Syllabus for M.S. (Pharm.)/ Ph.D Courses, offered *by* NIPER - Hyderabad

CONTENTS

SUMMARY OF ORDINANCE & REGULATIONS FOR MASTERS AND DOCTORAL PROGRAMMES

1. Students of all programmes have to renew the registration every semester till submission of the dissertation (for masters) and thesis (for Ph.D.). Teaching in the Institute will be organized around the credit system. Each course will have a certain number of credits which will describe its weightage. The letter grades and their equivalent grade points are:

   A (Outstanding) = 10
   A (-) (Excellent) = 9
   B (Very Good) = 8
   B (-) (Good) = 7
   C (Average) = 6
   C (-) (Below Average) = 5
   D (Marginal) = 4
   E (Poor) = 2
   F (Very Poor) = 0

2. A student (of Master Programme) is not entitled to avail more than two repeat examinations in each semester in courses in which he/she has obtained E or F grade(s) or where he/she has scored a CGPA of less than 6.00.

3. Due to lack of fulfillment of all the requirements for the course on account of extra ordinary circumstances subject to having 50% attendance, a candidate can be put under I-grade and shall be permitted to appear second time in a course(s).

4. The minimum credit requirement for masters degree is 50 valid credits including a minimum of 28 credits of course work and balance credits of the project work.

5. The minimum CGPA required for the award of Masters Degree is 6.00 The maximum period for completion of the Master Programme will be 3 years from the date of joining the programme.

6. The Masters Degree holders of the Institute getting into the Ph.D programme will have to complete doctoral courses of minimum 12 credits and all other students will have to complete minimum of 28 credits (not less than 16 credits from the specialization)

7. The minimum CGPA requirement for Ph.D. is 6.50. If CGPA is above 6.00 but below 6.50, student will be asked to take more courses in order to make up the required CGPA. If CGPA is below 6.00 at the end of any semester he/she will have to discontinue the Ph.D. programme.

8. A Ph.D. student will be required to clear the comprehensive examination before the beginning of sixth semester, after completing course work. A maximum of two attempts will be allowed to a student to clear the comprehensive examinations. The student will be required to be registered for a period of not less than 3 years and submit the thesis within 5 years from the date of registration.

9. Students (of all Programmes) are required to attend every lecture and practical class during the semester. However, in the case of the late registration, sickness and other contingencies, the attendance required will be a minimum 75% of the classes actually held.

10. For Masters Programme: A student is entitled to a maximum of 45 days leave in addition to general holidays during the four semester of their stay at the Institute. 10 days of medical leave every year besides 45 days leave can be granted. A student is not entitled to any vacation. For Ph.D. degree programme, a student is entitled to 30 days leave in each year in addition to the general holidays. Women student will be entitled to 3 months maternity leave besides the 30 days leave, once during their tenure. Leave with scholarship may be granted to students for attending academic meetings/conferences/symposia

NOTE:

This is the summarized form of Ordinance and Regulations of the Institute for the benefit of the students. For details, original documents on Ordinances and Regulations shall be referred to.

Medicinal Chemistry

M.S (Pharm)

Course No.	Course Name	Credits
Semester-I		
MC-510	Basics of Drug Action	2
MC-511	Spectral Analysis	2
MC-520	Logic in Organic Synthesis-I	3
NP-510	Separation Techniques	1
PC-540	Chemotherapy of Parasitic and Microbial Infections	1
PT-510	Industrial Process and Scale-up Techniques	1
GE-510	Biostatistics	2
GE-511	Seminar	1
LG-510	General Laboratory Experience	3
	Total Credits	**16**
Semester-II		
MC-610	Drug Design	2
MC-620	Logic in Organic Synthesis-II	3
MC-630	Structure and Function of Biomolecules	2
MC-650	Stereochemistry and Drug Action	2
PC-610	Drug Metabolism	1
PC-611	Pharmacological Screening and Assays	1
GE-611	Seminar	1
LS-610	General Laboratory Experience in the area of Specialization	2
	Total Credits	**14**
Semester-III		
Project (22 weeks)		
TH-598	Synopsis	5
TH-599	Presentation	3
	Total Credits	**8**
Semester-IV		
TH-698	Thesis	9
TH-699	Defence of thesis	3
	Total Credits	**12**
	Total Credits (I to IV semesters)	**50**

Semester-I

MC-510 Basics of Drug Action (2 credits)

1. *Inter and intramolecular interactions:* Weak interactions in drug molecules; Chirality and drug action; Covalent, ion, ion-dipole, hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, van der Waals interactions and the associated energies.

2. Energy concept and its importance in drug action; First, second and third laws of thermodynamics and the principles derived from these laws which are of significance to drug action; Free energy and relationship between thermodynamics and statistics; Importance of chemical potential in drug action; Thermodynamic cycle.

3. Statistical thermodynamics in predicting the structure of biomolecules and their interaction with drug molecules; Macromolecular vs. micromolecular correlation using thermodynamics and statistical thermodynamics.

4. *Receptorology:* Drug-receptor interactions, receptor theories and drug action; Occupancy theory, rate theory, induced fit theory, macromolecular perturbation theory, activation-aggregation theory. Topological and stereochemical consideration

5. Kinetics, enzyme kinetics in drug action. Do all molecules of an enzyme have same kinetics? Mechanisms of enzyme catalysis; Electrostatic catalysis and desolvation; Covalent catalysis, acid-base catalysis, strain / distortion in enzyme catalysis; Coenzyme catalysis; Example based on hemoglobin; Theories of enzyme inhibition and inactivation; Enzyme activation of drugs-prodrugs.

6. Nucleic acids (NA) as targets for drug action; NA-interactive agents; Classes of drugs that interact with nucleic acids; Intercalation, NA-alkylation, NA-strand breaking and their importance in drug action.

7. Drug like molecules and theories associated with the recognition of drug like properties.

8. Physical organic chemistry of drug metabolism, drug deactivation and elimination; Phase-I and phase-II transformations; Concept of hard and soft drugs; Chemistry of ADME and toxicity properties of drugs.

MC-511 Spectral Analysis (2 credits)

1. *Ultra violet and visible spectroscopy:* Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules; Influence of substituent, ring size and strain on spectral characteristics; Solvent effect; Stereochemical effect; Non-conjugated interactions. Spectral correlation with structure

2. *Infrared spectroscopy (IR):* Characteristic regions of the spectrum. Influence of substituents, ring size, hydrogen bonding, vibrational coupling and field effect on frequency. Determination of stereochemistry; Spectral interpretation with examples

3. *Nuclear magnetic resonance spectrometry (NMR):* Magnetic nuclei, chemical shift and shielding, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy, spin-spin splitting, Pascal's triangle, coupling constant, mechanism of coupling, quadrupole broadening and decoupling, effect of conformations and stereochemistry on the spectrum, diastereomeric protons, virtual coupling, long range coupling-epi, peri, bay effects. Shift reagents-mechanism of action, spin decoupling and double resonance.

4. Mass Spectrometry (MS): Molecular ion and metastable peak, fragmentation patterns, nitrogen and ring rules, McLafferty rearrangement, electron and chemical ionization modes, applications.

MC-520 Logic in Organic Synthesis-I (3 Credits)

1. *Organic reaction mechanism :* Methods of determining reaction mechanisms (kinetic and non-kinetic methods); Energy profile diagrams, reaction intermediates, crossover experiments and isotopic labelling; Order of reactions, reversible, consecutive and parallel reactions, solvent, ionic strength and salt effects; Acid-base catalysis; Nucleophilic substitution reactions; Uni- and bimolecular reactions, attacking and leaving groups, steric and electronic effects; Neighbouring group participation; Formation and hydrolysis of esters, amides and acyl halides; Different mechanisms. Electrophilic substitution reactions; Aromatic electrophilic substitutions including Friedel-Crafts reactions; Addition and elimination reactions.

2. *Principles of synthetic planning :* Logic-centered molecular synthesis; Dislocation, synthetic tree, synthons, logical imposition of boundary conditions, direct associated approach; Structure-functionality relationships, functionality and unsaturation levels; Polar reactivity analysis; Control elements, consonant and dissonant circuits; Protocol for synthetic design.

3. *Alkylation :* Enolates; Regio- and stereo-selective enolate generation, “O” versus “C”- alkylation, effects of solvent, counter cation and electrophiles; Symbiotic effect; Thermodynamically and kinetically controlled enolate formations; Various transition-state models to explain stereoselective enolate formation; Enamines and metallo-enamines; Regioselectivity in generation, applications in controlling the selectivity of alkylation.

4. *Reaction of ylides:* Phosphorous ylides; Structure and reactivity, stabilized ylides, effects of ligands on reactivity, Wittig, Horner–Wadsworth–Emmons (HWE) reactions- mechanistic realizations; E/Z selectivity for olefin formation, Schlosser modification; Petersons olefin synthesis. Sulphur Ylides; Stabilized and non-stabilized ylides; Thermodynamically and kinetically controlled reactions with carbonyl compounds, regio- and stereo-selective reactions.

5. *Hydroboration :* Control of chemo-, regio- and stereo-selectivity, rearrangement of alkylboranes; Alkylboranes as organometallic reagents, e.g., 9-BBN, thexylboranes, siamylborane, chiral boranes- Ipc_2BH $IpcBH_2$ etc.

NP-510 Separation Techniques (1 Credit)

1. *Chromatography:* General principles, classification of chromatographic techniques, normal and reversed phase, bonded phase, separation mechanisms.

2. *Column chromatography:* Merits and demerits, short-column chromatography and flash chromatography, vacuum liquid chromatography (VLC), medium pressure liquid chromatography, high pressure liquid chromatography (HPLC).

3. TLC, HPTLC, over pressure layer chromatography (OPLC), centrifugal chromatography.

4. Counter-current chromatography, droplet counter-current chromatography, ion-exchange, affinity, size exclusion and ion-pair chromatography.

5. Gas chromatography, introduction to GC-MS and LC-MS techniques.

PC-540 Chemotherapy of Parasitic and Microbial Infections (1 Credit)

1. Introduction to parasitic and infectious diseases.
2. Biology of tuberculosis.
3. Mechanism of action of antituberculosis drugs.
4. Targets for anti-tuberculosis drug development.
5. Mechanism of drug-resistance in tuberculosis.
6. Biology of human amoebiasis.
7. Mechanism of action anti-amoebic drugs.

8. Biology of filarial infections.
9. Mechanism of action of anti-filarial drugs.
10. Targets of anti-filarial drug development.
11. Biology of viral infection.
12. Mechanism of action of anti-HIV drugs.
13. Targets for anti-HIV drug development.
14. Biology of malaria.
15. Mechanism of action of anti-malarial drugs.
16. Targets for anti-malarial drug development.
17. Mechanism of drug-resistance in malaria.
18. Biology of leishmaniasis.
19. Mechanism of action of anti leishmanial drugs.
20. Targets for anti-leishmanial drug development.
21. Drug-resistance in leishmaniasis.

PT-510 Industrial Process and Scale up Techniques (1 credit)

1. Status of pharmaceutical industry (bulk drugs, natural products and formulations) in India vis-a-vis industrialized nations.
2. Scale-up techniques for process optimization, maximization of productivity, in process control techniques with examples.
3. Chemical technology of selected bulk drugs; Case studies with emphasis on rationale for selection of routes, raw materials, process control methods, pollution control procedures etc. (examples depicting novel routes); Data collection during pilot plant trails, preparations of flow diagrams, material balance sheets and technical data sheets.
4. Isolation techniques for natural products from plants, animals, marine and microbial sources.
5. Process technologies for some selected natural products of commercial interest.
6. Scale-up techniques for industrial pharmacy, typical standard operating procedures for different dosage forms; In-process control procedures.
7. Pharmaceutical manufacturing equipment in bulk drugs and formulations.

GE-510 Biostatistics (2 credits)

1. *Statistics*: Introduction, its role and uses. Collection; Organization; Graphics and pictorial representation of data; Measures of central tendencies and dispersion. Coefficient of variation.
2. *Probability*: Basic concepts; Common probability distributions and probability distributions related to normal distribution.
3. *Sampling*: Simple random and other sampling procedures. Distribution of sample mean and proportion.
4. Estimation and hypothesis testing: Point and interval estimation including fiducial limits.Concepts of hypothesis testing and types of errors. Student- t and Chi square tests.Sample size and power.
5. *Experimental design and analysis of variance*: Completely randomized, randomized blocks. Latin square and factorial designs. Post- hoc procedures.
6. *Correlation and regression*: Graphical presentation of two continuous variables; Pearson's product moment correlation coefficient, its statistical significance. Multiple and partial correlations. Linear regression; Regression line, coefficient of determination, interval estimation and hypothesis testing for population slope. Introduction to multiple linear regression model. Probit and logit transformations.
7. *Non-parametric tests:* Sign; Mann-Whitney U; Wilcoxon matched pair; Kruskal wallis and Friedman two way ANOVA tests. Spearman rank correlation.
8. Statistical techniques in pharmaceutics: Experimental design in clinical trials; Parallel and crossover designs. Statistical test for bioequivalence. Dose response studies;Statistical quality control.

GE-511 Seminar (1 credit)

1. Introduction, information retrieval systems.
2. Writing term papers and reports.
3. Organization of scientific material, thesis, dissertation and references.
4. Reading research papers.
5. Skill in oral presentation.

Each student has to present a seminar before end of the semester.

LG-510 General Laboratory Experience 15 hours/week (3 credits)

1. *Analytical Techniques (75 hours)*

    a. Spectral Analysis workshop (45 hours)
    b. Separation Techniques (30 hours)

2. *Computer and application in pharmaceutical sciences (100 hours):* Introduction to computers, basic unit and functions, H/W and S/W, operating systems, word processing, spread sheet, graphic programs, dbase, windows, statistical S/W programs and packages. Steps involved in S/W development, computer languages with emphasis to FORTRAN language and programming, hands on experience in pharmaceutical software systems. Use of computers in information retrieval systems

3. *Specialization (95 hours):* Two to three step synthesis involving Wittig reaction, glycidic ester condensation, etc. Purification by chromatographic technique and identification by IR, NMR, and MS

Semester-II

MC-610 Drug Design (2 credits)

1. *Structure Activity Relationships in drug design:* Qualitative versus quantitative approaches, advantages and disadvantages; Random screening, nonrandom screening, drug metabolism studies, clinical observations, rational approaches to lead discovery; Homologation, chain branching, ring-chain transformations, bioisosterism; Insights into molecular recognition phenomenon; Structure based drug design, ligand based drug design.

