Course Curriculum for M.Tech. PROGRAMME

2-Year M.Tech. Programme in Pharmaceutical Science and Engineering

Course Philosophy

- This M.Tech course provides the training and development necessary to meet demand for highly skilled scientist/technocrats within the expanding and national and global pharmaceutical Sector.

- It can lead to a wide range of careers including academic, commercial, industrial and healthcare applications of pharmaceutical sciences

- The course has been designed to respond to the increasing demand for suitably trained professional chemist, essential to speed up the critical task of translating basic laboratory pharmaceutical research into commercially-ready medical essentials and drugs that can be used for human Well Beings

- We are committed to providing our students with the best possible experience. We continue to invest in both our facilities and our innovative approach to education and learning

Name Program	**M.Tech. Programme in Pharmaceutical Science and Engineering**

Distribution of Total Credits		
Departmental Core (DC)	**Departmental/Open Elective (DE/OE)**	**Total Credits**
111	**63**	**174**

Distribution of credits: Semester-wise				
Semester I	**Semester II**	**Semester III**	**Semester IV**	**Total**
51	**51**	**36**	**36**	**174**

Course-Structure

FIRST SEMESTER

Course No.	Course Name	L	T	P	C
Departmental Core-course Theory					
CYC 525	Basic of Pharmacology & Drug Design	3	0	0	9
CYC 526	Pharmaceutical Process Technology	3	0	0	9
CYC 523	Numerical Analysis and Methods in Chemistry	3	0	0	9
CYC 527	Formulation & Drug Delivery Technology	3	0	0	9
CHC 525	Unit Operations for Pharmaceutics	3	0	0	9
Departmental Core-course Practical					
CYC 528	Process Chemistry Lab	0	0	3	3
CYC 518	Analytical Techniques lab	0	0	3	3
	Total	**15**	**0**	**6**	**51**

SECOND SEMESTER

Course No.	Course Name	L	T	P	C
Departmental Core Course Theory					
CHE 530	Reaction Engineering	3	0	0	9
MCD 535	Bioinformatics	3	0	0	9
Departmental Elective					
Departmental Elective 1: Any one course from Departmental Elective Group A		3	0	0	9
Departmental Elective 2: Any one course from Departmental Elective Group A, excluding the course already chosen as Departmental Elective 1		3	0	0	9
Open Electives					
Open Elective 1: Any one course from Open Elective Group A or Any one from the courses offered by another Department as Open Elective		3	0	0	9
Departmental Core Course Practical					
CHC 531	Chemical Engineering Lab	0	0	3	3
CYC 529	Formulation/Manufacturing Lab	0	0	3	3
	Total	**15**	**0**	**6**	**51**

Departmental Elective Group – A	
CYD 525	Biopharmaceutics and Pharmacokinetics
CYD 526	Quality Control and Pharmaceutical Analysis
CYD 527	Pharmacognosy and Phytopharmaceutical
CYD 528	Modern Separation Techniques
CYD 529	Computer Aided Drug Discovery
CYD 530	Pharmacovigilance and Regulatory Affairs
CYD 531	Biotechnology in Pharmaceutical Sciences

Open Elective Group -A	
CYO 501	Instrumental Techniques for Material Characterization
CYD 534	Heterocyclic Chemistry
CYD 535	Main Group Chemistry

THIRD SEMESTER

Course No.	**Course Name**	**L**	**T**	**P**	**C**
CYC 530	Thesis Unit 1	0	0	0	9
CYC 531	Thesis Unit 2	0	0	0	9
CYC 532	Thesis Unit 3	0	0	0	9
CYC 533	Thesis Unit 4	0	0	0	9
	Total	**0**	**0**	**0**	**36**

FOURTH SEMESTER

Course No.	**Course Name**	**L**	**T**	**P**	**C**
Departmental Electives or Open Electives					
Departmental Elective 3: Any one from Departmental Elective Group B		3	0	0	9
Open Elective 2: Any one from the courses offered by Department as Open Elective from Group B or Any one from the courses offered by another Department as Open Elective		3	0	0	9
CYC 534	Thesis Unit 5	0	0	0	9
CYC 535	Thesis Unit 6	0	0	0	9
	Total	**6**	**0**	**0**	**36**

Departmental Elective Group – B	
ESD 506	Biomedical and Hazardous Waste Management
ESD 505	Advanced water and wastewater treatment

Open Elective Group - B	
MSO 503	Financial Econometrics
MSO 504	Supply Chain Management

Indian Institute of Technology (Indian School of Mines), Dhanbad

Syllabus for 2-Year M. Tech Programme in Pharmaceutical Science &Engineering

Semester-I					
CYC 525	**Basic of Pharmacology & Drug Design**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- This enables the students to get a broad idea on Pharmacology and Drug Discovery mechanisms, its related terms and concepts of designing of drugs and their effects.

Learning Outcomes:

- The topics are framed to enhance the student's knowledge in various areas of drug action in biological system.
- Pharmacokinetics, Molecular Docking, Drug Design Techniques, Molecular modelling.

Unit I	**Drugs and drug targets** -Introduction. Proteins, Enzymes, receptors and nucleic acids as drug targets, Genomics in target discovery: Concept of genome, genes and gene expression; genome sequencing and sequence comparison methods (microarray); Study of Pharmacology of diseases and drugs with mode of action especially for diabetes, cancer, Neuro diseases, hypertension *etc*. Mechanism of drug action, drug-receptor interaction.	**12L**
Unit II	**Protein expression systems**: Gene expression in bacteria, yeast, insect and mammalian cells. Enzyme purification and assay: Various protein purification methods; enzyme based assay for small molecule screening.	**6L**
Unit III	**Principles of drug design**: Analogue synthesis versus rational design; Molecular Docking: Structure guided drug design (SGDD), Rigid docking, Flexible docking, Manual docking. Molecular dynamics: dynamics of drugs, biomolecules, drug receptor complexes, Pharmacophore identification, Prodrugs.	**12L**
Unit IV	**Classification of drugs**- Based on the structure or a pharmacological basis with examples. Anti-bacterials, antivirals, antifungal, anticancer agents, statins, antidiabetic drugs, cardiovascular drugs	**9L**

References:

1.The Pharmacological Basis of Therapeutics, Louis S. Goodman, Alfred Gilman Sr., Edited by Laurence L. Brunton, John, S.L., K.L. Parker, McGraw Hill Education, 11th Edition (2005).
2. Oxford Textbook of Clinical Pharmacology and Drug Therapy, D.G. Grahame-Smith and J.K. Aronson, Oxford University Press, 3rd Edition (2002).
3. Organic Chemistry of drug design and drug action, R.B. Silverman, AcademicPress, 2nd Edition (2004).
4. Statistical Methods in Biology, Bailey, M.A., Norman, T.J., Cambridge University Press, 3rd Edition (1995).
5. A Text book of Drug design and development, Povl. Krogsgaard-LarsenTommy L. and U Madsen, CRC Press, 2nd Edition (1996).

