

Department of Pharmacy

Programme: Master of Pharmacy (Pharmaceutical Chemistry)



**Central University of Rajasthan
NH-8, Bandarsindri,
Kishangarh-305817, Dist. Ajmer**

1. ABOUT THE PROGRAMME

Among the many branches in Pharmacy, Pharmaceutical Chemistry can be regarded as the important basic streams of Pharmacy. However, unlike other basic sciences, these programmes have appeared as interdependent scientific offshoots amalgamating the principles of various scientific domains. These courses provides pharmacy students with a comprehensive understanding of the mechanism of drug action, the relationship between the structure of drugs and the differences in activity which is referred to as QSAR, the relationship between physicochemical properties of drugs and its impact on activity, absorption, distribution, metabolism, excretion, and toxicity (ADMET), and the formulation aspects. An understanding of the chemical basis of drug action coupled with understanding of its pharmacokinetics give pharmacy students the ability to answer rationally the “why” and “how” of drug action, and to modulate the activity by fine tuning various attributes of the drugs. This knowledge puts the pharmacist in a unique position among the various health care professionals. By imparting an exclusive knowledge base, the courses offered play a vital role in providing critical thinking and evidence-based problem-solving skills to pharmacy students, enabling them to make optimal decisions in this area of pharmacy.

2. PROGRAM OBJECTIVES (PO)

P01	Appreciation of deeper insights for basics and advances including modern knowledge of pharmaceutical chemistry and in-particular to drug discovery process.
P02	Building foundation for higher studies as well as capable to get suitable employment in the area of Pharmaceuticals.
P03	Development of positive attitudes to realize the importance of hard work, commitment, ethics and excellence.
P04	Development of better scientific attitude, analytical and rational thinking among students.
P05	Developing confidence for independent pursuit of projects, start-ups and entrepreneurship in the students.

3. APPROVED INTAKE: 15 (Fifteen)

4. MINIMUM ELIGIBILITY FOR ENTRY

A pass in the following examinations –

- B. Pharm degree examination of an Indian University established by Law in India from an institution approved by Pharmacy Council of India and has scored not less than 55% (50% for

the candidate belonging to SC/ST/OBC/PWD/EWS category) of the maximum marks (aggregate of four years of B. Pharm).

b. Every student should have obtained Registration with the State Pharmacy Council or should obtain the same within one month from the date of his admission, failing which the admission of the candidate shall be cancelled. A candidate with valid GPAT Score will be given preference for admission; however such candidate has to register for CUCET 2020.

5. COURSE STRUCTURE

Core Courses (C)	Course Code
Modern Pharmaceutical Analytical Techniques	MPC101T
Advanced Organic Chemistry -I	MPC102T
Advanced Medicinal Chemistry	MPC103T
Chemistry of Natural Products	MPC104T
Advanced Spectral Analysis	MPC201T
Advanced Organic Chemistry -II	MPC202T
Computer Aided Drug Design	MPC203T
Pharmaceutical Process Chemistry	MPC204T
Discussion / Presentation (Proposal Presentation)	MPC303PP
Research Work	MPC304RW& MPC402RW
Discussion/Final Presentation	MPC403FP
Discipline Elective Courses (D)	
Modern Pharmaceutical Analytical Techniques	MPC101T
Seminar/Assignment	MPC 106S & MPC 206S
Journal Club	MPC302JC&MPC401JC
Elective Courses (Ex-discipline; E)	
Research Methodology and Biostatistics	MRM 301T
Lab Courses	
Pharmaceutical Chemistry Practical I	MPC105P
Pharmaceutical Chemistry Practical II	MPC205P

SEMESTER WISE DISTRIBUTION OF THE COURSES

Semester I

Code	Title of Course	Type of Course	Credit
MPC101T	Modern Pharmaceutical Analytical Techniques	D	4
MPC102T	Advanced Organic Chemistry -I	C	4
MPC103T	Advanced Medicinal Chemistry	C	4
MPC104T	Chemistry of Natural Products	C	4
MPC105P	Pharmaceutical Chemistry Practical I	L	6
MPC106S	Seminar/Assignment	D	2

Total Credit: 24

C-Core Courses; D-Discipline Elective Course; E-Elective Course; L-Laboratory

Semester II

Code	Title of Course	Type of Course	Credit
MPC201T	Advanced Spectral Analysis	C	4
MPC202T	Advanced Organic Chemistry -II	C	4
MPC203T	Computer Aided Drug Design	C	4
MPC204T	Pharmaceutical Process Chemistry	C	4
MPC205P	Pharmaceutical Chemistry Practical II	L	6
MPC206S	Seminar/Assignment	D	2

Total Credit: 24

C-Core Courses; D-Discipline Elective Course; E-Elective Course; L-Laboratory

Semester III

Code	Title of Course	Type of Course	Credit
MRM 301T	Research Methodology and Biostatistics	E	4
MPC302JC	Journal club	D	2
MPC303PP	Discussion / Presentation (Proposal Presentation)	C	4
MPC304RW	Research Work	C	14

C-Core Courses; D-Discipline Elective Course; E-Elective Course

Total Credit: 24

Semester IV

Code	Title of Course	Type of Course	Credit
MPC401JC	Journal Club	D	2
MPC402RW	Research Work	C	18
MPC403FP	Discussion/Final Presentation	C	4

C-Core Courses; D-Discipline Elective Course; E-Elective Course; S-Societal Course