2. *Molecular Modeling:* Energy minimization, geometry optimization, conformational analysis, global conformational minima determination; Approaches and problems; Bioactive vs. global minimum conformations; Automated methods of conformational search; Advantages and limitations of available software; Molecular graphics; Computer methodologies behind molecular modeling including artificial intelligence methods.

3. *QSAR:* Electronic effects; Hammett equation, Lipophilicity effects; Hansch equation, Steric Effects; Taft Equation; Experimental and theoretical approaches for the determination of physico-chemical parameters, parameter inter-dependence; Case studies; Regression analysis, extrapolation versus interpolation, linearity versus non-linearity; The importance of biological data in the correct form; 2D – QSAR; 3D-QSAR-examples CoMFA and CoMSIA.

4. *Molecular docking and dynamics:* Rigid docking, flexible docking, manual docking; Advantages and disadvantages of flex-X, flex-S, autodock and dock softwares with successful examples; Monte Carlo simulations and molecular dynamics in performing conformational search, docking etc.

5. *Pharmacophore:* Concept, pharmacophore mapping, methods of conformational search used in pharmacophore mapping; Comparison between the popular pharmacophore methods like catalyst/HipHop, DiscoTech, GASP, etc. with practical examples.

6. *Electronic structure methods and quantum chemical methods:* Semi-empirical and *ab initio methods*; Conformational analysis, energy minimization, comparison between global minimum conformation and bioactive conformation; Predicting the mechanism of organic reactions using electronic structure methods; Complete and constrained conformational search methods their advantages and disadvantages; Theoretical aqueous solvation calculations for the design of ligands. Conformational interconversion, transition-state determination and their role in designing rigid analogs

7. *De novo drug design techniques.*

8. *Informatics methods in drug design:* Bioinformatics, cheminformatics, genomics, proteomics, chemogenomics, pharmainformatics; ADME databases, chemical biochemical and pharmaceutical databases; Drug design techniques using these databases.

MC-620 Logic in Organic Synthesis-II (3 credits)

1. *Metal/ammonia reduction:* Reduction of mono-, bi- and tri-cyclic aromatic systems and various functional groups, reductive alkylation, regio- and stereo- selectivity; Reduction of alkynes; Complex metal hydrides and selectrides.

2. *Reaction of electron-deficient intermediates:* Carbene-nitrene and free radical-structure, stability and modes of generation; Addition and insertion reactions of carbenoids and nitrenoids - regio- and stereoselectivity, role of the metal catalysts in the transition-metal catalyzed reactions, other types of reaction of carbenoids, e.g., ylide generation, 1,3-dipolar addition, rearrangement etc.; Intra-molecular radical trapping process leading to ring annulation - Baldwin's rule.

3. *Organometallics:* Applications of organo-lithium, cadmium and cerium reagents, heteroatom directed lithiation; Oxy- and amido-mercurations; Gilman reagent, mixed and higher order cuprates, uses in nucleophilic substitution, cleavage of epoxides and conjugate addition reactions; Mechanism of

action; Spiro-annulation; Wacker oxidation, Wilkinson's catalyst, carbonylation/hydroformylation reactions; Heck arylation; Role of metal- ligands in controlling regio- and stereo-selectivity; Catalytic and stoichiometric oxidation reactions; Homogeneous and heterogenous processes; Chemo-selective reactions; Bio-mimicking processes.

4. *Umpolung and umpoled sythons:* Concept, acyl and glycine cation/anion, homoenolate anion, vicinyl dicarbonian, carbonyl dication equivalence etc.

5. *Asymmetric synthesis:* Chiral induction-factors controlling facial selectivity; Chiral reagents/catalysts, auxiliaries, enzymes and antibodies; Kinetic resolution, double asymmetric induction, acyclic diastereoselection, asymmetric amplification; Asymmetric synthesis of amino acids and beta lactams.

6. *Concerted reactions and photochemistry:* Molecular orbital symmetry, frontier orbitals of 1,3-butadiene, 1,3,5- hexatrienes, allyl system, classification of pericyclic reactions; FMO approach, Woodward-Hoffman correlation diagram method and PMO approach to pericyclic reactions;Electrocyclic reactions- conrotatory and disrotatory motions, [4n], [4n+2] and allyl systems, secondary orbiatl interaction; Cycloaddition- antarafacial and suprafacial additions, [4n] and [4n+2] sytems with stereo chemical effects, 1,3 -dipolar cycloadditions, chelotropic reactions; Sigmatropic rearrangements-supra and antarafacial shifts of H, sigmatropic shifts of carbon moiety, retention and inversion of configuration, [3,3] and [3,5] sigmatropic rearrangements, fluxional tautomerism, ene reactions; Franck-Condon principle, Jablonski diagram, singlet and triplet states, photosensitization, quantum efficiency; Photochemistry of carbonyl compounds, norish type-I and type-II cleavages, Paterno-Büchi reaction, photoreduction, photochemistry of enones and para-benzoquinones.

7. *Synthesis of complex molecules:* Various approaches for the synthesis of Taxol, Forskolin, FK-506, Gibberellines, Prostaglandins, Spatol, Aphidicolin etc. on the basis of disconnection and direct associative approaches.

MC-630 Structure and Function of Biomolecules (2 credits)

1. *Methods for the determination of structure of biomolecules:* Biological crystallography- crystallization data collection, refinement, identification of active site, phase determination heavy atom derivatives, electron density maps; Differences in the small molecule and biomolecules crystallography; Spectrofluorimetry-basic principles of fluorescence, intensity of fluorescence, fluorescent group, sensitivity of fluorescence to environment and biological applications; Optical activity measurements, ORD/CD applications to nucleic acids and proteins; Differential Scanning Calorimetry (DSC) and theormogravimetric analysis (TA) of biomolecules and other thermodynamics based instrumental methods estimating the structural features of biomolecules.

2. Properties of amino acids and peptide bond, end group determination of peptides, sequencing of peptides using various chemical and analytical techniques; Application of various structural determination techniques with case studies like LHRH and TRH peptide.

3. Protein structure building block to quaternary structure of proteins; Ramachandran plots; Peptidomimetics; Protein-ligand interactions; Multiple binding modes.

4. Structure of lipoproteins and glycoproteins in relation to their function.

5. Structure of lipids, polysaccharides and carbohydrates; Relationship between their physico-chemical properties and their biological function.

6. Detailed structure of nucleic acids and protein-nucleic acid interactions; Nucleic acid and small molecule interactions; DNA damage and repair.

7. Structure and function of biomolecules pertaining to different thearapeutic areas: Cancer- tubuline-role in cell proliferation, various binding sites, the chemistry and biology of tubuline inhibitors; farnesyl transferase- X-ray structure, ras protein and its role; Inflammation- COX-1 and COX-2 their structures and physiological role; Hyperlipidimia- HMG-CoA its structure and role in cholesterol manipulation.

MC-650 Stereochemistry and Drug Action (2 credits)

1. *Molecular isomerism:* Molecular motion, time scales and energy; Conformation of open chain and saturated cyclic systems.
2. Chirality and molecular symmetry; Nomenclature and representations; Macromolecular stereochemistry; Dynamic stereochemistry.
3. *Resolution procedures:* Biological and chemical; Analytical chiral integrity determinations; Pfeiffer rule and its violations; Recent attempts to develop continuous scale for chirality; Chiral ligands as topological probes.
4. Realization that stereoselectivity is a pre-requisite for evolution; Role of chirality in selective and specific therapeutic agents; Case studies; Enantioselectivity in drug absorption, metabolism, distribution and elimination.

PC-610 Drug Metabolism (1 credit)

1. Biotransformation of drugs, enzymes responsible for bio-transformations, microsomal and non-microsomal mechanisms; Factors influencing enzyme induction and inhibition.
2. Extraction of drugs, biliary and fecal excretion; Factors effecting drug metabolism; Drug metabolism in fetus and new born; Models to study drug metabolism; Dose effect relationships.
3. Adverse drug reactions and drug interactions; Toxic reactions, allergic reactions, idiosy-ncracy, acute poisoning and its treatment.

PC-611 Pharmacological Screening and Assays (1 credit)

1. General principles of screening, correlations between various animal models and human situations, animal ethics.
2. Pharmacological screening models for therapeutic areas such as hypertension, cerebral ischaemia, pain, epilepsy, depression, Parkinson's disease, Alzheimer's disease, diabetic, leishmania etc.
3. Correlation between *in-vitro* and *in-vivo* screens; Special emphasis on cell based assay, biochemical assay, radioligand binding assay, high through put screening, high through put pharmacokinetic analysis, specific use of reference drugs and interpretation of results.

GE-611 Seminar (1 credit)

Students are required to submit written record and present details of the project to be pursued in semester-III. This should include the purpose and basis of the project, stating aims, objectives and probable outcomes, be able to supplement these with necessary information, literature review towards it and process for the project itself.

LS-610 General Laboratory Experience 10 hours/week (2 credits)

Synthesis of a complex drug includes 4 to 5 steps, isolate each product, analyze all the intermediate and final products using spectral and other analytical methods, report the yield, study the theoretical organic chemistry using computation methods for the same reaction and learn the techniques of molecular modeling.

Ph.D. courses

MC-710 Asymmetric Synthesis (2 credits)

1. *General concept:* Differentiation of molecules, group selectivity, topicity and prochirality, substrate and product selectivities, necessary conditions for stereoselectivity, concept of enantio/diastereo-differentiation, methods of inducing stereo-selectivity, strategies for stereoselective synthesis,

kinetics and thermodynamics of stereoselective reactions, modifications of CIP classification of chirality- constitutional properties of CIP system, continuous symmetry measure of chirality-degree of shape chirality, topological Chirality and significance of drug stereochemistry.

2. *Determination of enantiomeric purity:* Various tools, chiral derivatizing agents, chiral shift reagents, chiral solvating agents. Racemization, Separation of enantiomers by Kinetic resolution, enzymatic resolution and chromatography

3. *Enantioselective synthesis:* Stereoselective catalytic reduction- homogeneous hydrogenation (chiral ligands, effect of solvent/ pressure/ temperature/ addendum, substrate dependence of enantioselectivity, mechanistic aspects), stereoselective heterogeneous hydrogenation, hydrogenation, hydrosilylation, hydrocyanation; stereoselective oxidation – enantio / diastereoselective epoxydation and dihydroxylation, ligand accelerated catalysis; Asymmetric alkylation; Self replication of chirality- catalytic self-replicating molecules, control of Chirality memory, Pi -stacking effect, selectivity and mechanism of catalytic asymmetric synthesis.

4. *Stereroselective C-C bond formation:* Nucleophilic addition to C=X (X=C, O, S, N), Stereoselective hydroformylation, Pericyclic reaction – asymmetric induction in [3+2] and [2+2] cycloaddition, stereoselective carbene addition, chirality transfer in sigmatropic rearrangements.

MC-720 Principles of Peptide Chemistry (2 Credits)

1. *Importance of peptides in drug discovery*

2. *Protection and Deprotection of amino acids:* General aspects, need for protection, minimal versus global protection, protection of amino group by acid and base labile groups, protection of carboxyl group, concept of orthogonal protection in peptide synthesis, importance of side-chain functional group protection and details of protective groups used for masking individual amino acids, methods used for deprotection.

3. *Coupling reactions in peptide synthesis*

4. *Side reactions in peptide synthesis:* Deletion peptides, side reactions initiated by proton abstraction, protonation, over-activation and side reactions of individual amino acids

5. *Segment and sequential strategies for solution phase peptide synthesis with case studies*

6. *Principle of solid phase peptide synthesis*, t-BOC and FMOC protocols, various solid supports and linkers: Activation procedures, peptide bond formation, deprotection and cleavage from resin, low and high HF cleavage protocols, formation of free peptides and peptide amides, purification and case studies, site-specific chemical modifications of peptides

MC-730 Carbohydrates (2 Credits)

1. Overview, as an introduction to the topic and to emphasize the importance of carbohydrates in food and nutrition and biology.

2. Discussion on the structures, shapes and various sources of carbohydrates. This may complement course “MC-630 Structure and Function of Biomolecules” in certain respects.

3. *Reactions of carbohydrates:* Discussion on the relative reactivities of the hydroxyl groups; preparation of carbohydrate derivatives (esters, ethers, acetals etc.)

4. *Synthesis:* Discussion on the chemical and enzymatic methods after highlighting the need for synthesis.

5. *Carbohydrate-based drugs:* Discussion on various drugs (aminoglycoside antibiotics including glycopeptides, enediynes, macrolides, anthracyclines, etc., alkaloid, steroid and terpenoid. Glycosides: polyphenol glycosides etc.) that contains carbohydrate moiety (moieties) including polysaccharide therapeutics.

6. *Polysaccharide vaccines*.

MC-740 Advanced Topics in Drug Action and Drug Design (1 Credit)

Molecular recognition and supra-molecular chemistry; Molecular associations involving weak interactions; Solvation effects on molecular associations;

Metalloenzymes in medicinal chemistry; Metals in medicine- reversible and irreversible enzyme inhibition; Mechanisms of drug activation; Enzyme activation of drugs; Bioprocess prodrugs, chemistry of metabolic reactions; Organic chemistry of drug metabolism- conjugation reactions, reductive reactions, oxidative reactions.

Molecular interaction fields- Molecular electrostatic potentials in understanding drug action; Drug action on biomembranes- organic chemistry of drug permeability through membranes; Molecular similarity and molecular diversity in drug design.

MC-750 Synthetic Strategies in the Total (2 credits)

Synthesis of Complex Organic Molecules

1. *Retrosynthetic analysis, disconnections and reliability of reactions, synthons:* Donor and acceptor, functional group interconversions, one group carbon-heteroatom and carbon–carbon disconnections, two group carbon-heteroatom and carbon-carbon disconnections, chemo-, regio- and stereo-selectivity considerations, natural reactivity and umpolung.