CYC 526	**Pharmaceutical Process Technology**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- To develop synthetic routes that is safe, cost-effective, environmentally friendly, and efficient.

Learning Outcomes:

- Knowledge about not only about reactions but also about impurities that may develop from side reactions.
- Knowledge of taking synthesized drugs in milligram stage from laboratory to manufacturing scale.

Unit I	**Reaction progress kinetic analysis:** Streamlining reaction steps, route selection, characteristics of expedient routes, characteristics of cost-effective routes, reagent selection, families of reagents useful for scale-up, solvent selection, selecting solvents based on physical characteristics, selected solvent impurities.	**8L**
Unit II	**Green chemistry:** 12 Principles of green chemistry, examples of greener route to chemical reactions, designing robust reaction conditions, reaction media for green chemistry, organic reactions in water, sustainable development of a process.	**6L**
Unit III	**Impurity consideration:** Introduction, Steps to optimizing reactions, minimizing the impurity formation by identifying impurities first, method development for the separation, synthesis and isolation of impurities and their characterization, Statistical design of experiments.	**6L**
Unit IV	**Scale-up Techniques:** Scale-up techniques for process optimization, maximization of productivity, in-process control techniques. Scale-up techniques for industrial pharmacy, typical standard operating procedures for different dosage forms; In-process control procedures. **Chemical technology of selected drugs**: Case studies with emphasis on rationale for selection of routes, raw materials, process control methods, pollution control procedures, etc. Data collection during pilot plant trails, preparations of flow diagrams, material balance sheets and technical data sheets.	**12L**
UNIT V	Process technologies for some selected natural products of commercial interest.	**7L**

References:

1.Process Chemistry in Pharmaceutical Industry, Kumar Gadamasetti, Vol I & II, CRC Press, 1st Edition (1999).
2. Advanced Organic Chemistry, Jerry March, Wiley-Blackwell, 3rd Edition (1985).
3. Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up, Peter J. Harrington, Wiley-Blackwell, 1st Edition (2011).
4. Practical Process Research and Development, Neal G. Anderson, Academic Press, 2nd Edition (2012).
5. Strategies for Organic Drug Synthesis and Design, Daniel Lednicer, Wiley-Interscience; 1st edition (1998).

CYC 523	Numerical Analysis and Methods in Chemistry	L	T	P	C
		3	0	0	9

Course Objectives:

- Course Philosophy:
- The course is aimed to introduce the basics of theoretical and numerical methods for computer simulation of model systems. It also intends to develop elementary programming skills in C++ to enable them write short programs for performing scientific calculations.
- Introduction of various simulation techniques using standard softwares.

Learning Outcomes:

- At the end of the course, the learners should be able to:
- Write short, simple programs in C++
- The students should be able to perform basic molecular modeling for various chemical and physical problems using standard softwares such as TeraChem, Gaussian, NAMD, AMBER, etc. The student should be also understand simulated results and correlate with corresponding experimental observations.

Unit I	Errors in Chemical Analyses, Random Errors in Chemical Analysis, Statistical Data Treatment and Evaluation, Sampling. Standardization, and Calibration. Usage of packages (e.g. ORIGIN; EXCEL) for data analysis. Curve Fitting: Linear and Non-linear fitting of data.	**6L**
Unit II	Introduction to programming languages (C++) : data types, arrays, functions, classes and objects, constructors and destructors, function overloading, operator overloading; Basic numerical analysis: solution of linear and nonlinear equations.	**15L**
Unit III	Review of Basic Concepts: Length and Time Scales, Intermolecular Interactions and Potential Energy Surfaces, Classical Molecular Dynamics (MD): Langevin and Newtonian equations of motions, Various integration algorithms, and Force calculations. All atom and ab-initio molecular dynamics, Quantum mechanics/molecular mechanics (QM/MM) approaches. Use of various commercially available molecular modelling and simulation software (NAMD, AMBER, TeraChem, and GAUSSIAN).	**18L**

References:

1. Elementary Numerical Analysis-An Algorithm Approach, S.D. Conte and C. De Boor, McGraw Hill, 1980.
2. Programming: Principles and Practice Using C++, Bjarne Stroustroup, Addison-Wesley Publisher, 2017.
3. Introduction to Computational Chemistry, F. Jensen, John, Wiley & Sons, 2nd Edition (2007).

CYC 527	Formulation & Drug Delivery Technology	L	T	P	C
CHC 525	Unit Operations for Pharmaceutics	L	T	P	C
		3	0	0	9

Course Objectives:

- This course will introduce the students to the principles of drug formulation and delivery.

Learning Outcomes:

The students should be able to:

- Understanding how the dosage form can be tailored to the needs of the patient and disease to be treated**.**
- Learn about the physicochemical and physiological principles that are forming the basis of a rational development of modern dosage forms.

Unit I	Preformulation studies: Preformulation studies of drug substances, proteins and peptides. Role of pre-formulation in drug discovery: Material properties in lead selection, high throughput pre-formulation studies, 'drug ability' of new chemical entities, tools to assist in lead selection. Preformulation as a support for formulation development, identification of challenges during formulation development, dosage form specific studies.	**6L**
Unit II	Influence of Drug Properties and Routes of Drug Administration on the design of sustained and controlled release systems: Rationale for controlled drug delivery, physiochemical properties and biological factors influencing the design and performance of sustained/controlled release products.	**6L**
Unit III	Biopharmaceutic and pharmacokinetic aspects of PO CRDDS: Strategies and design, factor effecting controlled release drug delivery systems, Computation of desired release rate and dose for CRDDS, Pharmacokinetic design for DDS; in-vitro/in-vivo considerations, Intermittent zero order and first order release.	**8L**
Unit IV	Peroral controlled-release delivery**:** Design and fabrication of oral systems, dissolution controlled release, diffusion controlled release, diffusion and dissolution controlled release, ion- exchange resins, pH-independent formulations, osmotically controlled release, altered density formulations, Case studies. Overview of different carrier systems for drug delivery.	**9L**
Unit V	Transdermal/skin drug delivery system Principles of skin permeation, factors affecting percutaneous absorption of drugs, sorption promoters, absorption enhancement by energy input - iontophoresis, sonophoresis and electroporation, pharmacokinetics of skin permeation, development and evaluation of transdermal devices, Case studies. Drug targeting: Different levels of targeting-first order, second order and third order targeting, active and passive targeting, prodrug based drug targeting, brain targeting, tumor targeting.	**10L**

Reference Books:

1.Performulation in Solid Dosage Form Development, Edited by Moji ChristianahAdeyeye and Harry G. Brittain, CRC Press, 1st Ed. (2008).
2. Handbook of Performulation: Chemical, Biological and Botanical Drugs, Edited by Sarfaraz K. Niazi, CRC Press, 2nd Ed. (2019).
3. Handbook of Pharmaceutical Excipients, Rowe, R.C.,P. J. Sheskey, Pharmaceutical Press, 6th Ed. (2009).
4. Pharmaceutical Excipients: Characterization by IR, Raman, NMR Spectroscopy, M. Dekker. Bugay, D.E. and W.P. Findlay, CRC Press, 6th Ed. (1999).
5. Drug Delivery Systems, KK Jain, Humana Press, 1st Ed. (2008).

