CENTRAL UNIVERSITY OF PUNJAB

Master of Pharmacy

(Pharmaceutical Chemistry)

Session - 2024-26

Department of Pharmaceutical Sciences and Natural Products

Course structure for M. Pharm. (Pharmaceutical Chemistry)

Course Code	Name of the course	Credit hours	Credit points	Hrs/ wk	Marks
SEMESTER I					
MPC101T	Modern Pharmaceutical Analytical Techniques	4	4	4	100
MPC102T	Advanced Organic Chemistry–I	4	4	4	100
MPC103T	Advanced Medicinal Chemistry	4	4	4	100
MPC104T	Chemistry of Natural Products	4	4	4	100
MPC105P	Pharmaceutical Chemistry Practical-I	12	6	12	150
MPC106S	Seminar/Assignment	7	4	7	100
	Total	**35**	**26**	**35**	**650**
SEMESTER II					
MPC201T	Advanced Spectral Analysis	4	4	4	100
MPC202T	Advanced Organic Chemistry – II	4	4	4	100
MPC203T	Computer Aided Drug Design	4	4	4	100
MPC204T	Pharmaceutical Process Chemistry	4	4	4	100
MPC205P	Pharmaceutical Chemistry Practical-II	12	6	12	150
MPC206S	Seminar/Assignment	7	4	7	100
XXX	Inter-Disciplinary Course (or through MOOC)	2	2	2	50
	Total	**37**	**28**	**37**	**700**
SEMESTER III					
MRM 301T	Research Methodology & Biostatistics	4	4	4	100
MPC302T	Journal club	1	1	1	25
MPC303T	Discussion/ Presentation (Proposal Presentation)	2	2	-	50
MPC599	Research Work	28	14	-	350
	Total	**35**	**21**	**5**	**525**
SEMESTER IV					
MPC401T	Journal club	1	1	1	25
MPC402T	Discussion / Presentation	3	3	-	75
MPC599	Research Work, thesis and viva-voce[#]	31	16	-	400
	Total	**35**	**20**	**1**	**500**

[#]To be evaluated by external expert

Examination pattern

Core, Discipline Elective, Compulsory Foundation,			**Interdisciplinary Course, Value Added, Entrepreneurship, Innovation and skill development Courses**	
	Marks	Evaluation	Marks	Evaluation
Internal Assessment	25	Various methods	-	-
Mid-semester test (MST)	25	Descriptive	50	Descriptive (70%) Objective (30%)
End-semester test (EST)	50	Descriptive (70%) Objective (30%)	50	Descriptive (70%) Objective (30%)

Objective Questions- one-word/sentence answers, fill-in the blanks, MCQs', and matching

Descriptive Questions- Short answer and essay type questions

Internal assessment- any two or more of the given methods: Surprise Tests, open book examination, assignments, term paper, etc.).

Evaluation criteria for practical:

Item	**Synopsis**	**Performance**	**Practical Note book and continuous evaluation**	**Viva voce**
Marks	20	50	50	30

Thesis/Dissertation Proposal (Third Semester)			**Thesis/Dissertation (Fourth Semester)**		
	Marks	**Evaluation**		**Marks**	**Evaluation**
Supervisor	200	Dissertation proposal and presentation	Supervisor	200	Continuous assessment (regularity in work, mid-term evaluation) dissertation report, presentation, final viva-voce
HoD and senior-most faculty of the department	150	Dissertation proposal and presentation	External expert, HoD and senior-most faculty of the department	200	Dissertation report (100), presentation (50), final viva-voce (50)

Evaluation pattern similar to third and fourth semester dissertation will apply for internship

Graduate attributes for M. Pharm. in Pharmaceutical Chemistry

After completing a Master of Pharmacy in Pharmaceutical Chemistry; the graduates will have a quality conscious service providing attitude by adopting the knowledge of spectral analysis and chromatographic techniques in manufacturing and Research & Development of drugs. They will have a perspective to develop efficacious, safe, and affordable drugs in a reasonable time using transformative digital technologies and will be able to implement Computer Aided Drug Design principles in modern drug discovery and development process in higher studies and at the industrial level. They will be able to apply the knowledge of chemistry for the development of synthetic methodologies including peptide chemistry, retro-synthesis and green chemistry for making the drugs affordable to the public and will be having an attribute to become self- reliant in APIs by the development of scale-up of APIs and intermediates, unit operations and industrial safety guidelines. The graduates will have a positive attitude to implement the sustainable development goals to make the planet safe for the next generations by implementing a circular economy and a philosophy to comprehend the socio-economy of medicines and make the world healthy. This program will also help graduates make careers in industry, government organizations or institutions of higher learning.

Semester 1

Course Title: Modern Pharmaceutical Analytical Techniques

L	T	P	Credits
4	0	0	4

Paper Code: MPC101T

Course Hours: 60h

Learning Outcomes:

After completing this course, the learner will be able to:

CLO1: Conceptualize general principle, theory and applications of UV-Vis, IR and spectroflourimetry

CLO2: Describe the concept and instrumentation of NMR and Mass techniques

CLO3: Separate different constituents of mixture by chromatographic techniques

CLO4: Conceptualize general principle and theory of electrophoresis and X-ray crystallography with handling of instruments.

