

**Centre for Pharmaceutical Sciences and Natural Products**  
**Scheme of Programme: M.Pharm. (Pharmacognosy and Phytochemistry)**

*Duration of the Course: Two Years*

*Eligibility: Bachelor's degree in Pharmacy with 55% marks from a recognized Indian or foreign university and also having valid GPAT score.*

**SEMESTER 1**

S.No	Paper		Course Title	L	T	P	Cr	% Weightage				E
	Type of Course	Code						A	B	C	D	
1	FC	PPP.501	Computer Applications	2	1	-	2	10	15	15	10	50
2	EC	PPP.502	Organic Chemistry-I	4	1	-	4	25	25	25	25	100
3	CC	PPP.503	Advances in Pharmacognosy and Phytochemistry	4	1	-	4	25	25	25	25	100
4	CC	PPP.504	Laboratory of Pharmacognosy and Phytochemistry	-	-	4	2	-	-	-	-	50
5	CC	PPP.505	Spectral Analyses-Practical	-	-	4	2	-	-	-	-	50
6	FC	PPP.506	Computer Applications-Practical	-	-	4	2	-	-	-	-	50
7	EC	PPP. 507	Seminar	-	-	4	2	-	-	-	-	50
8	EC	XXX.###	Inter-Disciplinary Course (From Other Departments)	2	-	-	2	10	15	15	10	50
Opt any one course from following elective courses												
9	EC	PPP. 508	Spectral Analyses	4	1	-	4	25	25	25	25	100
		PPP. 509	Medicinal Chemistry									
		PPP. 510	Logics of Organic Synthesis									
				<b>16</b>	<b>4</b>	<b>16</b>	<b>24</b>					<b>600</b>
Interdisciplinary courses offered by Chemical and Pharmaceutical Faculty (For students of other Centres)												
01		PPP.551	Diseases and Medicines	2	-	-	2	10	15	15	10	50
02		PPP.552	Chemicals of Everyday Life	2	-	-	2	10	15	15	10	50
03		PPP.553	Spectroscopy in Drug Development and Analyses	2	-	-	2	10	15	15	10	50

- A: Continuous Assessment: Based on Objective Type Tests
- B: Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
- C: Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)
- D: End-Term Exam (Final): Based on Objective Type Tests
- E: Total Marks
- L: Lectures T: Tutorial P: Practical Cr: Credits**
- CC: Core Course, EC: Elective Course, FC: Foundation Course**

## SEMESTER 2

S.No	Paper		Course Title	L	T	P	Cr	% Weightage				E
	Type of Course	Code						A	B	C	D	
1	CC	PPP.511	Organic Chemistry-II	4	1	-	4	25	25	25	25	100
2	CC	PPP.512	Phytochemical techniques and analysis	4	1	-	4	25	25	25	25	100
3	CC	PPP.513	Basics of Drug Design and Drug Actions	4	1	-	4	25	25	25	25	100
4	CC	PPP.514	Extraction and Isolation of Natural Products- Practical	-	-	4	2	-	-	-	-	50
5	CC	PPP.515	Analyses and Molecular Modeling of Natural Products-Practical	-	-	4	2	-	-	-	-	50
6	EC	PPP.516	Seminar	-	-	4	2	-	-	-	-	50
7	EC	XXX.###	Inter-Disciplinary Course (From Other Departments)	2	-	-	2	10	15	15	10	50
Opt any one course from following elective courses												
8	EC	PPP. 517	Chemistry of Natural Products	4	1	-	4	25	25	25	25	100
		PPP. 518	Advance Medicinal Chemistry									
		PPP. 519	Green Chemistry									
				<b>16</b>	<b>4</b>	<b>12</b>	<b>24</b>					<b>600</b>
Interdisciplinary courses offered by Chemical and Pharmaceutical Faculty (For students of other Centres)												
01		PPP.551	Diseases and Medicines	2	-	-	2	10	15	15	10	50
02		PPP.552	Chemicals of Everyday Life	2	-	-	2	10	15	15	10	50
03		PPP.553	Spectroscopy in Drug Development and Analyses	2	-	-	2	10	15	15	10	50

A: Continuous Assessment: Based on Objective Type Tests

B: Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)

C: Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged

Subjective Type)

D: End-Term Exam (Final): Based on Objective Type Tests

E: Total Marks

**L: Lectures T: Tutorial P: Practical Cr: Credits**

**CC: Core Course, EC: Elective Course, FC: Foundation Course**

**SEMESTER 3**

S.No	Paper		Course Title	L	T	P	Cr	% Weightage				E
	Type of Course	Code						A	B	C	D	
1	FC	PPP. 601	Research Methodology	2	-	-	2	10	15	15	10	50
2	FC	PPP. 602	Biostatistics	2	-	-	2	10	15	15	10	50
3	FC	PPP. 603	Biostatistics - Practical	-	-	4	2	-	-	-	-	50
4	CC	PPP. 604	Mid-Term Evaluation of Thesis	-	-		18					450
				<b>04</b>	<b>-</b>	<b>4</b>	<b>24</b>					<b>600</b>

**CC: Core Course, EC: Elective Course, FC: Foundation Course**

### SEMESTER 4

S.No	Paper		Course Title	L	T	P	Cr	% Weightage				E
	Type of Course	Code						A	B	C	D	
1	EC	PPP. 605	Medicinal Chemistry of Anticancer Agents	4	1	-	4	25	25	25	25	100
2	CC	PPP. 606	Thesis Evaluation and Viva Voce	-	-	-	20	-	-	-	-	500
				<b>04</b>	<b>-</b>	<b>4</b>	<b>24</b>					<b>600</b>

A: Continuous Assessment: Based on Objective Type Tests

B: Pre-Scheduled Test-1: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)

C: Pre-Scheduled Test-2: Based on Objective Type & Subjective Type Test (By Enlarged Subjective Type)

D: End-Term Exam (Final): Based on Objective Type Tests

E: Total Marks

**L: Lectures T: Tutorial P: Practical Cr: Credits**

**CC: Core Course, EC: Elective Course, FC: Foundation Course**

## Semester 1

**Course Title: Computer Applications**

**Paper Code: PPP.501**

L	T	P	Credits	Marks
2	0	0	2	50

### Unit 1

**18 hours**

**Fundamentals of computers:** Parts of computers, Hardware, BIOS, Operating systems, Binary system, Logic gates and Boolean algebra.

**Application software:** Spreadsheet applications, Word-processing applications, Presentation applications, Internet browsers, Reference Management, and Image processing applications.

### Unit 2

**18 hours**

**Computer language:** Basic DOS commands, AutoHotKey scripting language, HTML and basic structure of a webpage, Designing websites.

**World wide web:** Origin and concepts, Latency and bandwidth, Searching the internet, Advanced web-search using Boolean logic, Cloud computing.

### *Suggested Readings:*

1. Gookin, D. (2007). *MS Word 2007 for Dummies*. Wiley.
2. Harvey, G. (2007). *MS Excel 2007 for Dummies*. Wiley.
3. Johnson, S. (2009). *Windows 7 on demand*. Perspiration Inc.
4. Norman, G. and Streiner, D. (3<sup>rd</sup> edn) (2008). *Biostatistics: The Bare Essentials*. Decker Inc., Canada.
5. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*, W.H. Freeman and Company, New York.
6. Thurrott, P. and Rivera, R. (2009). *Windows 7 Secrets*. Wiley.

**Course Title: Organic Chemistry-I**

L	T	P	Credits	Marks
4	1	0	4	100

**Paper Code: PPP.502****Unit 1****22 hours**

**Stereochemistry:** IUPAC nomenclature of organic molecules, Elements of symmetry, chirality, Projection formulae [Fly wedge, Fischer, Newman and Saw horse], Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity, racemic mixture and their resolution, configurational notations of simple molecules, DL and RS configurational notations, threo and erythro isomers, methods of resolution, optical purity, enantiotopic and diastereotopic atoms, groups and faces, stereospecific and stereoselective synthesis, Asymmetric synthesis, Optical activity in the absence of chiral carbon (biphenyls, allenes and spiranes), chirality due to helical shape, stereochemistry of the compounds containing nitrogen, sulphur and phosphorus, conformational analysis of cyclic compounds such as cyclopentane, cyclohexane, cyclohexanone derivatives, decalins, 1,2-, 1,3-, 1,4-disubstituted cyclohexane derivatives and D-Glucose, effect of conformation on the course of rate of reactions, effect of conformation on reactivity, conformation of sugars, strain due to unavoidable crowding, geometrical isomerism, *cis-trans* and E-Z conventions, methods of inter-conversion of E and Z isomers, determination of configuration by physical and chemical methods.

**Unit 2****18 hours**

**Aliphatic nucleophilic substitution reaction:** The SN<sub>2</sub>, SN<sub>1</sub>, mixed SN<sub>1</sub> and SN<sub>2</sub> and SET mechanism, The S<sub>N</sub>i mechanism. Nucleophilic substitution at an allylic, aliphatic and vinylic carbon. Reactivity effects of substrate structure, attacking nucleophile, leaving group and reaction medium, ambident nucleophile, regioselectivity, competition between SN<sub>1</sub> and SN<sub>2</sub> mechanism.

