

PUNJAB TECHNICAL UNIVERSITY, JALANDHAR
M. Pharm. (PHARMACEUTICAL CHEMISTRY)
Scheme and Syllabus

FIRST SEMESTER

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Exam. (hr)	Credit
			L	T	P	Int	Ext	Total		
01	PHCHM 131	Advanced Organic Chemistry -I	4	1	-	20	80	100	3	5
02	PHCHM 133	Modern Analytical Techniques	4	1	-	20	80	100	3	5
03	PHCHM 135	Medicinal Chemistry -I	4	1	-	20	80	100	3	5
04	PHCHM 137	Pharmaceutical Chemistry Laboratory -I	-		16	20	80	100	8	5
		Total (31)	12	03	16	80	320	400		20

SECOND SEMESTER

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Exam. (hr)	Credit
			L	T	P	Int	Ext	Total		
01	PHCHM 132	Advanced Organic Chemistry -II	4	1	-	20	80	100	3	5
02	PHCHM 134	Chemistry of Natural Products	4	1	-	20	80	100	3	5
03	PHCHM 136	Medicinal Chemistry -II	4	1	-	20	80	100	3	5
04	PHCHM 138	Pharmaceutical Chemistry Laboratory -II	-		16	20	80	100	8	5
		Total (31)	12	03	16	80	320	400		20

THIRD AND FOURTH SEMESTER

Research Work for one year

The thesis shall be presented by the candidate at the end of record academic year. The thesis shall be evaluated as under :

Evaluation of written thesis : MM 200

Presentation of seminar on thesis : MM 100

and viva-voce

Total : 300 marks

[Note : Credit System : 1 credit = 20 marks, L- Lecture – Tutorial , P – Practical]

M. PHARM. (PHARMACEUTICAL CHEMISTRY)

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
01	PHCHM 131	Advanced Organic Chemistry -I	4	1	-	20	80	100	5

Module 01

1. Acids and Bases

Bronsted and lewis concepts, acidic and basic catalysis, hard and soft acids and bases, effect of structure on the strength of acids and bases, effect of medium on the acidic and basic strength.

2. Mechanisms and Methods for Determination

Thermodynamic requirements for reaction, kinetic requirements for reaction, basic mechanistic concepts, kinetics versus thermodynamic control.

Methods for determining mechanisms:

- (a) Non-kinetic: Identification of products, determination of the presence of intermediate, isolation of an intermediate, detection of an intermediate, trapping of an intermediate and addition of suspected intermediate, study of catalysis, isotopic labelling stereochemical evidences and crossover experiments.
- (b) Kinetic studies: First order reactions, second order reactions, third order reactions, determination of the order of reaction and reversible reactions.

Module 02-03

Stereochemistry

Elements of symmetry: Plane of symmetry and center of symmetry, alternating axis of symmetry, simple axis of symmetry. Kinds of molecules displaying optical activity: compounds with a chiral carbon atom, compounds with other quadrivalent chiral atoms, compounds with tervalent chiral atoms suitably substituted adamantanes. Optical isomerism in compounds containing no chiral atom: biphenyls, allenes, compounds with exocyclic double bonds, spiranes, chirality due to a helical shape, chirality caused by restricted rotation of other types. Cis-trans isomerism: resulting from double bonds, monocyclic compounds, fused ring systems, out-in isomerism. Enantiotopic and diastereotopic atoms, groups and faces. Chirality and importance of chiral drugs, techniques for preparing chiral drugs (chirality pool, enzymatic transformation and asymmetric synthesis).

Module 04

Alkylation of Nucleophilic Carbon, Enolates and Enamines

Generation of carbanions by deprotonation, regioselectivity and stereoselectivity in enolate formation, other means of generating enolates, alkylation of enolates, oxygen versus carbon as the site of alkylation, alkylation of aldehydes, esters, amides and nitriles. The nitrogen analogs of enols and enolates enamines and imine anions.