CLO5: Explain the Principle, thermal transitions and Instrumentation of DSC, DTA and TGA

Course Contents

Units/Hours	Content	Mapping with course learning outcomes
Unit 1 **10 Hours**	**UV-Visible Spectroscopy** • Introduction, Theory, Laws, and Instrumentation associated with UV-Visible spectroscopy • Choice of solvents and solvent effect • Applications of UV- Visible spectroscopy • Difference/ Derivative spectroscopy **IR Spectroscopy** • Theory, Modes of Molecular vibrations, Sample handling • Instrumentation of Dispersive and Fourier - Transform IR Spectrometer • Factors affecting vibrational frequencies •Applications of IR spectroscopy, data interpretation **Spectroflourimetry** • Theory of Fluorescence • Factors affecting fluorescence (characteristics of drugs that can be analysed by flourimetry), Quenchers, Instrumentation • Applications of fluorescence spectrophotometer	**CLO1**

	Flame Emission Spectroscopy and Atomic Absorption Spectroscopy • Principle, Instrumentation, Interferences and Applications. **Learning activities:** Learner will be engaged in hands on training on different instruments like UV, IR and spectrophotometer.	
Unit 2 **10 Hours**	**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 **Learning activities:** Learner will be familiarized with the instrument and provided NMR for the characterization of compounds.	**CLO2**
Unit 3 **10 Hours**	**Mass Spectroscopy** • Principle, Theory, Instrumentation of Mass Spectroscopy • Different types of ionization like electron impact, 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 • Applications of Mass spectroscopy **Learning activities:** Learner will be provided mass spectra for the characterization of compounds.	**CLO2**
Unit 4 **10 Hours**	**Chromatography** Principle, apparatus, instrumentation, chromatographic parameters, factors affecting resolution, isolation of drug from excipients, data interpretation and applications of the following: • Thin Layer chromatography • Ion exchange chromatography • Column chromatography	**CLO3**

	• Gas chromatography • High Performance Liquid chromatography •Ultra-High Performance Liquid chromatography • Affinity chromatography • Gel Chromatography **Learning activities:** Learner will be familiarized and trained in different chromatographic techniques like TLC, Column, HPLC, HPTLC and GC for the purification and characterization of compounds.	
Unit 5 **10 Hours**	**Electrophoresis** Principle, Instrumentation, working conditions, factors affecting separation and applications of the following: • Paper electrophoresis • Gel electrophoresis • Capillary electrophoresis • Zone electrophoresis • Moving boundary electrophoresis • Isoelectric focusing **X ray Crystallography** • Production of X rays • Different X ray diffraction methods • Bragg's law, Rotating crystal technique, X ray powder technique • Types of crystals and applications of X-ray diffraction **Learning activities:** Learner will be provided conceptual learning based on electrophoresis as well as handling of instruments.	**CLO4**
Unit 6 **10 Hours**	**Potentiometry** • Principle, working, ion selective electrodes • Application of potentiometry **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 Analysis (DTA)** • Principle, instrumentation	**CL05**

	• Advantage and disadvantages • Pharmaceutical applications • Derivative differential thermal analysis (DDTA) **TGA** • Principle, instrumentation • Factors affecting results • Advantage and disadvantages • Pharmaceutical applications. **Learning activities:** Learner will be provided Web based learning to explain thermal techniques	

REFERENCES

1. Spectrometric Identification of Organic compounds – Robert M Silverstein, 8th edition, John Wiley & Sons, 2015.
2. Principles of Instrumental Analysis – Doglas A Skoog, F. James Holler, Timothy A. Nieman, 6th edition, Cengage, 2014.
3. Instrumental methods of analysis – Willards, 7th edition, CBS publisher, 2004.
4. Practical Pharmaceutical Chemistry – Beckett and Stenlake, Vol II, 4th edition, CBS Publishers, New Delhi, 2007.
5. Organic Spectroscopy – William Kemp, 3rd edition, ELBS, 2008.
6. Quantitative Analysis of Drugs in Pharmaceutical formulation – P D Sethi, 3rd edition, CBS Publishers, New Delhi, 2007.
7. Pharmaceutical Analysis – Modern Methods – Part B – J W Munson, Vol 11, Marcel, Dekker Series 1984 (Reprint 2012)
8. Spectroscopy of Organic Compounds, 6th edn., P. S. Kalsi, Wiley Eastern Ltd., Delhi, 2016.
9. Textbook of Pharmaceutical Analysis, KA. Connors, 3rd Edition, John Wiley & Sons, 2007.
10. Introduction to spectroscopy. 4th Edition, Pavia DL, Lampman GM, Kriz GS, Vyvyan JA.; Cengage Learning, 2008
11. Pharmaceutical quality by design: a practical approach. Schlindwein WS, Gibson M, editors. John Wiley & Sons; 2018.