**Aromatic nucleophilic substitution:** The S<sub>N</sub>Ar, benzyne and SN<sub>1</sub> mechanism, reactivity effect of substrate structure, leaving group and attacking nucleophile.

**Aliphatic electrophilic substitution:** Bimolecular mechanisms SE<sub>2</sub> and SE<sub>1</sub> mechanism, electrophilic substitution accompanied by double bond shifts, effect of substrates, leaving groups and the solvent polarity on the reactivity.

**Aromatic electrophilic substitution:** The arenium ion mechanism, orientation and reactivity, energy profile diagrams, ortho/para ratio, ipso attack, orientation in other ring systems, quantitative treatment of reactivity in substrates and electrophiles, Diazonium coupling, Vilsmeier reaction, Gatterman-Koch reaction.

**Unit 3****16 hours**

**Elimination reactions:** The E<sub>2</sub>, E<sub>1</sub> and E<sub>1</sub>cB mechanisms and their spectrum, orientation of the double bond, reactivity effects of substrate structures, attacking base, the leaving group and the medium, mechanism and orientation in pyrolytic elimination.

**Addition to carbon-carbon multiple bonds:** Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, Regio- and



chemoselectivity, orientation and reactivity, hydroboration, alkylation, epoxidation and hydroxylation, addition of halogen polar reagents to alkenes.

#### Unit 4

16 hours

**Addition to carbon-hetero multiple bonds:** Reactivity of carbonyl group, homologation and dehomologation of carbonyl compounds, nucleophilic addition of hetero-atoms (N,O,S), conjugate addition reactions, acylation of carbonyl carbon, carbonyl cyclizations and cleavages, carboxylic acids and derivatives, decarboxylation reactions, addition of Grignard, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds, mechanism of condensation reactions involving enolates-Aldol, Knoevenagel, Claisen, Mannich, Benzoin, Perkin and Stobbe reactions, hydrolysis of esters and amides, ammonolysis of esters.

#### *Suggested Readings:*

1. Finar, I.L., (2003). *Organic Chemistry Vol. 1*. Pearson Education, 4<sup>th</sup> edition.
2. Mc Murry J., *Organic Chemistry*, Asian Book Pvt. Ltd, 8<sup>th</sup> edition, New Delhi
3. Smith, M. B. (2013). *March's advanced organic chemistry: reactions, mechanisms, and structure*. John Wiley & Sons.
4. Ahluwalia, V. K., and Parasar R. K., (2011). *Organic Reaction Mechanism*, Narosa Publishing House (P) Ltd., 4<sup>th</sup> edition, New Delhi-110002.
5. Bansal, R. K., (2010). *A text book of Organic Chemistry*, New Age International (P) Ltd., 5<sup>th</sup> edition, New Delhi.
6. Bansal R.K., (2010). *Organic Reaction Mechanism*, New Age International (P) Ltd., New Delhi.
7. Kalsi, P.S., (2010). *Organic Reactions and Their Mechanisms*. New Age International Pub., 3<sup>rd</sup> edition, New Delhi.
8. Kalsi, P.S., (2010). *Stereochemistry: Conformation and Mechanism*, New Age International (p) Ltd. New Delhi.
9. Lowry, T. H., Richardson K. S., (1998). *Mechanism and Theory in Organic Chemistry*, Addison-Wesley Longman Inc., 3<sup>rd</sup> edition, New York.
10. Morrison, R.T., Boyd, R.N. (2011). *Organic Chemistry*, Prentice- Hall of India, 6<sup>th</sup> edition, New Delhi.
11. Mukherjee, S.M. Singh, S.P., (2009). *Reaction Mechanism in Organic Chemistry*. Macmillan India Ltd., 3<sup>rd</sup> edition, New Delhi.
12. Robert and Casereo, (1977). *Basic principle of Organic Chemistry*, Addison-Wesley, 2<sup>nd</sup> edition.
13. Solomn, C.W.G, Fryble, C.B. (2009). *Organic Chemistry*. John Wiley and Sons, Inc., 10<sup>th</sup> edition.
14. Sykes, P., (1997). *A Guide Book to Mechanism in Organic Chemistry*, Prentice Hall, 6<sup>th</sup> edition.
15. Eliel, E. L., & Wilen, S. H. (2008). *Stereochemistry of organic compounds*. John Wiley & Sons.

**Course Title: Advances in Pharmacognosy and Phytochemistry**

L	T	P	Credits	Marks
4	1	0	4	100

**Paper Code: PPP.503****Unit 1****12 hours**

**Natural Products as drugs:** Historical background, present status and future scope of natural products in drug discovery; Lipinski rule; Different approaches to drug discovery- Rational (sense), irrational (non-sense) and antisense approach; Selection of natural sources for drug development based on random, phytoconstituents and ethnopharmacological records

**Unit 2****14 hours**

**Biotechnological aspects:** DNA recombinant technology, mutation, polyploidy and hybridization to improve the quality of vegetable drugs and their constituents, chemical races. Plant growth regulators and their use, scope and limitations in Pharmacognosy, Effect of growth hormones on production of secondary plant metabolites, Pharming in plants, Transgenic medicinal plants *Catharanthus roseus*, *Papaver somniferum*, *Panax ginseng*.

**Unit 3****20 hours**

**Pharmacognostic aspects of tissue culture:** Plant tissue culture techniques & its application in relation to phytopharmaceuticals: Techniques of initiation & maintenance of various types of cultures, Immobilized cell techniques (survey of recent advances), Germ plasm storage, biotransformation studies, recent advances in elicitor techniques and production of biological active constituents in static, suspension, multiple shoot cultures. Bioreactors for production of biologically active constituents and other applications of plant tissue culture techniques. Biosynthetic potential of tissue cultures and factors affecting production of secondary metabolites by tissue culture techniques. *Azadirachta indica*, *Melia azadirachta*, *Cassia fistula*

**Unit 4****14 hours**

**Cultivation methods** developed in India for the following medicinal plants and commercial significance: *Stevia rebaudiana*, *Podophyllum hexandrum*, *Ocimum sanctum*, *Colchium officinalis*, *Curcuma longa*, *Taxus baccata*, *Glycyrrhiza glabra*, *Azadirachta indica*.

**Unit 5****12 hours**

Discovery of Lead Molecules from Natural Sources and their Contribution to Modern Therapeutics: Vinca alkaloids, podophyllum lignans, quinine, artemisinin, digitalis glycosides, paclitaxel, Volatile oils and aromatherapy, Industrial scenario of nutraceuticals in India

**Suggested Readings**

1. W.C. Evans, Trease and Evans, Pharmacognosy, 15th edition, W.B. Saunders & Co., London, 2002.

2. Tyler, V.E., Brady, L.R. and Robbers, J.E., Pharmacognosy, 9th Edn., Lea and Febiger, Philadelphia, 1988.
2. H.E. Street, Plant Tissue and Cell Culture, Blackwell Scientific Publication, London, 1977.
3. A.N. Kalia, Textbook of Industrial Pharmacognosy, CBS Publishers, New Delhi
4. Margaret L, Vickery and Brian Vickery, Secondary Plant Metabolism, The Macmillan Press Ltd, London, 1981.
5. R Endress, Plant cell Biotechnology, Springer-Verlag, Berlin, 1994.
6. Torseel KBG. Natural Product Chemistry. John Wiley and Sons, New York. Latest Edition.
7. Harborne JB. Phytochemical Methods. Chapman and Hall, London. Latest Edition.
8. Atal, C.K., Kapur, B.M., Cultivation and Utilization of Medicinal and Aromatic Plants, R.R.L., Jammu.
9. Staba, E.J., Applied and Fundamental Aspects of Plant Cell, Tissue and organ (Reivert J. and Y.P.S., Bajaj Ed.), Berlin.
10. Tabata, M., Plant Tissue Culture and its Biotechnological Applications, Berlin.
11. Reinhard, E., Tissue Culture and Plant Science, Academic Press, London.
12. Gene Cloning and DNA Analysis,-An Introduction (2001) Brown T. A., Blackwell Publishing
13. Principles of Gene Manipulation and Genomics (2001) - Primrose S. B. & Twyman R. M, Blackwell Publishing
14. Hopkins, W.G. and Huner, N.P.A. (2010). *Introduction to Plant Physiology*. 4<sup>th</sup> Edition, John Wiley and Sons, Inc.
15. Taiz, L. and Zeiger, E. (2010). *Plant Physiology*. Sinauer Associates Inc. U.S.A.
16. Ali, M. (2011). Pharmacognosy (Pharmacognosy and Phytochemistry). CBS Publisher & Distributors P Ltd.
17. Kokate, CK, Purohit, AP and Gokhale, SB. (2011). Pharmacognosy. Nirali Prakashan.
18. Denston, TC. (2012). A Textbook of Pharmacognosy. Kellock Robertson Press.
19. Mukherjee, PK. (2012). Quality Control of Herbal Drugs, Business Horizons; Reprint 2012 edition.
20. Rogers, K. (2012). Out of Nature: Why Drugs from Plants Matter to the Future of Humanity, University of Arizona Press; 1 edition.
21. Kar, A. (2007). Pharmacognosy and Pharmaco- biotechnology, New Age International Pvt Ltd Publishers.