2. *General synthetic reaction patterns and strategies:* Aliphatic nucleophilic and electrophilic substitutions, aromatic nucleophilic and electrophilic substitutions, addition to carbon–carbon and carbon-heteroatom multiple bonds, eliminations, rearrangements, oxidations and reductions.

3. *Chemistry of protecting groups:* Protection for alcohols, carbonyl groups, carboxylic groups and amino groups.

4. *Applications of synthetic strategies in the total synthesis of selected organic molecules:*

   (a) Cholesterol (b) Estrone (c) Progesterone (d) Reserpine (e) Penicillin (f) Prostaglandin (g) Longifolene (h) Taxol

MC-760 Organometallic and Sustainable Chemistry (2 credits) in Synthesis of Pharmaceuticals

1. *Carbon-carbon and carbon-heteroatom coupling reactions:* Suzuki, Hiyama, Stille, Negishi, Kumada, Heck, Sonogashira, Ullmann, Chan-Lam, Buchwald-Hartwig reactions; Cross-coupling of unactivated arenes; Use in synthesis of pharmaceutically important molecules.

2. *Metathesis:* Grubbs (first and second generation) and Schrock catalysts, Olefin, alkyne, ring closing, ring opening and multiple metathesis; Application in synthesis of heterocycles, natural products and pharmaceuticals.

3. *Green chemistry:* Principles, metrics, perspective of pharmaceutical industries; Green discoveries, greener reactions, catalysis, alternative reaction media, greener technologies; Sustainable synthesis of pharmaceuticals.

4. *Click Chemistry:* Click reactions, criteria, water as solvent; Huisgen cycloaddition, nucleophilic ring opening of epoxide and aziridine; Use in creating new drug candidates, combinatorial, structure based and in situ click chemistry.

5. *Multicomponent reactions:* Ugi, Passerini, Biginelli, Hantzsch, Mannich, Petasis, Strecker, Kabachnik-fields reactions; Diversity oriented synthesis; Convergent synthesis of pharmaceutically relevant molecules.

GE- 711 Seminar (1 credit)

1. Introduction, information retrieval systems.
2. Writing term papers and reports.
3. Organization of scientific material, thesis, dissertation and references.
4. Reading research papers.
5. Skill in oral presentation.

Each student has to present a seminar.

Pharmaceutical Analysis

M.S (Pharm.)

Course No.	Course Name	Credits
Semester-I		
PA-510	Topics in Pharmaceutical Analysis	2
MC-511	Spectral Analysis	2
NP-510	Separation Techniques	1
PE-510	Dosage Form Design Parameters	1
BT-510	Biotechnology in Pharmaceutical Sciences	1
PT-560	Fundamentals of Intellectual Property (IP) and Technology Management	1
GE-510	Biostatistics	2
GE-511	Seminar	1
LG-510	General Lab Experience	3
	Total Credits	**14**
Semester-II		
PA-610	Pharmacopoeial Methods of Analysis	2
PA-620	Modern Instrumental Techniques for Evaluation of APIs and Drug Products	2
PA-630	Stability Testing	1
PA-640	Quality Control and Quality Assurance	2
NP-640	Structure Elucidation	2
PC-611	Pharmacological Screening and Assays	1
PE-630	Pharmaceutical Product Development-I	2
PE-660	Solid State Pharmaceutics	1
GE-611	Seminar	1
LS-610	General Lab Experience in the area of specialization	2
	Total Credits	**16**
Semester-III		
	Project (22 weeks)	
TH-598	Synopsis	5
TH-599	Presentation	3
	Total Credits 8	
Semester-IV		
TH-698	Thesis	9
TH-699	Defence of thesis	3
	Total Credits	**12**
	Total Credits (I to IV semesters)	**50**

Semester-I

PA-510 Topics in Pharmaceutical Analysis (2 credits)

1. Introduction to pharmaceutical analysis and techniques.
2. Material and product specifications.
3. Reference standards.
4. Documentation-STPs, certificate of analysis, laboratory books.
5. Introduction to methods development.
6. *Methods validation:* Definition and methodology.
7. Bio-analysis and bio-analytical method validation.
8. Impurity profiling.
9. Calibration and qualification of equipment.
10. Automation and computer-aided analysis, LIMS.
11. Management of analytical laboratory.
12. Laboratory inspections.

MC-511 Spectral Analysis (2 credits)

1. *Ultra violet and visible spectroscopy:* Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules. Influence of substituent, ring size and strain on spectral characteristics; Solvent effect; Stereochemical effect; Non-conjugated interactions; Spectral correlation with structure.

2. *Infrared spectroscopy (IR):* Characteristic regions of the spectrum. Influence of substituents, ring size, hydrogen bonding, vibrational coupling and field effect on frequency. Determination of stereochemistry. Spectral interpretation with examples.

3. *Nuclear magnetic resonance spectrometry (NMR):* Magnetic nuclei, chemical shift and shielding, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy, spin-spin splitting, Pascal's triangle, coupling constant, mechanism of coupling, quadrupole broadening and decoupling, effect of conformations and stereochemistry on the spectrum, diastereomeric protons, virtual coupling, long range coupling-epi, peri, bay effects. Shift reagents-mechanism of action, spin decoupling, double resonance.

4. *Mass spectrometry (MS):* Molecular ion and metastable peak, fragmentation patterns, nitrogen and ring rules, McLafferty rearrangement, electron and chemical ionization modes, applications.

NP-510 Separation Techniques (1 credit)

1. *Chromatography:* General principles, classification of chromatographic techniques, normal and reversed phase, bonded phase, separation mechanisms.

2. *Column chromatography:* Merits and demerits, short-column chromatography and flash chromatography, vacuum liquid chromatography (VLC), medium pressure liquid chromatography, high pressure liquid chromatography (HPLC).

3. TLC, HPTLC, over pressure layer chromatography (OPLC), centrifugal chromatography.

4. Counter-current chromatography, droplet counter-current chromatography, ion-exchange, affinity, size exclusion and ion-pair chromatography.

5. Gas chromatography, introduction to GC-MS and LC-MS techniques.

PE-510 Dosage Form Design Parameters (1 credit)

1. *Physicochemical aspects:*
    a. pKa
    b. Partition Coefficient

c. Solubility
d. Solid state characterization and physical behavior of drugs.
e. Reaction kinetics and mechanisms.

2. *Biological aspects:*
   a. Role of physicochemical parameters on drug absorption and their implications.
   b. Routes of administrations and implications on bioavailability
   c. Physicochemical aspects of drugs and first pass metabolism.
3. *Dissolution:*
   a. Theories of dissolution, release rates and constants.
   b. Mechanisms of conventional release and controlled release.
   c. Dissolution data handling and correction factors.
   d. Dissolution equipments
   e. IVIVC.

BT-510 Biotechnology in Pharmaceutical Sciences (1 credit)

1. *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.

2. *Genomics in target discovery*: Concept of genome, genes and gene expression. Genome sequencing and sequence comparison methods (e.g. BLAST), gene expression comparison methods (microarray). Comparative genomics and expression genomics for target discovery of communicable disease and lifestyle disease.

3. *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.

4. *Expression purification and assay:* Gene expression in E. coli, in baculovirus, in mammalian cells. Various protein purification methods. Enzymes based assay for small molecule screening.

5. *Bioprocess technology:* Introduction to microbial growth, media formulation, fermentation processes, design, operation and characteristics of fermentation processes, instrumentation and bioprocess control.

6. *Downstream process*: Introduction to various downstream process operations in biopharmaceutical manufacturing such as centrifugation, filtration, tangential flow filtration, cell disintegration, solvent-solvent extraction, supercritical fluid extraction etc.

7. *Biotechnology in pharmaceutical industry*: Major areas for biotechnology in the pharmaceutical industry such as antibiotics, vaccines, diagnostics, antibodies, biopharmaceuticals (insulin, interferon, GSF, CSF & therapeutic proteins etc.); Commercial aspects, priorities for future biotechnological research.

8. *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.

PT-560 Fundamentals of Intellectual Property (IP) and Technology Management (1 credit)

1. *Intellectual property:* Concepts and fundamentals; Concepts regarding intellectual property (IP), intellectual property protection (IPP) and intellectual property rights (IPR); Economic importance, mechanisms for protection of intellectual property-patents, copyrights, trademark; Factors effecting choice of IP protection; Penalties for violation; Role of IP in pharmaceutical industry; Global ramifications and financial implications.

2. *Trade related aspects of intellectual property rights:* Intellectual property and international trade; Concept behind WTO (World Trade Organisation), WIPO (World Intellectual Property Organisation) GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trade in Services); Protection of plant and animal genetic resources; Biological materials; Gene patenting; Biotechnology / drug related IPR issues; Status in India and other developing countries; Case studies and examples; TRIPS issues on herbal drugs.

3. *Nuts and bolts of patenting, copyright and trademark protection criteria for patentability, types of patents; Indian Patent Act, 1970; WTO and modifications under TRIPS:* Filing of a patent application; Precautions before patenting-disclosures / non-disclosures, publication-article / thesis; Prior art search-published patents, internet search patent sites, specialized services-search requests, costs; Patent application-forms and guidelines, fee structure, time frames, jurisdiction aspects; Types of patent applications-provisional, non provisional, PCT and convention patent applications; International patenting-requirement procedures and costs; Financial assistance for patenting-introduction to schemes by NRDC and TIFAC; Publication of patents-gazette of India, status in Europe and US; Patent annuity; Patent attorneys technical aspects, criteria for selection, addresses, fee, rights and responsibilities of a patentee; Practical aspects regarding maintaining of a PATENT FILE; Patent infringement- meaning, scope, litigation, case studies and examples; Patenting by research students, lecturers and scientists-University / organizational rules in India and abroad; Thesis research paper publication, credit sharing by workers, financial incentives; Useful information sources for patents related information-internet sites, brouchers, periodicals, CD roms; Significance of copyright protection for researchers; Indian Copyright Law and digital technologies-Beme convention, WIPO copyright treaty (WCT), WIPO performance and Phonogram Treaty (WPPT); Protection for computer data bases, multi media works; Trade marks legislation and registration system in India-an introduction, meaning of trademark criteria for eligibility; filling application for trademark registration; Trade secrets-scope modalities and protection; Case studies-drug related patents infringements.

4. *Technology development / transfer / commercialization related aspects:* Technology development-meaning; Drug related technology development; Toxicological studies, bioequivalence (BU), clinical trials-phase-I, phase-II and phase-III; Approved bodies and agencies; Scale-up, semi-commercialization and commercialization-practical aspects and problems; Significance of transfer of technology (TOT), bottlenecks; Managing technology transfer-guidelines for research students, scientists and related personnel; TOT agencies in India-APCTD, NRDC, TIFAC, BCIL, TBSE/SIDBI; TOT related documentation-confidentiality agreements, licensing, MOUs, legal issues; Compulsory licensing excess to medicine issues; DOHA declaration, POST WTO product patent regime from 2005; Challenges for Indian pharmaceutical industry in the context of globalization of IP; Drug registration and licensing issues-national and global; Drug master file submissions, SOPS; Related registration and marketing issues; Case studies-antiretroviral drugs and others.

5. *Funding sources for commercialization of technology:* Preparation of a project report, financial appraisal, business models; GOI schemes and incentives; NRDC, TePP, HGT, TDB schemes. PATSER; Venture capitalists, banks. Incubator concept-Case studies with respect to IIT, CCMB, IMTECH, NIPER. Documentation and related aspects.

6. *Ethics and values in IP:* IP and ethics-positive and negative aspects of IPP; Societal responsibility; Avoiding unethical practices; Echo-responsibility-economic, social and environmental benefits of modern biotechnology; Voluntary adoption of pollution control strategies.

GE-510 Biostatistics (2 credits)

1. *Statistics*: Introduction, its role and uses. Collection; Organization; Graphics and pictorial representation of data; Measures of central tendencies and dispersion. Coefficient of variation.
2. *Probability*: Basic concepts; Common probability distributions and probability distributions related to normal distribution.
3. *Sampling*: Simple random and other sampling procedures. Distribution of sample mean and proportion.
4. Estimation and hypothesis testing: Point and interval estimation including fiducial limits.Concepts of hypothesis testing and types of errors. Student- t and Chi square tests.Sample size and power.
5. *Experimental design and analysis of variance*: Completely randomized, randomized blocks. Latin square and factorial designs. Post- hoc procedures.
6. *Correlation and regression*: Graphical presentation of two continuous variables; Pearson's product moment correlation coefficient, its statistical significance. Multiple and partial correlations. Linear regression; Regression line, coefficient of determination, interval estimation and hypothesis testing for population slope. Introduction to multiple linear regression model. Probit and logit transformations.
7. *Non-parametric tests:* Sign; Mann-Whitney U; Wilcoxon matched pair; Kruskal wallis and Friedman two way ANOVA tests. Spearman rank correlation.
8. Statistical techniques in pharmaceutics: Experimental design in clinical trials; Parallel and crossover designs. Statistical test for bioequivalence. Dose response studies;Statistical quality control.

GE- 511 Seminar (1 credit)

1. Introduction, information and retrieval systems.
2. Writing term papers and reports.
3. Organization of scientific material, thesis, dissertation and references.
4. Reading research papers.
5. Skills in oral presentation.

Each student has to present a seminar before end of the semester.

LG-510 General Laboratory Experience-15 hours/week (3 credits)

1. *Analytical techniques:* (75 hours)
   a. Spectral analysis workshop (45 hours)
   b. Separation Techniques (30 hours)

2. *Computer and application in pharmaceutical sciences* (100 hours): Introduction to computers, basic unit and functions, H/W and S/W, operating systems, word processing, spread sheet, graphic programs, dDbase, windows, statistical S/W programs and packages. Steps involved in S/W development, computer languages with emphasis to FORTRAN language and programming, hands on experience in pharmaceutical software systems. Use of computers in information retrieval systems.