Total Credit: 24

**Central University of Rajasthan
Department of Pharmacy**

**Semester-wise structure for the
M. Pharm. in Pharmaceutical Chemistry (MPC)
Programme Semester I**

No.	Sub. Code	Title of the Course	Type of Course	Credits	Contact hours/week			ESE (hour)		Weightage (%)		
					L	I.L	P	T	P	CIE		ESE
			C/D/E/L							IA-I	IA-II	
1.	MPC 101T	Modern Pharmaceutical Analytical Techniques	D	4	3	1	-	3	-	20	20	60
2.	MPC 102T	Advanced Organic Chemistry -I	C	4	3	1	-	3	-	20	20	60
3.	MPC 103T	Advanced Medicinal Chemistry	C	4	3	1	-	3	-	20	20	60
4.	MPC 104T	Chemistry of Natural Products	C	4	3	1	-	3	-	20	20	60
5.	MPC 105P	Pharmaceutical Chemistry Practical I	L	6	-	-	12	-	6	20	20	60
6.	MPC 106S	Seminar/Assignment	D	2	-	2	-	1	-	-	-	100

Total Credits: Semester I–24 Credits

CIE: Continuous Internal Evaluation; **ESE:** End Semester Examination; **IA:** Internal Assessment, **L:** Lectures, **I. L:** Integrated Learning involving Tutorials, Group Discussions, Assignments, Field Work; **L:** Practicals, Lab. work, Project, **C:** Core, **E:** Elective, **D:** Discipline Elective Course.

The guide will be chosen based on the mutual consent of the student and faculty members. After selection of the research guide the student will formulate his/her Seminar topic (MPC107S).

Semester II

No.	Sub. Code	Title of the Course	Type of Course	Credits	Contact hours/week			ESE (hour)		Weightage (%)		
					L	I.L	P	T	P	CIE		ESE
			C/D/E/L		L	I.L	P	T	P	IA-I	IA-II	
1	MPC 201T	Advanced Spectral Analysis	C	4	3	1	-	3	-	20	20	60
2	MPC 202T	Advanced Organic Chemistry -II	C	4	3	1	-	3	-	20	20	60
3	MPC 203T	Computer Aided Drug Design	C	4	3	1	-	3	-	20	20	60
4	MPC 204T	Pharmaceutical Process Chemistry	C	4	3	1	-	3	-	20	20	60
5	MPC 205P	Pharmaceutical Chemistry Practical II	L	6	-	-	12	-	6	20	20	60
6	MPC 206S	Seminar/Assignment	D	2	-	2	-	1	-	-	-	100

Total Credits: Semester II –24

CIE: Continuous Internal Evaluation; **ESE:** End Semester Examination; **IA:** Internal Assessment, **L:** Lectures, **I. L:** Integrated Learning involving Tutorials, Group Discussions, Assignments, Field Work; **L:** Practicals, Lab. work, Project, **C:** Core, **E:** Elective, **D:** Discipline Elective Course.

Semester III

No.	Sub. Code	Title of the Course	Type of Course	Credits	Contact hours/week			ESE (hour)		Weightage (%)		
					L	IL	P	T	P	CIE		ESE
			C/D/E/L							IA-I	IA-II	
1	MRM 301	Research Methodology and Biostatistics	E	4	3	1	-	3	-	20	20	60
2	MPC 302JC	Journal Club	D	2	1	1	-	3	-	-	-	100
3	MPC 303PP	Discussion / Presentation (Proposal Presentation)	C	4	-	4	-	1	-	-	-	100
4	MPC 304RW	Research Project	C	14	-	-	-	1	-	-	-	100

Total Credits: Semester III –24

The research work will commence this Semester. The students will submit a progress report and present seminar(s) based on the progress of his/her research work that should be attended by all students in the department, the research guide, the HOD and other faculty of the Department. The student will be evaluated by an external expert. The progress report should be handed in by the student the next day after the delivery of the seminar.

*During this semester, the student is free to opt one open elective course of his/her interest, offered by any department of the University, however, the subject will appear in the Marks Sheet (if examination is qualified), but credits will not be accumulated.

Semester IV

No.	Sub. Code	Title of the Course	Type of Course	Credits	Contact hours/week			ESE (hour)		Weightage (%)		
					L	I.L	P	T	P	CIE		ESE
			C/D/E/Lab							IA-I	IA-II	
1	MPC 401JC	Journal Club	D	2	-	2	-	1	-	-	-	100
2	MPC 402RW	Research Work	C	18	-	4	-	1	-	-	-	100*
3	MPC 403FP	Discussion / Presentation (Final Presentation)	C	4	-	-	-	1	-	-	-	100

Total Credits: Semester IV –24

This Semester is devoted totally to research which will culminate in the submission of a thesis. The student will deliver a pre-submission seminar before submission of his/her thesis at a date and time fixed by the department, that should be attended by all students in the department, the research guide, the HOD and other faculty of the Department. The Seminar will be followed by a discussion.

* MPC 402RW will be evaluated by an external subject expert.

Strong emphasis should be placed on the novelty/IPR aspects of the plagiarism free research work, beside publications in peer reviewed journals of good impact factors. Students should be encouraged to attend conferences, seminars where they will present their research work.

Semester I

MPC 101T	Modern Pharmaceutical Analytical Techniques	Credit: 4
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Course Outcome

After completion of course student is able to know about chemicals and excipients

- ✓ The analysis of various drugs in single and combination dosage forms
- ✓ Theoretical and practical skills of the instruments

Unit	Details	Contact Hours
I	<p>a. UV-Visible spectroscopy: Introduction, Theory, Laws, Instrumentation associated with UV-Visible spectroscopy, Choice of solvents and solvent effect and Applications of UV-Visible spectroscopy, Difference/Derivative spectroscopy.</p> <p>b. IR spectroscopy: Theory, Modes of Molecular vibrations, Sample handling, Instrumentation of Dispersive and Fourier -Transform IR Spectrometer, Factors affecting vibrational frequencies and Applications of IR spectroscopy, Data Interpretation.</p> <p>c. Spectrofluorimetry: Theory of Fluorescence, Factors affecting fluorescence (Characteristics of drugs that can be analysed by fluorimetry), Quenchers, Instrumentation and Applications of fluorescence spectrophotometer.</p> <p>d. Flame emission spectroscopy and Atomic absorption spectroscopy: Principle, Instrumentation, Interferences and Applications.</p>	10
II	<p>NMR spectroscopy: Quantum numbers and their role in NMR, Principle, Instrumentation, Solvent requirement in NMR, Relaxation process, NMR signals in various compounds, Chemical shift, Factors influencing chemical shift, Spin-Spin coupling, Coupling constant, Nuclear magnetic double resonance, Brief outline of principles of FT-NMR and ¹³C NMR. Applications of NMR spectroscopy.</p>	10
III	<p>Mass Spectroscopy: Principle, Theory, Instrumentation of Mass Spectroscopy, Different types of ionization like electron impact,</p>	10