**Course Title: Laboratory of Pharmacognosy and Phytochemistry-Practical**

L	T	P	Credits	Marks
-	-	4	2	50

**Paper Code: PPP.504**

Microscopical methods of examining crude drugs, Determination of stomatal index, Palisade ratio, Determination of stomatal number, Determination of total ash, Determination of acid insoluble, water soluble and sulphated ash, Determination of Iodine value, Method of alkaloid determination

Maceration, Hot continuous extraction, percolation, Ultrasound-assisted, Microwave-assisted, Accelerator-assisted solvent extraction, spraying reagents for identification of different secondary metabolites: terpenoids, Flavonoids, alkaloids, steroids, carbohydrates

Thin layer chromatography: Determination of purity of a given sample, monitoring the progress of chemical reactions, identification of unknown organic compounds by comparing the  $R_f$  values of known standards, preparative TLC for separation of mixtures.

Study of molecules using molecular models

***Suggested Readings:***

1. Handa, S.S, Khanuja, SPS, Longo, G and D.D.Rakesh. Extraction technologies for Medicinal and Aromatic plants. International Centre for Science and High technology, CRC Press, USA
2. Protocol for testing Ayurvedic, Siddha, and Unani Medicines, Department of Ayush, Government of India
3. Khandelwal, KR. (2008). Practical Pharmacognosy, Nirali Prakashan; 18th edition.
4. Zafar, R and Gandhi, N. (2007). Practical Pharmacognosy, CBS Publishers & Distributors.

**Course Title: Spectral Analysis-Practical**

L	T	P	Credits	Marks
-	-	4	2	50

**Paper Code: PPP.505**

Structure elucidation of unknown medicinal/ organic compounds via interpretation of their  $^1\text{H}$ ,  $^{13}\text{C}$  NMR, FT-IR and Mass spectra.

**Course Title: Computer Applications-Practical**  
**Paper Code: PPP.506**

L	T	P	Credits	Marks
-	-	4	2	50

1. Experimental design and analysis
2. Training on basic usage of Microsoft Word, Microsoft Excel, Microsoft PowerPoint and Internet Explorer
3. Optimizing web search: Google advanced search, Boolean operators, Literature search using Google Scholar, HighWire
4. Bibliography management and research paper formatting using reference software EndNote
5. Creating a functional website using HTML
6. Basic programming using DOS batch files and AutoHotKey

***Suggested Readings:***

1. Gookin, D. (2007). *MS Word 2007 for Dummies*. Wiley.
2. Harvey, G. (2007). *MS Excel 2007 for Dummies*. Wiley.
3. Johnson, S. (2009). *Windows 7 on demand*. Perspiration Inc.
4. Thurrott, P. and Rivera, R. (2009). *Windows 7 Secrets*. Wiley.

**Course Title: Seminar**  
**Paper Code: PPP.507**

L	T	P	Credits	Marks
-	-	4	2	50

## Elective Courses

Course Title: Spectral Analyses

Paper Code: PPP.508

L	T	P	Credits	Marks
4	1	0	4	100

### Unit 1

18 hours

**UV-Visible spectroscopy:** Principle of UV-Visible Spectroscopy, Chromophores and their interaction with UV-visible radiation and their utilization in structural, qualitative and quantitative analysis of drug molecules. Woodward-Fieser rule, solvent effects, stereochemical effect.

**Infrared Spectroscopy:** Infrared radiation and its interaction with organic molecules, vibrational mode of bonds, instrumentation and applications, effect of hydrogen bonding and conjugation on absorption bands, interpretation of IR spectra. FTIR.

### Unit 2

18 hours

**Nuclear magnetic resonance spectroscopy:** Magnetic properties of nuclei, Field and precession, Chemical shift concept, Isotopic nuclei, Reference standards and solvents.  $^1\text{H}$ - NMR spectra, Chemical shifts, Spin spin coupling, Coupling constants, Integration of signals, Interpretation of spectra, Decoupling, double resonance and shift reagent methods, Long range coupling, Resonance of other nuclei e.g.  $^{19}\text{F}$ ,  $^{15}\text{N}$ ,  $^{31}\text{P}$ .

### Unit 3

18 hours

Principles of FT-NMR with reference to  $^{13}\text{C}$  NMR, Free induction decay, Average time domain and frequency domain signals, Spin-spin and spin-lattice relaxation phenomenon, Nuclear Overhauser enhanced (NOE),  $^{13}\text{C}$  NMR spectra, their interpretation and application. APT and DEPT techniques, Principle of 2-D NMR, Correlation spectroscopy (COSY) Homo COSY ( $^1\text{H}$ - $^1\text{H}$  COSY), Hetro COSY ( $^1\text{H}$ - $^{13}\text{C}$  COSY, HMQC), long range  $^1\text{H}$ - $^{13}\text{C}$  COSY (HMBC), NOESY, DEPT and 2D INADEQUATE experiments and their application, Solid-state NMR.

### Unit 4

18 hours

**Mass spectrometry:** Basic principles and brief outline of instrumentation, Ion formation, molecular ion, metastable ion, Mc Lafferty rearrangement, Nitrogen rule, fragmentation process in relation to molecular structure and functional groups. Relative abundance of isotopes, chemical ionization, FAB, ESI and MALDI other recent advances in mass spectrometry.

### Suggested Readings:

1. Banwell, C.N.; McCash, E. M. (2000). *Fundamentals of molecular spectroscopy*, Tata McGraw-Hill, New Delhi.
2. Dyer, J.R. (2009). *Application of Absorption Spectroscopy of Organic Compounds*, Publisher: Phi Learning.
3. Kalsi, P.S. (2004). *Spectroscopy of Organic Compounds*, New Age International Ltd.
4. Kemp, W. (1991). *Organic spectroscopy*, ELBS London.

5. Khopkar, S.M. (2007). *Basic Concepts of Analytical Chemistry*, New Age International Pvt Ltd.
6. Melinda J.D., (2010). *Introduction to solid NMR Spectroscopy*, Wiley India Pvt Ltd
7. Mendham, J.; Denney, R.C.; Barnes, J. D.; Thomas, M. J. K. (2003). *Vogel's Textbook of Quantitative Chemical Analysis*, Pearson Education Pvt. Ltd., New Delhi.
8. Pavia, D.L.; Lampman, G. M. (2010). *Introduction to Spectroscopy*, G. S. Kriz, Harcourt College, NY.
9. Popov, A.I.; Halenga, K. (1991). *Modern NMR techniques and their Applications*, Marcel Dekker.
10. Silverstein, R.M. (2006). *Spectrometric Identifications of Organic Compounds*, John Wiley.
11. Skoog, D.A.; West, D.M.; Holler, F.J.; Crouch, S.R. (2004). *Fundamental of Analytical Chemistry*, Saunders College Publishing, New York.
12. Willard, H.H.; Merrit, L.L.; Dean, J.A.; Settle, F.A. (2001). *Instrumental methods of analysis*, CBS Publishers and Distributors.
13. Williams, D.H.; Fleming, I. (2004). *Spectroscopy Methods in Organic Chemistry*, Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

Course Title: Medicinal Chemistry

L	T	P	Credits	Marks
4	1	-	4	100

Paper Code: PPP.509

**Unit 1** **10 hours**

**History of drug discovery:** Introduction, Drug discoveries, Recent trends in drug discovery.

**Unit 2** **20 hours**

**Medicinal chemistry:** Definitions and objectives, Drug activity phases, Drug classification system.

**Measurement and expression of drug effects:** Introduction, In-vitro experiments, Ex-vivo experiments, In-vivo experiments.

**Unit 3** **22 hours**

**Molecular drug targets:** Introduction, Enzymes as drug targets, Membrane transporters as drug targets, Voltage-gated ion channels as drug targets, Non-selective cation-channels as drug targets, Direct ligand gated ion channels, Receptors with intrinsic enzyme activity, Receptors coupled to various cytosolic proteins, G-Protein coupled receptors, Nuclear receptors.

**Unit 4** **20 hours**

**Drug targets, target identification, validation and screening:** Introduction, Improving the resolution of disease etiology, Biopharmaceutical therapies, Drug target identification, Hit to lead, Clinical biomarkers

***Suggested Readings:***

1. Delgado, J. N. and Remers W A, Ed. (2010). *Wilson & Gisvold's Textbook of Organic and Pharmaceutical Chemistry*, J. Lippincott Co., Philadelphia.
2. Foye, W. C. (2008). *Principles of Medicinal Chemistry*, Publisher: Lea and Febiger, Philadelphia.
3. King, F. D. (2006). *Medicinal Chemistry Principles and Practice*, Royale Society of Chemistry, Second Edition.
4. Nogardy, T. and Weaver D F (2005). *Medicinal Chemistry: A Molecular and Biochemical Approach*, Oxford University Press, Third Edition.
5. Patrick, G.L. (2009). *An Introduction to Medicinal Chemistry*, Publisher: I.K. International Pvt. Ltd.
6. Singh, H., Kapoor, V.K. (Latest Edition). *Medicinal and Pharmaceutical Chemistry* Vallabh Prakashan, Delhi.



7. Smith, H.J. (2006). *Introduction to the Principles of Drug Design and Action*, Taylor and Francis, Fourth Edition.
8. Wermuth, C.G. (2009). *The Practice of Medicinal Chemistry*, Academic Press (Elsevier).
9. Wolff, M E, Ed., (Latest Edition). *Burger's Medicinal Chemistry and Drug Discovery* John Wiley and Sons, New York.