		3	**0**	**0**	**9**

Course Objectives:

- The course is to provide experience in a number of important chemical/pharmaceutical engineering unit operations ensuring a thorough understanding of the principles of unit operation and the appropriate theory.

Learning Outcomes:

- Understand the theoretical principles involved in unit operations
- Apply the knowledge of unit operations in the formulations of various dosage forms.

Unit I	**Heat Transfer**: Basic principles of heat Transfer, Heat transfer from solid surface and fluid-fluid systems. Elementary knowledge of heat transfer equipment such as heat exchangers, condensers, boilers, evaporator, etc. **Mass Transfer**: Principles of mass transfer, solid/fluid and fluid/fluid mass transfer.	**13L**
Unit II	**Filtration**: Theory and mechanism of filtration process, filter media, filter aids, types and operation of filters, industrial filters-leaf filter, filter press, rotary filter, Edge filters, Membrane filter, etc. Batch filtration. Applications of filtration in pharmaceutical industry. **Centrifugation**: Principle and theory of centrifugation, industrial centrifuges and their application in pharmaceutical industry. **Drying:** Principles and mechanism of drying, drying rate and time calculations, drying of dilute solutions and suspensions. Drying of solid materials. Drying in pharmaceutical industry.	**16L**
Unit III	Humidification and Dehumidification: Theory and calculations of humidification and dehumidification processes, humidification equipment. Humidity control in pharmaceutical processes such as formulation of tablets, capsules, etc.	**5L**
Unit IV	Refrigeration and Air Conditioning: Basic concepts of refrigeration cycles and air conditioning. Applications in pharmaceutical industry	**5L**

Reference Books:

1. Transport Processes and Separation Process Principles, C. J. Geankoplis, Prentice Hall, 2003.
2. Unit Operations of Chemical Engineering,W. McCabe, J.Smith and P.Harriot, McGraw-Hill, 7th edition (2014).

CYC 528	Process Chemistry Lab	L	T	P	C
		0	0	3	3

Course Objectives:

- Training for synthesizing new chemotypes, designing and development of small organic molecules with medicinal value.

Learning Outcomes:

- Students will be able to learn various organic synthetic methodologies and studying their therapeutic effects.

Exp. 1.	Synthesis of a drug that includes 4 to 5 reaction steps	**4 weeks**
Exp. 2.	Identification of structure of products by spectral and other analytical techniques; Report writing	**2 week**
Exp. 3.	Understanding the correlation between theoretical and practical aspects of chemistry	**1 week**
Exp. 4.	Study of theoretical organic chemistry using computation methods for the reactions and learning the techniques of molecular modelling	**1 weeks**
Exp 5	Kilo Lab Synthesis and scaleup of drug molecules	**3 weeks**

References:

1. Systematic Identification of Organic Compounds, A lab. Manual, R. L. Shriner, R. C. Fuson and D.Y. Curtin, Wiley, New York, 6th edition.
2. Vogel's Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G.Smith, A. R. Tatchell, Addisson Wesley Longman Limited, UK, 5th Edition (1997).
3. Experimental Organic Chemistry, L. M. Harwood and C.J.Moody, Blackwell Scientific, London, 1989.

CYC 518	Analytical Techniques Lab	L	T	P	C
		0	0	3	3

Course Objectives:

- The purpose of this course is to provide in-depth practical training in laboratory techniques with a diverse toolbox in analytical sciences and instrumentation.
- Also it will enhance student-centered activity and inquiry-based learning to strengthen the connections to real-life**.**

Learning Outcomes:

- Students gain hands-on practical experience with a range of equipment in the field of analytical sciences which can intensify the fundamental understanding of instruments and its background theory.
- Students should able to apply the analytical instruments confidently and accurately in order to address their needs.

1. IR spectrophotometry: Sample preparation for liquid and solid samples, identification of functional groups.
2. UV-Vis spectrophotometry: Simultaneous analysis of two component systems.
3. UV-Vis spectrophotometry: Determination of pK_a and isosbestic points.
4. Titrimetric: Estimation of phosphoric acid content in cold drinks.
5. Titrimetric: Estimation of acetic acid content in vinegar.
6. Estimation of paracetamol content in analgesic tablets.
7. Cyclic voltammetry: Study the redox property of a series of transition metal complexes.
8. SEM-EDX: Sample preparation and study of SEM and EDX data of a series of samples.
9. Gas-Chromatography: Determination of hydrocarbons in a sample.
10. Mass spectrometry: Separation and determination of organic compounds in

	a mixture. 11. NMR Spectroscopy: Identification of samples using NMR spectroscopy. 12. HPLC Techniques and separation methods	

Reference Books:

1. Fundamentals of analytical chemistry, Douglas Skoog, Donald West, F. Holler, Stanley Crouch, Cengage Learning, 9th Ed. (2013).
2. Advanced Practical Inorganic Chemistry, Gurdeep Raj, Krishna Prakasan M. (Pvt.) Ltd., 22nd Ed. (2010).
3. Physical Chemistry, P. Atkins and J. de Paula, Oxford University Press, New Delhi, 8th Ed. (2008).

	Semester 2	L	T	P	C
CHE 530	**Reaction Engineering**	**3**	**0**	**0**	**9**

Course Objectives:

- To learn about reaction kinetics for single, multiple, isothermal, non-isothermal reactions and reactor design procedures.

Learning Outcomes:

- Ability to analyse reaction systems.
- Designing experiments involving chemical reactors, and analyzing and interpreting data.
- Design and sizing of industrial scale reactor on the basis of kinetic data obtained at lab scale.

Unit I	Kinetics of chemical and biochemical reactions: Kinetics of homogeneous reactions: single and multiple, elementary and non-elementary reactions, rate equations; kinetic theories and models; Kinetics of enzymatic and biochemical reactions; determination of kinetic parameters from experimental data; Effect of temperature and pressure on rate equations.	**12L**
Unit II	Reactor Types and Performance: Types of reactors-ideal and non-ideal, and mole balance for ideal reactors; operation and performance of batch and continuous reactors, Interpretation of batch reactor data under constant volume and variable volume conditions.	**12L**
Unit III	Design of Reactors: Design of single homogeneous ideal reactors; comparison of volume of single reactors; Simple methods for calculating optimum reactor size, combination of ideal reactors and their performance.	**10L**
Unit IV	Multiple reactions: Multiple reactions and product distribution.	**5L**

Reference Books:

1. Chemical Reaction Engineering, O. levenspiel, Wiley Student Edition, 2004.
2. Elements of Chemical Reaction Engineering, H.S. Fogler, Pearson, 5th Ed. (2016).