3. *Pharmacology (25 hours)*: Animal handling, route of administration of drugs, dose response relationship, acute toxicity testing of drugs, analgesic activity of a compound, estimation of protein and hematological parameters.

4. Biotechnology for pharmaceutical sciences (20 hours)
   Day-1: Preparation for plasmid miniprep.
   Day-2: Plasmid miniprep and restriction digestion.
   Day-3: Gel electrophoresis and molecular weight calculation.
   Day-4: Discussion of result and viva.

5. *Specialization (50 hours)*
   a) To calibrate thermometer
   b) To calibrate the common glassware (volumetric flask, burette and pipette) found in an analytical laboratory
   c) Calibration of pH meter
   d) To determine water content in the given sample by Karl Fischer reagent
   e) To determine moisture content in the given sample using infrared moisture balance
   f) To construct calibration curve for a drug by UV spectrophotometer
   g) To perform dissolution test on the given sample
   h) Determination of pKa of given sample by spectrophotometric method.

Semester-II

PA-610 Pharmacopoeial Methods of Analysis (2 credits)

1. Physical tests.
2. Limit tests.
3. Special tests.
4. Microbiological assays.
5. Biological tests.
6. Dissolution tests
7. Miscellaneous tests

PA-620 Modern Instrumental Techniques for Evaluation of APIs and Drug Products (2 credits)

1. *Spectroscopic techniques:* FT-NIR, ATR, FT-Raman.
2. *Thermal techniques:* DSC, DTA, TGA
3. *Particle sizing:* Laser diffraction equipment, photo correlation spectroscopy.
4. *Electrophoresis:* Capillary electrophoresis.
5. *Chromatographic techniques:* HPLC
6. *Hyphenated techniques:* LC-MS

PA-630 Stability Testing (1 credit)

1. Drug development cycle and stability-testing.
2. Stress testing of drug substances.
3. Stability-indicating assays.
4. Role of kinetic studies.
5. Stability-testing protocols.
6. Retest period/shelf-life determination.
7. Photostability testing.
8. Stability testing of biotechnological products.
9. Stability testing of phytopharmaceuticals.
10. Post-approval changes.
11. Reduced stability-testing plans.
12. Ongoing and follow-up stability-testing.
13. Stability-test equipment.

PA-640 Quality Control and Quality Assurance (2 credits)

1. Good manufacturing practices and its applications to pharmaceutical industry.
2. Basic principles and concepts of quality management viz. quality control, quality assurance, quality auditing and ISO system etc.
3. Sampling, finished products testing and release, control of packaging materials and labeling, distribution records.
4. *Document control:* Issuance, storage and retrieval.
5. Standard operating procedures, change control procedure and annual product review.
6. Basic principles of validation, validation protocols, analytical method validation and process validation.
7. Technology transfer from R & D to manufacturing.
8. Product change over, basic requirements of cleaning and its validation.
9. Market complaint and handling of returned goods.

NP-640 Structure Elucidation (2 credits)

Some typical structure elucidation insights for natural products by combination of classical, spectroscopic, synthetic and degradative methods depicting examples

1. Use of spectroscopic techniques such as ^{1}H NMR, ^{13}C NMR, NOE, DEPT, HMQC, HMBC, COSY, NOESY, HRMS and FAB mass for structural elucidation of selected natural products.

2. Structure elucidation of natural products by spectroscopy and degradative methods:

   Examples of natural products from following classes of secondary metabolites
   Alkaloids 2-3 examples; Flavonoids 2-3 examples. Sterols 2-3 examples;
   Coumarins 2-3 examples Triterpenes 2-3 examples; Xanthones 2-3 examples

PC-611 Pharmacological Screening and Assays (1 credit)

1. General principles of screening, correlations between various animal models and human situations and animal ethics.

2. Pharmacological screening models for therapeutic areas such as hypertension, heart failure, myocardial ischemia, cerebral ischaemia, pain, epilepsy, depression, Parkinson's disease, Alzheimer's disease, diabetic, leishmania etc.

3. Correlation between in-vitro and in-vivo screens; Special emphasis on cell based assay, biochemical assay, radioligand binding assay, high through put screening, high through put pharmacokinetic analysis, specific use of reference drugs and interpretation of results.

PE-630 Pharmaceutical Product Development-I (2 credits)

1. *Preformulation studies:* Preformulation studies of drug substances, proteins and peptides. Preformulation work sheet.
2. *Complexation:* Metal and organic molecular complexes, inclusion compounds with reference to cyclodextrins, methods of analysis.
3. *Solubilization:* Solubility and solubilization of nonelectrolyte, drug solubilization in surfactant systems, use of co-solvents, solid-state manipulations and drug derivitization.
4. *Rheology:* Viscosity and measurements.
5. *Micromeritics:* Particle size distribution, evaluation and its implications in formulations, measurements, and solid dosage forms.
6. Development of dosage forms, 4-stage development, biological basis and opportunities, dosage form and its implications. Manipulation of physiological processes.
7. Case studies will be discussed after each topic with current literature.

PE-660 Solid State Pharmaceutics (1 credit)

1. *Molecular Level :* Crystallinity , crystal habit, polymorphism, amorphous state, solvates, hydrates, analytical techniques for characterization, molecular modeling in solid state characterization- case studies and regulatory perspective.
2. *Particle level :* Particle size, particle shape, porosity, surface area, compaction, particle engineering in pharmaceuticals and relevance in doses form designing.
3. *Bulk level :* Bulk density, compressibility, flow properties, cohesivity, electrostatistics, aggregation, agglomeration, role in formulation development and processing.

GE-611 Seminar (1 credit)

Students are required to submit written record and present details of the project to be pursued in semester-III. This should include the purpose and basis of the project, stating aims, objectives and probable outcomes, be able to supplement these with necessary information, literature review towards it, and process for the project itself.

LS-610 General Laboratory Experience-10 hours/week (2 credits)

Practicals in lab:

1. Analysis of a drug sample by a pharmacopoeial method and preparation of its certificate of analysis.
2. Determination of viscosity of given samples using Ostwald viscometer and rotoviscometer.
3. Estimation of the given drug in urine and blood samples using HPLC and identification of metabolites.
4. Stress study of a drug sample in proposed conditions and establishment of a stability indicating assay using HPLC.
5. Separation of an impurity in a sample on a preparative HPLC.
6. Establishment of dissolution characteristics of a given controlled release preparation using an automated dissolution tester.
7. Particle size and shape analysis using of an automated particle size analyzer.
8. Determination of tapped and bulk density.
9. Study of different packaging materials and their evaluation.
10. Determination of osmolality of given solutions.

11. Moisture determination of given substances using infrared moisture balance.

Practicals in CIL:

1. Determination of instrument calibration, melting behavior and polymorphic behavior of various compounds by DSC.
2. Spectrofluorimetric analysis of a given sample.
3. Study of hydrate forms of ampicillin trihydrate using TGA.
4. Study of the given sample by AAS.
5. Freeze drying of a sample.
6. Separation of impurities of betamethasone velerate on LC-MS using BP method and study the mass values of impurities.
7. Study of a given mixture by GC-MS.
8. Study of given sample on polarimeter.
9. ATR analysis of a given drug sample.
10. Conduct of a titration using an autotitrator.

Ph.D. courses

PA-710 Impurity Profiling (1 Credit)

1. Introduction: Basics of impurity
2. Impurity profiling : Practical approach
3. Regulatory perspectives.
4. Basic of intrumentation techniques: HPLC, LC-MS, LC-NMR, LC-IR
5. Case Studies: Impurity profiling, Isolation and Characterization.

PA-720 Bioanalytical Methods and Metabolite profiling (1 Credit)

1. Role of bio-analysis in drug discovery and development
2. Immuno assays in Pharmacokinetic and Pharmacodynamic bioanalysis
3. The importance of protein binding in drug development and the techniques used for measuring protein binding.
4. Metabolite profiling: practical approach
5. Metabolite identification: In-vitro/in-vivo approaches and sample preparation.
6. Metabolite identification using radioligand techniques.
7. Bio-analytical method development, validation and transfer for high throughput bioanalytical techniques: LC-MS/MS etc.
8. Case studies: metabolite profiling, Isolation and Characterization.

PA-730 Method Development and troubleshooting - GC and HPLC (2 Credit)

1. Preparation of drug sample for analysis-Introduction, compatibility with the instrumental method, fundamental theories controlling preparation techniques.
2. Specific sample preparation techniques: soxhlet extraction, Liquid-liquid extraction, solid phase extraction, solid phase micro extraction, protein precipitation methods, Ultra filtration, direct injection methods, derivatization methods, residual sample preparation, different sample preparation methods for pharmaceutical dosage forms: tablets, capsules, ointments etc,
3. Gas Chromatography: inlets and injectors, GC column characteristics, GC detectors, GC preventive maintenance and trouble shooting, method development process, method validation and QA Processes
4. HPLC: Detectors- PDA, ELSD, Conductivity, UV, Refractive Index, Fluorescence, Mass, HPLC column selection and mobile phases, mobile phase additives.
5. HPLC Method development by using different stationary phases, mechanism of interactions, HPLC preventive maintenance and troubleshooting, case studies.
6. Calibration methods: external, internal and standard addition methods.

PA-740 CE and SFC in pharmaceutical analysis (2 Credit)

1. Overview of CE in pharmaceutical analysis, Basic configuration, CE characteristics, principles of CE, methods and modes of CE.
2. Improved performance of CE methods- gerenal considerations, method development, CE as orthogonal technique to chromatography. Crown ethers as buffer additives in capillary electrophoresis.

3. SFC Introduction, developing achiral separation methods in pharmaceutical development, preps SFC, some case histories from Pharma.
4. Investigation into the use of atypical organic solvents with immobilized chiral stationary phases in SFC mode,
5. Use of chiroptical and ELSD detection in analytical and prep.SFC,
6. Pharmaceutical analysis applications.

PA-750 Liquid chromatography in Pharmaceutical Analysis (1 Credit)

1. HPLC Method development for biomolecules, monolithic stationary phases-applications, chiral stationary phases, principle of chiral recognition,molecular imprinted polymers as sorbents for separation and extraction.
2. Assay and stability testing by HPLC, application of HPLC for cleaning validation, HPLC in dissolution testing, HPLC in chiral analysis of pharmaceuticals.
3. New develpments in HPLC-Role of Ultra, Nano liquid chromatography in pharmaceutical analyses, Immobilized Polysaccharide CSPs: advancement in enantiomeric separations, reversed phase chiral method development.
4. Preparative HPLC, practical aspects of preparative HPLC: Equipment, sample solubility, effect of sample size: Touching-Band separations, column saturation capacity, gradient elution, heavily overload separations, unusual isothermal behavior and recovery.
5. Examples of preparative method developments: normal, reversed phase and chiral phases, recent advances in preparative HPLC separations.

PA-760 Analytical Chemometrics (1 Credit)

1. General introduction and its application in optimization, Modeling and parameter estimation, Sampling.
2. Calibration, Resolution, Factor analysis, Signal processing, structure-property relationship, pattern recognition.
3. Propagation of measurement uncertainties (inaccuracy and imprecision).
4. Multivariate Calibration, Multivariate Curve Resolution, Chemoinformatics, Library Searching, Data Preprocessing and Feature Selection, Image Analysis, Microarrays.
5. Analytical validation techniques, Non-linear regression analysis, good manufacturing practice (GMP), Good lab practice (GLP), lab and industrial safety.

PA-770 Mass Spectrometry in Pharmaceutical Analysis (2 Credit)

1. Importance of chromatographic separation, mass analyzers, atmospheric pressure ionization techniques: ESI, APPI, APCI.
2. Interpretation of API mass spectra: Molecular weight determination, typical fragmentation behavior for individual functional groups: (i) phosphorous (ii) sulfur (iii) nitrogen (iv) oxygen (5) halogen substituent's (6) alkyl and aryl substitution on the aromatic ring, polycyclic aromatic hydrocarbons, alkenes and alkynes.
3. Liquid chromatography - electrospray ionization - mass spectrometry (LC-ESI-MS) to the detection and determination of antibiotics drugs, antidiabetics, antitumour, antiretroviral drugs.
4. EI-MS of small molecular mass of selected drugs- fragmentation information.

MC-740 Advanced Topics in Drug Action and Drug Design (1 credit)

Molecular recognition and supra-molecular chemistry; Molecular associations involving weak interactions; Solvation effects on molecular associations; Metalloenzymes in medicinal chemistry; Metals in medicine- reversible and irreversible enzyme inhibition. Mechanisms of drug activation; Enzyme activation of drugs; Bioprocess prodrugs chemistry of metabolic reactions. Organic chemistry of drug metabolism- conjugation reactions, reductive reactions, oxidative reactions. Molecular interaction fields- Molecular electrostatic potentials in understanding drug action. Drug action on biomembranes- organic chemistry of drug permeability through membranes. Molecular similarity and molecular diversity in drug design.

GE- 711 Seminar (1 Credit)

1. Introduction, information retrieval systems.
2. Writing term papers and reports.
3. Organization of scientific material, thesis, dissertation and references.
4. Reading research papers.
5. Skill in oral presentation.

Each student has to present a seminar.

Pharmacology and Toxicology

M.S. (Pharm.)