**Course Title: Logics of Organic Synthesis**

L	T	P	Credits	Marks
4	1	-	4	100

**Paper Code: PPP.510****Unit 1** **16 hours**

**Reaction mechanism, structure and reactivity:** Type of mechanisms, types of reactions, thermodynamic and kinetic requirements, kinetic and thermodynamic control, Hammond's postulate, Curtin-Hammett principle, Potential energy diagrams, transition states and intermediates, methods of determining mechanisms, isotopes effects, effect of structure on reactivity; resonance, inductive, electrostatic and steric effect, quantitative treatment, the Hammett equation and linear free energy relationship, substituent and reaction constants, Taft equation.

**Unit 2** **16 hours**

**Photochemistry:** Franck-Condon principle, Jablonski diagram, Singlet and triplet states, Photosensitization, Quantum efficiency, Photochemistry of carbonyl compounds, Norrish type-I and type-II cleavages, Paterno-Buchi reaction, Photoreduction, Photochemistry of enones and para-benzoquinones, Di  $\pi$  – methane rearrangement.

Photochemistry of aromatic compounds, Photo-Fries reactions of anilides, Photo-Fries rearrangement, Barton reaction, Singlet molecular oxygen reactions, Photochemical formation of smog, Photo degradation of polymers, Photochemistry of vision

**Unit 3** **18 hours**

**Metal and non-metal mediated oxidation and reductions:** Mechanism, selectivity, stereochemistry and applications of oxidation reactions, Oppenauer, Baeyer-Villiger, Oxidation reactions using DDQ, NBS, leadtetraacetate, selenium dioxide, DCC, PCC, CAN, Cr and Mn reagents, periodic acid, Osmium tetroxide, Swern oxidations, hydroboration, dehydrogenation, ozonolysis, epoxidations using peracids.

Mechanism, selectivity, stereochemistry and applications of catalytic hydrogenations using Pd, Pt and Ni catalysts, Clemmensen reduction, Wolff-Kishner reduction, Meerwein-Ponndorf-Verley reduction, Dissolving metal reductions, metal hydride reductions using  $\text{NaBH}_4$ ,  $\text{LiAlH}_4$ , DIBAL. Wilkinson's Rh catalysis, Boron in reduction

**Unit 4** **22 hours**

**Heterocyclic chemistry:** Replacement and systematic nomenclature (Hantzsch-Widman system) for monocyclic, fused and bridged heterocycles, Aromatic heterocycle, Non-aromatic heterocycle: Bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles and their synthesis

(a) Three-membered and four-membered heterocycles: synthesis and reactions of aziridines, oxiranes, thiranes, azetidines, oxetanes and thietanes.

(b) Five membered heterocycles containing two heteroatoms (S,N,O): Diazoles, oxazoles and thiazoles.

(c) Benzo-fused five-membered and six membered heterocycles: Synthesis and reactions of indoles, benzofurans and benzimidazoles, benzothiazoles.

(d) Six-membered heterocycles with one heteroatom: Synthesis and reactions of pyrylium salts and pyrones, coumarins, chromones.

(e) Six-membered heterocycles with 2 or more nitrogen atoms: Synthesis, reactivity, aromatic character and importance of the following heterocycles: 1,2,3-triazoles, 1,2,4-triazoles, tetrazoles, 1,2,4-oxadiazole, 1,3,4-oxadiazole, 1,2,5-oxadiazole, 1,2,3-thiadiazoles, 1,2,4-thiadiazoles, 1,3,4- thiadiazoles, 1,2,5- thiadiazoles, 1,2,3-triazine, 1,2,4- triazine, 1,3,5- triazine and tetrazines.

### ***Suggested Readings:***

1. Acheson, R.M. (1976). *An introduction to the Chemistry of heterocyclic compounds*, Wiley India Pvt. Ltd., 3<sup>rd</sup> edition.
2. Ahluwalia, V. K., and Parasar R. K., (2011). *Organic Reaction Mechanism*, Narosa Publishing House (P) Ltd., 4<sup>th</sup> edition, India.
3. Bansal, R. K., (2012). *Organic Reaction Mechanism*, New Age International (P) Ltd., 4<sup>th</sup> edition, New Delhi.
4. Bansal, R. K., (2007). *A text book of Organic Chemistry*, New Age International (P) Ltd., 5<sup>th</sup> edition, New Delhi.
5. Bansal, R.K. (2010). *Heterocyclic Chemistry*, New Age International (P) Ltd., 5<sup>th</sup> edition, New Delhi.
6. Carey B. F. A., Sundberg R.J., (2007). *Advanced Organic Chemistry Part A and Part B*, Springer, 5<sup>th</sup> edition.
7. Finar, I. L. S., (2012). *Organic Chemistry Vol. 1*, Pearson Education, 6<sup>th</sup> edition, UK.
8. Gilchrist, T.L. (1997). *Heterocyclic Chemistry*, Longman, Prentice Hall, 3<sup>rd</sup> edition, US.
9. Gupta R.R., Kumar M., Gupta V. (2010). *Heterocyclic Chemistry-II Five Membered Heterocycles Vol. 1-3*, Springer Verlag, India.
10. Joule, J.A., Mills, K. (2010). *Heterocyclic Chemistry*, Blackwell Publishers, 5<sup>th</sup> edition, New York.
11. Kalsi, P. S., (2008). *Stereochemistry: Conformation and Mechanism*, New Age International (P) Ltd., 7<sup>th</sup> edition, India.
12. Kalsi P. S., (2010). *Organic Reactions and Their Mechanisms*, New Age International Publication, 3<sup>rd</sup> edition, New Delhi.
13. Lowry, T. H., Richardson K. S., (1998). *Mechanism and Theory in Organic Chemistry*, Addison-Wesley Longman Inc., 3<sup>rd</sup> edition, US.
14. Morrison, R.T., Boyd R.N., (2011). *Organic Chemistry*, Prentice- Hall of India, New Delhi.
15. Mukherjee S. M., Singh S. P., (2009). *Reaction Mechanism in Organic Chemistry*, Macmillan India Ltd., New Delhi.
16. R. Katritzky, (2010). *Handbook of Heterocyclic Chemistry* Elsevier, 3<sup>rd</sup> edition, UK.

17. Smith, M. B. (2013). *March's advanced organic chemistry: reactions, mechanisms, and structure*. John Wiley & Sons.

## Interdisciplinary Courses

**Course Title: Diseases and Medicines**

**Paper Code: PPP.551**

L	T	P	Credits	Marks
2	0	0	2	50

**Course Objective:** This course is designed to provide the students with basic diseases and their common medicines used for their treatment.

### Unit 1

**18 hours**

General awareness of Life style diseases like hypertension, diabetes, etc. management, use of medicines, and their side effects. General awareness of cancer and medicines for their treatment and management along with their side effects.

### Unit 2

**18 hours**

General awareness of Viral, bacterial, or other infectious diseases, precautions, medicines, their uses and side effects. General awareness of cancer and medicines for their treatment and management along with their side effects.

#### ***Suggested Readings:***

1. Brunton, Laurence L., John S. Lazo, and Keith L. Parker. "Goodman and Gilman's the pharmacological basis of therapeutics." *McGraw-Hill, New York, Latest Edition.*
2. Tripathi, K. D. *Essentials of medical pharmacology.* JP Medical Ltd, 2013.  
Katzung, Bertram G., ed. "Basic & clinical pharmacology." *Latest Edition.*

**Course Title: Chemicals of Everyday Life**  
**Paper Code: PPP.552**

L	T	P	Credits	Marks
2	0	0	2	50

**Unit 1** **9 hours**

**Chemicals and safety**

Chemicals in daily life, Cosmetics, Perfumes, Soaps and detergents, Cleaning action of detergent, Handling of strong acids and bases, Disinfectant, Insecticides and pesticides, Chemical treatment of vegetables and fruits

**Unit 2** **9 hours**

**Common chemical processes**

Chemical reactions, Basics of organic synthesis, Chemistry of photosynthesis, Rusting, Electrochemical cells, Metal electroplating, Acid base titration in the lab

Use of polymers in daily life, Polymer based products, Teflon, Polystyrene, Plastic bags, ATM cards.

**Unit 3** **9 hours**

**Chemistry of small bioactive molecules**

Caffeine, Nicotine, Paracetamol, Aspirin, DNA and RNA bases, Carbohydrates

Abused substances like morphine, Cannabis, Cocaine etc.