Module 05

Electrophilic Additions to Carbon - Carbon Multiple Bonds

Addition of hydrogen halides, hydration and other acid-catalyzed additions, oxymercuration, addition of halogens to alkenes, electrophilic substitution alpha to carbonyl groups, addition of allenes and alkynes. Addition at double bonds via organoboranes: hydroboration, reactions of organoboranes, enantioselective hydroboration, hydroboration of alkynes.

Module 06

Reactive Intermediates

Generation of carbocation, carbanions, carbenes, nitrenes/nitrenium ions and free radicals, stability, structure and reactivity of these intermediates.

Elimination Reactions

E2, E1 and E1cb mechanisms, orientation effects in elimination reactions, stereochemistry of E2 elimination reactions, elimination not involving C-H bonds.

Reading Material Recommended

1. Carey FA and Sundberg RJ. Advanced Organic Chemistry. Part B: Reactions and Synthesis. Plenum Press, London. Latest Edition.
2. Ernest EI and Samuel H. Stereochemistry of Organic Compounds. John Wiley and Sons, New York. Latest Edition.
3. Lehr RE and Marchand AP. Orbital Symmetry: A Problem Solving Approach. Academic Press, New York. Latest Edition.
4. March J. Advanced Organic Chemistry: Reactions, Mechanisms and Structures. John Wiley and Sons, New York. Latest Edition

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
02	PHCHM 133	Modern Analytical Techniques	4	1	-	20	80	100	5

Module 01

1. Infrared Spectroscopy

The Hook's law and calculation of stretching frequencies for different types of bonds and their bond strengths, coupled interactions, hydrogen bonding, examination of infrared spectrum, survey of important functional groups with examples, radiation source, detectors used, sample handling, quantitative applications, qualitative applications with special reference to stereochemical aspects and hydrogen bonding, Near-IR spectroscopy, absorption and reflectance spectrophotometry, instrumentation, applications, Far Infrared spectroscopy. Introduction to FTIR and its applications.

Raman spectroscopy Introduction, theory and polarization measurement, rules of selection and polarization, instrumentation, applications in pharmaceutical sciences. Comparison of Infrared and Raman spectra.

Module 02

Ultraviolet/Visible Spectroscopy and Fluorimetry

Energy level and selection rules, effect of substituents, effect of conjugation, conformation and geometry, the Woodward-Fisher rules, the Fisher-Kuhn rules, applications of UV with reference to different electronic systems. Derivative spectroscopy and its applications. Fluorescence and chemical structure, fluorescence intensity, factors affecting fluorescence, instrumentation, comparison of fluorimetry with spectrophotometry, applications of fluorimetry in pharmaceutical analysis.

Module 03

Nuclear Magnetic Resonance Spectroscopy

¹H-NMR spectroscopy Magnetic equivalence, failure of the N+1 rule, chemical shifts, local diamagnetic shielding, hybridization effects, magnetic anisotropy, mechanism of spin-spin coupling, the origin of spin-spin splitting, Pascal's triangle, the coupling constant, protons on oxygen, nitrogen and sulphur, diastereomeric protons, chemical shift reagents, long range coupling, spin decoupling methods, nuclear over Hauser effect. Correlation NMR spectrometry: introduction to ¹H -¹H cosy and ¹H - ¹³C cosy and its applications. Introduction and applications of 2D NMR; solid state NMR. 13

C-NMR spectroscopy

Introduction, peak assignments, off resonance decoupling, selective proton decoupling; chemical shift equivalence; chemical shifts; spin coupling. Spectrometry of other important nuclei Introduction to ¹⁵N, ¹⁹F, ³¹P, basic concepts.

Electron Spin Resonance Spectroscopy

Introduction, derivative curves, g values, hyperfine splitting, ESR instrumentation, ESR spectra of free radicals, applications.

Module 04

Mass Spectrometry

Basic principle and theory involved; instrumentation, type of ions; various ion sources, electron impact source, chemical ionization sources, field ionization sources, desorption sources, mass analysers, double focusing, quadripole, time of flight, ion trap analyzer, ionization, fragmentation, rearrangements, mass

spectra of representative compounds, recognition of molecular ion peak, metastable peak, isotopic peaks, applications.