	chemical, field, FAB and MALDI, APCI, ESI, APPI Analyzers of Quadrupole and Time of Flight, Mass fragmentation and its rules, Meta stable ions, Isotopic peaks and Applications of Mass spectroscopy.	
IV	<p>Chromatography: Principle, apparatus, instrumentation, chromatographic parameters, factors affecting resolution, isolation of drug from excipients, data interpretation and applications of the following:</p> <p>a) Thin Layer chromatography b) High Performance Thin Layer Chromatography c) Ion exchange chromatography d) Column chromatography e) Gas chromatography f) High Performance Liquid chromatography g) Ultra High Performance Liquid chromatography h) Affinity chromatography i) Gel Chromatography</p>	10
V	<p>a. Electrophoresis: Principle, Instrumentation, Working conditions, factors affecting separation and applications of the following: a) Paper electrophoresis b) Gel electrophoresis c) Capillary electrophoresis d) Zone electrophoresis e) Moving boundary electrophoresis f) Iso electric focusing</p> <p>b. X ray Crystallography: Production of X rays, Different X ray methods, Bragg's law, Rotating crystal technique, X ray powder technique, Types of crystals and applications of X-ray diffraction.</p>	10
VI	<p>a. Potentiometry: Principle, working, Ion selective Electrodes and Application of potentiometry.</p> <p>b. Thermal Techniques: Principle, thermal transitions and Instrumentation (Heat flux and power-compensation and designs), Modulated DSC, Hyper DSC, experimental parameters (sample preparation, experimental conditions, calibration, heating and cooling rates, resolution, source of errors) and their influence, advantage and disadvantages, pharmaceutical applications. Differential Thermal</p>	10

	<p>Analysis (DTA): Principle, instrumentation and advantage and disadvantages, pharmaceutical applications, derivative differential thermal analysis (DDTA). TGA: Principle, instrumentation, factors affecting results, advantage and disadvantages, pharmaceutical applications.</p>	
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Suggested Readings

1. Spectrometric Identification of Organic compounds - Robert M Silverstein, Sixth edition, John Wiley & Sons, 2004.
2. Principles of Instrumental Analysis - Douglas A Skoog, F. James Holler, Timothy A. Nieman, 5th edition, Eastern press, Bangalore, 1998.
3. Instrumental methods of analysis – Willards, 7th edition, CBS publishers.
4. Practical Pharmaceutical Chemistry – Beckett and Stenlake, Vol II, 4th edition, CBS Publishers, New Delhi, 1997.
5. Organic Spectroscopy - William Kemp, 3rd edition, ELBS, 1991.
6. Quantitative Analysis of Drugs in Pharmaceutical formulation - P D Sethi, 3rd Edition, CBS Publishers, New Delhi, 1997.
7. Pharmaceutical Analysis - Modern Methods – Part B - J W Munson, Vol 11, Marcel. Dekker Series
8. Spectroscopy of Organic Compounds, 2nd edn., P.S/Kalsi, Wiley estern Ltd., Delhi.
9. Textbook of Pharmaceutical Analysis, KA. Connors, 3rd Edition, John Wiley & Sons, 1982.

Course Outcome

Upon completion of course, the student shall be to understand

- The principles and applications of retrosynthesis
- The mechanism & applications of various named reactions
- The concept of disconnection to develop synthetic routes for small target molecule.
- The various catalysts used in organic reactions
- The chemistry of heterocyclic compounds

Unit	Details	Contact Hours
I	<p>1. Basic Aspects of Organic Chemistry:</p> <ol style="list-style-type: none"> 1. Organic intermediates: Carbocations, carbanions, free radicals, carbenes and nitrenes. Their method of formation, stability and synthetic applications. 2. Types of reaction mechanisms and methods of determining them, 3. Detailed knowledge regarding the reactions, mechanisms and their relative reactivity and orientations. <p>2. Addition reactions</p> <ol style="list-style-type: none"> a) Nucleophilic uni- and bimolecular reactions (SN1 and SN2) b) Elimination reactions (E1 & E2; Hoffman & Saytzeff's rule) c) Rearrangement reaction 	12
II	<p>Study of mechanism and synthetic applications of following named Reactions:</p> <p>Ugi reaction, Brook rearrangement, Ullmann coupling reactions, Dieckmann Reaction, Doebner-Miller Reaction, Sandmeyer Reaction, Mitsunobu reaction, Mannich reaction, Vilsmeier-Haack Reaction, Sharpless asymmetric epoxidation, Baeyer-Villiger oxidation, Shapiro & Suzuki reaction, Ozonolysis and Michael addition reaction</p>	12
III	<p>Synthetic Reagents & Applications: Aluminium isopropoxide, N-bromosuccinamide, diazomethane, dicyclohexylcarbodiimide, Wilkinson reagent, Wittig reagent. Osmium tetroxide, titanium chloride, diazopropane, diethyl azodicarboxylate, Triphenylphosphine, Benzotriazol-1-yloxy tris (dimethylamino) phosphonium hexafluorophosphate (BOP).</p> <p>Protecting groups</p> <ol style="list-style-type: none"> a. Role of protection in organic synthesis b. Protection for the hydroxyl group, including 1,2-and 1,3-diols: ethers, esters, carbonates, cyclic acetals & ketals c. Protection for the Carbonyl Group: Acetals and Ketals d. Protection for the Carboxyl Group: amides and hydrazides, esters e. Protection for the Amino Group and Amino acids: carbamates and amides 	12