**Unit 4** **9 hours**

**Green chemical processes**

Environment friendly process, Principle of green chemistry, Atom economy and scope, Prevention/Minimization of hazardous/toxic products, Designing safer chemicals, Selection of appropriate auxiliary substances (solvents, separation agents etc), Use of renewable starting materials, Avoidance of unnecessary derivatization-careful use of blocking/protection groups

**Microwave in organic synthesis:** Introduction to synthetic organic transformation under microwave (i) Microwave assisted reactions in water (ii) Microwave assisted reactions in organic solvents. (iii) Microwave in solvent free reactions

**Suggested Readings**

1. Singh, K.; *Chemistry in Daily Life*, PHI learning, 3<sup>rd</sup> edition India
2. Glasstone, S.; *Chemistry in Daily Life*, Cornell University, Methuen & Company Limited, 1929
3. Cohan, L.; *Chemistry in Daily Life; Popular Lectures*, HardPress, 2012
4. Anastas, P.T.; Warner J. C. (2000). *Green chemistry, Theory and Practical*. Oxford University Press, 1<sup>st</sup> edition, US.
5. Grieco, P.A. (1997). *Organic Synthesis in Water*. Blackie, 1<sup>st</sup> edition

**Course Title: Spectroscopy in Drug Development and Analyses**

L	T	P	Credits	Marks
2	-	0	2	50

**Paper Code: PPP.553****Unit 1** **9**  
**hours**

**UV-Visible spectroscopy:** Principle of UV-Visible Spectroscopy, Chromophores and their interaction with UV-visible radiation and their utilization in structural, qualitative and quantitative analysis of drug molecules. Woodward-Fieser rule, solvent effects

**Unit 2** **9**  
**hours**

**Infrared spectroscopy:** Infrared radiation and its interaction with organic molecules, Determination of functional groups of drug molecules by IR, interpretation of IR spectra, FTIR.

**Unit 3** **9**  
**hours**

**Nuclear magnetic resonance spectroscopy:** Applications of NMR for determining the structure of drug molecules, <sup>1</sup>H- NMR spectra, <sup>13</sup>C NMR, DEPT, HMQC, HMBC, quantitative analysis

**Unit 4** **9**  
**hours**

**Mass spectrometry:** Basic principles and brief outline of instrumentation, Applications of mass spectroscopy for determining the structure of the drug, GC, LC

**Suggested Readings:**

1. Banwell, C.N.; McCash, E. M. (2000). *Fundamentals of molecular spectroscopy*, Tata McGraw-Hill, 4<sup>th</sup> edition, New Delhi.
2. Dyer, J.R. (2009). *Application of Absorption Spectroscopy of Organic Compounds*, PHI Learning, 2<sup>nd</sup> edition.
3. Kalsi, P.S. (2004). *Spectroscopy of Organic Compounds*, New Age International Ltd., 6<sup>th</sup> edition, New Delhi.
4. Kemp, W. (1991). *Organic spectroscopy*, ELBS London, 2<sup>nd</sup> edition.
5. Khopkar, S.M. (2007). *Basic Concepts of Analytical Chemistry*, New Age International Pvt Ltd.
6. Melinda J.D., (2010). *Introduction to solid-state NMR Spectroscopy*, Blackwell publishing, Oxford UK.
7. Mendham, J.; Denney, R.C.; Barnes, J. D.; Thomas, M. J. K. (2003). *Vogel's Textbook of Quantitative Chemical Analysis*, Pearson Education Pvt. Ltd., 6<sup>th</sup> edition, New Delhi.
8. Pavia, D.L.; Lampman, G. M. (2010). *Introduction to Spectroscopy*, G. S. Kriz, Harcourt College, 4<sup>th</sup> edition, NY.

9. Popov, A.I.; Halenga, K. (1991). *Modern NMR techniques and their Applications in Chemistry*, Marcel Dekker.
10. Sethi, P. D.; Sethi, R. (2007). *HPLC: High performance of liquid chromatography*, Vol 2, CBS Publishers and Distributors.
11. Silverstein, R.M. (2006). *Spectrometric Identifications of Organic Compounds*, John Wiley, 6<sup>th</sup> edition, .
12. Skoog, D.A.; West, D.M.; Holler, F.J.; Crouch, S.R. (2004). *Fundamental of Analytical Chemistry*, Saunders College Publishing, 7<sup>th</sup> edition, New York.
13. Willard, H.H.; Merrit, L.L.; Dean, J.A.; Settle, F.A. (2001). *Instrumental methods of analysis*, CBS Publishers and Distributors, 2<sup>nd</sup> edition.
14. Williams, D.H.; Fleming, I. (2004). *Spectroscopy Methods in Organic Chemistry*, Tata McGraw-Hill Publishing Co. Ltd., 7<sup>th</sup> edition, New Delhi.



## Semester 2

Course Title: Organic Chemistry-II

Paper Code: PPP.511

L	T	P	Credits	Marks
4	1	0	4	100

### Unit 1

14 hours

**Reactive intermediates:** Generation, structure and reactions of carbocation, carbanion, free radicals, carbenes, nitrenes, benzyne, classical and non-classical carbocations, phenonium ions and norbornyl system, neighbouring group participation.

**Aromaticity:** Benzenoid and non-benzenoid compounds – generation and reactions.

### Unit 2

20 hours

**Synthetic methodologies:** Synthon, Synthetic equivalent, Functional group interconversion (FGI), Functional group addition, Functional group elimination, Criteria for selection of target, Linear and convergent synthesis, Retrosynthetic analysis and synthesis involving chemoselectivity, Regioselectivity, Reversal of Polarity (Umpolung), Synthesis of cyclic molecules, Strategic bond: Criteria for disconnection of strategic bonds, Importance of the order of events in organic synthesis. One group and two group C-X disconnections in 1,2-, 1,3-, 1,4 & 1,5- difunctional compounds, One group C-C disconnections, alcohol and carbonyl compounds, regioselectivity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis, Two group C-C disconnections, Diels-Alder reaction, 1,3-difunctionalised compounds, Control in carbonyl condensation, 1,5-difunctionalised compounds.

### Unit 3

16 hours

**Rearrangements:** General mechanistic considerations-nature of migration, migratory aptitude, memory effects, Mechanistic study of the following rearrangements: Pinacol-pinacolone, Wagner-Meerwein, Demjanov, Benzil-Benzilic acid, Favorskii, Arndt-Eister syntheses, Neber, Beckmann, Hofmann Curtius, Schmidt, Baeyer-Villiger, Shapiro reaction, Carroll, Claisen, Cope, Gabriel-Colman, Smiles and Sommelet-Hauser rearrangements.

**Selective Name Reactions:** Aldol, Perkin, Stobbe, Dieckmann Condensation, Reimer-Tiemann, Reformatsky and Grignard reactions, Diels-Alder reaction, Robinson Annelation, Michael addition, Mannich reaction, Stork-enamine, Sharpless Assymmetric Epoxidation, Ene, Barton, Hofmann-Loffler Fretag, Shapiro reaction, Chichibabin Reaction.

### Unit 4

22 hours

**Pericyclic chemistry:** Introduction, Main features of pericyclic reactions, Classification of pericyclic reactions. Phases, nodes and symmetry properties of molecular orbitals in ethylene, 1,3-butadiene, 1,3,5- hexatriene. Allyl cation, allyl radical, pentadienyl cation and pentadienyl radical. Thermal and photochemical pericyclic reactions.

Electrocyclic reactions: Conrotation and disrotation. Electrocyclic closure and opening in  $4n$  and  $4n+2$  systems. Woodward-Hoffmann selection rules for electrocyclic reactions. Explanation for the mechanism of electrocyclic reactions by (i) symmetry properties of HOMO of open chain partner (ii) Conservation of orbital symmetry and orbital symmetry correlation diagrams and (iii)

Huckel-Mobius aromatic and antiaromatic transition state method. Examples of electrocyclic reactions.

Cycloaddition reactions: Suprafacial and antarafacial interactions.  $\pi^2 + \pi^2$  and  $\pi^4 + \pi^2$  cycloadditions. Cycloreversions. Stereochemical aspects in supra-supra, supra-antara, antara-supra and antara-antara  $\pi^2 + \pi^2$  and  $\pi^4 + \pi^2$  cycloadditions. Diels-Alder reaction. Woodward-Hoffmann Selection rules for cycloaddition reactions. Explanation for the mechanism of cycloaddition reactions by (i) Conservation of orbital symmetry and orbital symmetry correlation diagrams (ii) Fukui Frontier Molecular Orbital (FMO) theory and (iii) Huckel-Mobius aromatic and antiaromatic transition state method. Endo-exo selectivity in Diels-Alder reaction and its explanation by FMO theory. Examples of cyclo addition reactions.

Sigmatropic reactions: [1,j] and [i,j] shifts. Suprafacial and antarafacial shifts. Selection rules for [lj] shifts. Cope, and Claisen rearrangements. Explanation for the mechanism of sigmatropic reactions by (i) symmetry properties of HOMO (ii) Huckel-Mobius aromatic and antiaromatic transition state method. Introduction to Cheletropic reactions and the explanation of mechanism by FMO theory.