Module 05

X-Ray Spectroscopy

Introduction, production and properties of the X-ray, X-ray emission, X-ray absorption, principles of X-ray diffraction, powder diffraction, X-ray diffraction methods, application of X-ray diffraction technique in pharmaceutical sciences. Electron microscopy and electron diffraction.

Thermal Analysis

Pharmaceutical applications of thermo gravimetric analysis (TGA), differential thermal analysis (DTA), differential scanning calorimetry (DSC) and microcalorimetry, different types of calorimeters and micro calorimeters, advantages of microcalorimetry over DSC.

Optical Rotatory Dispersion and Circular Dichroism

Definition, cotton effect and stereochemistry, octet rule and applications.

Module 06

Chromatography:

(a) General principle, classification, chromatographic techniques, normal and reverse phase, column chromatography.

(b) Gas Chromatography: Gas liquid chromatography, gas solid chromatography, instrumentation and applications (GC-MS and GC-FTIR). Derivatization as a means of sampling of thermosensitive compounds.

(c) High Performance Liquid Chromatography: Partition, adsorption, ion exchange, size exclusion; pharmaceutical applications of HPLC and LC-MS. Super critical fluid chromatography; brief introduction to HPTLC.

Reading Material Recommended

1. Silverstein RM and Webster FX. Spectrometric Identification of Organic Compounds. John Wiley and Sons, New York. Latest Edition.
2. Chatten LG. Pharmaceutical Chemistry, Vol. I & II. Marcel Dekker, New York. Latest Edition.
3. James WD and Kenneth HT. Analytical Chemistry by Open Learning: Thermal Methods. John Wiley and Sons, New York. Latest Edition.
4. Abraham RJ, Fisher J and Bftus P. Introduction to NMR Spectroscopy. John Wiley and Sons, New York. Latest Edition.
5. Pavia DL, Lampman GM and Kriz GS. Introduction to Spectroscopy. Harcourt College Publishers, Orlando. Latest Edition.

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
03	PHCHM 135	Medicinal Chemistry -I	4	1	-	20	80	100	5

Module 01

Drug Design

Analogue synthesis versus rational design, discovery of lead compounds, pharmacophore identification, structure modification, physicochemical alterations, prodrug approach, quantitative structure activity relationship, molecular modeling, combinatorial chemistry and high throughput screening.

Module 02

Structure of Cell Membrane

Membrane lipids, membrane proteins, membrane carbohydrates, passage through membrane and drug action that effects the structure of cell membranes (antifungal, antibacterial and local anaesthetics).

Module 03

Receptors

Drug receptor interaction, G-protein coupled receptors, ion channel linked receptors. ligand gated ion channels (LGICs). Ligand-receptors theories: Clarks occupancy theory, rate theory, induced fit theory, macromolecular perturbation theory and activation aggregation theory.

Module 04

Enzymes

Introduction, kinetics, enzyme kinetics in drug action, mechanism 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.

Module 05-06

Nitric Oxide (Second Messenger)

Introduction, chemical properties of nitric oxide, reaction of nitric oxide with metals, interplay between the reactions of nitric oxide in biological systems, nitric oxide synthetase iso-enzymes, mechanism of NOS-mediated nitric oxide biosynthesis, NOS inhibitors, cytotoxic role of nitric oxide, therapeutic significance of NOS inhibitors and nitric oxide.

Reading Material Recommended

1. Wolff ME. Burger's Medicinal Chemistry and Drug Discovery, Principle and Practice. John Wiley and Sons, New York. Latest Edition.
2. Alnley W and James EF. Martindale, The Extra Pharmacopoeia. Pharmaceutical Press, London. Latest Edition.
3. Nogrady T. Medicinal Chemistry, A Biochemical Approach. Oxford University Press, New York. Latest Edition.
4. Monographs and relevant review articles appearing in various periodicals and journals.
5. Franke R. Theoretical Drug Design Methods, Vol. VII. Elsevier, New York. Latest Edition.