Course Title: Advanced Organic Chemistry - I

L	T	P	Credits
4	0	0	4

Paper Code: MPC102T
Course Hours: 60h

Learning Outcomes:

After completing this course, the learner will be able to:

CLO1: Describe and understand basic chemistry of elimination and addition reactions
CLO2: Through understating of the chemistry and mechanism of various named reactions having application in synthetic and medicinal chemistry.
CLO3: Understanding of chemistry and applications of various synthetic reagents including the protecting groups and various organic transformations.
CLO4: Describe nomenclature and synthetic methodologies of heterocyclic systems
CLO5: Describe disconnection approaches applied on synthetic strategies and mechanism prediction

Course Contents

Units/Hours	Content	Mapping with course learning outcomes
Unit 1 **12 Hours**	**Basic Aspects of Organic Chemistry**: 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 w.r.t addition, substitution, elimination and rearrangement reactions. 4. Chemistry of enolates **Learning activities:** Learner will be engaged in molecular models to explain the structure stability and conformation of organic intermediates to explain the stereochemistry in organic transformations and knowledge of reaction mechanisms.	**CLO1**
Unit 2 **10 Hours**	**Study of Mechanism and Synthetic Applications of Following Named Reactions**	**CLO2**

	• Ugi reaction, Brook rearrangement, Ullmann coupling reactions, Dieckmann Reaction, Doebner-Miller Reaction, Sandmeyer Reaction, Mitsunobu reaction, Mannich reaction, Vilsmeyer-Haack Reaction, Sharpless asymmetric epoxidation, Baeyer-Villiger oxidation, Shapiro & Suzuki reaction, Ozonolysis and Michael addition reaction. **Learning activities:** Learner will be engaged hand on training in some of the named reactions with applications in organic and drug synthesis.	
Unit 3 **12 Hours**	**Synthetic Reagents and Applications** • Aluminiumisopropoxide, N-bromosuccinamide, diazomethane, dicyclohexylcarbodimide, Wilkinson reagent, Witting reagent, Osmium tetroxide, titanium chloride, diazopropane, diethyl azodicarboxylate, Triphenylphosphine, Benzotriazol-1-yloxy) tris (dimethylamino) phosphonium hexafluoro-phosphate (BOP) **Protecting Groups** • Role of protection in organic synthesis • Protection for the hydroxyl group, including 1,2-and1,3-diols: ethers, esters, carbonates, cyclic acetals & ketals • Protection for the Carbonyl Group: Acetal and Ketals • Protection for the Carboxyl Group: amides and hydrazides, esters • Protection for the Amino Group and Amino acids: carbamates and amides **Learning activities:** Learner will be engaged in performing experiments using various the synthetic reagents and protection of various functional groups.	**CLO3**
Unit 4 **12 Hours**	**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,	**CLO4**

	Bernthsen Acridine Synthesis, Smiles rearrangement and Traube purine synthesis. • 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. **Learning activities:** Learner will be engaged in performing the synthesis and characterization of some of the representative heterocyclic compounds as well as drugs based on these heterocycles.	
Unit 5 **12 Hours**	**Synthon Approach and Retrosynthesis Applications** • Basic principles, terminologies and advantages of retrosynthesis; guidelines for dissection of molecules • Functional group interconversion and addition (FGI and FGA) • C- X disconnections; C- C disconnections – alcohols and carbonyl compounds; 1,2- , 1,3- ,1,4- , 1,5- , 1,6- difunctionalized compounds • Strategies for synthesis of three, four, five and six- membered ring **Learning activities:** Learner will be engaged in Group discussion to explain disconnection approaches in synthesis	**CLO5**

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 Woihers, Oxford University Press.
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, Wily India.
10. Principles of Organic Synthesis, ROC Norman and JM Coxan, NelsonThorns.
11. Organic Synthesis- Special Techniques. VK Ahluwalia and R Agarwal, Narosa Publishers.
12. Organic Reaction Mechanisms. VK Ahluwalia and RK Parashar, Narosa Publishers

The following are some of the modes of classroom transaction

- Lecture
- Group discussion
- Demonstration
- Team teaching
- Tutorial
- Self-learning

Transaction Mode

- PPT
- YouTube
- Google drive
- Google meet

Course Title: Advanced Medicinal Chemistry
Paper Code: MPC103T
Course Hours: 60h

L	T	P	Credits
4	0	0	4

Learning Outcomes
After completing this course, the learner will be able to:

CLO1: Describe drugs interaction with various types of enzymes and receptors

CLO2: Conceptualize the process of drug discovery and its progress

CLO3: Rational design and synthesis of covalent and non-covalent inhibitors as drug candidates in medicinal chemistry

CLO4: Knowledge of peptidomimetic design and understanding of coupling procedures for its synthesis including stereochemical aspects and backbone modification.

Course Content

Units/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**Drug Discovery** • Stages of drug discovery, lead discovery; identification, validation and diversity of drug targets **Biological Drug Targets** • Receptors, types, binding and activation, theories of drug receptor interaction, drug receptor interactions, agonists vs antagonists, artificial enzymes. **Learning activities:** Learner will be explained about drug interaction and target through molecular modeling studies	**CLO1**
Unit 2 **12 Hours**	**Prodrug Design and Analog design** **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.	**CLO2**

	Combating drug resistance Causes for drug resistance, strategies to combat drug resistance in antibiotics and anticancer therapy, Genetic principles of drug resistance. **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. **Learning activities:** Learner will be engaged in learning the methods and concepts used for prodrug design, drug targeting and modification of lead compounds in wet lab as well as using in silico tools to optimize their biological and physical properties.	
Unit 3 **12 Hours**	**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**: a). Anti-hypertensive drugs, Psychoactive drugs, H1 & H2 receptor antagonist, COX1 & COX2 inhibitors, Antineoplastic and Antiviral agents. **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, enantioselectivity in drug adsorption, metabolism, distribution and elimination. **Learning activities:** Learner will be engaged in Group discussion to explain SAR, Mechanism of action and given hands on training for the synthesis of selective drugs mentioned above.	**CLO2**
Unit 4 **12 Hours**	**Rational Design of Enzyme Inhibitors** • Enzyme kinetics & Principles of enzyme	**CLO3**

	inhibitors, Enzyme inhibitors in medicine, Enzyme inhibitors in basic research, rational design of non-covalently and covalently binding enzyme inhibitors. **Learning activities:** Learner will be engaged in performing experiments to determine the enzyme kinetics and *in silico* design of enzyme inhibitors having applications in medicinal chemistry.	
Unit 5 **12 Hours**	**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 **Learning activities:** Learner will be engaged in in performing coupling experiments, amino acid synthesis, stereochemistry of biomolecules and *in silico* experiments for design of peptidomimetics.	**CLO4**

