K. C. E. Society's
Moolji Jaitha College
An 'Autonomous College' Affiliated to
K.B.C. North Maharashtra University, Jalgaon.
NAAC Reaccredited Grade - A (CGPA : 3.15 - 3rd Cycle)
UGC honoured "College of Excellence" (2014-2019)
DST(FIST) Assisted College

KNOWLEDGE IS POWER
ESTD. 1945

के. सी. ई. सोसायटीचे
मूळजी जेठा महाविद्यालय
क.ब.चौ. उत्तर महाराष्ट्र विद्यापीठ, जळगाव संलग्नित
'स्वायत्त महाविद्यालय'
नॅकद्वारा पुनर्मानांकित श्रेणी – 'ए' (सी.जी.पी.ए. : ३.१५ – तिसरी फेरी)
विद्यापीठ अनुदान आयोगाद्वारा घोषित 'कॉलेज ऑफ एक्सलन्स' (२०१४-२०१९)
डी.एस.टी. (फीस्ट) अंतर्गत अर्थसहाय्य प्राप्त

Date :- 01/08/2024

NOTIFICATION

Sub :- CBCS Syllabi of M. Sc. in Organic Chemistry (Sem. III & IV)

Ref. :- Decision of the Academic Council at its meeting held on 27/07/2024.

The Syllabi of M. Sc. in Organic Chemistry (Third and Fourth Semesters) as per **NATIONAL EDUCATION POLICY – 2020 (2023 Pattern)** and approved by the Academic Council as referred above are hereby notified for implementation with effect from the academic year 2024-25.

Copy of the Syllabi Shall be downloaded from the College Website (www.kcesmjcollege.in)

Sd/-
Chairman,
Board of Studies

To :

1) The Head of the Dept., M. J. College, Jalgaon.
2) The office of the COE, M. J. College, Jalgaon.
3) The office of the Registrar, M. J. College, Jalgaon.

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समर्थ कॉलनी जवळ, जळगांव – ४२५ ००२. (महाराष्ट्र, भारत) । दूरध्वनी क्र. : +९१ २५७–२२३७३६३, २२३४२८१ । ई–मेलः mjcollege@kces.in । वेबसाईटः mjcollege.kces.in

Khandesh College Education Society's

Moolji Jaitha College, Jalgaon

An "Autonomous College"

Affiliated to KBC North Maharashtra University, Jalgaon

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SYLLABUS

M.Sc. II Organic Chemistry

Under Choice Based Credit System (CBCS)

and

as per NEP-2020 Guidelines

[w.e.f. AcademicYear:2024-25]

Preface

The curriculum is designed to impart the fundamental and technical skills to the students to work effectively in the field of organic chemistry. Organic chemistry is a highly creative science and it has huge applications which includes, but is not limited to, pharmaceuticals, petrochemicals, food, explosives, paints, and cosmetics. To comply the needs of job industries and research; the present curriculum includes necessary fundamentals and higher concept of core chemistry subjects like Physical, Inorganic and Organic Chemistry at Part I. It also includes specialized topics of Organic Chemistry such as Organic Reaction Mechanism, Stereochemistry, Natural Products, along with modern information of Spectroscopy, Photochemistry, nanochemistry, green chemistry in Part II. Therefore the curriculum will let students to adopt the desired skills and knowledge of organic chemistry required for their professional life, and to qualify for training as scientific researcher. The laboratory practical courses are designed to bridge the gap between theoretical and practical organic chemistry. Practical courses are useful to learn skillful handling of chemicals, designing and monitoring of chemical reactions/synthesis, and identification of the chemical intermediates/products. Completion of the laboratory courses by students will lead them to a resourceful chemist with sound chemistry background, capable of performing the task in research, academia and industry. Ultimately the the completion of programme will provide Job Opportunities**.** Some of the best job opportunities for the students after completion of MSc in Organic chemistry curriculum are.

Program Outcomes (PO) for M.Sc. Organic ChemistryProgram:

Program outcomes associated with an M.Sc. Organic Chemistry degree are as follows:

1. Student possess an in-depth understanding of advanced theories, concepts, and methodologies in their specific field of study.
2. Student should demonstrate advanced technical skills and proficiency in utilizing specialized equipment, software, and methodologies relevant to their field of study.
3. Student should be capable of critically analyzing complex problems and synthesizing information from various sources.
4. Student should be proficient in effectively communicating scientific information to both technical and non-technical audiences. They should be able to present their experimental findings through oral presentations, scientific writing, and the use of appropriate visual aids.
5. Student should demonstrate leadership qualities and the ability to work effectively as part of a team.
6. Student should have developed advanced research skills and the ability to independently design and conduct rigorous scientific investigations. They should be able to analyze scientific literature,formulate research questions, develop research plans, collect and analyze data, draw valid conclusions and know about IPR.