		L	T	P	C
MCD 535	**Bioinformatics**	**3**	**0**	**0**	**9**

Course Objectives:

- This course will provide knowledge on Bioinformatics

Learning Outcomes:

- Students will learn about the application of Bioinformatics in Data Analytics.

Unit I	Biological Databases: Organisation, searching and retrieval of information, accessing global bioinformatics resources using internet links.	**9L**
Unit II	Nucleic acids sequence assembly, restriction mapping, finding simple sites and transcriptional signals, coding region identification, RNA secondary structure prediction.	**10L**

Unit III	Similarity and Homology, dotmatrix methods, dynamic programming methods, scoring systems, multiple sequence alignments, evolutionary relationships, genome analysis	**10L**
Unit IV	Protein physical properties, structural properties – secondary structure prediction, hydrophobicity patterns, detection of motifs, structural database (PDB). Genome databases, Cambridge structure database, data mining tools and techniques, Structural Bioinformatics	**10L**

Reference Books:

1. Bioinformatics: Sequence and Genome Analysis, Mount, D.W., Cold. Spring Harbor Laboratory Press, 2001.
2. Bioinformatics: A practical guide to the analysis of the genes and proteins, Baxevanis, A.D., and Ouellette, B.F.F. (Eds), Wiley-Interscience, 1998.

Syllabus of Departmental Elective Courses "Group A" for Semester-II

CYD 525	**Biopharmaceutics and Pharmacokinetics**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- Knowledge of the process of drug uptake by biological system and their distribution and metabolism. onset, duration and Intensity of drug action
- **Learning Outcomes:**
- To examine the interrelationship of the physical/chemical properties of the drugs and dosage form.
- Mechanism of Body response to drugs administered.

Unit I	Definitions, ADME, concentration time profile, plotting the data, different fluid compartments and blood flow rate compartment models, biological half-life, elimination rate constant. Biopharmaceutics and pharmacokinetics in drug research. Mechanism, physico-chemical, biological and pharmaceutical factors affecting drug absorption through GIT. Techniques for the GIT absorption assessment.	**8L**
Unit II	Total body clearance, renal clearance, mechanism of clearance, clearance ratio, factors affecting renal clearance, hepatic clearance, volume of distribution and its significance. Factors affecting protein binding, kinetics of protein binding, determination of rate constant and different plots (direct, scatchard and reciprocal), Implication of protein binding on pharmacokinetic parameters	**6L**
Unit III	Definitions, federal requirements, methods of determination of bioavailability using blood and urinary excretion data. Protocol design for bioavailability assessment. Methods for bioequivalence determination. Pharmacokinetics of drugs following one/ two compartment open models with first order elimination kinetics as applied to rapid intravenous injection, Intravenous transfusion and oral administration. Determination of absorption rate constant using Wagner-Nelson, Loo Riegelman methods. Flip-flop models, method of residual. Urinary excretion data and its application in pharmacokinetic characterization of drugs. Pharmacokinetics of multiple dosing	**10L**
Unit IV	Dosage regimen adjustment in patients with renal and hepatic diseases. Drug dosage in elderly, children and obese patients. Various causes of non-linearity, Michaelis-Menten kinetics, In-vivo estimation of K_m and V_m. Case studies.	**7L**

Unit V	Mean Residence Time; Statistical Moment Theory; Application and limitations of physiologic pharmacokinetic models. Chronopharmacokinetics, Drug toxicity and forensic pharmacokinetics, kinetics of maternal-fetal drug transfer, pharmacokinetics v/s pharmacological/ clinical response, metabolic kinetics	**8L**

Reference Books

1. Medicinal Chemistry-An Introduction, Gareth Thomas, Wiley,NY, 2nd Ed. (2007).
2. An introduction to Medicinal Chemistry, Graham L. Patrick, Oxford, 4thEd. (2009)
3. Applied Biopharmaceuticsand Pharmacokinetics, Shargel, L., S. Wu-Pong,Mc Graw Hill, 7th Ed. (2016).
4. Biopharmaceutics and Pharmacokinetics: An Introduction, Notari, R. E.,CRC Press, 4th Ed. (1986)

CYD 526	**Quality Control and Pharmaceutical Analysis**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- To know the strategies to maintain the quality of drugs in order ensure that each medicine reaching a patient is safe, effective, and of appropriate quality.

Learning Outcomes:

- Knowledge about QC & QA and their use in pharmaceutical industry analytical method and their validation.

Unit I	Good manufacturing practices (GLP) and its applications to pharmaceutical industry. Basic principles and concepts of quality management viz. quality control, quality assurance, quality auditing and ISO system etc. Sampling, finished products labeling, distribution records.	**14 L**
Unit II	Document control: Issuance, storage and retrieval. Standard operating procedures: Change control procedure and annual product review.	**10 L**
Unit III	Basic principles of validation: Validation protocols, analytical method validation and process validation. Technology transfer from R & D to manufacturing. Product change over, basic requirements of cleaning and its Validation Market complaint and handling of returned goods.	**15L**

Reference Books:

1. Quality Assurance of Pharmaceuticals: A Compendium of Guidelines and Related Materials by D.H. Shah, Q.A. Manual, World Health Organization, 2nd Ed. (2007).
2. Good Pharmaceutical Manufacturing Practice: Rationale and Compliance, JohnSharp, CRC Press, 1st Ed. (2004).

CYD 527	**Pharmacogonosy and Phytopharmaceutical**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- Medicinal Botany. Study of Physical, Chemical, Biochemical and Biological properties of drugs

Learning Outcomes:

- Search of new drugs of natural origin.
- Enhance the use of Ayurvedic medicines, thus reducing the side effects caused by various drugs available in the market.

Unit I	**Introduction to Pharmacogonosy and Phytochemistry:** General introduction to the importance of Pharmacognosy and Phytochemistry in herbal drug industry, Basic terms and terminologies in Pharmacogonosy and Phytochemistry. Recent advances in the field of pharmacognosy and phytochemistry with special reference to anticancer, antidiabetic, anti-inflammatory, hepatoprotective, adaptogenic and immunomodulators, memory enhancers, antiviral agents, antihyperlipidemics General aspects involved in the cultivation of medicinal plants.	**10L**
Unit II	**Chemotaxonomy:** Significance in classification of medicinal plants, distribution of chemotaxonomical groups of constituents in plant kingdom like alkaloids, glycosides and terpenoids. Systematic study of medicinal plants cultivated in India with reference to constituents and uses of Senna, Clove, Opium, Ispaghula, Solanum, Lkhasianum, Vinca, Garcinia, Ashwagandha, Lemongrass, Acorus calamus, Safed musli, Turmeric, Pepper, Coffee, Aloe and Henna.	**8L**
Unit III	**Advances in Pharmacognosy and Phytochemistry**: Application of UV, IR, NMR, ^{1}HNMR, ^{13}CNMR and Mass spectroscopy for structural elucidation of phytosterols, flavonoids and terpenoids. Biotechnological mutation, polyploidy and hybridization to improve the quality of vegetable drugs and their constituents, chemical races. Plant growth regulators and their use, scope and limitations in Pharmacognosy.	**8L**
Unit IV	**Application of tissue culture in improvement of medicinal plants**: Yield improvement, stress tolerant plants, disease resistant plants, pesticide tolerant plants, synthetic seed production, germplasm storage and cryopreservation for conservation of plants.	**6L**
Unit V	**Standardization and Evaluation of Natural Product Drugs and Formulations**: Factors affecting quality of crude drugs, methods for documentation and preservation of crude drugs and their products Bioavailability and pharmacokinetic significance for herbal drugs with examples of clinically used herbal drugs. Preparation of DMF for herbal medicines. WHO.	**7L**