Suggested Readings:

1. Medicinal Chemistry by Burger, Vol I –VI.
2. Wilson and Gisvold's Text book of Organic Medicinal and Pharmaceutical Chemistry, Lppincott Williams & Wilkins, Woltess 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 Moor.
5. Introduction to Quantitative Drug Design by Y.C. Martin.
6. Principles of Medicinal Chemistry by William Foye, 7th Edition, Lippincott Williams & Wilkins, Woltess 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, Elsevier
Publishers, New Delhi.
10. An Introduction to Medicinal Chemistry, Graham L.Patrick, Oxford University Press, USA.
11. Biopharmaceutics and pharmacokinetics, DM.Brahmankar, Sunil B. Jaiswal, Vallabh Prakashan, New Delhi.
12. Peptidomimetics in Organic and Medicinal Chemistry by Antonio Guarna and Andrea Trabocchi, Wiley publishers.

The following are some of the modes of classroom transaction

- Lecture
- Group discussion
- Demonstration
- Team teaching

Transaction Mode

- Molecular Models
- PPT
- YouTube
- Software for *In silico* study
- Google meet

Course Title: Chemistry of Natural Products

L	T	P	Credits
4	0	0	4

Paper Code: MPC104T
Course Hours: 60h

Learning Outcomes
After completing this course, the learner will be able to:

CLO1: Understand chemistry and structural modifications of natural leads for drug discovery and development
CLO2: Conceptualize the nomenclature, synthesis and structure of alkaloids steroids
CLO3: Describe categories, synthesis and biosynthesis of terpenoids and vitamins
CLO3: Understand and apply modern biotechnological methods, scientific principles and technologies in drug discovery/ hands on participation in laboratory
CLO5: Explain the structural characterization of natural products using advanced spectroscopic techniques

Course Content

Units/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**Study of Natural Products as Leads for New Pharmaceuticals for the Following Class of Drugs** • Drugs affecting the Central Nervous System: Morphine Alkaloids • Anticancer Drugs: Paclitaxel and Docetaxel, Etoposide, and Teniposide • Cardiovascular Drugs: Lovastatin, Teprotide and Dicoumarol • Neuromuscular Blocking Drugs: Curare alkaloids • Anti-malarial drugs and Analogues • Chemistry of macrolid antibiotics (Erythromycin, Azithromycin, Roxithromycin, and Clarithromycin) and β - Lactam antibiotics (Cephalosporins and Carbapenem) **Learning activities-** Learner will be engaged in understanding principles and methodologies involved in drug discovery and development from natural r**e**sources	**CLO1**
Unit 2 **12 Hours**	**Alkaloids** • General introduction, classification, isolation, purification, molecular modification and biological activity of alkaloids • General methods of structural determination of alkaloids	**CLO2**

	• Structural elucidation and stereochemistry of ephedrine, morphine, ergot, emetine and reserpine **Flavonoids** • Introduction, isolation and purification of flavonoids • General methods of structural determination of flavonoids • Structural elucidation of quercetin **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) **Learning activities-** Learner will be able to explain and perform various chemical tests for the identification of plant alkaloids to explain the structure and stereochemistry of steroids using ball and stick model.	
Unit 3 **12 Hours**	**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 terpenoids (Squalene,Ginsenoside) carotinoids (β carotene) **Vitamins** • Chemistry and Physiological significance of Vitamin A, B1, B2, B12, C, E, Folic acid and Niacin. **Learning activities-** Learner will be engaged in molecular models to explain the structure and stereochemistry of terpenoids, perform various identification tests to confirm their presence and familiarize with the use of various spectral techniques for the structure elucidation of terpenoids based drugs.	**CLO3**
Unit 4 **12 Hours**	**a. Chemistry of Carbohydrates** Introduction, classification, configuration and conformation, reactions of monosaccharides; oxidation, reduction, osazone formation, chain shortening and chain lengthening, mutarotation. Structure elucidation and chemistry of Glucose **b. Active Constituent of Certain Crude Drugs Used in Indigenous System** • Diabetic Therapy: Gymnema sylvestre, Salacia reticulate, Pterocarpus marsupiam, Swertia chirata, Trigonella foenum graccum • Liver dysfunction: Phyllanthus niruri • Antitumor: Curcuma longa Linn. **Learning activities-** Learner will be engaged in	**CLO3**

	performing and handling various techniques/ experiments used in the isolation of active constituents of crude drugs including their characterization. Perform various experiments for the synthesis and functional group analysis in sugars including their stereochemical aspects.	
Unit 5 **12 Hours**	**Structural Characterization of Natural Compounds** • Structural characterization of natural compounds using IR, 1HNMR, 13CNMR and MS Spectroscopy of specific drugs e.g., Penicillin, Morphine, Camphor, Vit-D, Quercetin and Digitalis glycosides. **Learning activities:** Learner will be provided spectral data for the identification of above-mentioned natural compounds	**CLO5**

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, Chapmannstall.
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.
15. Phytochemical methods of Harborne, Springer, Netherlands.
16. Burger's Medicinal Chemistry.