### ***Suggested Readings:***

1. Acheson, R.M. (1976). *An introduction to the Chemistry of heterocyclic compounds*, Wiley India Pvt. Ltd., 3<sup>rd</sup> edition.
2. Ahluwalia, V. K., and Parasar R. K., (2011). *Organic Reaction Mechanism*, Narosa Publishing House (P) Ltd., 4<sup>th</sup> edition, India.
3. Bansal, R. K., (2012). *Organic Reaction Mechanism*, New Age International (P) Ltd., 4<sup>th</sup> edition, New Delhi.
4. Bansal, R. K., (2007). *A text book of Organic Chemistry*, New Age International (P) Ltd., 5<sup>th</sup> edition, New Delhi.
5. Bansal, R.K. (2010). *Heterocyclic Chemistry*, New Age International (P) Ltd., 5<sup>th</sup> edition, New Delhi.
6. Carey B. F. A., Sundberg R.J., (2007). *Advanced Organic Chemistry Part A and Part B*, Springer, 5<sup>th</sup> edition.
7. Finar, I. L., (2012). *Organic Chemistry Vol. 1*, Pearson Education, 6<sup>th</sup> edition, UK.
8. Gilchrist, T.L. (1997). *Heterocyclic Chemistry*, Longman, Prentice Hall, 3<sup>rd</sup> edition, US.
9. Gupta R.R., Kumar M., Gupta V. (2010). *Heterocyclic Chemistry-II Five Membered Heterocycles Vol. 1-3*, Springer Verlag, India.
10. Joule, J.A., Mills, K. (2010). *Heterocyclic Chemistry*, Blackwell Publishers, 5<sup>th</sup> edition, New York.
11. Kalsi, P. S., (2008). *Stereochemistry: Conformation and Mechanism*, New Age International (P) Ltd., 7<sup>th</sup> edition, India.
12. Kalsi P. S., (2010). *Organic Reactions and Their Mechanisms*, New Age International Publication, 3<sup>rd</sup> edition, New Delhi.

13. Lowry, T. H., Richardson K. S., (1998). *Mechanism and Theory in Organic Chemistry*, Addison-Wesley Longman Inc., 3<sup>rd</sup> edition, US.
14. Morrison, R.T., Boyd R.N., (2011). *Organic Chemistry*, Prentice- Hall of India, New Delhi.
15. Mukherjee S. M., Singh S. P., (2009). *Reaction Mechanism in Organic Chemistry*, Macmillan India Ltd., New Delhi.
16. R. Katritzky, (2010). *Handbook of Heterocyclic Chemistry* Elsevier, 3<sup>rd</sup> edition, UK.
17. Smith, M. B. (2013). *March's advanced organic chemistry: reactions, mechanisms, and structure*. John Wiley & Sons.
18. Sykes, P., (1997). *A Guide Book to Mechanism in Organic Chemistry*, Prentice Hall, US.
19. Norman, R.O.C.; Coxon, J.M. *Principles of Organic Synthesis*, Blackie Academic & Professional.
20. Warren, S. *Organic Synthesis: The Disconnection Approach*, John Wiley.
21. Cheng, Xue-Min; Corey, E.J. *The Logic of Chemical Synthesis*, John Wiley.

**Course Title: Phytochemical techniques and analysis**

L	T	P	Credits	Marks
4	1	0	4	100

**Paper Code: PPP.512****Unit 1****18 hours**

**Extraction techniques:** Different extraction methods (maceration, percolation, hot continuous extraction, hydro distillation) including advanced extraction techniques like supercritical fluid extraction, accelerated solvent extraction, microwave-assisted extraction, ultrasound assisted extraction, solid-phase micro extraction including headspace techniques;

**Unit 2****18 hours**

**Isolation techniques:** Fractionation and solvent partitioning, General principles, classification, normal and reversed phase, bonded phase, separation mechanisms, Chromatographic separations including column chromatography, vacuum liquid chromatography, flash chromatography, prep TLC, Droplet counter-current chromatography (DCCC), ion exchange chromatography, centrifugal counter-current chromatography (CCC), Centrifugally accelerated chromatography, HPLC, HPTLC, GC

**Unit 3****18 hours**

**Structural characterization:** Purification techniques for isolated phytochemicals, Chemical assays for different natural products, introduction to different techniques of characterization of bioactive constituents such as flavonoids, terpenoids, alkaloids and steroids

**Unit 4****18 hours**

**Plant Drug Standardization:** Macroscopic: Organoleptic methods including morphology, sampling, preliminary examination and foreign matter; Microscopic: General microscopy, Histochemistry, Quantitative microscopic; Physico-chemical: Solubility, specific gravity, optical rotation, refractive index, melting point, swelling index, foaming index, moisture content, ash value, extractive values including volatile oil; General methods of assays for alkaloids, steroids, terpenoids, flavonoids, glycosides, tannins and coumarins. Fingerprint profiling of crude drugs and single and multicomponent herbal preparation, stability testing of natural products

**Suggested Readings**

1. Sethi, P. D.; Sethi, R. (2007). *HPLC: High performance of liquid chromatography*, Vol 2, CBS Publishers and Distributors.
2. Silverstein, R.M. (2006). *Spectrometric Identifications of Organic Compounds*, John Wiley, 6<sup>th</sup> edition, .
3. Skoog, D.A.; West, D.M.; Holler, F.J.; Crouch, S.R. (2004). *Fundamental of Analytical Chemistry*, Saunders College Publishing, 7<sup>th</sup> edition, New York.
4. Willard, H.H.; Merrit, L.L.; Dean, J.A.; Settle, F.A. (2001). *Instrumental methods of analysis*, CBS Publishers and Distributors, 2<sup>nd</sup> edition.
5. S.S.Handa, S.P.S.Khanuja, G.Longo, D.D.Rakesh. Extraction technologies for Medicinal and Aromatic plants. International Centre for Science and High technology, CRC Press, USA

**Course Title: Basics of Drug Design and Drug Actions**

L	T	P	Credits	Marks
4	1	0	4	100

**Paper Code: PPP.513****Unit 1****12 hours**

**Interactions in drug molecules;** Chirality and drug action; Covalent, ion-dipole, hydrogen bonding, C-H hydrogen bonding, dihydrogen bonding, van der waals interactions and the associated energies, Receptor & biological response, Drug-receptor interactions, receptor theories and drug action, Occupancy theory, rate theory, induced fit theory, macromolecular perturbation theory, activation-aggregation theory. Topological and stereochemical consideration.

**Theoretical Aspects of Drug Action:** Drug distribution, Active transport, Passive transport, The Ferguson Principal Physicochemical Parameters and Pharmacological Activity-Solubility, Partition Coefficient, Surface Activity, pKa, Ionisation, Stereochemical Factors, Bio-isosterism.

**Unit 2****12 hours**

**Enzyme kinetics in drug action:** Mechanisms of enzyme catalysis, Electrostatic catalysis and desolvation, Covalent catalysis, acid-base catalysis, strain / distortion in enzyme catalysis, Coenzyme catalysis, Theories of enzyme inhibition and inactivation, Enzyme activation of drugs-prodrugs.

**Drug metabolism:** Metabolic Processes- Phase-I (Oxidation, Reduction & Hydrolysis) and Phase-II (Glucuronide Conjugation, Acetylation, Methylation, Sulphate Conjugation, Conjugation with amino acids and Mercapturic acid formation), Routes of Elimination, Factors Affecting Metabolism–Genetic Factors, Physiological Factors, Pharmaceutical Factors, Drug Interactions.

**Unit 3****14 hours**

**Discovery of Lead molecules and Drug Design:** Natural products as lead structures in drug discovery. Structure pruning technique in lead modification e.g. morphine. Discovery of lead structure from natural hormones or neurotransmitters. Serendipitous discovery of leads e.g. Penicillin and Librium. Existing drugs as leads. Molecular graphics based lead discovery. Principles of design of agonists (e.g. Salbutamol), antagonists e.g. Cimitidine) and enzyme inhibitors (e.g. Captopril). Principles of prodrug design.

**Unit 4****14 hours**

**Lead modification, SAR studies:** Lead modification strategies: Bioisosterism, variation of alkyl substituents, chain homologation and branching, variation of aromatic substituents, extension of structure, ring expansion or contraction, ring variation, variation and position of hetero atoms, ring fusion, simplification of the lead, rigidification of lead. Discovery of oxaminquine, salbutamol, cimitidine and captopril. Structure-Activity Relationship studies in sulfa drugs, benzodiazepines, barbiturates, and taxol analogs.

**Quantitative structure activity relationship (QSAR) studies:** Introduction to Quantitative Structure Activity Relationship (QSAR) studies. 2-D QSAR, QSAR parameters. 3-D QSAR, CoMFA and CoMSIA. Receptor based 3-D QSAR, molecular docking.

**Combinatorial synthesis and chiral drugs:** Introduction, Combinatorial approach. Combinatorial library, Solid phase synthesis, requirements, resins, linkers. Parallel synthesis. Haughton's tea bag procedure, Automated parallel synthesis, Mix and Split combinatorial synthesis, Structure determination of active compounds, Synthesis of heterocyclic combinatorial libraries, Analytical characterization of synthetic organic libraries, High throughput screening Introduction to chiral drugs, Eutomer, distomer and eudesmic ratio. Pfeiffer's rule, Three point contact model. Synthesis of (S) naproxen, (S) propranolol, (S,S,S)-enalapril, (2S,3S)- diltiazem, indinavir sulfate.