IV	<p>Heterocyclic Chemistry: Organic Name reactions with their respective mechanism and application involved in synthesis of drugs containing five, six membered and fused hetrocyclics such as Debus-Radziszewski imidazole synthesis, Knorr Pyrazole Synthesis Pinner Pyrimidine Synthesis, Combes Quinoline Synthesis, Bernthsen Acridine Synthesis, Smiles rearrangement and Traube purine synthesis.</p> <p>Synthesis of few representative drugs containing these hetrocyclic nucleus such as Ketoconazole, Metronidazole, Miconazole, celecoxib, antipyrin, Metamizole sodium, Terconazole, Alprazolam, Triamterene, Sulfamerazine, Trimethoprim, Hydroxychloroquine, Quinine, Chloroquine, Quinacrine, Amsacrine, Prochlorpherazine, Promazine, Chlorpromazine, Theophylline, Mercaptopurine and Thioguanine.</p>	12
V	<p>Synthon approach and retrosynthesis applications</p> <ol style="list-style-type: none"> i. Basic principles, terminologies and advantages of retrosynthesis; guidelines for dissection of molecules. Functional group inter-conversion and addition (FGI and FGA) ii. C-X disconnections; C-C disconnections – alcohols and carbonyl compounds; 1,2-, 1,3-, 1,4-, 1,5-, 1,6-difunctionalized compounds iii. Strategies for synthesis of three, four, five and six-membered ring. 	12

Suggested Readings

1. "Advanced Organic chemistry, Reaction, Mechanisms and Structure", J March, John Wiley and Sons, New York.
2. "Mechanism and Structure in Organic Chemistry", ES Gould, Hold Rinchart and Winston, New York.
3. "Organic Chemistry" Clayden, Greeves, Warren and Wothers., Oxford University Press 2001.
4. "Organic Chemistry" Vol I and II. I.L. Finar. ELBS, Pearson Education Lts, Dorling Kindersley (India) Pvt. Ltd.,
5. A guide to mechanisms in Organic Chemistry, Peter Skyes (Orient Longman, New Delhi).
6. Reactive Intermediates in Organic Chemistry, Tandom and Gowel, Oxford & IBH Publishers.
7. Combinational Chemistry – Synthesis and applications – Stephen R Wilson & Anthony W Czarnik, Wiley – Blackwell.
8. Carey, Organic Chemistry, 5th Edition (Viva Books Pvt. Ltd.)
9. Organic Synthesis - The Disconnection Approach, S. Warren, Wiley India
10. Principles of Organic Synthesis, ROC Norman and JM Coxan, Nelson Thorns.
11. Organic Synthesis - Special Techniques. VK Ahluwalia and R Agarwal, Narosa Publishers.
12. Organic Reaction Mechanisms IVth Edtn, VK Ahluwalia and RK Parashar, Narosa Publishers.

Course Outcome

At completion of this course it is expected that students will be able to understand

- Different stages of drug discovery
- Role of medicinal chemistry in drug research
- Different techniques for drug discovery
- Various strategies to design and develop new drug like molecules for biological targets
- Peptidomimetics

Unit	Details	Contact Hours
I	<p>Drug discovery: Stages of drug discovery, lead discovery; identification, validation and diversity of drug targets.</p> <p>Biological drug targets: Receptors, types, binding and activation, theories of drug receptor interaction, drug receptor interactions, agonists vs antagonists, artificial enzymes.</p>	12
II	<p>Prodrug Design and Analog design:</p> <p>a) Prodrug design: Basic concept, Carrier linked prodrugs/ Bioprecursors, Prodrugs of functional group, Prodrugs to improve patient acceptability, Drug solubility, Drug absorption and distribution, site specific drug delivery and sustained drug action. Rationale of prodrug design and practical consideration of prodrug design.</p> <p>b) Combating drug resistance: Causes for drug resistance, strategies to combat drug resistance in antibiotics and anticancer therapy, Genetic principles of drug resistance.</p> <p>Analog Design: Introduction, Classical & Non classical, Bioisosteric replacement strategies, rigid analogs, alteration of chain branching, changes in ring size, ring position isomers, design of stereo isomers and geometric isomers, fragments of a lead molecule, variation in inter atomic distance.</p>	12
III	<p>a) Medicinal chemistry aspects of the following class of drugs Systematic study, SAR, Mechanism of action and synthesis of new generation molecules of following class of drugs:</p> <p>a) Anti-hypertensive drugs, Psychoactive drugs, Anticonvulsant drugs, H1 & H2 receptor antagonist, COX1 & COX2 inhibitors, Adrenergic & Cholinergic agents, Antineoplastic and Antiviral agents.</p> <p>b) Stereochemistry and Drug action: Realization that stereo selectivity is a pre-requisite for evolution. Role of chirality in selective and specific therapeutic agents. Case studies, Enantio selectivity in drug adsorption, metabolism, distribution and elimination.</p>	12

IV	Rational Design of Enzyme Inhibitors Enzyme kinetics & Principles of Enzyme inhibitors, Enzyme inhibitors in medicine, Enzyme inhibitors in basic research, rational design of non-covalently and covalently binding enzyme inhibitors.	12
V	Peptidomimetics: Therapeutic values of Peptidomimetics, design of peptidomimetics by manipulation of the amino acids, modification of the peptide backbone, incorporating conformational constraints locally or globally. Chemistry of prostaglandins, leukotrienes and thromboxones.	12