Reference Books:

1. Pharmacognosy,Evans, W.C., Trease& Evans,WB. Saunders & Co., London, 2002.
2. Plant Taxonomy and Biosystematics,Stace C.A., Edward Arnold, London, 1985.
3. Introduction to Plant Tissue Culture, Rajdan, M., Oxford IBH Publishing Co. Pvt. Ltd., New Delhi.
4. Plant Cell and Tissue Culture, Street H.E., Blackwell Scientific, London, 1997.
5. Pharmacognosy (Phytochemistry and Plant Cultivation), Vol. 2, Mohd. Ali, CBS Publishers, New Delhi, 2008.

CYD 528	Modern Separation Techniques	L	T	P	C
		3	0	0	9

Course Objectives: Introduction to different separation methods use in pharmaceutical industry

Learning Outcomes:

- Knowledge about the purification techniques of Active Pharmaceutical Ingredients (API)

Unit I	**Separation Techniques:** Need for learning separation techniques, separation techniques in natural product research and drug discovery, extraction techniques.	**6L**
Unit II	**Chromatography:** General principles, classification of chromatographic techniques, normal and reverse phase, bonded phase chromatography, stationary phases, activity of stationary phases, elutropic series, and separation mechanisms. **Column Chromatography and Short Column Chromatography**: Column packing, sample loading, column development, detection **Flash Chromatography and Vacuum Liquid Chromatography**: Objectives,optimization studies, selecting column and stationary phases, selecting suitable mobile phases, automated flash chromatography, and reverse phase flash chromatography.	**10L**
Unit III	**High Performance Liquid Chromatography**: Principles, instrumentation, peak shapes, capacity factor, selectivity, plate number, plate height, resolution, band broadening, pumps, injector, detectors, columns, column problems, gradient HPLC, HPLC solvents, trouble shooting, sample preparation, method development. **Planar Chromatography** - TLC/HPTLC/OPLC: Basic principles, sample application, development of plates, visualization of plates, 2D TLC, densitometry, Over pressure layer chromatography.	**8L**
Unit IV	**Counter Current Chromatography**: Basic principles, droplet counter current chromatography, centrifugal partition chromatography, choice of solvents for SP and MP. **Gas Chromatography**: Principles, instrumentation, split-splitless injector, head space sampling, columns for GC, detectors, quantification.	**6L**
Unit V	**Biochromatography**: Size exclusion chromatography, ion exchange chromatography, ion pair chromatography, affinity chromatography general principles, stationary phases and mobile phases. **Hyphenated Techniques**: Introduction to GC-MS and LC-MS techniques and their applications in natural products.	**9L**

Reference Books:

1.Methods in Biotechnology, Natural Product Isolation, Sarker, Latif, Gray, Humana Press, 2nd Ed. (2005).
2. Methods in Biotechnology, Natural Product Isolation, Richard Canell, Humana Press, 1998.
3. Various Reviews and Research Papers.

CYD 529	Computer Aided Drug Discovery	L	T	P	C
		3	0	0	9

Course Philosophy:

Introduction to different computational methods for drug discovery and development.

Learning Outcome:

- Introductory knowledge of Computer aided drug design and drug discovery stages consisting

target identification and validation

- To be well equipped with of modern cheminformatics and bioinformatics approaches including QSAR, pharmacophore modelling, molecular docking, Protein structure prediction etc.

UNIT I	Force Field methods, Energy minimization, geometry optimization, conformational analysis,global conformational minima determination, Approaches and problems, Bioactive vs global minimum conformations, Automated methods of conformational search, Dynamics of drugs, biomolecules, drug-receptor complexes, Molecular dynamics methods, Estimation of freeenergy from dynamical methods.	**10 L**
UNIT II	Rigid docking, flexible docking, manual docking; Advantages and disadvantages of flex-X, flex-S, Autodock and Dock softwares.	**5L**
UNIT III	Qualitative versus quantitative approaches- advantages and disadvantages; Random screening, Non-random screening, Insights into molecular recognition phenomenon; Structure based drug design, ligand-based drug design. QSAR: Electronic effects Hammett equation, Lipophilicity effects; Hansch equation, Steric Effects; 2D-QSAR; 3D-QSAR. ADMET modelling.	**10 L**
UNIT IV	Pharmacophore mapping, methods of conformational search used in pharmacophore mapping; Comparison between the popular pharmacophore methods. Pharmacokinetics and pharmacodynamics.	**10 L**
UNIT V	Receptor/enzyme cavity size prediction. Predicting the functional components of cavities, designing drugs fitting into cavity. Brief introduction to bioinformatics, cheminformatics, and their relation to drug design.	**5 L**

Reference Books:

1. Understanding Molecular Simulations: From Algorithms to Applications, D. Frenkel and B. Smit, Academic Press, 2002.
2. Molecular modeling Principles and Applications. A. R. Leach. Pearson, ISBN-13: 978-0582382107, 2001.
3. An Introduction to Cheminformatics, A. R. Leach., Springer, ISBN: 978-1-4020-6291-9, 2007.
4. In Silico Drug Discovery and Design: Theory, Methods, Challenges, and Applications. C. N. Cavasotto, CRC Press, ISBN: 978-1138747586, 2017.
5. Computational Drug Design: A Guide for Computational and Medicinal Chemists, D. C. Young, Wiley-Blackwell, ISBN: 978-0470126851, 2009.

CYD 530	**Pharmacovigilance and Regulatory Affairs**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- Focus on Drug Safety in Pharmacological Science. Knowledge of Adverse Drug Reactions (ADRs).
- **Learning Outcomes:**
- The students will get an understanding of quality acceptance criteria of medicines in various geographies.
- Tools, techniques and methodologies used in drug safety evaluation from prescription and consumption standpoints.