6. Silverman RB. The Organic Chemistry of Drug Design and Action. Academic Press Inc., San Diego, USA. Latest Edition.
7. Thomas, G. Medicinal Chemistry, Second Edition, Wiley India Pvt. Ltd..
8. H. Singh and V.K.Kapoor, Medicinal and Pharmaceutical Chemistry, Third Edition, Vallabh Prakashan, Delhi 2012

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
04	PHCHM 137	Pharmaceutical Chemistry Laboratory -I	-		16	20	80	100	5

PHCHM-517: Pharmaceutical Chemistry Practical-I

(12 hours/ week)

1. Qualitative analysis of organic mixtures.
2. Synthesis involving oxidation, reduction, nitration, halogenations.
3. Synthesis involving rearrangements and named reaction.
4. Workshops on stereomodel, spectral interpretations and drug design.
5. Paper Reading/Seminar with respect to the latest developments in pharmaceutical chemistry

Reading Material Recommended

1. Indian Pharmacopoeia, Central Indian Pharmacopoeia Laboratory, Govt. of India, Ministry of Health & Family Welfare, Ghaziabad, Latest Edition.
2. U. S. Pharmacopoeia – NF, The United States Pharmacopoeial Convention, Rockville, USA, Latest Edition.
3. European Pharmacopoeia, Directorate for the Quality of Medicines of the Council of Europe (EDQM), Strasbourg, Europe, Latest Edition.
4. British Pharmacopoeia, The Stationary Office on behalf of the Medicine Health Care Product Regulatory Agency (MHRA), London, Latest Edition.
5. Mendham J, Denney RC, Barnes JD and Thomas M. Vogel's Textbook of Quantitative Chemical Analysis. Pearson Education Limited, Singapore. Latest Edition.
6. Silverstein RM and Webster FX. Spectrometric Identification of Organic Compounds. John Wiley and Sons, New York. Latest Edition.
7. Eliel and H. Samuel. Stereochemistry of Organic Compounds, John Wiley & Sons. New York (Latest Edition).

M. Pharm. SEMESTER II

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
01	PHCHM 132	Advanced Organic Chemistry - II	4	1	-	20	80	100	5

Module 01

Aromatic Substitution Reactions

Electrophilic aromatic substitution: Nitration, halogenation, Friedel-Crafts alkylations and acylations. Nucleophilic aromatic substitution: aromatic diazonium ions as synthetic intermediates, substitution by the addition-elimination mechanism, substitution by the elimination-addition mechanism, substitution by the S_N1 mechanism.

Module 02

Reactions of Carbon Nucleophiles with Carbonyl Groups

Aldol condensation: The general mechanism, mixed aldol condensation with aromatic aldehydes, control of regiochemistry and stereochemistry of mixed aldol condensation of aliphatic aldehydes and ketones, intramolecular aldol condensations and the Robinson annulation. The Mannich reaction, amine-catalyzed condensation reactions. Acylation of carbanions, the Wittig and related reactions, nucleophilic addition-cyclization.

Functional Group Interconversion by Nucleophilic Substitution

Conversion of alcohols to alkylating agents: Sulphonate esters, halides. Introduction of functional groups by nucleophilic substitution at saturated carbon, general solvent effects. Interconversion of carboxylic acid derivatives: preparation of reaction reagents for acylation, preparation of esters, preparation of amides.

Module 03

Synthetic Strategies

Protection and deprotection of various groups. Synthetic methodologies for obtaining drugs: disconnection approach, synthons for carbon-carbon bond formation, difunctional compounds, selective functional group interconversions (FGI), retrosynthetic analysis. Synthetic approaches for attaching heterocyclic ring systems in drug molecules having five-membered and six-membered heteroaromatic rings, fused ring systems

Module 04

Rearrangements

Carbon to carbon migration: Wagner-Meerwein and related reactions, expansion and contraction of rings, acid-catalyzed rearrangements of aldehydes and ketones, dienone-phenol rearrangement, benzil-benzilic acid rearrangement, Favorskii rearrangement, Arndt-Eistert synthesis, homologization of aldehydes and ketones; Neber's rearrangement.