The following are some of the modes of classroom transaction

- Lecture
- Group discussion
- Demonstration
- Tutorial

Transaction Mode

- PPT
- YouTube
- Google meet

Course Title: Organic Synthesis –I (Practical)

L	T	P	Credits
0	0	12	6

Paper Code: CMC 507
Course Hours: 60h

Learning Outcomes:
After completing this course, the learner will be able to:

CLO1: Interpret stereochemistry of organic compounds
CLO2: Explain the handling, storage and disposal of hazardous chemicals and their Material safety data sheets (MSDS)
CLO3: Monitor the progress of chemical reactions by thin layer chromatography
CLO4: Purify a given organic compound through crystallization, fractional distillation or column chromatography

Course Content

Practical	Content/Title	Mapping with course learning outcome
1.	Analysis of Pharmacopoeial compounds and their formulations by UV Vis spectrophotometer, RNA & DNA estimation	**CLO1**
2.	Simultaneous estimation of multi component containing formulations by UV spectrophotometry	**CLO1**
3.	Experiments based on Column chromatography	**CLO2**
4.	Experiments based on HPLC	**CLO3**
5.	Experiments based on Gas Chromatography	**CLO4**
6.	Estimation of riboflavin/quinine sulphate by fluorimetry	**CLO4**
7.	Estimation of sodium/potassium by flame photometry	**CLO4**
8.	8. To perform the following reactions of synthetic importance: a. Purification of organic solvents, column chromatography b. Claisen-schimidt reaction c. Benzyllic acid rearrangement d. Beckmann rearrangement e. Hoffmann rearrangement f. Mannich reaction g. Synthesis of medicinally important compounds involving more than one step along with purification and Characterization using TLC, melting point and IR spectroscopy (4 experiments) h. Estimation of elements and functional groups in organic natural compounds	**CLO4**

	i. 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. j. Some typical degradation reactions to be carried on selected plant constituents	

Suggested Readings:

1. Adams, R., Johnson, J.R., Wilcox, C.F. (1970). *Laboratory Experiments in Organic Chemistry*, The Macmillan Limited, London.
2. Mann, F. G. (2009). *Practical Organic Chemistry*. Pearson Education India.
3. Pasto, D.P., Johnson, C., Miller, M. (2010). *Experiments and Techniques in Organic Chemistry*, Prentice Hall.
4. Roberts, R.M., Gilbert, J.C., Rodewald, L.B., Wingrove, A.S. (1969). *An Introduction to Modern Experimental Organic Chemistry*, Ranehart and Winston Inc., New York.
5. Vogel, A.I. (latest edition). *Text Book of Practical Organic Chemistry*, Pearson
6. Williamson, K.L., Health, D.C. (1999). *Macroscale and Microscale Organic Experiments*, *Heath,* D. C & Co., Lexington, MA.
7. Armarego, W. L., & Chai, C. (2012). *Purification of Laboratory Chemicals*. Butterworth-Heinemann.
8. Young, J. A. (Ed.). (1991). *Improving Safety in the Cemical Laboratory: a Practical Guide*. Wiley.
9. Zercher, C. A. (2010). *Organic Syntheses*. John Wiley & Sons.
10. Leonard, J., Lygo, B., Procter, G. (2013). *Advanced Practical Organic Chemistry*. CRC Press.

The following are some of the modes of classroom transaction

- Experimentation
- Group discussion
- Demonstration
- Self-learning

Transaction Mode

- PPT
- YouTube
- Google drive
- Google meet

Course Title: Seminar/Assignment

Paper Code: MPC106S

L	T	P	Credits	Marks
0	0	0	4	100

Learning outcome: Students who successfully complete this course will be able to

- Perform literature review on a given topic
- Prepare a report on a given topic
- Prepare a power point presentation on a given topic

Evaluation criteria:

- Literature survey/background information
- Organization of content
- Physical presentation
- Questions and answers
- Report evaluation

Semester –II

Course Title: Advanced Spectral Analysis
Paper Code: MPC201T
Course Hours: 60hr

L	T	P	Credits
4	0	0	4

Learning Outcomes
After completion of the course, student shall be able to understand:

CLO1: Conceptualize general principle and theory of UV-Vis, IR and spectroflourimetry
CLO2: Describe the concept and instrumentation of NMR and Mass techniques
CLO3: Separate different constituents of mixture by chromatographic techniques
CLO4: Explain the Principle, thermal transitions and Instrumentation of DSC, DTA and TGA with application of Raman spectroscopy and radio immunoassay