Suggested Readings

1. Medicinal Chemistry by Burger, Vol I –VI.
2. Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, 12th Edition, Lippincott Williams & Wilkins, Wolters Kluwer (India) Pvt.Ltd, New Delhi.
3. Comprehensive Medicinal Chemistry – Corwin and Hansch.
4. Computational and structural approaches to drug design edited by Robert M Stroud and Janet. F Moore
5. Introduction to Quantitative Drug Design by Y.C. Martin.
6. Principles of Medicinal Chemistry by William Foye, 7th Edition, Ippincott Williams & Wilkins, Wolters Kluwer (India) Pvt.Ltd, New Delhi.
7. Drug Design Volumes by Arienes, Academic Press, Elsevier Publishers, Noida, Uttar Pradesh..
8. Principles of Drug Design by Smith.
9. The Organic Chemistry of the Drug Design and Drug action by Richard B.Silverman, II Edition, Elsevier Publishers, New Delhi.
10. An Introduction to Medicinal Chemistry, Graham L.Patrick, III Edition, Oxford University Press, USA.
11. Biopharmaceutics and pharmacokinetics, DM.Brahmankar, Sunil B. Jaiswal II Edition, 2014, Vallabh Prakashan, New Delhi.
12. Peptidomimetics in Organic and Medicinal Chemistry by Antonio Guarna and Andrea Trabocchi, First edition, Wiley publishers.

Course Outcome

At completion of this course it is expected that students will be able to understand-

- Different types of natural compounds and their chemistry and medicinal importance
- The importance of natural compounds as lead molecules for new drug discovery
- The concept of rDNA technology tool for new drug discovery
- General methods of structural elucidation of compounds of natural origin
- Isolation, purification and characterization of simple chemical constituents from natural source

Unit	Details	Contact Hours
I	<p>Study of Natural products as leads for new pharmaceuticals for the following class of drugs</p> <p>a) Drugs Affecting the Central Nervous System: Morphine Alkaloids</p> <p>b) Anticancer Drugs: Paclitaxel and Docetaxel, Etoposide, and Teniposide</p> <p>c) Cardiovascular Drugs: Lovastatin, Teprotide and Dicoumarol</p> <p>d) Neuromuscular Blocking Drugs: Curare alkaloids</p> <p>e) Anti-malarial drugs and Analogues</p> <p>f) Chemistry of macrolid antibiotics (Erythromycin, Azithromycin, Roxithromycin, and Clarithromycin) and β - Lactam antibiotics (Cephalosporins and Carbapenem)</p>	12
II	<p>a) Alkaloids General introduction, classification, isolation, purification, molecular modification and biological activity of alkaloids, general methods of structural determination of alkaloids, structural elucidation and stereochemistry of ephedrine, morphine, ergot, emetine and reserpine.</p> <p>b) Flavonoids Introduction, isolation and purification of flavonoids, General methods of structural determination of flavonoids; Structural elucidation of quercetin.</p> <p>c) Steroids General introduction, chemistry of sterols, sapogenin and cardiac glycosides. Stereochemistry and nomenclature of steroids, chemistry of contraceptive agents male & female sex hormones (Testosterone, Estradiol, Progesterone), adrenocorticoids (Cortisone), contraceptive agents and steroids (Vit - D).</p>	12
III	<p>a) Terpenoids Classification, isolation, isoprene rule and general methods of structural elucidation of Terpenoids; Structural elucidation of drugs belonging to mono (citral, menthol, camphor), di (retinol, Phytol, taxol) and tri</p>	12

	terpenoids (Squalene, Ginsenoside) carotinoids (β carotene). b) Vitamins Chemistry and Physiological significance of Vitamin A, B1, B2, B12, C, E, Folic acid and Niacin.	
IV	a). Recombinant DNA technology and drug discovery rDNA technology, hybridoma technology, New pharmaceuticals derived from biotechnology; Oligonucleotide therapy. Gene therapy: Introduction, Clinical application and recent advances in gene therapy, principles of RNA & DNA estimation b). Active constituent of certain crude drugs used in Indigenous system Diabetic therapy – <i>Gymnema sylvestre</i> , <i>Salacia reticulata</i> , <i>Pterocarpus marsupium</i> , <i>Swertia chirata</i> , <i>Trigonella foenum graecum</i> ; Liver dysfunction – <i>Phyllanthus niruri</i> ; Antitumor – <i>Curcuma longa</i> Linn.	12
V	Structural Characterization of natural compounds Structural characterization of natural compounds using IR, ¹ HNMR, ¹³ CNMR and MS Spectroscopy of specific drugs e.g., Penicillin, Morphine, Camphor, Vit-D, Quercetin and Digitalis glycosides.	12

Suggested Readings

1. Modern Methods of Plant Analysis, Peech and M.V.Tracey, Springer – Verlag, Berlin, Heidelberg.
2. Phytochemistry Vol. I and II by Miller, Jan Nostrant Rein Hld.
3. Recent advances in Phytochemistry Vol. I to IV – Scikel Runeckles, Springer Science & Business Media.
4. Chemistry of natural products Vol I onwards IWPAC.
5. Natural Product Chemistry Nakanishi Gggolo, University Science Books, California.
6. Natural Product Chemistry “A laboratory guide” – Rapheal Khan.
7. The Alkaloid Chemistry and Physiology by RHF Manske, Academic Press.
8. Introduction to molecular Phytochemistry – CHJ Wells, Chapmanstall.
9. Organic Chemistry of Natural Products Vol I and II by Gurdeep and Chatwall, Himalaya Publishing House.
10. Organic Chemistry of Natural Products Vol I and II by O.P. Agarwal, Krishan Prakashan.
11. Organic Chemistry Vol I and II by I.L. Finar, Pearson education.
12. Elements of Biotechnology by P.K. Gupta, Rastogi Publishers.
13. Pharmaceutical Biotechnology by S.P.Vyas and V.K.Dixit, CBS Publishers.
14. Biotechnology by Purohit and Mathur, Agro-Bios, 13th edition.
15. Phytochemical methods of Harborne, Springer, Netherlands.
16. Burger’s Medicinal Chemistry.