Course No.	Course Name	Credits
Semester-I		
PC-511	Pathophysiology	1
PC-520	General Pharmacology	2
PC-530	Experimental Pharmacology	1
PC-540	Chemotherapy of Parasitic and Microbial Infections	1
NP-510	Separation Techniques	1
PE-520	Biopharmaceutics and Pharmacokinetics	2
BT-510	Biotechnology in Pharmaceutical Sciences	1
GE-510	Biostatistics	2
PT-560	Fundamentals of Intellectual Property (IP) and Technology Management	1
GE-511	Seminar	1
LG-510	General Laboratory Experience	3
	Total Credits	**16**
Semester-II		
PC-610	Drug Metabolism	1
PC-611	Pharmacological Screening and Assays	1
PC-620	CNS and Respiratory Pharmacology	2
PC-630	Autonomic, CVS, Blood, Renal and GI Pharmacology	2
PC-640	Autocoid and Endocrine Pharmacology	1
PC-650	Clinical Pharmacology and Regulatory Toxicology	2
PC-660	Chemotherapy and Immunopharmacology	2
GE-611	Seminar	1
LS-610	General Laboratory Experience in the area of Specialization	2
	Total Credits	**14**
Semester-III		
	Project (22 weeks)	
TH-598	Synopsis	5
TH-599	Presentation	3
	Total Credits	**8**
Semester-IV		
TH-698	Thesis	9
TH-699	Defence of thesis	3
	Total Credits	**12**
	Total Credits (I to IV semesters)	**50**

Semester-I

PC-511 Pathophysiology (1 credit)

1. Factors influencing the disease conditions such as sex, age, nutritional status, genetic make up etc.

2. Pathogenesis, symptoms and signs, laboratory findings and complications of respiratory, urinary tract, venereal and menigial infections; Congestive heart failure, hypertension, cardiac arrhythmias: Ulcer, pancreatitis, hepatitis and cholecystitis; Bronchial asthma, depression, schizophrenia, epilepsy, Parkinsonism and Alzheimer disease; Hypo and hyper thyroidism, diabetes mellitus and other endocrine diseases; Rheumatoid arthritis, gout and anemia.

PC-520 General Pharmacology (2 credits)

1. Drug receptor interaction theories, occupation theory, rate theory.
2. Receptor occupation and response relationship, spare receptors, silent receptors, orphan receptors, presynaptic and postsynaptic receptors.
3. *Receptor characterization methods:* Pharmacological characterization, radioligand methods, monoclonal *anti*-bodies, receptor subtypes, IUPHAR nomenclature, clinical significance of receptor subclassification.
4. Receptor down regulation and upregulation.
5. Structure activity relationships, pharmacodynamic and pharmacokinetic aspects of chiral drugs, allosteric binding, thermodynamics of drug interactions with the receptors.
6. Transmembrane signal mechanisms, second messengers, viz., cAMP, cGMP, calcium.
7. Dose response relationship and different types of antagonisms.
8. Desensitization and tachyphylaxis.
9. Drug dependence and withdrawal responses.
10. Non therapeutic uses of drugs.

PC-530 Experimental Pharmacology (1 credit)

1. Common laboratory animals and their physiological parameters, breeding types, inbred strains, F1 hybrids; Random breeding, selective breeding, breeding methods, factors affecting the nature and degree of pharmacological responses; Handling and care of different animals; Bleeding and different routes of administration and chemical euthanasia.
2. *In vitro experimentation:* Advantages and disadvantages; Physiological salt solutions, recording transducers, resting tensions, equilibrium, dose cycles; Methods of stimulation, stimulating devices, operation of recording devices, superfusion, cascade superfusion, perfusion, some commonly used isolated preparations.
3. *In vivo experimentation:* Advantages and disadvantages; Anaesthesia used in laboratory animals, common agents, dose calculations, cannulation methodology, ventilation rate, recording of arterial blood pressure, intestinal motility, etc.
4. Conscious animal experimentation precautions to be taken in behavioural experiments.
5. Animal cell-culture techniques, aseptic handling, cell counting and cell viability assays.
6. Protein and DNA gel electrophoresis, western, northern, southern blot hybridization and PCR techniques. -
7. Ultra, differential and analytical centrifugation, protein purification and identification by RF-HPLC, LCMS-MS, MALDI.
8. *Radiochemical methods of analysis:* Principle of radiation and radioactivity, decay of radioactivity, units, isotopes detection, scintillation detector (crystal and liquid), quenching, radioimmunoassay.
9. Drug solution preparations, storage, concentration expression, common solvents, stabilizing agents, storage conditions, reference standards, methods of procurement of reference standards.
10. Data collection, data reduction, data representation, cumulative and noncumulative dose response curves, transformation of data logit, probit, pA scale, pD scale.

PC-540 Chemotherapy of Parasitic and Microbial Infections (1 credit)

1. Introduction to parasitic and infectious diseases.
2. Biology of tuberculosis.

3. Mechanism of action of anti-tuberculosis drugs
4. Targets for anti-tuberculosis drug development.
5. Mechanism of drug-resistance in tuberculosis.
6. Biology of human amoebiasis.
7. Mechanism of action anti-amoebic drugs.
8. Biology of filarial infections.
9. Mechanism of action of anti-filarial drugs.
10. Targets of anti-filarial drug development.
11. Biology of viral infection.
12. Mechanism of action of anti-HIV drugs.
13. Targets for anti-HIV drug development.
14. Biology of malaria.
15. Mechanism of action of anti-malarial drugs.
16. Targets for anti-malarial drug development.
17. Mechanism of drug-resistance in malaria.
18. Biology of leishmaniasis.
19. Mechanism of action of anti-leishmanial drugs.
20. Targets of anti-leishmanial drug development.
21. Drug-resistance in leishmaniasis.

NP-510 Separation Techniques (1 credit)

1. *Chromatography:* General principles, classification of chromatographic techniques, normal and reversed phase, bonded phase, separation mechanisms.
2. *Column chromatography:* Merits and demerits, short-column chromatography and flash chromatography, vacuum liquid chromatography (VLC), medium pressure liquid chromatography, high pressure liquid chromatography (HPLC).
3. TLC, HPTLC, over pressure layer chromatography (OPLC), centrifugal chromatography.
4. Counter-current chromatography, droplet counter-current chromatography, ion-exchange, affinity, size exclusion and ion-pair chromatography.
5. Gas chromatography, introduction to GC-MS and LC-MS techniques.

PE-520 Biopharmaceutics and Pharmacokinetics (2 credits)

1. Introduction, concentration time profile, plotting the data, different fluid compartments and blood flow rates compartment models.
2. Protein and tissue binding, factors effecting protein binding, kinetics of protein binding, determination of rate constants and different plots (direct, scatchard and reciprocal); Significance volume of distribution, implications and in vitro methodologies.
3. *Pharmacokinetic characterization of drugs:* Absorption rate constants (Wagner-Nelson, Loo-Reigelman methods), limitations, lag-time, pharmacokinetics in presence of lag-time; Flip-flop model.
4. Case studies.

5. Drug disposition, renal clearance, mechanism of clearance , clearance ratio, determination of clearance, hepatic clearance, % drug metabolized, relationship between blood flow, intrinsic clearance, hepatic clearance and protein binding, different volumes of distribution, significance, and integration kinetics.

6. Pharmacokinetics of multiple dosing, dosage regimen design based on mean average, minimum and maximum, plasma/serum concentrations, limited fluctuation methods; Repeated one point method; Dosage adjustment in disease patients.

7. Nonlinear pharmacokinetics, direct, liner and orbit graph methods of dosing. Non-linear pharmacokinetics due to drug-protein binding.

8. *Topics:* Chronopharmacokinetics; Drug toxicity and forensic, pharmacokinetics; Case study; Pharmacokinetics in elderly; Drug dosage in children, obese patient; First dose size; Kinetics of maternal-fetal drug transfer; Pharmacokinetics- pharmacologic/clinical response; Distribution kinetics; Metabolic kinetics; Dose and time dependencies; Turnover concepts; Small volume of distribution; Dialysis.

9. Biopharmaceutics and pharmacokinetics in drug research.

BT-510 Biotechnology in Pharmaceutical Sciences (1 credit)

1. *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.

2. *Genomics in target discovery*: Concept of genome, genes and gene expression. Genome sequencing and sequence comparison methods (e.g. BLAST), gene expression comparison methods (microarray). Comparative genomics and expression genomics for target discovery of communicable disease and lifestyle disease.

3. *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.

4. *Expression purification and assay:* Gene expression in E. coli, in baculovirus, in mammalian cells. Various protein purification methods. Enzymes based assay for small molecule screening.

5. *Bioprocess technology:* Introduction to microbial growth, media formulation, fermentation processes, design, operation and characteristics of fermentation processes, instrumentation and bioprocess control.

6. *Downstream process*: Introduction to various downstream process operations in biopharmaceutical manufacturing such as centrifugation, filtration, tangential flow filtration, cell disintegration, solvent-solvent extraction, supercritical fluid extraction etc.

7. *Biotechnology in pharmaceutical industry*: Major areas for biotechnology in the pharmaceutical industry such as antibiotics, vaccines, disgnostics, antibodies, biopharmaceuticals (insulin, interferon, GSF, CSF & therapeutic proteins etc.); Commercial aspects, priorities for future biotechnological research.

8. *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.

GE-510 Biostatistics (2 credits)

1. *Statistics*: Introduction, its role and uses. Collection; Organization; Graphics and pictorial representation of data; Measures of central tendencies and dispersion. Coefficient of variation.

2. *Probability*: Basic concepts; Common probability distributions and probability distributions related to normal distribution.

3. *Sampling*: Simple random and other sampling procedures. Distribution of sample mean and proportion.

4. Estimation and hypothesis testing: Point and interval estimation including fiducial limits.Concepts of hypothesis testing and types of errors. Student- t and Chi square tests.Sample size and power.

5. *Experimental design and analysis of variance*: Completely randomized, randomized blocks. Latin square and factorial designs. Post- hoc procedures.

6. *Correlation and regression*: Graphical presentation of two continuous variables; Pearson's product moment correlation coefficient, its statistical significance. Multiple and partial correlations. Linear regression; Regression line, coefficient of determination, interval estimation and hypothesis testing for population slope. Introduction to multiple linear regression model. Probit and logit transformations.

7. *Non-parametric tests:* Sign; Mann-Whitney U; Wilcoxon matched pair; Kruskal wallis and Friedman two way ANOVA tests. Spearman rank correlation.

8. Statistical techniques in pharmaceutics: Experimental design in clinical trials; Parallel and crossover designs. Statistical test for bioequivalence. Dose response studies;Statistical quality control.

PT-560 Fundamentals of Intellectual Property (IP) and Technology Management (1 credit)

1. *Intellectual property:* Concepts and fundamentals; Concepts regarding intellectual property (IP), intellectual property protection (IPP) and intellectual property rights (IPR); Economic importance, mechanisms for protection of intellectual property-patents, copyrights, trademark; Factors effecting choice of IP protection; Penalties for violation; Role of IP in pharmaceutical industry; Global ramifications and financial implications.

2. *Trade related aspects of intellectual property rights:* Intellectual property and international trade; Concept behind WTO (World Trade Organisation), WIPO (World Intellectual Property Organisation) GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trade in Services); Protection of plant and animal genetic resources; Biological materials; Gene patenting; Biotechnology / drug related IPR issues; Status in India and other developing countries; Case studies and examples; TRIPS issues on herbal drugs.

3. *Nuts and bolts of patenting, copyright and trademark protection criteria for patentability, types of patents; Indian Patent Act, 1970; WTO and modifications under TRIPS:* Filing of a patent application; Precautions before patenting-disclosures / non-disclosures, publication-article / thesis; Prior art search-published patents, internet search patent sites, specialized services-search requests, costs; Patent application-forms and guidelines, fee structure, time frames, jurisdiction aspects; Types of patent applications-provisional, non provisional, PCT and convention patent applications; International patenting-requirement procedures and costs; Financial assistance for patenting-introduction to schemes by NRDC and TIFAC; Publication of patents-gazette of India, status in Europe and US; Patent annuity; Patent attorneys technical aspects, criteria for selection, addresses, fee, rights and responsibilities of a patentee; Practical aspects regarding maintaining of a PATENT FILE; Patent infringement- meaning, scope, litigation, case studies and examples; Patenting by research students, lecturers and scientists-University / organizational rules in India and abroad; Thesis research paper publication, credit sharing by workers, financial incentives; Useful information sources for patents related information-internet sites, brouchers, periodicals, CD roms; Significance of copyright protection for researchers; Indian Copyright Law and digital technologies-Beme convention, WIPO copyright treaty (WCT), WIPO performance and Phonogram Treaty (WPPT); Protection for computer data bases, multi media works; Trade marks legislation and registration system in India-an introduction, meaning of trademark criteria for eligibility; filling application for

trademark registration; Trade secrets-scope modalities and protection; Case studies-drug related patents infringements.

4. *Technology development / transfer / commercialisation related aspects:* Technology development-meaning; Drug related technology development; Toxicological studies, bioequivalence (BU), clinical trials-phase-I, phase-II and phase-III; Approved bodies and agencies; Scale-up, semi-commercialisation and commercialisation-practical aspects and problems; Significance of transfer of technology (TOT), bottlenecks; Managing technology transfer-guidelines for research students, scientists and related personnel; TOT agencies in India-APCTD, NRDC, TIFAC, BCIL, TBSE/SIDBI; TOT related documentation-confidentiality agreements, licensing, MOUs, legal issues; Compulsary licensing excess to medicine issues; DOHA declaration, POST WTO product patent regime from 2005; Challenges for Indian pharmaceutical industry in the context of globalisation of IP; Drug registration and licensing issues-national and global; Drug master file submissions, SOPS; Related registration and marketing issues; Case studies-antiretroviral drugs and others.

5. *Funding sources for commercialization of technology:* Preparation of a project report, financial appraisal, business models; GOI schemes and incentives; NRDC, TePP, HGT, TDB schemes. PATSER; Venture capitalists, banks. Incubator concept-Case studies with respect to IIT, CCMB, IMTECH, NIPER. Documentation and related aspects.

6. *Ethics and values in IP:* IP and ethics-positive and negative aspects of IPP; Societal responsibility; Avoiding unethical practices; Echo-responsibility-economic, social and environmental benefits of modern biotechnology; Voluntary adoption of pollution control strategies.

GE-511 Seminar (1 credit)

1. Introduction, information retrieval systems
2. Writing term papers and reports.
3. Organization of scientific material , thesis, dissertation and references.
4. Reading research papers
5. Skills in oral presentation.

Each student has to present a seminar before end of the semester.