***Suggested Readings:***

1. Ellis, G.P., West, G. B. (1983). *Progress in Medicinal Chemistry Series*. Elsevier Science.
2. Foye, W.O.; Lemke, T. L.; Williams, D. A. (1995). *Principles of Medicinal Chemistry*, Indian Ed. Waverly, Pvt. Ltd. New Delhi.
3. Ganellin, C.R.; Roberts S. M., (1993). *Medicinal Chemistry: The Role of Organic Chemistry in Drug Research*. Publisher: Academics Press Inc.
4. Kadam, Mahadik, Bothara (2010). *Principle of Medicinal Chemistry (Volume I & II )*, Nirali publication
5. Kulkarni, V. M., Bothra, K.G., (2008). *Drug Design*, Nirali Publication.
6. Lawton, G., Witty, D.R. (2011). *Progress in Medicinal Chemistry Series. Volume 50*.
7. Lednicer D., Laster A. M. (1998). *The Organic Chemistry of Drug Synthesis (3 Volumes)* John Wiley & Sons.
8. Lednicer, D. (2008). *Strategies for Organic Drug Synthesis and Design* Publisher: John Wiley & Sons.
9. Lemke, T.L., Williams, D.A. (2009). *Foye's Principles of Medicinal Chemistry*.
10. Silverman R.B., (2004). *Organic Chemistry of Drug Design and Drug Action*, Publisher: Elsevier.
11. Wilson, C.O.; Block, J.H.; Gisvold, O.; Beale, J. M. Wilson and Gisvold's (2003) *Textbook of Organic Medicinal and Pharmaceutical Chemistry*. Lippincott Williams & Wikins.

**Course Title: Extraction and Isolation of Natural Products - Practical**

L	T	P	Credits	Marks
-	-	4	2	50

**Paper Code: PPP.514**

Extraction of organic compounds from natural sources. (Any five)

- Isolation of caffeine from tea leaves.
- Isolation of benzoic acid from tea leaves.
- Isolation of casein from milk (the students are required to try some typical color reactions of proteins).
- Isolation of lactose from milk (purity of sugar should be checked by TLC).
- Isolation of nicotine dipicrate from tobacco.
- Isolation of cinchonine from cinchona bark.
- Isolation of piperine from black pepper.
- Isolation of lycopene from tomatoes.
- Isolation of  $\beta$ -carotene from carrots.
- Isolation of oleic acid from olive oil (involving the preparation of complex with urea and separation of linoleic acid).
- Isolation of eugenol from clove.

**Suggested Readings:**

- Clarke, H.T. (1975). *A Handbook of Organic. Analysis Qualitative and Quantitative*. Edward Arnold Publishers Ltd London.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J., Smith, P.W.G. (1996). *Textbook of Practical Organic Chemistry*. Prentice-Hall.
- 

**Course Title: Analyses and Molecular Modelling of Natural Products-Practical**

L	T	P	Credits	Marks
-	-	4	2	50

**Paper Code: PPP.515**

To illustrate the topics included under theory.

Practical based on Molecular modeling. A sufficient training will be given through exercises using molecular modeling softwares like autodock, schrodinger, etc.

**Course Title: Seminar**

L	T	P	Credits	Marks
-	-	4	2	50

**Paper Code: PPP.516**

## Elective Courses

Course Title: Chemistry of Natural Products

Paper Code: PPP.517

L	T	P	Credits	Marks
4	1	0	4	100

### Unit 1

18 hours

**Terpenoids and carotenoids:** Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Geraniol, Menthol and  $\beta$ -Carotene.

### Unit 2

18 hours

**Alkaloids:** Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Ephedrine, Nicotine and Morphine.

### Unit 3

18 hours

**Steroids:** Occurrence, nomenclature, basic skeleton and stereochemistry, Structure determination and synthesis of cholesterol, partial synthesis of Testosterone, Progesterone, Biosynthesis of steroids.

### Unit 4

9 hours

**Plant pigments:** Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of anthocyanins.

**Porphyrins:** Structure of haemoglobin.

### Unit 5

9 hours

**Glycosides:** Occurrence, properties, classification, isolation, characterisation and chemical tests.

### Suggested Readings:

1. Bhat, S.V., Nagasampagi, B.A., Meenakshi, S. (2009). *Natural Product Chemistry & Applications*, Narosa Publishing House, New Delhi.
2. Bhat, S.V., Nagasampagi, B.A., Sivakumar, M. (2005), *Chemistry of Natural Products*. Narosa Publishing House, New Delhi.
3. Brahamchari, G. (2009). *Natural Product: Chemistry, Biochemistry and Pharmacology*. . Narosa Publishing House, New Delhi.
4. Cseke, L.J. (2009). *Natural Products from plants*. CRC Press, Taylor and Francis, 2<sup>nd</sup> edition, US.
5. Dewick, P.M. (2009). *Medicinal Natural Products: A Biosynthetic Approach*. Willey & Sons, 3<sup>rd</sup> edition, UK.
6. Finar, I.L. (2006). *Organic Chemistry: Stereochemistry and the Chemistry of Natural Products*. Dorling Kindersley Pvt. Ltd., 6<sup>th</sup> edition, India.
7. Peterson, F., Amstutz, R. (2008). *Natural Compounds as drugs*. Birkhauser Verlay.
8. Thomson, R.H. (2008). *The Chemistry of Natural Products*, Springer, 1<sup>st</sup> edition.



**Course Title: Advance Medicinal Chemistry**

L	T	P	Credits	Marks
4	1	0	4	100

**Paper Code: PPP.518****Unit 1** **16 hours**

**Antiviral Agents:** DNA and RNA viruses, retroviruses, strategies to design anti-HIV drugs, viral replication, medicinally significant negative strand viruses, FDA-approved anti-viral agents for RNA-virus infections, development of new drugs (ZDV, 3TC, ABC, D4T, Didanosine, Nevirapine, Delaviridine, Efavirenz), combination drug therapy.

**Unit 2** **18 hours**

**Psychopharmacological Agents:** Antidepressant drugs, Antianxiety agents and Antipsychotic agents: Introduction, biochemical basis of mental disorders, treatment approaches, SAR of Phenothiazines, Tricyclic antidepressants and Benzodiazepines.

**Unit 3** **16 hours**

**Peptidomimetics:** Recent advances in drug design. **Prodrug concept** for drug design, drug targeting and antibody directed enzyme prodrug therapy (ADEPT), soft drug design.

**Unit 4** **22 hours**

**Advances** in medicinal chemistry of cardiovascular agents, antiarrhythmics, antianginal, antihypertensive, antihyperlipidemics, FDA approved drugs, new molecules under clinical trials. Antidiabetics (latest advances and FDA approved drugs), Chemical contraceptives (latest advances and FDA approved drugs), Current scenario of drug discovery in National research laboratories and Indian Pharmaceutical Industry.

**Suggested Readings:**

1. Delgado, J. N. and Remers W A, Ed. (2010). *Wilson & Gisvold's Textbook of Organic and Pharmaceutical Chemistry*, J. Lippincott Co., Philadelphia.
2. Foye, W. C. (2008). *Principles of Medicinal Chemistry*, Publisher: Lea and Febiger, Philadelphia.
3. King, F. D. (2006). *Medicinal Chemistry Principles and Practice*, Royale Society of Chemistry, Second Edition.
4. Nogardy, T. and Weaver D F (2005). *Medicinal Chemistry: A Molecular and Biochemical Approach*, Oxford University Press, Third Edition.
5. Patrick, G.L. (2009). *An Introduction to Medicinal Chemistry*, Publisher: I.K. International Pvt. Ltd.
6. Singh, H., Kapoor, V.K. (Latest Edition). *Medicinal and Pharmaceutical Chemistry* Vallabh Prakashan, Delhi.
7. Smith, H.J. (2006). *Introduction to the Principles of Drug Design and Action*, Taylor and Francis, Fourth Edition.
8. Wermuth, C.G. (2009). *The Practice of Medicinal Chemistry*, Academic Press (Elsevier).

9. Wolff, M E, Ed., (Latest Edition). *Burger's Medicinal Chemistry and Drug Discovery*  
John Wiley and Sons, New York.

Course Title: Green Chemistry

L	T	P	Credits	Marks
4	1	0	4	100

Paper Code: PPP.519

### Unit 1

22 hours

**Introduction to green chemistry:** History, need and goals. Green chemistry and sustainability, dimensions of sustainability, limitations/obstacles in pursuit of the goals of green chemistry. Opportunities for the next generation of materials designers to create a safer future. Basic principles of green chemistry: Atom economy and scope, Prevention/Minimization of hazardous/toxic products, Designing safer chemicals, Selection of appropriate auxiliary substances (solvents, separation agents, etc.), use of renewable starting materials, Avoidance of unnecessary derivatization-careful use of blocking/protection groups. Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents, Designing biodegradable products, Prevention of chemical accidents, Strengthening/development of analytical techniques to prevent and minimize the generation of hazardous substances in chemical processes. Development of accurate and reliable sensors and monitors for real time in process monitoring.

### Unit 2

20 hours

**Approaches to green synthesis:** Basic principles of green synthesis. Different approaches to green synthesis, Use of green reagents in green synthesis: polymer supported reagents, polymer supported peptide coupling reagents. Green catalysts, Phase-transfer catalysts in green synthesis. Advantages of PTC, Reactions to green synthesis, Application of PTCs in C-alkylation, N-alkylation, S-alkylation. Darzens reaction, Williamsons synthesis, Wittig reaction. Use of Crown ethers in esterification, saponification, anhydride formation, aromatic substitution and elimination reactions. Ionic liquids as green solvents.

### Unit 3

18 hours

**Microwave induced and ultrasound assisted green synthesis:** Introduction to synthetic organic transformation under microwave (i) Microwave assisted reactions in water (ii) Microwave assisted reactions in organic solvents. (iii) Microwave solvent free reactions  
Ultrasound assisted reactions: Introduction, substitution reactions, addition, oxidation, reduction reactions. Biocatalysts in organic synthesis: Introduction, Biochemical oxidation and reductions.