Details

1. Analysis of Pharmacopoeial compounds and their formulations by UV Vis spectrophotometer, RNA & DNA estimation
2. Simultaneous estimation of multi component containing formulations by UV spectrophotometry
3. Experiments based on Column chromatography
4. Experiments based on HPLC
5. Experiments based on Gas Chromatography
6. Estimation of riboflavin/quinine sulphate by fluorimetry
7. Estimation of sodium/potassium by flame photometry

To perform the following reactions of synthetic importance

1. Purification of organic solvents, column chromatography
2. Claisen-schimidt reaction.
3. Benzylic acid rearrangement.
4. Beckmann rearrangement.
5. Hoffmann rearrangement
6. Mannich reaction
7. Synthesis of medicinally important compounds involving more than one step along with purification and Characterization using TLC, melting point and IR spectroscopy (4 experiments)
8. Estimation of elements and functional groups in organic natural compounds
9. Isolation, characterization like melting point, mixed melting point, molecular weight determination, functional group analysis, co-chromatographic technique for identification of isolated compounds and interpretation of UV and IR data.
10. Some typical degradation reactions to be carried on selected plant constituents

Course Outcome

At completion of this course it is expected that students will be able to understand-

- Interpretation of the NMR, Mass and IR spectra of various organic compounds
- Theoretical and practical skills of the hyphenated instruments
- Identification of organic compounds

Unit	Details	Contact Hours
I	UV and IR spectroscopy: Wood ward – Fieser rule for 1,3- butadienes, cyclic dienes and α , β -carbonyl compounds and interpretation compounds of enones. ATR-IR, IR Interpretation of organic compounds.	12
II	NMR spectroscopy: 1-D and 2-D NMR, NOESY and COSY, HECTOR, INADEQUATE techniques, Interpretation of organic compounds.	12
III	Mass Spectroscopy Mass fragmentation and its rules, Fragmentation of important functional groups like alcohols, amines, carbonyl groups and alkanes, Meta stable ions, Mc Lafferty rearrangement, Ring rule, Isotopic peaks, Interpretation of organic compounds.	12
IV	Chromatography: Principle, Instrumentation and Applications of the following : a)GC-MS b) GC-AAS c) LC-MS d) LC-FTIR e) LC-NMR f) CE- MS g) High Performance Thin Layer chromatography h) Super critical fluid chromatography i) Ion Chromatography j) I-EC (Ion- Exclusion Chromatography) k) Flash chromatography	12
V	a). Thermal methods of analysis Introduction, principle, instrumentation and application of DSC, DTA and TGA. b). Raman Spectroscopy Introduction, Principle, Instrumentation and Applications. c). Radio immuno assay Biological standardization , bioassay, ELISA, Radioimmuno assay of digitalis and insulin.	12

Suggested Readings

1. Spectrometric Identification of Organic compounds - Robert M Silverstein, Sixth edition, John Wiley & Sons, 2004.
2. Principles of Instrumental Analysis - Doglas A Skoog, F. James Holler, Timothy A. Nieman, 5th edition, Eastern press, Bangalore, 1998.
3. Instrumental methods of analysis – Willards, 7th edition, CBS publishers.

4. Organic Spectroscopy - William Kemp, 3rd edition, ELBS, 1991.
5. Quantitative analysis of Pharmaceutical formulations by HPTLC - P D Sethi, CBS Publishers, New Delhi.
6. Quantitative Analysis of Drugs in Pharmaceutical formulation - P D Sethi, 3rd Edition, CBS Publishers, New Delhi, 1997.
7. Pharmaceutical Analysis- Modern methods – Part B - J W Munson, Volume 11, Marcel Dekker Series

Course Outcome

Upon completion of course, the student shall able to understand

- The principles and applications of Green chemistry
- The concept of peptide chemistry.
- The various catalysts used in organic reactions
- The concept of stereochemistry and asymmetric synthesis.

Unit	Details	Contact Hours
I	<p>Green Chemistry:</p> <p>a. Introduction, principles of green chemistry</p> <p>b. Microwave assisted reactions: Merit and demerits of its use, increased reaction rates, mechanism, superheating effects of microwave, effects of solvents in microwave assisted synthesis, microwave technology in process optimization, its applications in various organic reactions and heterocycles synthesis</p> <p>c. Ultrasound assisted reactions: Types of sonochemical reactions, homogenous, heterogeneous liquid-liquid and liquid-solid reactions, synthetic applications</p> <p>d. Continuous flow reactors: Working principle, advantages and synthetic applications.</p>	12
II	<p>Chemistry of peptides</p> <p>a. Coupling reactions in peptide synthesis</p> <p>b. Principles 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</p> <p>c. Segment and sequential strategies for solution phase peptide synthesis with any two case studies Side reactions in peptide synthesis: Deletion peptides, side reactions initiated by proton abstraction, protonation, over- activation and side reactions of individual amino acids.</p>	12
III	<p>Photochemical Reactions</p> <p>Basic principles of photochemical reactions. Photo-oxidation, photo-addition and photo-fragmentation.</p> <p>Pericyclic reactions</p> <p>Mechanism, Types of pericyclic reactions such as cyclo addition, electrocyclic reaction and sigmatropic rearrangement reactions with examples</p>	12