LG-510 General Laboratory Experience-15 hours/week (3 credits)

1. *Analytical techniques:* (30 hours) Separation Techniques
2. *Computer and application in pharmaceutical sciences* (100 hours): Introduction to computers, basic unit and functions, H/W and S/W, operating systems, word processing, spread sheet, graphic programs, dDbase, windows, statistical S/W programs and packages. Steps involved in S/W development, computer languages with emphasis to FORTRAN language and programming, hands on experience in pharmaceutical software systems. Use of computers in information retrieval systems.
3. *Pharmacology (25 hours)* Animal handling, route of administration of drugs, dose response relationship, acute toxicity testing of drugs, analgesic activity of a compound, estimation of protein and haematological parameters.
4. Biotechnology for pharmaceutical sciences (20 hours)

   Day-1: Preparation for plasmid miniprep.

   Day-2: Plasmid miniprep and restriction digestion.

   Day-3: Gel electrophoresis and molecular weight calculation.

   Day-4: Discussion of result and viva.

5. *Specialization (95 hours)*

   ECG recording in rat, pA2 value for atropine in G.pig ileum, strength of an unknown sample of histamine by four point assay, analgesic effect of pentazocine using hot plate method, demonstration of receptor binding studies, effects of a drug on food and water intake. Demonstration of recording of rat blood pressure, anticonvulsive activity of a drug, locomotor activity, muscle relaxant activity using rotarod apparatus; Working of physiograph, chlopromazine induced catalepsy, anti-inflammatory property of indomethacin, plasma glucose levels in streptozotocin treated rats; histology, cell culture techniques, cell viability assay, isolation of DNA from sample, SDS PAGE and DNA gel electrophoresis, genotoxic effects of drugs.

Semester-II

PC-610 Drug Metabolism (1 credit)

1. Biotransformation of drugs, enzymes responsible for bio-transformations, microsomal and non-microsomal mechanisms. Factors influencing enzyme induction and inhibition.

2. Excretion of drugs, biliary and fecal excretion; Factors effecting drug metabolism; Drug metabolism in fetus and new born; Models to study drug metabolism; Dose effect relationships.

3. Adverse drug reactions and drug interactions; Toxic reactions, allergic reactions, idiosyncrasy, acute poisoning and its treatment.

PC-611 Pharmacological Screening and Assays (1 credit)

1. General principles of screening, correlations between various animal models and human situations, animal ethics.

2. Pharmacological screening models for therapeutic areas such as hypertension, cerebral ischaemia, pain, epilepsy, depression, Parkinson's disease, Alzheimer's disease, diabetis, leishmaniasis etc.

3. Correlation between in-vitro and in-vivo screens; Special emphasis on cell based assay, biochemical assay, radioligand binding assay, high through put screening, high through put pharmacokinetic analysis, specific use of reference drugs and interpretation of results.

PC-620 CNS and Respiratory Pharmacology (2 credits)

1. Chemical transmission and drug action in the central nervous system, emphasis on noradrenaline, dopamine, 5-HT, acetylcholine, excitatory amino acids, GABA, glycine and histamine.

2. Peptides as mediators.

3. *Pharmacodynamic, pharmacokinetic, therapeutic and toxicological facets of the following:* Benzodaizepines and its antagonists. Barbiturates, 5-HT agonists and antagonists, tricyclic antidepressants, MAOI, atypical antidepressants, lithium, antiepileptics, drugs used in the treatment of Parkinsonism, centrally acting muscle relaxants, narcotic analgesics, psychomotor stimulants and psychotomimetic drugs, antipsychotic drugs, drugs used in Alzheimer's disease, local anesthetics.

4. Respiratory stimulants, bronchodilators and anti-inflammatory agents used in asthma, cough suppressants.

PC-630 Autonomic, CVS, Blood, Renal, and GI Pharmacology (2 credits)

1. Chemical transmission of the autonomic nervous system.

2. *Pharmacodynamic, pharmacokinetic, therapeutic and toxicological facets of the following:* Muscarinic cholinergic receptor agonists and antagonists. Ganglionic stimulants and blocking agents, neuromuscular blocking agents, drugs acting on adrenoceptors.

3. Cardiac glycosides and other cardiotonic agents, anti dysrhythmic drugs, antianginal drugs, antihypertensives, calcium channel antagonists, ACE inhibitors, endothelium derived relaxing factors, lipid lowering agents. Diuretics, drug altering the pH of urine, excretion of organic molecules.

4. Oral anticoagulants, factors increase/decrease the efficacy of oral anticoagulants, heparin, platelet adhesion and activation, antiplatelet agents, thrombolytic agents and antifibrinolytic agents and hemostatic agents. Factors necessary for erythropoiesis, homopoietic growth factors.

5. H2 receptor antagonists, proton pump inhibitors, antacids, emetics, antiemetics and cancer chemotherapy, purgatives, drugs regulate the GI motility, cholagogues and drugs used in cholelithiasis.

PC-640 Autacoids and Endocrine Pharmacology (1 credit)

Pharmacodynamic, pharmacokinetic, therapeutic and toxicological facets of the following: Histamine and bradykinin agonist and antagonists, drugs acting through eicosanoids and platelet activating factor. Adenohypophyseal hormones and related substances, thyroid and antithyroid drugs, insulin and oral hypoglycemic agents and endocrine pancreas, adrenocortical hormones, adrenocortical steriods and inhibitors of the synthesis, agents affecting the clacification, estrogens and progesterone and their antagonists, oral contraceptive, androgens.

PC-650 Clinical Pharmacology and Regulatory Toxicology (2 credits)

1. Introduction to clinical pharmacology, importance of clinical pharmacokinetics, therapeutic monitoring of important drugs.

2. Drug-drug interactions; Drug-food interactions; Drug-pollutant interaction.

3. Investigational new drug application, new drug application requirements; FDA requirements.

4. Preclinical testing strategy; Vis a-vis envisaged clinical studies; Experimental clarification of possible human risk; Technical details of experiments; Flow chart for development of preclinical testing.

5. Design and organisation of phase-I to phase-IV clinical studies.

6. Single dose and repeat dose toxicity studies; Factors influencing such studies such as species, sex, size, route, dose level; Data evaluation and regulatory requirements.

7. Reproductive toxicology assessment of male reproductive toxicity, spermatogenesis; Risk assessment in male reproductive toxicity; Female reproductive toxicology; Oocyte toxicity; alterations in reproductive endocrionology; relationship between maternal and developmental toxicity.

8. Mutagenicity; Mechanisms of mutagenesis, point mutations; Individual chromosomes and complete genome mutations, germ cell mutations, somatic cell mutation; Tests systems in vitro, test for gene mutation in bacteria, chromosome damage, gene mutation, in vivo micronucleus tests in rodent, metaphase analysis.

9. Carcinogenicity; Principles of carcinogenicity, prechronic studies for dose testing, chronic study, transplacental carcinogenesis; Cocarcinogenisis/tumor promotion, estimation of carcinogenicity of complex mixtures.

10. *Toxicokinetics, animals and dose groups; Exposure measurement;* determination of metabolites complicating factors in exposure interpretation, analytical method, good laboratory practices; Stereiosomerism vis-à-vis regulatory requirements; Single enantiomers; Racemate enantiomer switch; Regulatory requirements.

11. Toxicokinetic methods validation; assay development; Assay validation, study monitoring, calibration of standards; validation report.

12. Preclinical toxicological requirements for biologicals and biotechnological products; safety analysis; problems specific to recombinant products – secondary pharmacology, antibodies, transmission of viral infections, residual DNA, etc.

PC-660 Immunopharmacology and Chemotherapy (2 credits)

1. Introduction to immunopharmacology, immunomodulators, immunostimulants and immunosuppressants.

2. General considerations of antimicrobial agents.

3. *Spectrum of activity, mechanism of action, ADME and therapeutic aspects of the following:* Quinolones, sulphonamides, penicillins, cephalosporins, clavulanic acid, aminoglycosides, broad spectrum antibiotics, chemotherapeutic agents used in tuberculosis, antifungal agents, antiprotozoal agents, antimalarial agents, antiparasitic drugs, antiviral drugs, drugs used in the treatment of AIDS, antineoplastic agents.

GE-611 Seminar (1 credit)

Students are required to submit written record and present details of the project to be pursued in semester-III and IV. This should include the purpose and basis of the project, stating aims, objectives and probable outcomes, be able to supplement these with necessary information, literature review towards it, and process for the project itself.

LS-610 General Laboratory Experience in the area of Specialization-10 hours/week (2 credits)

Effect of drugs on rat blood pressure, estimation of blood glucose in normal and diabetic rats, OGTT test, effect of unknown drug on food and water intake, effect of unknown drug on rat ECG, effect of cyclophosphamide on neutrophil counts, in vitro experiment on rat prostrate, in vitro experiment on rat vas deferens, effect of drug on passive avoidance apparatus, effect of drug on TFL using analgesiometer, demonstration of ischemic model, effect of antioxidants on lipid peroxidation, genotoxic effect of unknown drug (micronucleus test and chromosomal aberration), demonstration of nerve conduction velocity in rats, effect of antidepressant on tail suspension test, identification of stages of estrus cycle in rats, antinflammtory activity of unknown compounds using carrageenan induced paw oedema in rats, finding out pA2 value of atropine, antihistaminic activity of unknown drug in g.pig cell culture techniques, effect of drug on locomotor activity, to study motor incordination using rota rod apparatus, effect of unknown drug on PTZ seizure, effect of unknown drug on MES seizure, effect of unknown drug on gastric emptyping, effect of NSAIDs on gastric mucosa, effect of unknown drug using elevated plus maze, effect of unknown drugs on gastric acid secretion in pylorus ligated rats, demonstration of brain oedema/ BBB disruption, demonstration of blood flow, measurement of cholesterol and TGs in rats, radioligand binding demonstration, effect of unknown agent on hot plate test, demonstration of molecular biology technique, SDS PAGE, DNA GEL electrophoresis, MALDI and LCMS. Microarray technique, effect of cyclophosphamide on neutrophil counts; Microscopic techniques, blood cell counting and histopathological studies.

Ph.D. courses

PC-710 Receptor Mechanisms (2 credits)

1. Molecular and chemical characterization of membrane receptors; Use of monoclonal antibodies in receptor characterization and purification; Immunopreciptation and eletrophoretic analysis of membrane proteins; Peptide mapping; Molecular weight determination by radiation inactivation; Solubilization of the receptors; Reconstitution of membrane receptors.

2. Biochemical mechanisms of cell signalling; Plasma membrane and cytosolic receptor structure; Plasma membrane as a signal transduction element; Mechanisms of receptor mediated signalling; Ion gated channels; Ligand activated receptors with intrinsic enzyme activity; Amplification of transmembrane signals.

3. Structure of G proteins, subclassification of G proteins; Role of heterotrimeric G proteins in signalling; Generation of intracellular second messengers; Modulation of G protein activity.

4. Calcium as second messenger, PIP2, IP3 receptors, calcium influx and efflux, intracellular sources of calcium and release, calcium oscillations; Intracellular clacium determinations in cell suspensions; Development of fluorescent indicators, fura-2, fluo-3, BAPTA; Digital ratio imaging in single cells.

5. Receptor dynamics and signalling; The mobile receptor paradigm; Receptor microclustering, patching, internalization, receptor mobility and cell activation; Homologous and heterologous regulation of receptors, sequestration, receptor turnover.

6. Signal transduction of neurotransmitters and neuromodulators viz., norepinephrine

7. HT, pathophysiological implications of neurotransmitter receptors.

8. Introduction to mechanistic approach of drug design, receptor mapping, and computer aided drug design.

PC-730 Free Radicals in Drug Research (2 credits)

1. Introduction to free radicals: Free radicals, reacting oxygen species, production of free radicals in cells, damaging reactions of free radicals, defences against free radicals, free radicals in human disease.

2. Measurement of free radicals: Lipid peroxidation products, lipid hydroperoxide, malondialdehyde, measurement of antioxidants.

3. Antioxidants: Endogenous antioxidants- enzymatic and nonenzymatic; Regulation of antioxidant defences, pharmacological antioxidants.

4. Free radicals in neurological and neurodegenerative diseases: Free radical scavengers in the treatment of brain injury.

5. Peroxynitrite induced toxicity : Interaction of nitric oxide with oxygen radicals and scavengers in ischaemic damage, role of poly (ADP) polymerase in cell death and PARP inhibitors in ischaemic injury. Oxidative stress and MAP kinases. Oxidative stress and apoptosis. Free radicals involvement in other disorders. Free radicals theory of ageing.

PC-840 Regulatory Toxicology and Drug Safety Evaluation (2 credits)

1. Concept and development of regulatory toxicity testing models, bio assays and endpoints: Human pharmaceutical products; Exposure characterization; Routes of exposure; ADME profiles.

2. Stages of drug development: Drug laws, FDA, OECD, ICH, schedule Y; Design of preclinical toxicity studies and clinical development, clinical risk/ benefit analysis. Safety evaluation of medical devices and bio materials. Good Laboratory Practices (GLP), issues and implementation.

3. Different methods in toxicity testing: Dose determination, response characterization, NOAEL, MTD and threshold limitations; Hormesis, lower dose extrapolation, in vitro and in vivo correlation, animal to human extrapolation; Flow chart.

4. Mechanism of toxicity: Evaluation across different models; Target organs, cell death, necrosis, apoptosis, oxidative stress, chromosome and DNA damage.

5. Acute and chronic toxicity, genetic toxicity: Types of genetic toxicity testing; Principles of detection; Genotoxicity of marketed drugs, test batteries, Salmonella test, micronucleus test, chromosome aberration test, comet assay, new-bio assays.

6. Reproductive toxicity, germ cell toxicant, effect on gonads, F1 generation study. Neonatal toxicity; Transplacental mutagenesis and carcinogenesis.

7. Carcinogenicity, carcinogen identification: Carcinogenesis process, drug induced carcinogenicity, lifetime carcinogenicity bio assays, neonatal mouse models; Short and medium term bio assays, limitations and impacts.

