title)	CHL110

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	BEN150 (5%), BEL401 (5%), BEL703 (5%)
8.3	Supercedes any existing course	None

9.	**Not allowed for** (indicate program names)	
10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☐ 2nd sem ☒ Either sem
11.	**Faculty who will teach the course** Anurag S. Rathore (Chem Engg), Mohammed Ali Haider (Chem Engg), Sudip Pattanayek (Chem Engg), Sanat Mohanty (Chem Engg), Shalini Gupta (Chem Engg)	
12.	**Will the course require any visiting faculty?**	No
13.	**Course objective** *(about 50 words)*: This course is intended for UG and PG students who may be interested in pursuing a career in the biopharmecutical industry. The course will present fundamenal concepts and practical applications related to process development and commercialization of biotech therapeutics. Industrial case studies that elucidate the above concepts will also be presented.	
14.	**Course contents** *(about 100 words) (Include laboratory/design activities)*: Introduction to biopharmaceutical industry. Monod kinetics. Michaelis Menten kinetics. Introduction to the different bioprocessing unit operations utilized in production of biotech drugs - upstream, harvest, and downstream. Design, control and scale up of bioreactor. Introduction to analytical methods used for characterization of biotech products and processes (high performance liquid	

	chromatography, mass spectrophotometry, capillary electrophoresis, near infrared spectroscopy, UV spectroscopy). Fundamentals and design of filtration and other membrane based separation techniques. Process chromatography - theory, practice, design and scale-up. Mixing, heat transfer and mass transfer in bioprocessing unit operations. Scale-up of filtration and chromatography unit operations utilized in bioprocessing: procedures, issues that frequently occur and possible solutions. Process design, control and optimization. Current topics in biopharmaceutical technology.

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to biotech industry	1
2	Monod kinetics and Michaelis Mentel Kinetics	2
3	Introduction to the different bioprocessing unit operations	2
4	Design, control and scale up of bioreactor	6
5	Introduction to analytical methods	2
6	Filtration and other membrane based separation techniques	5
7	Process chromatography - theory, practice, design and scale-up	6
8	Mixing, heat transfer and mass transfer in bioprocessing unit ops	6
9	Process design, control and optimization	6
10	Quality by Design and Process Analytical Technology	2
11	Basics of GMP manufcaturing and Technology Transfer	2
12	New technologies in bioprocessing	2
	COURSE TOTAL *(14 times 'L')*	42

16. Brief description of tutorial activities

Tutorials will involve either numerical problems to elucidate mathematical concepts introduced in the course or extra reading material and discussion designed to clarify complex topics

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Not applicable	
2		
3		
4		
5		
6		
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	COURSE TOTAL *(14 times 'P')*	

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. P. A. Belter, E. L. Cussler, W. –S. Hu. Bioseparations: Downstream Processing in Biotechnology, Wiley Interscience, 1988.
2. A. A. Shukla, M. R. Etzel and S. Gadam. Process Scale Bioseparations for the Biopharmaceutical Industry, Taylor and Francis, Boca Raton,FL, 2007.
3. J. E. Bailey and D. F. Ollis, Biochemical Engineering Fundamentals, McGraw Hill Book Company, Singapore, 1986.
4. Rajni Hati-Kaul and Bo Mattiasson, Isolation and Purification of Proteins, Marcel Dekker, 2003.

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	Microsoft office
19.2	Hardware	None
19.3	Teaching aides (videos, etc.)	None
19.4	Laboratory	None
19.5	Equipment	None
19.6	Classroom infrastructure	Laptop projection system
19.7	Site visits	None

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	Yes
20.2	Open-ended problems	No
20.3	Project-type activity	Yes
20.4	Open-ended laboratory work	No
20.5	Others (please specify)	None

Date: (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	INTRODUCTION TO MATERIALS FOR CHEMICAL ENGINEERS
3.	**L-T-P structure**	3-0-0
4.	**Credits**	3
5.	**Course number**	
6.	**Status** (*category* for *program*)	CORE

7.	**Pre-requisites** (course no./title)	None

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	AML120 (10%)
8.3	Supercedes any existing course	

9.	**Not allowed for** (indicate program names)	
10.	**Frequency of offering**	☐Every sem ☐1st sem ☐2nd sem ☒Either sem

11.	**Faculty who will teach the course** S. K. Pattanayek, S. Mohanty, R.Khanna, Shalini Gupta	
12.	**Will the course require any visiting faculty?**	No

13. Course objective *(about 50 words)*:

The objective of the course will be to give the students a basic introduction to the different classes of materials relevant to the Chemical Engineering industries. The intent of the course will be to relate the underlying molecular structure of the materials to their physical and chemical properties, and their processing and performance characteristics.