IV	<p>Catalysis:</p> <ol style="list-style-type: none"> Types of catalysis, heterogeneous and homogenous catalysis, advantages and disadvantages Heterogeneous catalysis – preparation, characterization, kinetics, supported catalysts, catalyst deactivation and regeneration, some examples of heterogeneous catalysis used in synthesis of drugs. Homogenous catalysis, hydrogenation, hydroformylation, hydrocyanation, Wilkinson catalysts, chiral ligands and chiral induction, Ziegler-Natta catalysts, some examples of homogenous catalysis used in synthesis of drugs Transition-metal and Organo-catalysis in organic synthesis: Metal-catalyzed reactions Biocatalysis: Use of enzymes in organic synthesis, immobilized enzymes/cells in organic reaction. Phase transfer catalysis - theory and applications 	12
V	<p>Stereochemistry & Asymmetric Synthesis</p> <ol style="list-style-type: none"> Basic concepts in stereochemistry – optical activity, specific rotation, racemates and resolution of racemates, the Cahn, Ingold, Prelog (CIP) sequence rule, meso compounds, pseudo asymmetric centres, axes of symmetry, Fischers D and L notation, cis-trans isomerism, E and Z notation. Methods of asymmetric synthesis using chiral pool, chiral auxiliaries and catalytic asymmetric synthesis, enantiopure separation and Stereo selective synthesis with examples. 	12
<p>Suggested Readings</p> <ol style="list-style-type: none"> “Advanced Organic chemistry, Reaction, mechanisms and structure”, J March, John Wiley and sons, New York. “Mechanism and structure in organic chemistry”, ES Gould, Hold Rinchart and Winston, NewYork. “Organic Chemistry” Clayden, Greeves, Warren and Woihers., Oxford University Press 2001. “Organic Chemistry” Vol I and II. I.L. Finar. ELBS, Sixth ed., 1995. Carey, Organic chemistry, 5th edition (Viva Books Pvt. Ltd.) Organic synthesis-the disconnection approach, S. Warren, Wily India Principles of organic synthesis, ROCNorman and JMCoxan, Nelson thorns Organic synthesis- Special techniques VK Ahluwalia and R Aggarwal, Narosa Publishers. Organic reaction mechanisms IV edtn, VK Ahluwalia and RK Parashar, Narosa Publishers. 		

Course Outcome

At completion of this course it is expected that students will be able to understand

- Role of CADD in drug discovery
- Different CADD techniques and their applications
- Various strategies to design and develop new drug like molecules.
- Working with molecular modeling softwares to design new drug molecules
- The *in silico* virtual screening protocols

Unit	Details	Contact Hours
I	Introduction to Computer Aided Drug Design (CADD) History, different techniques and applications. Quantitative Structure Activity Relationships: Basics History and development of QSAR: Physicochemical parameters and methods to calculate physicochemical parameters: Hammett equation and electronic parameters (σ), lipophilicity effects and parameters ($\log P$, π -substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physicochemical parameters.	12
II	Quantitative Structure Activity Relationships: Applications Hansch analysis, Free Wilson analysis and relationship between them, Advantages and disadvantages; Deriving 2D-QSAR equations. 3D-QSAR approaches and contour map analysis. Statistical methods used in QSAR analysis and importance of statistical parameters.	12
III	Molecular Modeling and Docking a) Molecular and Quantum Mechanics in drug design. b) Energy Minimization Methods: comparison between global minimum conformation and bioactive conformation c)Molecular docking and drug receptor interactions: Rigid docking, flexible docking and extra-precision docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AChE & BchE)	12
IV	Molecular Properties and Drug Design a) Prediction and analysis of ADMET properties of new molecules and its importance in drug design. b) <i>De novo</i> drug design: Receptor/enzyme-interaction and its analysis, Receptor/enzyme cavity size prediction, predicting the functional components of cavities, Fragment based drug design. c) Homology modeling and generation of 3D-structure of protein.	12
V	Pharmacophore Mapping and Virtual Screening	12

	<p>Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore modeling; Conformational search used in pharmacophore mapping.</p> <p><i>In Silico</i> Drug Design and Virtual Screening Techniques</p> <p>Similarity based methods and Pharmacophore based screening, structure based <i>In-silico</i> virtual screening protocols.</p>	
<p>Suggested Readings</p> <ol style="list-style-type: none"> 1. Computational and structural approaches to drug discovery, Robert M Stroud and Janet. F Moore, RCS Publishers. 2. Introduction to Quantitative Drug Design by Y.C. Martin, CRC Press, Taylor & Francis group.. 3. Drug Design by Ariens Volume 1 to 10, Academic Press, 1975, Elsevier Publishers. 4. Principles of Drug Design by Smith and Williams, CRC Press, Taylor & Francis. 5. The Organic Chemistry of the Drug Design and Drug action by Richard B. Silverman, Elsevier Publishers. 6. Medicinal Chemistry by Burger, Wiley Publishing Co. 7. An Introduction to Medicinal Chemistry –Graham L. Patrick, Oxford University Press. 8. Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, Ippincott Williams & Wilkins. 9. Comprehensive Medicinal Chemistry – Corwin and Hansch, Pergamon Publishers. 10. Computational and structural approaches to drug design edited by Robert M Stroud and Janet. F Moore 		

Course Outcome

At completion of this course it is expected that students will be able to understand

- The strategies of scale up process of APIs and intermediates
- The various unit operations and various reactions in process chemistry

Unit	Details	Contact Hours
I	<p>Process chemistry Introduction, Synthetic strategy Stages of scale up process: Bench, pilot and large-scale process. In-process control and validation of large-scale process. Case studies of some scale up process of APIs. Impurities in API, types and their sources including genotoxic impurities</p>	12
II	<p>Unit operations</p> <p>a) <i>Extraction</i>: Liquid equilibria, extraction with reflux, extraction with agitation, counter current extraction.</p> <p>b) <i>Filtration</i>: Theory of filtration, pressure and vacuum filtration, centrifugal filtration,</p> <p>c) <i>Distillation</i>: azeotropic and steam distillation</p> <p>d) <i>Evaporation</i>: Types of evaporators, factors affecting evaporation. <i>Crystallization</i>: Crystallization from aqueous, non- aqueous solutions factors affecting crystallization, nucleation. Principle and general methods of Preparation of polymorphs, hydrates, solvates and amorphous APIs.</p>	12
III	<p>Unit Processes - I</p> <p>a) Nitration: Nitrating agents, Aromatic nitration, kinetics and mechanism of aromatic nitration, process equipment for technical nitration, mixed acid for nitration,</p> <p>b) Halogenation: Kinetics of halogenations, types of halogenations, catalytic halogenations. Case study on industrial halogenation process.</p> <p>c) Oxidation: Introduction, types of oxidative reactions, Liquid phase oxidation with oxidizing agents. Nonmetallic Oxidizing agents such as</p>	12