Carbon to nitrogen migration: Hofmann rearrangement, Curtius rearrangement, Lossen rearrangement, Schmidt rearrangement, Beckmann rearrangement, Stieglitz and related rearrangements.

Carbon to oxygen and oxygen to carbon migration: Bayer-Villiger rearrangement, rearrangement of hydroperoxide and Claisen rearrangement.

Nitrogen to carbon, oxygen to carbon migrations: Stevens' rearrangement, Wittig rearrangement.

Module 05

Photochemistry and Pericyclic Reactions

Light absorption, electronic transition, Jablonski diagram, intersystem crossing, photosensitization, excited states of ketones & cleavage hydrogen abstraction, photochemistry of conjugated dienes, enones. Concept of molecular orbital symmetry, Woodward and Hoffmann Rules of conservation of orbital symmetry and its application to electrocyclic (Diels-Alder reaction) and sigmatropic reactions (Cope rearrangement, Benzidine rearrangement, Fischer synthesis). Cycloaddition and ene reactions.

Module 06

Reduction of Carbonyl and Other Functional Groups

Addition of hydrogen: Catalytic hydrogenation. Group III hydride-donor reagents: Reduction of carbonyl compounds, reduction of other functional groups by hydride donors. Group IV hydride donors.

Dissolving-Metal reductions: addition of hydrogen, reductive removal of functional groups, reductive carbon-carbon bond formation, reductive deoxygenation of carbonyl groups.

Reading Material Recommended

1. Carey FA and Sundberg RJ. Advanced Organic Chemistry. Part B: Reactions and Synthesis. Plenum Press, London. Latest Edition
2. Ernest EI and Samuel H. Stereochemistry of Organic Compounds. John Wiley and Sons, New York. Latest Edition.
3. March J. Advanced Organic Chemistry: Reactions, Mechanisms and Structures. John Wiley and Sons, New York. Latest Edition.
4. Lehr RE and Marchand AP. Orbital Symmetry: A problem solving approach. Academic Press, New York. Latest Edition.

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
02	PHCHM 134	Chemistry of Natural Products	4	1	-	20	80	100	5

Module 01 -02

Natural Products :

Introduction, sources (Plant, animal, microbial, marine), classification on chemical basis. Role of natural products in development of medicinal chemistry, providing "leads". Selected example taken from Cardiovascular, Antibiotics, Anticancer, Antidiabetic Antimalarials, Hepatoprotective and Antiviral .

Module 03

Natural products as medicinal agents along with their structurally modified form

- Ephedrine
- Ergot alkaloids
- Vasicine
- Taxol

Module 04

Medicinal agents obtained by chemical modification of natural products : Selected examples from the categories of antineoplastic agent (paclitaxel and its derivative) podophyllotoxin and its derivative like etoposide and tenoposide

Module 05

Bioactive compounds from marine sources. : Marine natural products and drug development

Toxins used as Drugs and Pharmaceuticals

Module 06

Nutraceuticals

Significant biosynthetic pathway; Acetate- mevalonate shikimic acid.

Reading Material Recommended

- Cordell GA. Introduction to Alkaloids. John Wiley and Sons, New York. Latest Edition.
- Fieser LF and Fieser M. Steroids. Reinhold Publishing Co., New York. Latest Edition.
- Wickery ML and Wickery B. Secondary Plant Metabolism. Mcmillan Press Ltd. London. Latest Edition.
- Torseel KBG. Natural Product Chemistry. John Wiley and Sons, New York. Latest Edition.
- Harborne JB. Phytochemical Methods. Chapman and Hall, London. Latest Edition.
- Finar IL. Organic Chemistry. The English Language Book Society, London. Latest Edition.
- Wolff ME. Burger's Medicinal Chemistry and Drug Discovery, Principle and Practice. John Wiley and Sons, New York. Latest Edition.
- Mitscher LA and Baker WR. A Search for Novel Chemotherapy Against Tuberculosis Amongst Natural Products. Pure and Applied Chemistry (1998) , Vol. 70, No.2, pp 365-371.