14. Course contents *(about 100 words) (Include laboratory/design activities)*:

Brief introduction to crystalline solids - metals and semiconductors, types of atomic bonding and lattices; a detailed discussion on semi-crystalline materials - ceramics, polymers, copolymers, liquid crystals and surfactants; a detailed overview of amorphous and composite systems such as glass, fibers, granular materials, matrices and alloys; role of materials selection in design; structure-property-processing-performance relationships; materials characterization via experimental techniques; special materials like biomaterials and zeolites

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction to materials as building blocks for engineers: Evolution of materials with time, role of materials selection in design, structure-property-processing-performance relationships	2
2	Review of Structure of materials and Strength of Materials	3
3	Semi-crystalline materials: Classification, structure and configutation of ceramics, polymers, copolymers, liquid crystals and amphiphiles	10
4	Noncrystalline/amorphous materials: Silicates, glass transition temperature, viscoelasticity	6
5	Polymer nano-Composite materials: Nanocomposites, role of reinforcement-matrix interface strength on composite behavior	4
6	Corrosion, Degradation and Recyling	6
7	Experimental techniques, such as XRD, NMR, PSA, etc. for material characterization highlighting links between molecular structure and macroscopic properties	6
8	Biomaterials, material realted to catalyst such as zeolites, silica etc. and other selected materials	5
9		
10		
11		
12		
	COURSE TOTAL *(14 times 'L')*	42

16. Brief description of tutorial activities

N/A

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	N/A	
2		
3		
4		
5		
6		
7		
8		
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10		
	COURSE TOTAL *(14 times 'P')*	

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1.RAL Jones, Soft Condensed Matter, Oxford University Press, 2002

2. W.D. Callister Jr. and D.G. Rethwisch, Fundamentals of Materials Science and Engineering: An Integrated Approach John Wiley & Sons, 2012

3. B.S. Mitchell An Introduction to Materials Engineering and Science for Chemical and

Materials Engineers, John Wiley & Sons, 2004
4. G.S. Upadhyaya and A. Upadhyaya, Material Science and Engineering, ANSHAN PUB, 2007

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	No
19.2	Hardware	No
19.3	Teaching aides (videos, etc.)	No
19.4	Laboratory	No
19.5	Equipment	No
19.6	Classroom infrastructure	Overhead projector
19.7	Site visits	No

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	N/A
20.2	Open-ended problems	N/A
20.3	Project-type activity	N/A
20.4	Open-ended laboratory work	N/A
20.5	Others (please specify)	N/A

Date: March 21, 2013 (Signature of the Head of the Department)

COURSE TEMPLATE

1.	**Department/Centre proposing the course**	Chemical Engineering
2.	**Course Title** *(< 45 characters)*	INSTRUMENTATION AND AUTOMATION
3.	**L-T-P structure**	1-0-2
4.	**Credits**	2
5.	**Course number**	CHLXXX
6.	**Status** (*category* for *program*)	Dept core for CH1, CH7

7.	**Pre-requisites** (course no./title)	CHL261

8.	**Status vis-à-vis other courses** *(give course number/title)*	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	CHP303 (control part)

9.	**Not allowed for** (indicate program names)	

10.	**Frequency of offering**	☐ Every sem ☐ 1st sem ☒ 2nd sem ☐ Either sem

11.	**Faculty who will teach the course** All ChE faculty	
12.	**Will the course require any visiting faculty?**	No

13.	**Course objective** *(about 50 words)*: To introduce the basics of instrumentation and principles of operation of different measuring devices for temperature, level, pressure, flow, PH, humidity, denstiy, and viscosity; to impart knowledge of transmitters, transducers, converters, control valves, digital and analog components related to PLC, DCS, SCADA systems with emphasis on practical hands-on training.

14.	**Course contents** *(about 100 words) (Include laboratory/design activities)*: Signals and standards (pneumatic, voltage, current); Basics of control loop components: sensors, transmitters, transducers, control valves, and converters; Measuring devices for process variables: temperature, pressure, level, flow, PH, humidity, density, and viscosity; Different control valves, actuators, positioners; computer-based control systems: PLC, DCS, SCADA

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Basics of control system components, signals and standards	1
2	Pressure measuring instruments/sensors	1
3	Level measurement	1
4	Flow measuring instruments	1
5	Temperature measuring devices	1
6	Humidity, density, viscosity and PH measuring devices	2
7	Pressure controllers: regulators, safety valves	1
8	Flow control actuators: different types of valves	1
9	Electrical and pneumatic signal conditioning and transmission	1
10	Computer process control, PLC, DCS, SCADA	4
11		
12		
COURSE TOTAL *(14 times 'L')*		14

16. Brief description of tutorial activities

NA

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	Control valves	2
2	Temperature & pressure measuring devices	4
3	Level & flow measuring devices	4
4	Viscosity & PH measuring devices	4
5	Transmitters & transducers	2
6	Open loop systems: lagged thermometer, stirred-tank heater	4
7	Temperature, level, & pressure control trainers	6
8	Flow-level cascade control	2
9		
10		
COURSE TOTAL *(14 times 'P')*		28

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

William C. Dunn, Fundamentals of Industrial Instrumentation and Process Control, Mc-GrawHill (2005).
S.K. Singh, Industrial Instrumentation and Control, 3rd edition, McGraw-Hill (2008).
Seborg, D.E., Edgar, T.F., Mellichamp, D.A. "Process Dynamics and Control", 2nd edition, John Wiley (2003).
Stephanopoulos, G. "Chemical Process Control: An Introduction to Theory and Practice", Pearson Education (1984).

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB/Labview
19.2	Hardware	

19.3	Teaching aides (videos, etc.)	LCD projector, bio-metric device for attendance
19.4	Laboratory	Instrumentation and process control Lab
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: (Signature of the Head of the Department)