Course Content

Units/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**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 **Learning activities:** Learner will be provided hands on training to different instruments like UV, IR and spectroflourimetry.	**CLO1**
Unit 2 **11 Hours**	**NMR Spectroscopy:** 1-D and 2-D NMR, NOESY and COSY, HECTOR, INADEQUATE techniques, Interpretation of organic compounds **Learning activities:** Learner will be provided NMR for the characterization of compounds.	**CLO2**
Unit 3 **10 Hours**	**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. **Learning activities:** Learner will be provided Mass spectra for the characterization of compounds.	**CLO2**
Unit 4 **12 Hours**	**Chromatography:** Principle, Instrumentation and Applications of the	**CLO3**

	following : • GC-MS • GC-AAS • LC-MS • LC-FTIR • LC-NMR • CE-MS • High Performance Thin Layer chromatography • Super critical fluid chromatography • Ion Chromatography • I-EC (Ion- Exclusion Chromatography) • Flash chromatography **Learning activities:** Learner will be provided experience of chromatography by using different techniques like TLC, Column, HPLC, HPTLC and GC.	
Unit 5 **12 Hours**	**Structure elucidation of following compounds by spectroscopic techniques using like UV, IR, Mass, NMR (^{1}H and ^{13}C)** a. Carvove, Citral, Menthol b. Luteolin, Kaempferol c. Nicotine, Caffeine d. Glycyrrhizin **Learning activities:** Learner will be provided spectral data of various natural and synthetic compounds for their characterization and structure elucidation using various spectroscopic techniques.	**CLO4**

REFERENCES:

1. Spectrometric Identification of Organic compounds - Robert M Silverstein, John Wiley & Sons.
2. Principles of Instrumental Analysis - Doglas A Skoog, F. James Holler, Timothy A. Nieman, Eastern press, Bangalore.
3. Instrumental methods of analysis – Willards, CBS publishers.
4. Organic Spectroscopy - William Kemp, ELBS.
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, CBS Publishers, New Delhi.
7. Pharmaceutical Analysis- Modern methods – Part B - J W Munson, Volume 11, Marcel Dekker Series

Course Title: Advanced Organic Chemistry-II

L	T	P	Credits
4	0	4	4

Paper Code: MPC 202T
Course Hours: 60h

Learning Outcomes
After completing this course, the student shall able to understand:

CLO1: The principles and applications of green chemistry.
CLO2: The concept of peptide chemistry.
CLO3: Apply principles of photochemistry and pericyclic reactions in various chemical transformations
CLO4: The various catalysts used in organic reactions.
CLO5: Describe the asymmetric synthesis, chiral resolution and apply it on the resolution of chiral drugs.

Course content

Unit/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**Green Chemistry:** a. Introduction, principles of green chemistry b. Microwave assisted reactions: merits 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 heterocyclic synthesis. c. Ultrasound assisted reactions: types of sonochemical reactions, homogenous, heterogeneous liquid-liquid and liquid-solid reactions, synthetic application d. Continuous flow reactors: working principle, advantages and synthetic applications. **Learning activities:** Learner will be engaged in practical's using greener synthetic routes such as microwave assisted synthesis and ultrasound and sonication assisted reactions for the synthesis of various key intermediates and drug molecules.	**CLO1**
Unit-2 **12 Hours**	**Chemistry of peptides:** a) Coupling reactions in peptide synthesis	**CLO2**

	b) Principles of solid phase peptides synthesis, t-BOC and FMOC protocols, various solid supports and linkers: Activation procedures, peptide and 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. c) Segment and sequential strategies for solution phase peptide synthesis with any two case studies d) Side reactions in peptide synthesis: Deletion peptides, side reactions initiated by proton abstraction, protonation, over- activation and side reactions of individual amino acids ide reactions in peptide synthesis: Deletion peptides, side reactions initiated by proton abstraction, protonation, over- activation and side reactions of individual amino acids. **Learning activities:** Learner will be engaged in practical's involving coupling, protection/deprotection and coupling reactions for peptide synthesis.	
Unit-3 **12 Hours**	**Photochemical reactions** • Basic principles of photochemical reactions. Photo-oxidation, photo-addition and photo-fragmentation **Pericyclic reactions** • Mechanism, Types of pericyclic reactions such as cyclo addition, electrocyclic reaction and Sigmatrophic rearrangement reactions with examples **Learning activities:** Learner will be engaged in solving exercises related to the mechanism of photochemical and pericyclic chemistry including rearrangements reactions in these with suitable examples and their applications in organic and medicinal chemistry.	**CLO3**
Unit-4 12 Hours	**Catalysis:** a) Types of catalysis, heterogeneous and homogenous catalysis, advantages and disadvantages b) Heterogeneous catalysis–preparation, characterization, kinetics, supported catalysts, catalyst deactivation and regeneration, some examples of heterogeneous catalysis used in synthesis of drugs c) 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 d) Transition-metal and Organo-catalysis in organic synthesis: Metal-catalyzed reactions e) Biocatalysis: Use of enzymes in organic synthesis, immobilized enzymes/cells in organic reaction f) Phase transfer catalysis - theory and applications **Learning activities:** Learner will be familiarize with the science of catalysis, their synthetic applications in various key organic transformations and will be engaged in hand-on synthesis using various catalysts/phase transfer catalyst in some important organic transformations of organic and medicinal interests.	
Unit-5 **12 Hours**	**Stereochemistry and Asymmetric Synthesis** a) 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. b) Methods of asymmetric synthesis using chiral pool, chiral auxiliaries and catalytic asymmetric synthesis, enantiopure separation and Stereo selective synthesis with examples. **Learning activities:** Learner will be engaged in Molecular models to understand and explain the stereochemistry of various chiral natural and organic molecules and performing asymmetric synthesis.	**CLO5**

REFERENCES:

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, NewYork.
3. Organic Chemistry Clayden, Greeves, Warren and Woihers., Oxford University Press.