9. Wermuth CG. The Practice of Medicinal Chemistry. Academic Press, Jordon Hill, Oxford. Latest Edition.
10. Boldi AM. Combinatorial Synthesis of Natural Product Based Libraries. Taylor and Francis, London. Latest Edition.
11. Monographs and relevant review articles

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
03	PHCHM 136	Medicinal Chemistry -II	4	1	-	20	80	100	5

The following classes of the drugs would be dealt with respect to the latest advances:

Module 01

Antineoplastic Agents

Molecular mechanism of cancer, oncogenes. DNA intercalating drugs: DNA intercalators, alkylating and strand breakers.

Module 02

Cardiovascular Agents

Antianginal, antiarrhythmics, antihypertensive, antihyperlipidemics.

Module 03

Psychotherapeutic Agents

Biochemical basis of mental disorder, antipsychotics, antidepressants and anti-anxiety drugs.

Antidiabetics

Module 04-05

Chemotherapy of Parasitic and Microbial Infections

Introduction, biology, mechanism of action, target for drug development and drug resistance (wherever involved) related to: Tuberculosis, amoebiasis, filariasis infections, viral infection and HIV infection, malaria and leishmaniasis.

Module 06

Prostaglandins and Other Eicosanoids

(7 Lectures)

Nomenclature, biosynthesis, design of eicosanoid drugs, biological activity, metabolism, structure activity relationship, eicosanoids approved for human clinical use.

Reading Material Recommended

1. Wolff ME. Burger's Medicinal Chemistry and Drug Discovery, Principle and Practice. John Wiley and Sons, New York. Latest Edition.
2. Alnley W and James EF. Martindale, The Extra Pharmacopoeia. Pharmaceutical Press, London. Latest Edition.
3. Nogrady T. Medicinal Chemistry, A Biochemical Approach. Oxford University Press, New York. Latest Edition.
4. Monographs and relevant review articles appearing in various periodicals and journals.
5. Franke R. Theoretical Drug Design Methods, Vol.VII. Elsevier, New York. Latest Edition.
6. Silverman RB. The Organic Chemistry of Drug Design and Action. Academic Press Inc., San Diego, USA. Latest Edition.
7. H. Singh and V.K.Kapoor, Medicinal and Pharmaceutical Chemistry, Third Edition, Vallabh Prakashan, Delhi 2012

S.No.	Subject Code	Subject Title	Teaching Load Allocation			Marks Distribution			Credit
			L	T	P	Int	Ext	Total	
04	PHCHM 138	Pharmaceutical Chemistry Laboratory -II	-		16	20	80	100	5

1. Synthesis of drugs involving multistep. Monitoring of reaction by TLC and characterization of product by modern analytical techniques.
2. Isolation & characterization of the active constituent from natural products.
3. Workshops/seminars.
4. Writing of papers, projects and reports.
5. Skills in oral presentation/presenting research papers.

Reading Material Recommended

1. Indian Pharmacopoeia, Central Indian Pharmacopoeia Laboratory, Govt. of India, Ministry of Health & Family Welfare, Ghaziabad, Latest Edition.
2. U. S. Pharmacopoeia – NF, The United States Pharmacopoeial Convention, Rockville, USA, Latest Edition.
3. European Pharmacopoeia, Directorate for the Quality of Medicines of the Council of Europe (EDQM), Strasbourg, Europe, Latest Edition.
4. British Pharmacopoeia, The Stationary Office on behalf of the Medicine Health Care Product Regulatory Agency (MHRA), London, Latest Edition.
5. Mendham J, Denney RC, Barnes JD and Thomas M. Vogel's Textbook of Quantitative Chemical Analysis. Pearson Education Limited, Singapore. Latest Edition.
6. Silverstein RM and Webster FX. Spectrometric Identification of Organic Compounds. John Wiley and Sons, New York. Latest Edition.
7. Eliel and H. Samuel. Stereochemistry of Organic Compounds, John Wiley & Sons. New York (Latest Edition).