### Unit 4

12 hours

**Organic synthesis in aqueous phase and in solid state:** Aqueous reactions. Solid state reactions (i) Solid phase synthesis without using any solvent (ii) Solid supported synthesis.

#### *Suggested Readings:*

1. Ahulwalia, V.K.; Kidwai M. (2004). *New Trends in Green Chemistry*, Springer
2. Anastas, P.T.; Warner J. C. (2000). *Green chemistry, Theory and Practical*. Oxford University Press.
3. Grieco, P.A. (1997). *Organic Synthesis in Water*. Publisher: Kluwer Academic.

### Semester 3

**Course Title: Research Methodology**

**Paper Code: PPP.601**

L	T	P	Credits	Marks
2	-	-	-	50

#### Unit 1

**10 hours**

**General principles of research:** Meaning and importance of research, Critical thinking, Formulating hypothesis and development of research plan, Review of literature, Interpretation of results and discussion.

**Technical writing:** Scientific writing, Writing research paper, Poster preparation and Presentation and Dissertation.

**Library:** Classification systems, e-Library, Reference management, Web-based literature search engines

#### Unit-2

**10 hours**

**Entrepreneurship and business development:** Importance of entrepreneurship and its relevance in career growth, Characteristics of entrepreneurs, Developing entrepreneurial competencies, Types of enterprises and ownership (large, medium SSI, tiny and cottage industries, limited, public limited, private limited, partnership, sole proprietorship), Employment, self-employment and entrepreneurship, Financial management-importance and techniques, Financial statements- importance and its interpretation,

#### Unit-3

**16 hours**

**Intellectual Property Rights:** Intellectual Property, intellectual property protection (IPP) and intellectual property rights (IPR), WTO (World Trade Organization), WIPO (World Intellectual Property Organization), GATT (General Agreement on Tariff and Trade), TRIPs (Trade Related Intellectual Property Rights), TRIMS (Trade Related Investment Measures) and GATS (General Agreement on Trades in Services), Nuts and Bolts of Patenting, Technology Development/Transfer Commercialization Related Aspects, Ethics and Values in IP.

#### *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. Copyright Protection in India [website: <http://copyright.gov.in>].
6. World Trade Organization [website: [www.wto.org](http://www.wto.org)].
7. Wadedhra B.L. Law Relating to Patents, Trademarks, Copyright Design and Geographical Indications. Universal Law Publishing, New Delhi. Latest Edition.

**Course Title: Biostatistics**

L	T	P	Credits	Marks
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Paper Code: PPP.602

2	-	-	-	50

**Unit 1**

**10 hours**

**Overview of biostatistics:** Difference between parametric and non-parametric statistics, Univariate and multivariate analysis, Confidence interval, Errors, Levels of significance, Hypothesis testing.

**Descriptive statistics:** Measures of central tendency and dispersal, Histograms, Probability distributions (Binomial, Poisson and Normal), Sampling distribution, Kurtosis and Skewness.

**Unit 2**

**5 hours**

**Experimental design and analysis:** Sampling techniques, Sampling theory, Various steps in sampling, collection of data-types and methods.

**Unit 3**

**12 hours**

**Comparing means of two or more groups:** Student's t-test, Paired t-test, Mann-Whitney U-test, Wilcoxon signed-rank, One-way and two-way analysis of variance (ANOVA), Critical difference (CD), Least Significant Difference (LSD), Kruskal-Wallis one-way ANOVA by ranks, Friedman two-way ANOVA by ranks,  $\chi^2$  test.

**Unit 4**

**9 hours**

**Regression and correlation:** Standard errors of regression coefficients, Comparing two regression lines, Pearson Product-Moment Correlation Coefficient, Spearman Rank Correlation Coefficient, Power and sampling size in correlation and regression.

**Suggested Readings:**

1. Norman, G. and Streiner, D. (3<sup>rd</sup> edn) (2008). *Biostatistics: The Bare Essentials*. Decker Inc., Canada.
2. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*, W.H. Freeman and Company, New York.
3. Bolton, S., & Bon, C. (2009). *Pharmaceutical statistics: practical and clinical applications*. CRC Press.

**Course Title: Biostatistics-Practical**

L	T	P	Credits	Marks
-	-	4	2	50

**Paper Code: PPP.603**

Performing statistics analyses using MS Excel Analysis toolpack and other softwares with respect to the topics mentioned in theory

***Suggested Readings:***

1. Norman, G. and Streiner, D. (3<sup>rd</sup> edn) (2008). *Biostatistics: The Bare Essentials*. Decker Inc., Canada.
2. Sokal, R.R. and Rohlf, F.J. (1994). *Biometry: The Principles and Practices of Statistics in Biological Research*, W.H. Freeman and Company, New York.

**Course Title: Mid-Term Evaluation of Thesis**

L	T	P	Credits	Marks
-	-	-	18	450

**Paper Code: PPP.604**

## Semester 4

Course Title: Medicinal Chemistry of Anticancer Agents

Paper Code: PPP.605

L	T	P	Credits	Marks
4	1	0	4	100

### Unit 1

**Introduction:** Cancer chemotherapy, role of chemistry in cancer chemotherapy, natural products in cancer chemotherapy; Antimetabolites: Introduction, inhibitors of biosynthesis of uridylic acid, 2'-Deoxyribonucleotides, Thymidilic acid, Dihydrofolate reductase (DHFR), Inhibitors of the *De Novo* Purin Biosynthesis pathway, Inhibitors of Adenosine Deaminase, Antimetabolite Enzymes.

Anticancer drugs that inhibit hormone action: Introduction, Estrogens and their involvement in Carcinogenesis, Antiestrogens as antitumor drugs, Aromatase inhibitors; Steroid sulfatase inhibitors; Androgen-Related Antitumor Agents; Miscellaneous Steroidal Hormone-Related Anticancer Therapy.

### Unit 2

**DNA Alkylating Agents:** Introduction, Nitrogen Mustards, Aziridines, Epoxides, Methanesulfonates, Nitrosoureas, Triazenes, Methylhydrazines, 1,3,5-Triazines, Miscellaneous alkylating and acylating agents antitumor Agents.

Alkylating and Non-Alkylating compounds interacting with the DNA Groove: Introduction, Nitrospiro, Distamycin and related compounds, Mitomycins, Tetrahydroisoquinoline alkaloids, cyclopropylindole alkylating agents, Pyrrolo[1,4]Benzodiazepines.

### Unit 3

**Anticancer drugs targeting tubulin and microtubules:** Introduction, Drugs that inhibit microtubule polymerization binding at the taxane site, Miscellaneous Anticancer drugs acting on novel sites on Tubulin.

Anticancer drugs acting via radical species, photosensitizers and photodynamic therapy cancer, Antithracyclines and their analogs, Mitoxantrone and related quinines, Actinomycin D; Chartreusin, Etoposides A and related compounds, Bleomycins, Eneidine Antibiotics, Tirapazamine, Penclomedine.

### Unit 4

**Anticancer drugs targeting receptor and cellular tyrosine kinases:** Other approach to targeted Therapy; proteasome Inhibitors, Epigenetic therapy etc.

#### *Suggested Readings:*

1. Avendanco, C., Menendez, J. C., (2010). *Medicinal Chemistry of Anti Cancer Drugs*, Elsevier publication.

2. Delgado, J. N., Remers, W.A. (2010). *Wilson & Gisvold's Textbook of Organic and Pharmaceutical Chemistry*, J. Lippincott Co., Philadelphia. Twelfth edition
3. Foye, W.C, (2008). *Principles of Medicinal Chemistry*, Lea & Febiger, Philadelphia. Sixth Edition.
4. King F.D. (2006). *Medicinal Chemistry: Principles and Practice*, Royale Society of Chemistry, Second Edition.
5. Neidle, S. (2008). *Cancer Drug Design and Discovery*, Academic Press, First Edition.
6. Nogardy T., Weaver, D.F. (2005). *Medicinal Chemistry: A Molecular and Biochemical Approach*, Oxford University Press, Third Edition.
7. Patrick, G.L. (2009). *An Introduction to Medicinal Chemistry*, I.K. International Pvt. Ltd, Fourth Edition.
8. Singh, H., Kapoor, V.K., (Latest Edition). *Medicinal and Pharmaceutical Chemistry* Vallabh Prakashan, Delhi.
9. Smith H.J. (2006). *Introduction to the Principles of Drug Design and Action*, Taylor and Francis, Fourth Edition.
10. Spencer P., Holt, W. (2009). *Anticancer drugs design, delivery and pharmacology*, Nova Biomedical Books (New York).
11. Tollefsbol, T. (2009). *Cancer Epigenetics*, CRC Press (Taylor and Francis), First Edition.
12. Weber, G. F. (2007). *Molecular Mechanism of Cancer*, Springer, First Edition.
13. Wermuth, C.G. (2009). *The Practice of Medicinal Chemistry*, Academic Press (Elsevier), Third Edition.
14. Wolff, M.E., (Latest Edition). *Burger's Medicinal Chemistry and Drug Discovery* John Wiley & Sons, New York.

**Course Title: Thesis Evaluation and Viva Voce**

**Paper Code: PPP.606**

L	T	P	Credits	Marks
-	-	-	20	500