	H ₂ O ₂ , sodium hypochlorite, Oxygen gas, ozonolysis	
IV	<p>Unit Processes – II</p> <p>a) Reduction: Catalytic hydrogenation, Heterogeneous and homogeneous catalyst; Hydrogen transfer reactions, Metal hydrides. Case study on industrial reduction process.</p> <p>b) Fermentation: Aerobic and anaerobic fermentation. Production of</p> <p>i. Antibiotics; Penicillin and Streptomycin,</p> <p>ii. Vitamins: B2 and B12</p> <p>iii. Statins: Lovastatin, Simvastatin</p>	12
V	<p>Industrial Safety</p> <p>a) MSDS (Material Safety Data Sheet), hazard labels of chemicals and Personal Protection Equipment (PPE)</p> <p>b) Fire hazards, types of fire & fire extinguishers</p> <p>c) Occupational Health & Safety Assessment Series 1800 (OHSAS-1800) and ISO-14001(Environmental Management System), Effluents and its management</p>	12

Suggested Readings

1. Process Chemistry in the Pharmaceutical Industry: Challenges in an Ever-Changing Climate-An Overview; K. Gadamasetti, CRC Press.
2. Pharmaceutical Manufacturing Encyclopedia, 3rd edition, Volume 2.
3. Medicinal Chemistry by Burger, 6th edition, Volume 1-8.
4. W.L. McCabe, J.C Smith, Peter Harriott. Unit operations of chemical engineering, 7th edition, McGraw Hill
5. Polymorphism in Pharmaceutical Solids. Dekker Series Volume 95 Ed: H G Brittain (1999)
6. Regina M. Murphy: Introduction to Chemical Processes: Principles, Analysis, Synthesis
7. Peter J. Harrington: Pharmaceutical Process Chemistry for Synthesis: Rethinking the Routes to Scale-Up
8. P.H.Groggins: Unit processes in organic synthesis (MGH)
9. F.A.Henglein: Chemical Technology (Pergamon)
10. M.Gopal: Dryden's Outlines of Chemical Technology, WEP East-West Press
11. Clausen, Mattson: Principle of Industrial Chemistry, Wiley Publishing Co.,
12. Lowenheim & M.K. Moran: Industrial Chemicals
13. S.D. Shukla & G.N. Pandey: A text book of Chemical Technology Vol. II, Vikas Publishing House
14. J.K. Stille: Industrial Organic Chemistry (PH)
15. Shreve: Chemical Process, Mc Grawhill.
16. B.K.Sharma: Industrial Chemistry, Goel Publishing House
17. ICH Guidelines
18. United States Food and Drug Administration official website www.fda.gov

Details

1. Synthesis of organic compounds by adapting different approaches involving (3 experiments)
 - a) Oxidation
 - b) Reduction/hydrogenation
 - c) Nitration
2. Comparative study of synthesis of APIs/intermediates by different synthetic routes (2 experiments)
3. Assignments on regulatory requirements in API (2 experiments)
4. Comparison of absorption spectra by UV and Woodward – Fieser rule
5. Interpretation of organic compounds by FT-IR
6. Interpretation of organic compounds by NMR
7. Interpretation of organic compounds by MS
8. Determination of purity by DSC in pharmaceuticals
9. Identification of organic compounds using FT-IR, NMR, CNMR and Mass spectra
10. To carry out the preparation of following organic compounds
11. Preparation of 4-chlorobenzhydrylpiperazine. (an intermediate for cetirizine HCl).
12. Preparation of 4-iodotoluene from p-toluidine.
13. NaBH₄ reduction of vanillin to vanillyl alcohol
14. Preparation of umbelliferone by Pechhman reaction
15. Preparation of triphenyl imidazole
16. To perform the Microwave irradiated reactions of synthetic importance (Any two)
17. Determination of log P, MR, hydrogen bond donors and acceptors of selected drugs using softwares
18. Calculation of ADMET properties of drug molecules and its analysis using softwares Pharmacophore modeling
19. 2D-QSAR based experiments
20. 3D-QSAR based experiments
21. Docking study based experiment
22. Virtual screening based experiment

Semester III

MRM 301T	Research Methodology & Biostatistics	Credit: 4
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Unit	Details	Contact Hours
I	General Research Methodology: Research, objective, requirements, practical difficulties, review of literature, study design, types of studies, strategies to eliminate errors/bias, controls, randomization, crossover design, placebo, blinding techniques.	
II	Biostatistics: Definition, application, sample size, importance of sample size, factors influencing sample size, dropouts, statistical tests of significance, type of significance tests, parametric tests (students "t" test, ANOVA, Correlation coefficient, regression), non-parametric tests (wilcoxon rank tests, analysis of variance, correlation, chi square test), null hypothesis, P values, degree of freedom, interpretation of P values.	
III	Medical Research: History, values in medical ethics, autonomy, beneficence, non-maleficence, double effect, conflicts between autonomy and beneficence/non-maleficence, euthanasia, informed consent, confidentiality, criticisms of orthodox medical ethics, importance of communication, control resolution, guidelines, ethics committees, cultural concerns, truth telling, online business practices, conflicts of interest, referral, vendor relationships, treatment of family members, sexual relationships, fatality.	
IV	CPCSEA guidelines for laboratory animal facility: Goals, veterinary care, quarantine, surveillance, diagnosis, treatment and control of disease, personal hygiene, location of animal facilities to laboratories, anesthesia, euthanasia, physical facilities, environment, animal husbandry, record keeping, SOPs, personnel and training, transport of lab animals.	
V	Declaration of Helsinki: History, introduction, basic principles for all medical research, and additional principles for medical research combined with medical care.	