Semester VI						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**C**
1	CH 402	Catalysis	3	0	0	3
2	CE 301	Environmental studies	3	0	0	6
3	EE 226	Control Systems and Laboratory	2	0	2	6
4		Programme elective-III	3	0	0	6
5		Programme elective-IV	3	0	0	6
6		Scientific presentation	0	0	3	3
7	CL 401	Chemical Reaction Engineering-II	3	0	3	6
		Total Credits				30

1	**Title of the course** (L-T-P-C)	**Catalysis** **(3-0-0-3)**
2	**Pre-requisite courses(s)**	Fundamental concepts and applications of chemistry (CH101)
3	**Course content**	Fundamentals of catalysis, including kinetics and mechanistic models. Heterogeneous and homogenous catalysis. The fundamentals of electrocatalysis and the effects of coupling proton and electron transfer for catalytic redox reactions. Surface properties and function in heterogeneous catalysis. Structure, bonding and reactivity of coordination compounds and metalloorganic complexes based on transition metals. MO theory and 18-electron rule. Ligand substitution, alkene isomerization hydroboration, hydrocyanation, hydrogenation of olefins, Wilkinson's catalyst hydroformylation of olefins, Wacker-Schmidt synthesis, Monsanto acetic acid process, Fischer-Tropsch process.
4	**Texts/References**	1. J. F. Hartwig, Organotransition Metal Chemistry: From Bonding to Catalysis, 1stEd, University Science Books, 2010. 2. Vishwanathan, S. Sivasanker, A.V. Ramaswamy, Catalysis – Principles & Applications

1	**Title of the course (L-T-P-C)**	**Environmental studies (3-0-0-6)**
2	**Pre-requisite courses(s)**	**Nill**
3	**Course content**	**Module A:** Natural Resources, Ecosystems, Biodiversity and its conservation: Natural resources and ecosystems, Forest, grassland, desert and aquatic ecosystems, biodiversity at global, national and local levels, conservation of biodiversity **Module B:** Air Pollution Introduction to understanding air quality management, fundamental processes of meteorology, Air Pollutants – Gaseous and particulate, Criteria for pollutants, ambient and source standards, Aerosols: Characterisation of aerosols, size distributions, measurement methods; Transport behaviour: diffusion, sedimentation, inertia; Visibility; principles of particulate control systems. **Module C:** Water Treatment Discussion of water quality constituents and introduction to the design and operation of water and wastewater treatment processes. **Module D:** Solid Waste Management and Climate Change Different aspects of solid and hazardous waste management. Climate change and greenhouse gas emissions, technologies would reduce the greenhouse gas emissions. Climate change and its possible causes. **Module E:** Sociology/Environmentalism Description: Environmentalism in sociological tradition, Sustainability, North-South divide, Political economy approaches in environmental studies, Debates over environmental issues. **Module F:** Economics Energy economics and financial markets, Market dynamics, Energy derivatives, Energy Efficiency; Sustainable Development: Concept, Measurement & Strategies, Interaction between Economic Development and the Environment **Module G:** Philosophy Environmental ethics, Deep ecology, Practical ecology, Religion and attitude towards environmental ethics, Ecofeminism and its evolution. **Module H**: Field work and project: visit to a local area to document environmental assets, case studies of a simple ecosystem and group discussions on current environmental issues.
4	**Texts/References**	**1.** Cunningham W.P. and Cunningham M.A. (2002), Principles of Environmental Science, Tata McGraw-Hill Publishing Company, New Delhi. **2.** Dasgupta, P. and Maler, G. (eds.), (1997), The Environment and Emerging Development Issues, Vol. I, Oxford University Press, New Delhi. **3.** Jackson, A.R.W. and Jackson, J.M. (1996), Environmental Sciences: The Environment and Human Impact, Longman Publishers. **4.** Nathanson, J.A., (2002), Basic Environmental Technology, Prentice Hall of India, New Delhi. **5.** Redclift, M. and Woodgate, G. (eds.), (1997), International Handbook of Environmental Sociology. **6.** Srivastava, K.P. (2002), An Introduction to Environmental Study, Kalyani Publishers, Ludhiana. **7.** Review articles from literature.

1	**Title of the course (L-T-P-C)**	**Control Systems and Laboratory (2-0-2-6)**
2	**Pre-requisite courses(s)**	--
3	**Course content**	• **Basic concepts:** Notion of feedback, open- and closed-loop systems. • **Modeling and representations of control systems:** Transfer function models of for suitable mechanical, electrical, thermal and pneumatic systems, Ordinary differential equations, Transfer functions, Block diagrams, Signal flow graphs, State-space representations. • **Performance and stability:** Time-domain analysis, Second-order systems, Characteristic-equation and roots, Routh-Hurwitz criteria. • **Basic modes of feedback control:** Proportional, Integral, Derivative. • **Root locus** method of design. • **Frequency-domain techniques:** Root-locus methods, Frequency responses, Bode-plots, Gain- margin and phase-margin, Nyquist plots. • **Compensatory design:** Proportional, PI and PID controllers, Lead-lag compensators. • **State-space concepts:** Controllability, Observability, pole placement result, Minimal representations. Laboratory involves set of experiments following the theory component covered in the class.
4	**Texts/References**	**1.** Norman Nise, Control System Engineering, Wiley, 6th Edition, 2011 **2.** K. Ogata, Modern Control Engineering, Pearson, 5th edition, 2010. **3.** Gene franklin et. al., "Feedback Control of Dynamic Systems", 7th Edition, Pearson **4.** B. Kuo, Automatic Control System, Wiley, 9th Edition, 2014

1	**Title of the course (L-T-P-C)**	**Chemical Reaction Engineering-II (3-0-3-6)**
2	**Pre-requisite courses(s)**	Reaction Engineering
3	**Course content**	Multiphase reactors (gas-liquid; liquid-liquid); yield, selectivity, reactor design for multiple reactions. Models of industrial reactors: pressure drop considerations, heat management, non-isothermal reactors, steady state multiplicity. Residence time distribution: theory; evaluation from tracer experiments. Non-ideal reactor modelling: use of rtd; zero, one and two parameter models; compartment modelling. Applications: polymerization; combustion; biochemical reactions; multi- functional reactors; stochastic approaches to kinetics.
4	**Texts/References**	1. H.S. Fogler, Elements of Chemical Reaction Engineering, Prentice Hall, 2nd ed., New Jersey, 1992. 2. O. Leven Spiel, Chemical Reaction Engineering, Wiley Eastern, 2nd ed., 1972. 3. J.M. Smith, Chemical Engineering Kinetics, 3rd ed., McGraw Hill, 1980.