4. Organic Chemistry" Vol I and II. I.L. Finar. ELBS.

5. Carey, Organic chemistry, Viva Books Pvt. Ltd.

6. Organic synthesis-the disconnection approach, S. Warren, Wily India.

7. Principles of organic synthesis, ROC Norman and JM Coxan, Nelson Thorns.

8. Organic synthesis- Special techniques VK Ahluwalia and R Aggarwal, Narosa Publishers.

9. Organic reaction mechanisms IV edtn, VK Ahluwalia and RK Parashar, Narosa Publishers

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Course Title: Fundamentals of Computer Aided Drug Design

L	T	P	Credits
4	0	0	4

Paper Code: MPC203T
Course Hours: 60h

Learning outcome:
After completing this course, the learner will be able to:

CLO1: Describe the role of CADD in drug discovery
CLO2: Different CADD techniques and their applications.
CLO3: Various strategies to design and develop new drug like molecules.
CLO4: Working with molecular modeling software to design new drug molecules.

Course Content

Units/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**Introduction to Computer Aided Drug Design (CADD)**: History, different techniques and applications. Quantitative Structure Activity Relationships: Basics. History and development of QSAR: Physiochemical parameters and methods to calculate physiochemical parameters: Hammett equation and electronic parameters (sigma), lipoiphilicity effects and parameters (log P, pi-substituent constant), steric effects (Taft steric and MR parameters) Experimental and theoretical approaches for the determination of these physiochemical parameters. **Learning activities:** Learner will be engaged in group discussion to explain 2D-QSAR, 3D-QSAR and importance of statistical parameters	**CLO1**
Unit 2 **12 Hours**	**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. **Learning activities:** Learner will be engaged in group discussion to explain 2D-QSAR, 3D-QSAR and importance of statistical parameter	**CLO1**
Unit 3 **12 Hours**	**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	**CLO2**

	docking. Agents acting on enzymes such as DHFR, HMG-CoA reductase and HIV protease, choline esterase (AchE & BchE) **Learning activities:** Learner will be engaged in molecular modeling of compounds.	
Unit 4 **12 Hours**	**Molecular Properties and Drug Design:** a) Prediction and analysis of ADMET properties of new molecules and its importance in drug design. b) De novo 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 modelling and generation of 3D-structure of protein. **Learning activities:** Learner will study Molecular model to explain interactions between ligand and drug target	**CLO3**
Unit 5 **12 Hours**	**Pharmacophore Mapping and Virtual Screening:** Concept of pharmacophore, pharmacophore mapping, identification of Pharmacophore features and Pharmacophore's modelling; Conformational search used in pharmacophore mapping. In-silico Drug Design and Virtual Screening Techniques. Similarity based methods and Pharmacophore based screening, structure based In-silico virtual screening protocols. **Learning activities:** Learner will be engaged in Pharmacophore band structure based *In-silico* virtual screening protocols	**CLO2, CLO3**

REFERENCES:

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, 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 Title: Process Chemistry
Paper Code: MPC204T
Course Hours: 60h

L	T	P	Credits
4	0	0	4

Learning outcome:
After completing this course, the learner will be able to:

CLO1: The strategies of scale up process of APIs and intermediate
CLO2: The various unit operations and various reactions in process chemistry
CLO3: Study the MSDS of hazardous chemicals

Course Content

Units/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**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 **Learning activities:** Learner will be provided training involving case studies on scale up of APIs.	**CLO1**
Unit 2 **12 Hours**	**Unit operations** *Extraction:* Liquid equilibria, extraction with reflux, extraction with agitation, counter current extraction. *Filtration*: Theory of filtration, pressure and vacuum filtration, centrifugal filtration, *Distillation*: azeotropic and steam distillation *Evaporation*: Types of evaporators, factors affecting evaporation. *Crystallization*: Crystallization from aqueous, non-aqueous solutions factors affecting crystallization, nucleation. Principle and general methods of Preparation of polymorphs, hydrates, solvates and amorphous APIs. **Learning activities:** Learner will be engaged in group discussion to understand Extraction, filtration, distillation, evaporation and crystallization processes	**CLO2**
Unit 3 **12 Hours**	**Unit process- II** **Reduction** Catalytic hydrogenation, Heterogeneous and homogeneous catalyst; Hydrogen transfer reactions, Metal hydrides Case study on industrial reduction process	**CLO2**

	Fermentation Aerobic and anaerobic fermentation Production of Antibiotics (Penicillin and Streptomycin), Vitamins (B2 and B12), Statins (Lovastatin, Simvastatin) **Reaction Progress Kinetic Analysis** Streamlining reaction steps, route selection Characteristics of expedient routes, characteristics of cost-effective routes, reagent selection, families of reagents useful for scale-up **Learning activities:** Learner will be engaged in group discussion to understand unit processes for reduction, fermentation and reaction progress kinetic analysis	
Unit 4 **12 Hours**	**Unit Processes - III** **Reduction:** Catalytic hydrogenation, Heterogeneous and homogeneous catalyst; Hydrogen transfer reactions, Metal hydrides. Case study on industrial reduction process. **Fermentation**: Aerobic and anaerobic fermentation. Production of Antibiotics; Penicillin and Streptomycin, Vitamins: B2 and B12 Statins: Lovastatin, Simvastatin Reaction progress kinetic analysis Streamlining reaction steps, route selection, Characteristics of expedient routes, characteristics of cost-effective routes, reagent selection, families of reagents useful for scale-up. **Learning activities:** Learner will be engaged in group discussion to understand unit processes for reduction, fermentation and reaction progress kinetic analysis	**CLO2**
Unit 5 **12 Hours**	Industrial Safety MSDS (Material Safety Data Sheet), hazard labels of chemicals and Personal Protection Equipment (PPE) Fire hazards, types of fire & fire extinguishers Occupational Health & Safety Assessment Series 1800 (OHSAS-1800) and ISO-14001(Environmental Management System), Effluents and its management **Learning activities:** Learner will be provided Awareness about industrial safety protocols	**CLO3**