8. Regulations, discovery-development gap: Risk characterization; Management and Communication; Future of regulatory toxicology in drug safety evaluation

MC-740 Advanced Topics in Drug Action and Drug Design (1 credit)

Molecular recognition and supra-molecular chemistry; Molecular associations involving weak interactions; Solvation effects on molecular associations; Metalloenzymes in medicinal chemistry; Metals in medicine- reversible and irreversible enzyme inhibition. Mechanisms of drug activation; Enzyme activation of drugs; Bioprocess prodrugs chemistry of metabolic reactions. Organic chemistry of drug metabolism- conjugation reactions, reductive reactions, oxidative reactions. Molecular interaction fields- Molecular electrostatic potentials in understanding drug action. Drug action on biomembranes- organic chemistry of drug permeability through membranes. Molecular similarity and molecular diversity in drug design.

PC-910 Diabetes, Pathophysiology and discovery of new drugs (2 credits)

1. Diabetes, Definition, Genetics and Pathogenesis: Definition, diagnosis and classification, Genetics of Type I and Type II diabetes, Insulin resistance and it pathogenesis of Type II diabetes, Beta cell dysfunction in Type II diabetes, Secondary forms of diabetes, syndromes of extreme insulin resistance

2. Obesity, treatment of lipid disorders in diabetes, Hypoglycemia and endocrine tumors of pancreas.

3. Approaches for the treatment of type I and type II diabetes, options available for treating insulin resistance, exercise in diabetic patients, pancreas and islet transplantation.

4. Micro and macrovascular complications in diabetes, diabetic nephropathy, diabetic neuropathy, diabetic retinopathy, diabetic cardiomyopathy, peripheral vascular diseases and other complications of diabetes and their treatment options.

5. Discovery of anti diabetic drugs, animal models for studying type I and type II diabetes, insulin resistance models, ob/ob and db/db mice, zucker fatty rats, n-STZ rats, invitro screening models, insulin secretogogue activity in RIN cells, glucose uptake studies in 3T3L1 adipocytes, and muscle cells, GLUT4 translocation and PPAR gamma agonism

6. Newer targets for diabetes, role of SGLT1 and SGLT2 receptors DPP4 inhibition, Beta cell regeneration and GLP1 inhibitors.

7. Oxidative stress in diabetes and its markers, different pathways of oxidative stress in diabetic complications.

PC-920 Current topics in Cancer Research (2 credits)

1. Diagnosis of Cancer, Treatment of cancer, Chemotherapy and radiotherapy, DNA replication and cancer cell cycle, Regulation of Growth: Growth Factors, Receptors, and Signaling Pathways, Oncogenesis, tumor suppressor genes and apoptosis, tumor immunity and immunotherapy, angiogenesis.

2. Cancer cell culture – Methods and Protocols: basic principles and essential techniques of cancer cell culture, Characterization and authentication of cancer cell lines , isolation and culture of colon, melanoma, brain tumor, renal, prostrate, ovarian and leukemia cancer cell lines.

3. The MTT assay, ELISA, DNA fragmentation assay, COMET assay, PARP cleavage as a means of apoptosis, different methods of detecting apoptosis, TUNEL Assay, Annexin V staining, cell adhesion assays.

4. Development of angiogenesis inhibitors, HDAC inhibition in cancer therapy, inhibitors of COX 2 in cancer drug development, Src and Bcr-Abl kinase for cancer therapy. Emphasis on cancer drug resistance.

5. Different animal models to study cancer, principles involved in mouse xenograft models in anticancer drug screening, pharmacokinetic knowledge based oncology drug development. Tumor targeting in cancer therapy.

GE- 711 Seminar (1 credit)

1. Introduction, information retrieval systems.

2. Writing term papers and reports.

3. Organization of scientific material, thesis, dissertation and references.

4. Reading research papers.

5. Skill in oral presentation.

Each student has to present a seminar.

Pharmaceutics

M.S (Pharm.)

Course No.	Course Name	Credits
Semester-I		
PE-510	Dosage Form Design Parameters 1	
PE-520	Biopharmaceutics and Pharmacokinetics 2	
MC-510	Basis of Drug Action	2
MC-511	Spectral Analysis	2
NP-510	Separation Techniques	1
BT-510	Biotechnology in Pharmaceutical Sciences	1
PT-560	Fundamentals of Intellectual Property (IP) and Technology Management	1
GE-510	Biostatistics	2
GE-511	Seminar	1
LG-510	General Lab Experience	3
	Total Credits	**16**
Semester-II		
PE-620	Drug Delivery Systems	2
PE-630	Pharmaceutical Product Development-I	2
PE-640	Pharmaceutical Product Development-II	2
PE-650	Biomaterials	2
PE-660	Solid State Pharmaceutics	1
PC-610	Drug Metabolism	1
PC-611	Pharmacological Screening and Assays	1
GE-611	Seminar	1
LS-610	General Lab Experience in the Area of specialization	2
	Total Credits	**14**
Semester-III		
	Project (22 weeks)	
TH-598	Synopsis	5
TH-599	Presentation	3
	Total Credits	**8**
Semester-IV		
TH-698	Thesis	9
TH-699	Defence of thesis	3
	Total Credits	**12**
	Total Credits (I to IV semesters)	**50**

Semester-I

PE-510 Dosage Form Design Parameters (1 credit)

1. *Physicochemical aspects:*
    a. pKa
    b. Partition Coefficient
    c. Solubility
    d. Solid state characterization and physical behavior of drugs.
    e. Reaction kinetics and mechanisms.
2. *Biological aspects:*
    a. Role of physicochemical parameters on drug absorption and their implications.
    b. Routes of administrations and implications on bioavailability
    c. Physicochemical aspects of drugs and first pass metabolism.
3. *Dissolution:*
    a. Theories of dissolution, release rates and constants.
    b. Mechanisms of conventional release and controlled release.
    c. Dissolution data handling and correction factors.
    d. Dissolution equipments
    e. IVIVC.

PE-520 Biopharmaceutics and Pharmacokinetics (2 credits)

1. Introduction, concentration time profile, plotting the data, different fluid compartments and blood flow rates compartment models.
2. Protein and tissue binding, factors effecting protein binding, kinetics of protein binding, determination of rate constants and different plots (direct, scatchard and reciprocal); Significance volume of distribution, implications and in vitro methodologies.
3. *Pharmacokinetic characterization of drugs:* Absorption rate constants (Wagner-Nelson, Loo-Reigelman methods), limitations, lag-time, pharmacokinetics in presence of lag-time; Flip-flop model.
4. Case studies.
5. Drug disposition, renal clearance, mechanism of clearance , clearance ratio, determination of clearance, hepatic clearance, % drug metabolized, relationship between blood flow, intrinsic clearance, hepatic clearance and protein binding, different volumes of distribution, significance, and integration kinetics.
6. Pharmacokinetics of multiple dosing, dosage regimen design based on mean average, minimum and maximum, plasma/serum concentrations, limited fluctuation methods; Repeated one point method; Dosage adjustment in disease patients.
7. Nonlinear pharmacokinetics, direct, liner and orbit graph methods of dosing. Non-linear pharmacokinetics due to drug-protein binding.
8. *Topics:* Chronopharmacokinetics; Drug toxicity and forensic, pharmacokinetics; Case study; Pharmacokinetics in elderly; Drug dosage in children, obese patient; First dose size; Kinetics of maternal-fetal drug transfer; Pharmacokinetics- pharmacologic/clinical response; Distribution kinetics; Metabolic kinetics; Dose and time dependencies; Turnover concepts; Small volume of distribution; Dialysis.
9. Biopharmaceutics and pharmacokinetics in drug research.

MC-510 Basics of Drug Action (2 credits)

1. *Inter and intramolecular interactions:* Weak interactions in drug molecules; Chirality and drug action; Covalent, ion, ion-dipole, hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, van der waals interactions and the associated energies.

2. Energy concept and its importance in drug action; First, second and third laws of thermodynamics and the principles derived from these laws which are of significance to drug action; Free energy and relationship between thermodynamics and statistics; Importance of chemical potential in drug action; Thermodynamic cycle.

3. Statistical thermodynamics in predicting the structure of biomolecules and their interaction with drug molecules; Macromolecular vs. micromolecular correlation using thermodynamics and statistical thermodynamics.

4. *Receptorology:* Drug-receptor interactions, receptor theories and drug action; Occupancy theory, rate theory, induced fit theory, macromolecular perturbation theory, activation-aggregation theory. Topological and stereochemical consideration.

5. Kinetics, enzyme kinetics in drug action. Do all molecules of an enzyme have same kinetics? Mechanisms of enzyme catalysis; Electrostatic catalysis and desolvation; Covalent catalysis, acid-base catalysis, strain / distortion in enzyme catalysis; Coenzyme catalysis; Example based on hemoglobin; Theories of enzyme inhibition and inactivation; Enzyme activation of drugs-prodrugs. 6. Nucleic acids (NA) as targets for drug action; NA-interactive agents; Classes of drugs that interact with nucleic acids; Intercalation, NA-alkylation, NA-strand breaking and their importance in drug action.

7. Drug like molecules and theories associated with the recognition of drug like properties.

8. Physical organic chemistry of drug metabolism, drug deactivation and elimination; Phase-I and phase-II transformations; Concept of hard and soft drugs; Chemistry of ADME and toxicity properties of drugs.

MC-511 Spectral Analysis (2 credits)

1. *Ultra violet and visible spectroscopy:* Energy levels and selection rules, Woodward-Fieser and Fieser-Kuhn rules. Influence of substituent, ring size and strain on spectral characteristics; Solvent effect; Stereochemical effect; Non-conjugated interactions; Spectral correlation with structure.

2. *Infrared spectroscopy (IR):* Characteristic regions of the spectrum. Influence of substituents, ring size, hydrogen bonding, vibrational coupling and field effect on frequency. Determination of stereochemistry. Spectral interpretation with examples.

3. *Nuclear magnetic resonance spectrometry (NMR):* Magnetic nuclei, chemical shift and shielding, relaxation processes, chemical and magnetic non-equivalence, local diamagnetic shielding and magnetic anisotropy, spin-spin splitting, Pascal's triangle, coupling constant, mechanism of coupling, quadrupole broadening and decoupling, effect of conformations and stereochemistry on the spectrum, diastereomeric protons, virtual coupling, long range coupling-epi, peri, bay effects. Shift reagents-mechanism of action, spin decoupling, double resonance.

4. *Mass spectrometry (MS):* Molecular ion and metastable peak, fragmentation patterns, nitrogen and ring rules, McLafferty rearrangement, electron and chemical ionization modes, applications.

NP-510 Separation Techniques (1 credit)

1. *Chromatography:* General principles, classification of chromatographic techniques, normal and reversed phase, bonded phase, separation mechanisms.

2. *Column chromatography:* Merits and demerits, short-column chromatography and flash chromatography, vacuum liquid chromatography (VLC), medium pressure liquid chromatography, high pressure liquid chromatography (HPLC).

3. TLC, HPTLC, over pressure layer chromatography (OPLC), centrifugal chromatography.

4. Counter-current chromatography, droplet counter-current chromatography, ion-exchange, affinity, size exclusion and ion-pair chromatography.

5. Gas chromatography, introduction to GC-MS and LC-MS techniques.

BT-510 Biotechnology in Pharmaceutical Sciences (1 credit)

1. *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.

2. *Genomics in target discovery*: Concept of genome, genes and gene expression. Genome sequencing and sequence comparison methods (e.g. BLAST), gene expression comparison methods (microarray). Comparative genomics and expression genomics for target discovery of communicable disease and lifestyle disease.

3. *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.

4. *Expression purification and assay:* Gene expression in E. coli, in baculovirus, in mammalian cells. Various protein purification methods. Enzymes based assay for small molecule screening.

5. *Bioprocess technology:* Introduction to microbial growth, media formulation, fermentation processes, design, operation and characteristics of fermentation processes, instrumentation and bioprocess control.

6. *Downstream process*: Introduction to various downstream process operations in biopharmaceutical manufacturing such as centrifugation, filtration, tangential flow filtration, cell disintegration, solvent-solvent extraction, supercritical fluid extraction etc.

7. *Biotechnology in pharmaceutical industry*: Major areas for biotechnology in the pharmaceutical industry such as antibiotics, vaccines, disgnostics, antibodies, biopharmaceuticals (insulin, interferon, GSF, CSF & therapeutic proteins etc.); Commercial aspects, priorities for future biotechnological research.

8. *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.

PT-560 Fundamentals of Intellectual Property (IP) and Technology Management (1 credit)

1. *Intellectual property:* Concepts and fundamentals; Concepts regarding intellectual property (IP), intellectual property protection (IPP) and intellectual property rights (IPR); Economic importance, mechanisms for protection of intellectual property-patents, copyrights, trademark; Factors effecting choice of IP protection; Penalties for violation; Role of IP in pharmaceutical industry; Global ramifications and financial implications.

2. *Trade related aspects of intellectual property rights:* Intellectual property and international trade; Concept behind WTO (World Trade Organisation), WIPO (World Intellectual Property Organisation) GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trade in Services);

Protection of plant and animal gentic resources; Biological materials; Gene patenting; Biotechnology / drug related IPR issues; Status in India and other developing countries; Case studies and examples; TRIPS issues on herbal drugs.

3. *Nuts and bolts of patenting, copyright and trademark protection criteria for patentability, types of patents; Indian Patent Act, 1970; WTO and modifications under TRIPS:* Filing of a patent application; Precautions before patenting-disclosures / non-disclosures, publication-article / thesis; Prior art search-published patents, internet search patent sites, specialized services-search requests, costs; Patent application-forms and guidelines, fee structure, time frames, jurisdiction aspects; Types of patent applications-provisional, non provisional, PCT and convention patent applications; International patenting-requirement procedures and costs; Financial assistance for patenting-introduction to schemes by NRDC and TIFAC; Publication of patents-gazette of India, status in Europe and US; Patent annuity; Patent attorneys technical aspects, criteria for selection, addresses, fee, rights and responsibilities of a patentee; Practical aspects regarding maintaining of a PATENT FILE; Patent infringement- meaning, scope, litigation, case studies and examples; Patenting by research students, lecturers and scientists-University / organisational rules in India and abroad; Thesis research paper publication, credit sharing by workers, financial incentives; Useful information sources for patents related information-internet sites, brouchers, periodicals, CD roms; Significance of copyright protection for researchers; Indian Copyright Law and digital technologies-Beme convention, WIPO copyright treaty (WCT), WIPO performance and Phonogram Treaty (WPPT); Protection for computer data bases, multi media works; Trade marks legislation and registration system in India-an introduction, meaning of trademark criteria for eligibility; filling application for trademark registration; Trade secrets-scope modalities and protection; Case studies-drug related patents infringments.