UNIT I	**Introduction to Pharmacovigilance**: Overview and Importance of Pharmacovigilance, Standard terms and terminologies in Pharmacovigilance, History and Development of Pharmacovigilance, Pharmacovigilance program of India (PvPI). Adverse Drug Reactions (ADRs) – Introduction, Definition and classification of ADRs.	**4L**

UNIT II	**Methodologies in pharmacovigilance and Case Processing:** Passive surveillance –Spontaneous Reports and case series stimulated reporting, Active surveillance – Sentinel sites Drug Event Monitoring Registries, Comparative observational studies – Cross sectional study (survey), Case control study, Cohort study of Targeted Clinical Investigations. Global perspective of pharmacovigilance, Single Case Processing, Case Narrative Writing.	**10L**
UNIT III	**Medical dictionaries for Regulatory Activities medDRA and Communication in Pharmacovigilance:** WHO adverse reaction terminologies, WHO drug dictionary. MedDRA (Medical Dictionary for Regulatory Activities) and standardised MedDRA queries. Eudravigilance medicinal product dictionary. Effective Communication in Pharmacovigilance, Communication in Drug Safety and Crisis Management.	**6L**
UNIT IV	**Statistical methods for evaluating medication safety data:** Pre-Clinical Phase, Clinical Phase and Post approval phase, Drug safety evaluation in special population- Paediatrics, Pregnancy and Lactation. PV database and signal detection, PSUR (Periodic Safety Update Report) and PBRER (Periodic Benefit Risk Evaluation Report). Risk Assessments and Managements	**6L**
UNIT V	**Drug Regulatory Affairs and Intellectual Property Rights:** Concept of total quality management, requirements of GMP, GLP, GCP, Regulatory requirements of drugs and Pharmaceutical (USFD-NDA/ ANDA) Documentation and Maintenance of records. Intellectual property rights patents, Trademarks, Copyrights, Patents Act. Environment protection Act, Pollution Control, Factories Act.	**8L**
UNIT VI	**Pharmacovigilance laws and Guidelines:** Regulatory guideline and Laws in PV, ICH and USFDA Guidelines for PV-Organization and objectives, Expedited reporting, Pharmacovigilance planning, Good Clinical practices in Pharmacovigilance studies.	**5L**

Reference Books

1. Pharmacovigilance, R.D. Mann, E.B. Andrews,Wiley, 2nd Edition,2007.
2. Fundamentals of Pharmacovigilance, S.Verma, Y.Gulati, Paras Medical Publisher, 2017.
3. Textbook of Pharmacovigilance, S.K.Gupta, S.Srivastava, Jaypee Brothers Medical Publishers, 2nd Edition, 2018.
4. Dictionary of Pharmacovigilance, Amer Alghabban, Pharmaceutical Press, 2004.
5. Mann's Pharmacovigilance, E.B. Andrews, N. Moore, Wiley, 2014.

CYD 531	**Biotechnology in Pharmaceutical Sciences**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- To apply the Principals of biotechnology in the development of drugs**.**

Learning Outcomes:

- Manipulation of biological system to produce more effective drugs.
- The knowledge gained in this *course* would be used to understand and evaluate the different pharmaceutical parameters of the current and future biotechnology related products on the market.

UNIT I	**Biotechnology in pharmaceutical Sciences perspective**: Biology in drug discovery; Traditional drug discovery vs rational drug discovery; rational drug discovery pipeline; concept of target based drug design and target discovery; role of plant biotechnology in edible vaccine development	**6L**
UNIT II	**Genomics in target discovery**: Concept of genome, genes and gene expression; genome sequencing and sequence comparison methods (microarray); comparative genomics and expression genomics for target discovery of communicable disease and lifestyle disease. Systems and methods of molecular biology: Isolation and validation of targets; PCR, RT-PCR nucleic acid isolation; cloning vectors (some examples), enzymes used in molecular cloning methods (some examples); cloning and characterization of biopharmaceuticals.	**10L**
UNIT III	**Protein expression system**s: Gene expression in bacteria yeast, insect and mammalian cells. Enzyme purification and assay: Various protein purification methods; enzyme based assay for small molecule screening. Bioprocess technology: Upstream process: Introduction to microbial growth, media formulation; sterilization, inoculum preparation.	**6L**
UNIT IV	**Bioprocess technology: Fermentation**: Fermentation process design, operation and characteristics of fermentation processes; batch, fed-batch and continuous culture systems, instrumentation and bioprocess control. Biotechnology in pharmaceutical industry Major areas of biotechnology in the pharmaceutical industry such as antibiotics, vaccines, diagnostics, antibodies, biopharmaceuticals (insulin, interferon, GSF, CSF and therapeutic proteins etc.); commercial aspects, priorities for future biotechnological research.	**10L**
UNIT V	**Industrial enzymes in drug development**: Penicillin amidase, lipase, oxidoreductase, nitrilase, protease etc.; use of all these enzymes for enantioselective synthesis of pharmaceutically important drugs/drug intermediates, future directions.	**7L**

Reference Books:

1. Bioinformatics Sequence and Genome Analysis, David W. Mount, CBS Publishers and Distributors, 2nd Edition 2005.
2. Bioinformatics: A Practical Approach,Shui Qing Ye., Chapman & Hall/CRC, 2008.
3. Bioinformatics for DNA Sequence Analysis,David Posada, Humana press, 2008.
4. Encyclopedia of Bioprocess technology: Fermentation, biocatalysis and Bioseparation, Michael C. Flickinger and Stephen W. Drew, Wiley Interscience, 1999.
5. Pharmaceuticals Biotechnology Concepts and Applications, Gary Walsh, Wiley, 2013.

Syllabus of Departmental Open Elective Courses "Group A" for Semester-II

CYO 501	**Instrumental Techniques for Materials Characterization**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Philosophy:

- With this course students will learn Principle, instrumentation and applications of various X-Ray, Microscopic and Thermal techniques for materials characterizations.

Learning Outcome:

- Characterize materials using advanced characterization techniques.
- Select and interpret analysis results.
- Design experiments with improved sample preparation, new measurement procedures and tools

➢ Utilize the concept of different materials characterization techniques for qualitative and quantitative analysis.		
UNIT I	**X-Ray Techniques**: Principle, Instrumentation and applications of XRD, XRF (EDS, WDS) and XPS. Crystal Structure determination by XRD. Qualitative and Quantitative elemental analysis by XRF. Surface chemical analysis by XPS. Neutron Diffraction for materials characterization.	**13 L**
UNIT II	**Microscopic Techniques:** Resolution, magnification, depth of field, Imaging – theory and concepts. Principle, Instrumentation and applications of Scanning electron microscopy, Transmission electron microscopy, Scanning Tunnelling Microscopy, Atomic Force Microscopy. Sample Preparation Techniques for microscopic analysis. Elemental analysis by EPMA. Electron energy loss spectroscopy (EELS) and selected area electron diffraction (SAED) in TEM.	**18 L**
UNIT III	**Thermal Techniques:** Principle, Instrumentation and applications of TGA, DSC and DTA. Factors affecting thermal analysis. Determination of degradation and cure kinetics by TGA and DSC.	**8L**

Reference Books:

1. Elements of X-Ray Diffraction, B.D. Cullity, S.R. Stock,Pearson,Third Edition, 2014.
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Y.Leng, Wiley, 2008.
3. Thermal Analysis, W. M. Wandlandt, Wiley,Third Edition, 1986.