REFERENCES:

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

Course code	Course Title	Credits
MPC205P	**Pharmaceutical Chemistry Practical- II**	**6**

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

- PPT
- YouTube
- Google drive
- Google meet

Course Title: Seminar/Assignment

Paper Code: MPC106S

L	T	P	Credits	Marks
0	0	0	4	100

Learning outcome: Students who successfully complete this course will be able to

- Perform literature review on a given topic
- Prepare a report on a given topic
- Prepare a power point presentation on a given topic

Evaluation criteria:

- Literature survey/background information
- Organization of content
- Physical presentation
- Questions and answers
- Report evaluation

Semester III

Course Title: Research Methodology & Biostatistics

L	T	P	Credits
4	0	0	4

Paper Code: MRM301T
Course Hours: 60h

Learning Outcomes:
After completing this course, the learner will be able to:

CLO1: Define an appropriate research problem
CLO2: Understand and interpret commonly reported statistical measures and analysis of different types of data using statistical software's
CLO3: Develop skills for scholarly investigations, pursuit of discovery including principles in research in clinical practice
CLO4: To understand and promote the care of animals in biomedical/behavioral and breeding of animals for this purpose
CLO5: To understand principles and history of human care in medical research

Course Content

Units/Hours	Content	Mapping with course learning outcome
Unit 1 **12 Hours**	**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. **Learning activities:** Learner will be engaged in literature search and study design	**CLO1, CLO2**
Unit 2 **12 Hours**	**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 (wilcoxan rank tests, analysis of variance, correlation, chi square test), null hypothesis, P values, degree of freedom, interpretation of P values. **Learning activities:** Learner will be engaged in Web based learning to explain concepts of biostatics in research problem and analysis of different type of statistical data	**CLO2**
Unit 3 **12 Hours**	**Medical Research** • History, values in medical ethics, autonomy,	**CLO3**

	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 **Learning activities:** Learner will be engaged to get familiarize with terms related to medical research and ethics in medical research	
Unit 4 **12 Hours**	**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 **Learning activities:** Learner will be engaged to develop a comprehensive understanding of ethical and practical consideration in care and use of animal in research settings.	**CLO4**
Unit 5 **12 Hours**	**Declaration of Helsinki** • History, introduction, basic principles for all medical research, and additional principles for medical research combined with medical care **Learning activities:** Learner will be engaged in understanding profound history and principles applicable to medical research	**CLO5**

Suggested Readings:

1. Gupta, S. (2005). *Research methodology and statistical techniques*, Deep & Deep Publications (p) Ltd. New Delhi.
2. Kothari, C. R. (2008.) *Research Methodology(s)*, New Age International (p) Limited.New Delhi
3. Best J. W., Khan J. V. (Latest Edition) *Research in Education*, Prentice Hall of India Pvt. Ltd.
4. *Safe Science: Promoting a Culture of Safety in Academic Chemical Research*; National Academic Press, www.nap.edu.
5. Creswell, D., & Creswell, J. W. (2017). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*.

The following are some of the modes of classroom transaction

- Lecture
- Group discussion
- Demonstration

Transaction Mode

- PPT
- YouTube
- Google drive

Course Title: Journal Club

Paper Code: MPC302T

L	T	P	Credits	Marks
0	0	0	1	25

Course Title: Discussion/ Presentation (Proposal Presentation)

Paper Code: MPC303T

L	T	P	Credits	Marks
0	0	0	2	50

Course Title: Research Work

Paper Code: MPC599

L	T	P	Credits	Marks
0	0	0	14	350

Learning outcome: Students who successfully complete this course will be able to

- Design a research problem and prepare synopsis
- Plan and execute experiments in the laboratory
- Interpret and analyze the results

Evaluation criteria:

- Literature survey/background information
- Organization of content
- Physical presentation
- Questions and answers
- Report evaluation

Semester IV

Course Title: Journal Club

Paper Code: MPC401T

L	T	P	Credits	Marks
0	0	0	1	25

Course Title: Discussion/ Presentation
Paper Code: MPC402T

L	T	P	Credits	Marks
0	0	0	3	75

Course Title: Research Work, Thesis and viva-voce

Paper Code: MPC599

L	T	P	Credits	Marks
0	0	0	16	400

Learning outcome: Students who successfully complete this course will be able to

- Design a research problem and prepare synopsis
- Plan and execute experiments in the laboratory
- Interpret and analyze the results

Evaluation criteria:

- Literature survey/background information
- Organization of content
- Physical presentation
- Questions and answers
- Thesis evaluation
- Viva-voce

The following are some of the **classroom transactional modes**

1. Lecture
2. Demonstration
3. Lecture cum demonstration
4. Project method
5. Seminar
6. Group Discussion
7. Focused group discussion
8. Team teaching
9. Experimentation
10. Tutorial
11. Problem solving
12. Self-learning

The following **tools** can be used in **different transactional modes**:

- PPT
- Facebook
- WhatsApp
- Video
- Multimedia packages
- TED Talks
- google drive