4. *Technology development / transfer / commercialisation related aspects:* Technology development-meaning; Drug related technology development; Toxicological studies, bioequivalence (BU), clinical trials-phase-I, phase-II and phase-III; Approved bodies and agencies; Scale-up, semi-commercialisation and commercialisation-practical aspects and problems; Significance of transfer of technology (TOT), bottlenecks; Managing technology transfer-guidelines for research students, scientists and related personnel; TOT agencies in India-APCTD, NRDC, TIFAC, BCIL, TBSE/SIDBI; TOT related documentation-confidentiality agreements, licensing, MOUs, legal issues; Compulsory licensing excess to medicine issues; DOHA declaration, POST WTO product patent regime from 2005; Challenges for Indian pharmaceutical industry in the context of globalisation of IP; Drug registration and licensing issues-national and global; Drug master file submissions, SOPS; Related registration and marketing issues; Case studies-antiretroviral drugs and others.

5. *Funding sources for commercialization of technology:* Preparation of a project report, financial appraisal, business models; GOI schemes and incentives; NRDC, TePP, HGT, TDB schemes. PATSER; Venture capitalists, banks. Incubator concept-Case studies with respect to IIT, CCMB, IMTECH, NIPER. Documentation and related aspects.

6. *Ethics and values in IP:* IP and ethics-positive and negative aspects of IPP; Societal responsibility; Avoiding unethical practices; Echo-responsibility-economic, social and environmental benefits of modern biotechnology; Voluntary adoption of pollution control strategies.

GE-510 Biostatistics (2 credits)

1. *Statistics*: Introduction, its role and uses. Collection; Organization; Graphics and pictorial representation of data; Measures of central tendencies and dispersion. Coefficient of variation.

2. *Probability*: Basic concepts; Common probability distributions and probability distributions related to normal distribution.

3. *Sampling*: Simple random and other sampling procedures. Distribution of sample mean and proportion.

4. Estimation and hypothesis testing: Point and interval estimation including fiducial limits.Concepts of hypothesis testing and types of errors. Student- t and Chi square tests.Sample size and power.

5. *Experimental design and analysis of variance*: Completely randomized, randomized blocks. Latin square and factorial designs. Post- hoc procedures.

6. *Correlation and regression*: Graphical presentation of two continuous variables; Pearson's product moment correlation coefficient, its statistical significance. Multiple and partial correlations. Linear regression; Regression line, coefficient of determination, interval estimation and hypothesis testing for population slope. Introduction to multiple linear regression model. Probit and logit transformations.

7. *Non-parametric tests:* Sign; Mann-Whitney U; Wilcoxon matched pair; Kruskal wallis and Friedman two way ANOVA tests. Spearman rank correlation.

8. Statistical techniques in pharmaceutics: Experimental design in clinical trials; Parallel and crossover designs. Statistical test for bioequivalence. Dose response studies;Statistical quality control.

GE- 511 Seminar (1 credit)

1. Introduction, information and retrieval systems.
2. Writing term papers and reports.
3. Organization of scientific material , thesis, dissertation and references.
4. Reading research papers.
5. Skills in oral presentation.

Each student has to present a seminar before end of the semester.

LG-510 General Laboratory Experience-15 hours/week (3 credits)

1. *Analytical techniques:* (75 hours)
   a. Spectral analysis workshop (45 hours)
   b. Separation Techniques (30 hours)

2. *Computer and application in pharmaceutical sciences* (100 hours): Introduction to computers, basic unit and functions, H/W and S/W, operating systems, word processing, spread sheet, graphic programs, dDbase, windows, statistical S/W programs and packages. Steps involved in S/W development, computer languages with emphasis to FORTRAN language and programming, hands on experience in pharmaceutical software systems. Use of computers in information retrieval systems.

3. *Pharmacology (25 hours)* Animal handling, route of administration of drugs, dose response relationship, acute toxicity testing of drugs, analgesic activity of a compound, estimation of protein and haematological parameters.

4. Biotechnology for pharmaceutical sciences (20 hours)

   Day-1: Preparation for plasmid miniprep.

   Day-2: Plasmid miniprep and restriction digestion.

   Day-3: Gel electrophoresis and molecular weight calculation.

   Day-4: Discussion of result and viva.

5. *Specialization (50 hours)*

Semester-II

PE-620 Drug Delivery Systems (2 credits)

1. Biopharmaceutic and pharmacokinetic aspects of PO CRDDS. Computation of desired release rate and dose for CRDDS. Pharmacokinetic design for DDS; Intermittent zero order and first order release.
2. Mathematical models for novel drug delivery systems: Membrane diffusion, diffusion controlled, biodegradable, osmotic pumps.
3. Peroral controlled-release delivery: Case studies.
4. Transdermal/skin drug delivery systems: Principles of skin permeation, sorption promoters, pharmacokinetics of skin permeation, development and evaluation of transdermal devices.
5. Transdermal controlled release delivery: Case studies (both iontophoresis and passive diffusion and combination approaches).
6. Parenteral drug delivery: Selection, design and development, polymer microspheres, and dispersed DDS.
7. Strategies and design, in-vitro/in-vivo considerations, factor effecting controlled release drug delivery systems.
8. Protein/peptide drug delivery systems, enzyme, epithelial/endothelial barriers, pharmacokinetics, different routes of delivery, practical considerations.
9. Drug targeting: Microspheres, nanoparti-cles, brain specific delivery, liposomes, monoclonal antibodies.
10. Localized drug delivery systems: Case studies.
11. Drug delivery strategies: Case studies; Drug delivery systems and drug development.

PE-630 Pharmaceutical Product Development-I (2 credits)

1. *Preformulation studies:* Preformulation studies of drug substances, proteins and peptides. Preformulation work sheet.
2. *Complexation:* Metal and organic molecular complexes, inclusion compounds with reference to cyclodextrins, methods of analysis.
3. *Solubilization:* Solubility and solubilization of nonelectrolyte, drug solubilization in surfactant systems, use of co-solvents, solid-state manipulations and drug derivitization.
4. *Rheology:* Viscosity and measurements.
5. *Micromeritics:* Particle size distribution, evaluation and its implications in formulations, measurements, and solid dosage forms.
6. Development of dosage forms, 4-stage development, biological basis and opportunities, dosage form and its implications. Manipulation of physiological processes.
7. Case studies will be discussed after each topic with current literature.

PE-640 Pharmaceutical Product Development-II (2 credits)

1. Formulation additives: Study of different types of additives e.g. antioxidants and preservatives, coloring and flavoring agents, emulsifying and suspending agents, basic materials for ointment bases, diluents and pharmaceutical solvents, new developments in excipient science, international patented excipients. drug-excipient interaction and incompatibilities; Physical, chemical, pharmaceutical and therapeutic.

2. Implication of quantitative selection of each excipient in product devlopment.
3. Formulation development: Principles, technology, problems and evaluations for different classes of dosage forms;
    a) Solid dosage forms.
    b) Liquids.
    c) Poly-disperse systems.
    d) Sterile products and admixtures.
    e) Aerosols.
4. Package development: Package types for different dosage forms, packaging materials, labelling, preformulation screening of package components.
5. Design of materials and product specifications: Factory design, laying down and optimization of material and product specifications, process and in-process controls.
6. Documentation: Protocols, forms and maintenance of records in product development department including clinical batches.

PE-650 Biomaterials (2 credits)

1. Introduction to biomaterials.
2. Synthesis and modification methods of biomaterials.
3. Physical and chemical characterization techniques: Thermal, spectroscopic, microscopic and laser based techniques.
4. Manipulating biomaterials in various forms depending upon end use specification: Hydrogels, micro and nano particles, films, fibres.
5. Host reaction to biomaterials and their evaluation: Inflammation, wound healing, foreign body response, systematic toxicity
6. Biocompatibility testing of biomaterials: In vitro assessment of tissue compatibility, invivo assessment of tissue compatibility, testing blood materials interactions.
7. Degradation of biomaterials in biological environment: Chemical and biochemical degradation of polymers; Degradative effects of biological environment.
8. Regulatory considerations.
9. Pharmaceutical and biomedical applications: Drug delivery, tissue engineering.

PE-660 Solid State Pharmaceutics (1 credit)

1. *Molecular Level :* Crystallinity , crystal habit, polymorphism, amorphous state, solvates, hydrates, analytical techniques for characterization, molecular modelling in solid state characterization- case studies and regulatory perspective.
2. *Particle level :* Particle size, particle shape, porosity, surface area, compaction, particle engineering in pharmaceuticals and relevance in doses form designing.
3. *Bulk level :* Bulk density, compressibility, flow properties, cohesivity, electrostatistics, aggregation, agglomeration, role in formulation development and processing.

PC-610 Drug Metabolism (1 credit)

1. Biotransformation of drugs, enzymes responsible for bio-transformations, microsomal and non-microsomal mechanisms. Factors influencing enzyme induction and inhibition.

2. Excretion of drugs, biliary and fecal excretion; Factors effecting drug metabolism; Drug metabolism in fetus and new born; Models to study drug metabolism; Dose effect relationships.

3. Adverse drug reactions and drug interactions; Toxic reactions, allergic reactions, idiosyncrasy, acute poisoning and its treatment.

PC-611 Pharmacological Screening and Assays (1 credit)

1. General principles of screening, correlations between various animal models and human situations, animal ethics.

2. Pharmacological screening models for therapeutic areas such as hypertension,' cerebral ischaemia, pain, epilepsy, depression, Parkinson's disease, Alzheimer's disease, diabetics, leishmaniasis etc.

3. Correlation between in-vitro and in-vivo screens; Special emphasis on cell based assay, biochemical assay, radio ligand binding assay, high through put screening, high through put pharmacokinetic analysis, specific use of reference drugs and interpretation of results.

LS-610 General Laboratory Experience -10 hours/week (2 credits)

Preparation and evaluation of biomaterials for different DDS, development and evaluation of drug delivery systems, formulation development and evaluation.

LABORATORY SAFETY

The following safety rule applies **at all times** in the laboratory rooms.

- No open food or drink is permitted at any time, whether a lab is in progress or not.
- No eating, drinking, or chewing of gum or tobacco is permitted.
- Never taste anything at all while in the lab rooms.

The following additional rules apply **while a laboratory session is in progress**.

- The lab is restricted to the students enrolled in the course. Visitors, especially children, are not allowed.
- You must wear goggles for eye protection during every laboratory period, until all students have completed all their experiments. Even if you wear prescription glasses or contact lenses, you need to wear goggles as well.
- Report all accidents to your laboratory instructor immediately.
- Know the location of the two main exits from the room, eye washes, safety shower, fire alarms, fire blanket and fire extinguishers. (First Aid box, nearest hospital)
- If a chemical comes in contact with your eye, immediately flush the eye with a gently flowing source of water from the eyewash. If you wear contact lenses, remove them. Continue flushing for at least 15 minutes. Use your thumb and forefinger to hold your eyelids away from the eyeball, move your eyes continuously—up and down and sideways—to flush out thoroughly behind the eyelids and behind the eyeball. Notify the laboratory instructor immediately. Promptly seek medical attention. If someone else in the lab has a chemical in their eye, help them get to the eyewash and help them operate it!
- Clothing must offer you good protection against chemical spills and splashes.
- No high heeled shoes, open toed shoes, sandals, or shoes made of loosely woven material not allowed.
- Legs must be covered by your clothing.
- No smoking is allowed in chemical laboratories.

- Every student must wear protective eye shields at all times in the laboratory. This is to protect you from your neighbour's mistakes as well as your own.
- Carry out experiments which produce toxic chemicals or vapours, and/or are likely to be violent, in a fume cupboard.
- Fire is a serious hazard in the laboratory and is usually caused by the careless handling of organic solvents. These must not be heated using a Bunsen burner.
- Do not peer into the mouth of a test tube which is being heated or in which a reaction may be occurring.
- If the clothing is splashed by a corrosive liquid, strip the clothing and treat the skin immediately. As a first treatment washing with water is generally appropriate, call a demonstrator to assist you.
- Wear a laboratory coat at all times in the practical laboratory to protect you and your cloths.
- Always carry a small towel to the laboratory to assist you in handling hot objects in addition to tongs.
- Bunsen burners may only be used in the fume cupboard or keep it away from the inflammable solvents.
- Most organic compounds are combustible. Those with low boiling points and high vapor pressure at room temperatures may present a serious fire hazard. Ether, for example, which has a boiling point of 35°C, may be ignited by a flame removed by sixteen feet. Hence, it is never permissible to heat over an open flame any substance in an open vessel containing such volatile liquids. Steam bath are ideal for this purpose.
- **Fire**

  Fire is one of the most serious and most likely hazards to occur in a laboratory. The most generally useful fire extinguisher in the laboratory is the Carbonodioxide cylinder which can be safely used with most chemicals and electric equipment, and is clean.

  Asbestos blankets are useful for smoothening small fires and burning clothings.
- **Chemical Hazards**

  Most compounds are highly toxic when injected orally. Many chemicals are poisonous, corrosive, carcinogenic or explosive.
- Corrosive chemicals such as acids and alkalis are stored in low shelves and opened with care.
- One should never taste any compound and odors of substances should be detected with extreme care.
- Mouth pipetting is always potentially dangerous and some form of safety pipette must be used instead.
- Sensitive tissues, for example, the eye should not be needlessly exposed to vapours. One should never place his/her face directly over a reaction mixture.
- It is mandatory that each student study each experiment prior to undertaking any laboratory procedure in order to understand the implications of the particular experiment.
- Dangers chemicals obtained from commercial sources usually carry a warning printed in the bottle. These warnings should be followed.
- It is the duty of all members of laboratory staff to co-operate in the prevention of accidents.
- In addition to the welfare of the staff of the laboratory there is concern for preservation of the building, equipment, furnishing and apparatus.