CYD 534	**Heterocyclic Chemistry**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Philosophy:

➢ The subject offers the readers a fundamental understanding of the basics of heterocyclic chemistry and their occurrence in bioactive molecules in advanced level.

Learning Outcome:

➢ Acquire knowledge about importance of heterocyclic molecules relevant to pharmaceutical chemistry.

UNIT I	Synthesis and reactions of heteroaromatics containing one hetero atom. General approaches to heterocycle synthesis – cyclisation and cycloaddition routes.	**12 L**
UNIT II	Synthesis, reactions and their mechanisms of aziridine, azetidine; pyrazines and their analogues; Synthesis of oxazole, thiazole, imidazole, iso-oxazole, isothiazole and corresponding fused systems; imidazopyridine, pteridines, folic acid. Synthesis of drugs like Nevirapine..	**17 L**
UNIT III	Nomenclature of bicyclic and tricyclic fused system. Synthesis of uracil, thymine and cytosine. Synthesis of adenine and guanine. Synthesis of uric acid, caffeine, pyrazine, synthesis of Triazole and tetrazole.	**10L**

References Books:

1. Organic Chemistry, I.L. Finar, Vol.II, ELBS,5th Edition, 1975.
2. Heterocyclic Chemistry, J. A. Joule and K. Mills, Wiley-Blackwell publishing, 5th Edition, 2010.
3. Heterocyclic Chemistry, T. Gilchrist,Prentice Hall,3rd edition, 1997.
4. Modern Heterocyclic Chemistry, Julio Alvarez-Builla, Juan Jose Vaquero, José Barluenga, Wiley-VCH, 2011.

CYD 535	Main Group Chemistry	L	T	P	C
		3	0	0	9

Course Philosophy:

- This course contains the chemistry of s- and p-block elements, synthesis, structure and bonding and their chemical reactivity. Organometallic chemistry of main group elements is included with a special focus on their applications in organic synthesis. Various applications of main group elements in catalysis and material chemistry will be explored.
- With this course students will learn the concepts involved in the syntheses, structure, physical and chemical properties of main group elements along with their application in various field

Learning Outcome:

- General synthetic procedures and characterization for inorganic and organometallic compounds
- Structure, binding and reactivity
- Application in multidisciplinary areas.

UNIT -I	s-block elements: Organometallic compounds of alkali and alkaline earth metals, synthetic methods, structure, bonding and reactivity, application catalysis, organometallic compounds of zinc, cadmium and mercury, application	**10L**
UNIT –II	p-block elements: General properties, synthesis, structure, bonding of organoelements compounds, spectroscopic characterization and application. Multiple bonding in main group elements, Hypervalency in p-block elements, heavier carbene analogues, small molecule activation, and unusual oxidation states of main group elements.	**10L**
UNIT-III	Inorganic rings, cages and polymers: boron, carbon, silicon, germanium, tin, nitrogen, phosphorus and arsenic, sulfur and selenium compounds, synthesis, structures, bonding, nomenclature, application in catalysis and material chemistry.	**19L**

Reference Books:

1. Inorganic Rings and Polymers of the p-Block Elements: From Fundamentals to Applications, Tristram Chivers and Ian Manners, RSC, 2009.
2. Organometallics, A concise introduction, C. Elschenbroich, A. Salzer, Wiley-VCH Verlag GmbH& Co, KGaA,Weinheim, Germany, 3rd Ed. 2006.
3. Inorganic and Organometallic Polymers, V. Chandrasekhar, Springer India, 2005.

CHC 531	Chemical Engineering Lab	L	T	P	C
		0	0	3	3

Course Objectives: The objective of the lab course is to provide practical experience in a number of pharmaceutical/chemical engineering unit operations involving heat, mass and momentum transfer.

Learning Outcomes: Understanding and hands-on practical experience of different unit operation techniques used in pharmaceutical industries in terms of working principle and operational procedure of equipment.

	1. Reynolds experiment for pipe flow in different discharge conditions 2. Determination of thermal conductivity of materials 3. Determination of overall heat transfer coefficient of shell and tube heat exchanger 4. Nano grinding in planetary ball mill 5. Settling characteristics of powder materials 6. Studies on kinetics of given reacting system 7. Determination of activation energy for a given reaction 8. Kinetics of solid dissolution 9. To study the drying characteristics of material 10. Determination of specific cake resistance and filter medium resistance for the filtration of given slurry using leaf filter	

Reference Books: Practical Mannual

CYC 529	**Formulation/Manufacturing Lab**	**L**	**T**	**P**	**C**
		0	**0**	**3**	**3**

Course Objectives:

- Development of advanced laboratory skills including familiarity with modern instrumentation and preparative techniques

Learning Outcomes:

- Ability to independently conceive and resolve significant formulation and manufacturing problems.

	1.Improvement of dissolution characteristics of slightly soluble drug by Solid dispersion technique. 2. Comparison of dissolution of two different marketed products /brands. 3. Protein binding studies of a highly protein bound drug & poorly protein bound drug. 4. Bioavailability studies of Paracetamol (Animal). 5. Pharmacokinetic and IVIVC data analysis by Winnoline R software 6. In vitro cell studies for permeability and metabolism 7. Formulation and evaluation of tablets 8. Formulation and evaluation of capsules. 9. Formulation and evaluation of injections. 10. Formulation and evaluation of emulsion. 11. Formulation and evaluation of suspension. 12. Formulation and evaluation of enteric coating tablets. 13. Preparation and evaluation of a freeze dried formulation. Preparation and evaluation of a spray dried formulation.	

Reference Books

1. Pharmaceutical Prdouction Facilities: Design and Applications G.C.Cole
2. The Theory and Practice of Industrial Pharmacy, Lachman Bombay, K. M. Warghese Co. 197
3. Pharmaceutical Dosage Forms Vol. I & II, Liebermann, New York, Marcel Dekker, 1996.
4. Drug Delivery Devices: Fundamentals and Applications, Tyle New York, Marcel Dekker 1988

Semester-IV					
Syllabus of Departmental Elective Courses of "Group – B" for the Semester-IV					
ESD 505	**Advanced Water and Wastewater Treatment**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

- To describe methods of advanced effluent treatment for higher discharge standards and effluentre-use.

Learning Outcomes:

- Understand the role of each unit process within typical treatment process trains, their interaction and the context of when they areapplied.
- Appreciate the advantages, disadvantages and limitations of the technologies and newdevelopments.

UNIT I	Biological nutrient removal: Nitrogen removal- nitrification, denitrification, processes for biological nitrogen removal, Anammox process; Phosphorous removal- Enhanced Biological Phosphorus Removal, application of phostrip, Bardenpho and phoredox process; Combined N and P removal by A2/O, bardenpho, UCT and VIP process; Gas stripping: Design of stripping towers.	**10L**
UNIT II	Membrane Filtration: Membrane process terminology & classification, Materials, membrane configurations, membrane operation, Reverse osmosis, ultrafiltration, microfiltration, nanofiltration, Electrodialysis.	**8 L**
UNIT III	Adsorption: Types of adsorbents, fundamentals of adsorption, sorption isotherm models and rate considerations, Design of granular and powdered activated carbon contactor; Ion Exchange: Fundamentals of ion exchange, types of ion exchange resins, application of ion exchange, operational considerations; Advanced Oxidation Process: Theory of advanced oxidation, technologies used to produce hydroxyl radicals, applications.	**13 L**
UNIT IV	Sludge handling and disposal: Thickening, stabilization, conditioning, dewatering, heat drying and thermal reduction, Design of aerobic and anaerobic sludge digesters, land application of sludge and design consideration.	**8 L**

Books and References:

Text Book:

1. Wastewater Engineering: Treatment and Reuse - Metcalf & Eddy, McGraw Hill Education; 4th Edition (2017).

Reference Book:

1. Wastewater Treatment for Pollution Control and reuse- SJ Arceivala, McGraw Hill Education; 3rd Edition (2017)

ESD 506	Biomedical and Hazardous Waste Management	L	T	P	C
		3	0	0	9

Course Objectives:

- Understanding the concept of biomedical and hazardouswastes.
- Basics of the treatment of hazardouswastes.
- Insight of regulatory framework related to hazardous wastemanagement.

Learning Outcomes:

- Understanding the concept of biomedical and hazardous wastes and their treatmentstrategies.
- Understanding the principles of regulatory framework for the treatment and disposal of hazardous wastes.

UNIT I	Biomedical Waste: categorization, generation, collection, transport, treatment and disposal, Infectious Waste, segregation processes, color coding and types of container for segregation processes of biomedical waste, Biomedical waste management.	**8L**
UNIT II	Hazardous Waste Treatment: waste reduction, neutralization, Incineration, combustion and Pyrolysis, unit operations, supply air, products of combustion, furnace temperature, furnace calculation, and environmental control, disposal. Precautions in collection,reception, treatment, transport, storage, and disposal, and import procedure for environmental surveillance.	**8L**
UNIT III	Hazardous Chemicals: Toxic chemicals, flammable chemicals, pesticides, explosives, reactive substances, Cyanide wastes, water-soluble chemical compounds of heavy metals, & toxic metals. Hydrocarbons, point pigment dyes, oil emulsion tars, phenols, asbestos, acid/alkaline slurry, Physical properties, and chemical composition and lethal dose and concentration on human life flora and fauna. Storage, collection, transport.	**8L**
UNIT IV	HWM, Regulatory framework, Basal Convention and other international statistics, monitoring of critical parameters/provide risk-analysis. HAZON, HAZOP, Consequence Analysis.Emergency Management: Indian and foreign legislation in respect of the above. Case studies, leakage, explosion, oil-spills and fire ofhazardouschemical storage. Leakage in atomic reactor plants.	**8L**
UNIT V	Radioactive wastes generated during mining, processing of atomic minerals, and in atomic reactors, and disposal of spent fuel rods. Treatment and disposal; remediation of contaminated sites. E-Waste: recovery of useful materials from e-waste, treatment of e-waste.	**7L**

Books and References:

Text Books

1. Hazardous waste incineration,Brunner, C. R.,John Wiley &Sons, 1989.
2. Hazardous waste management,Dawson, G. W., & Mercer, B. W.,John Wiley &Sons, 1989.

Reference Books

1. Municipal solid waste management: strategies and technologies for sustainable solutions. Ludwig, C., Hellweg, S., & Stucki, S., Springer Science & BusinessMedia, 2012.
2. Medical waste incineration and pollution prevention, A. E. S. Green, New York: Van NostrandReinhold, 1992.

Open Electives of Group-B for Semester-IV					
MSO 503	**Financial Econometrics**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**9**

Course Objectives:

The course is designed to

- Provide knowledge of modern econometric techniques commonly employed in the finance literature.
- Develop an understating of statistical tools in the area of finance.
- Introduces financial modelling for research oriented students in finance

Learning Outcomes:

Understand the essential foundations of time series models.

- Construct and evaluate forecast models using financial time-series. Explain and apply models of volatility using financial time-series.
- Understand and estimate the long run relationship between variables using financial time- series.
- Understand, construct and estimate panel data models. Understand and estimate the limited dependent variable models

UNIT I	Overview of the classical linear regression model (CLRM)- Recent development and analysis of the CLRM, CLRM assumptions and diagnostic tests, Univariate time series modelling and forecasting- Moving average processes, Autoregressive processes, ARMA processes, Building ARMA models: the Box--Jenkins approach.	**10L**
UNIT II	Multivariate models- Vector autoregressive models, Impulse responses and variance decompositions. Modelling long-run relationships in finance- Stationarity and unit root testing, Cointegration, Equilibrium correction or error correction models, Testing for and estimating cointegrating systems using the Johansen technique based on VARs	**10L**
UNIT III	Modelling volatility and correlation- Autoregressive volatility models, Autoregressive conditionally heteroscedastic (ARCH) models, Generalised ARCH (GARCH) models.	**10L**
UNIT IV	Panel data models-The fixed effects model, Time-fixed effects model, The random effects model. Limited dependent variable models- The linear probability model, The logit and probit models, Multinomial linear dependent variables.	**9L**

Reference Books:

1.Introductory Econometrics for Finance,Chris Brooks,Cambridge University Press,2nd Edition (2014).

2. Introduction to Econometrics, Christopher Dougherty, Oxford University Press,4th Edition (2011).

MSO 504	Supply Chain Management	L	T	P	C
		3	0	0	9

Course Objectives:

- A supply chain is comprised of all the parties involved in fulfilling a customer request. The integrated management of this network is a critical determinant of success in today's competitive environment. This objective of this course is to provide students with a strong understanding of supply chain management concepts.

Learning Outcomes:

- Learning the key concepts and techniques will allow students to analyse, manage and improve supply chain processes, assess supply chain performance and make recommendations to increase supply chain competitiveness.

UNIT I	**Introduction** : Definition of supply chain, Emergence of SCM, Realization of SCM, Decision phases in supply chain.	**6L**
UNIT II	**Achieving strategic fit and scope :** Supply chain performance, Supply chain drivers and obstacles	**6L**
UNIT III	**Strategic decisions :** Role of distribution in supply chain, Network design in a supply chain	**6L**
UNIT IV	**Aggregate level decisions :**Demand forecasting in supply chain, Aggregate planning, and Managing predictable variability	**6L**
UNIT V	**Sourcing and Transportation decisions**	**6L**
UNIT VI	**Supply chain coordination, Information Technology in Supply chain**	**6L**
UNIT VII	**E-Business**	**3L**

References:

1. Fundamentals of supply chain management: Twelve drivers of competitive advantage, Mentzer, J. T. (2004), Sage.

2.Supply chain logistics management, Donald, J. B., Closs, D., & Cooper, M. B, McGraw-Hill Companies, Inc. (2002).