7. Student should understand and adhere to ethical principles and professional standards in their field.
8. Student should recognize the importance of continuous learning and professional development. They should have the skills and motivation to stay updated with advancements in their field, engage in lifelong learning, and pursue further academic or professional opportunities.

Program Specific Outcome PSO (M.Sc. Organic Chemistry):

After completion of this course, students are expected to learn/understand the:

No.	PSO
1	Students are equiped with the required knowledge and generic skills required for employment or further training in R&D, science based industry and establishments, education, and training at management levels in other professions.
2	Study of chemistry provides the career opportunities in the field of: Pharmaceutical /drug development, Science education, Chemical analysis/forensic science, and Chemical synthesis.
3	Understand the theory and principal of ^{1}H NMR, ^{13}C NMR, MASS and 2D spectroscopy for analysis of structure of unknown compound in further research work.
4	Understand the laboratory techniques such as instrumentation, mixture separation, reflux, distillation, recrystallization, vacuum filtration, and thin-layer chromatography and good laboratory practices and safety etc.
5	Acquire the skills about modern chemical tools, Models, Chem-draw, ISI draw, charts, equipment‟s and develop research oriented skills.
6	Know the main synthetic routes and reactivity for variety of heterocycles and applications. They able to decide and design new synthetic routes, choice of reagents and conditions taking into account cost, safety and environmental factors.
7	To design an efficient total synthesis of a natural complex molecule by recognizing substructures and characterize various classes of natural products from their structures, appreciate the biogenesis of many natural products of pharmaceutical importance.
8	To get knowledge about stereochemical nomenclature, Cram„s rule, catalysts in asymmetric synthesis, stereochemical discrimination, Asymmetric synthesis and its applications, stereochemistry of cyclohexane, ORD and CD.
9	Predict the major and minor products of a variety of organic reactions with appropriate stereochemistry by effect of structure on reactivity. Also apply the knowledge of cabanion, Umpolung, Hammett equation, Taft equation and Hammonds postulates.
10	Students will know basic information on analytical techniques (IR, Raman, UV-VIS, NMR, and EPR). Student will be able to select molecular spectroscopy methods relevant and suitable for solving given scientific problem and to analyze results of measurements using molecular spectroscopy methods.

11	Courses will in-cultivate research aptitude and reasoning ability in the students.
12	Students are equiped with the required knowledge and generic skills required for employment or further training in R&D, science based industry and establishments, education, and training at management levels in other professions.

Credit distribution structure for two years/one-year PG M.Sc. Organic Chemistry Programme

Level	Sem	Major (Core) Subjects		Minor Subjects	OJT/Int, RP	Cumulative Credits/Sem	Degree/ Cumulative Cr.
		Mandatory (DSC)	Elective (DSE)				
6.0	I	DSC-1 (4T) DSC-2 (4T) DSC-3 (4T) DSC-4 (2P)	DSE-1(2T) A/B DSE-2(2P) A/B	RM (4T)		22	First-year PG OR One year PG diploma after 3 years UG
	II	DSC-5 (4T) DSC-6 (4T) DSC-7 (4T) DSC-8 (2P)	DSE-3(2T) A/B DSE-4(2P) A/B		OJT/Int (4)	22	
	Cum. Cr.	28	8	4	4	44	
	Exit option: PG diploma (44 Credits) after three-year UG degree						
6.5	III	DSC-9 (4T) DSC-10 (4T) DSC-11 (4T) DSC-12 (2P)	DSE-5(2T) A/B DSE-6(2P) A/B	--	RP (4)	22	Second-year PG after 3 years UG OR PG degree after 4 years UG
	IV	DSC-13 (4T) DSC-14 (4T) DSC-15 (2P) DSC-16 (2P)	DSE-7(2T) A/B DSE-8 (2P) A/B	...	RP (6)	22	
	Cum. Cr.	54	16	4	4+10	88	
2 Years-4 Sem. PG Degree (80-88 credits) after Three Year UG Degree or 1 Year-2 Sem PG Degree (40-44 credits) after Four Year UG Degree							

Sem- Semester, **DSC**- Department Specific Course, **DSE**- Department Specific Elective, **T**- Theory, **P**- Practical, **RM**- Research Methodology, **OJT**- On Job Training, **Int**- Internship, **RP**- Research Project, **Cum. Cr.** : Cumulative Credits

Multiple Entry and Multiple Exit options:

The multiple entry and exit options with the award of UG certificate/ UG diploma/ or three-year degree depending upon the number of credits secured;

Levels	Qualification Title	Credit Requirements		Semester	Year
		Minimum	Maximum		
6.0	One-year PG Diploma program after 3 Yr Degree	40	44	2	1
6.5	Two-year master's Degree program After 3-Yr UG Or PG Degree after 4- Yr UG	80	88	4	2

Examination Pattern for MSc

Theory Question Paper Pattern:

- 60 (External) +40 (Internal) for 4 credits
    - External examination will be of three hours duration
    - There shall be 5 questions, each carrying equal marks (12 marks each), while the tentative pattern of question papers shall be as follows;
    - Q1 Attempt any 3 out of 4 sub-questions; each 4 marks
    - Q 2, Q3, Q4 and Q5 Attempt any 2 out of 3 sub-question; each 6 marks.
- 30 (External) +20 (Internal) for 2 credits
    - External examination will be of 1½ hours duration
    - There shall be 3 questions Q1 carrying 6 marks and Q2, Q3 carrying 12 marks each. while the tentative pattern of question papers shall be as follows;
    - Q1 Attempt any 2 out of 3 sub-questions; each 3 marks
    - Q 2 and Q3 Attempt any 2 out of 3 sub-question; each 6 marks.

Rules of Continuous Internal Evaluation:

The Continuous Internal Evaluation for theory papers shall consist of two methods:

1. Continuous & Comprehensive Evaluation (CCE): CCE will carry a maximum of 30% weightage (30/15 marks) of the total marks for a course. Before the start of the academic session in each semester, the subject teacher should choose any three assessment methods from the following list, with each method carrying 10/5 marks:

i. Individual Assignments
ii. Seminars/Classroom Presentations/Quizzes
iii. Group Discussions/Class Discussion/Group Assignments
iv. Case studies/Case lets
v. Participatory & Industry-Integrated Learning/Field visits
vi. Practical activities/Problem Solving Exercises
vii. Participation in Seminars/Academic Events/Symposia, etc.
viii. Mini Projects/Capstone Projects
ix. Book review/Article review/Article preparation
x. Any other academic activity
xi. Each chosen CCE method shall be based on a particular unit of the syllabus, ensuring that three units of the syllabus are mapped to the CCEs.

2. Internal Assessment Tests (IAT): IAT will carry a maximum of 10% weightage (10/5 marks) of the total marks for a course. IAT shall be conducted at the end of the semester and will assess the remaining unit of the syllabus that was not covered by the CCEs. The subject teacher can decide which units will be assessed using CCEs and which unit will be assessed based on IAT.

The overall weightage of Continuous Internal Evaluation (CCE + IAT) shall be 40% of the total marks for the course. The remaining 60% of the marks shall be allocated to the semester-end examinations.

The subject teachers must communicate the chosen CCE methods and the corresponding syllabus units to the students at the beginning of the semester to ensure clarity and proper preparation.

Practical Examination Credit 2: Pattern (30+20)

External Practical Examination (30 marks):

- Practical examination shall be conducted by the respective department at the end of the semester.
- Practical examination will be of 3 hours and shall be conducted as scheduled.
- There shall be 05 marks for journal and viva voce. A certified journal is compulsory to appear for practical examination.
- The practical examination will be of a minimum of 3 hours duration and shall be conducted as per schedule for 2 consecutive days in case of practical where incubation conditions and allied aspects are essential.

Internal Practical Examination (20 marks):

- Internal practical examination of 10 marks will be conducted by the department as per the schedule given.
- For internal practical examination, students must produce the laboratory journal of practicals completed along with the completion certificate signed by the concerned teacher and department head.
- There shall be continuous assessment of 30 marks based on student performance throughout the semester. This assessment can include quizzes, group discussions, presentations and other activities the faculty assigns during regular practicals. For details, refer to internal theory examination guidelines.
- Finally, 40 (10+30) students' performance will be converted into 20 marks.

M.Sc. Organic Chemistry Course Structure

Semester	Course Module	Credit	Hours/ week	TH/ PR	Code	Title
I	DSC	4	4	TH	CHO-DSC-511	Advanced Physical Chemistry
	DSC	4	4	TH	CHO-DSC-512	Modern Inorganic Chemistry
	DSC	4	4	TH	CHO-DSC-513	Principles of Organic Chemistry
	DSE	2	2	TH	CHO-DSE-514 (A)	Laboratory Planning and Safety
	DSE	2	2	TH	CHO-DSE-514 (B)	Thermal and Electro Analytical Methods
	DSC	2	4	PR	CHO-DSC-515	Systematic Experimental Physical Chemistry
	DSE	2	4	PR	CHO-DSE-516 (A)	Systematic Experimental Inorganic Chemistry
	DSE	2	4	PR	CHO-DSE-516 (B)	Organic Compound Preparations
	DSC	4	4	TH	CHO-RM-517	Research Methodology for Chemistry
II	DSC	4	4	TH	CHO-DSC-521	Quantum Chemistry and Molecular Spectroscopy
	DSC	4	4	TH	CHO-DSC-522	Applied Inorganic Chemistry
	DSC	4	4	TH	CHO-DSC-523	Organic Reactions and Spectroscopy
	DSE	2	2	TH	CHO-DSE-524 (A)	Symmetry and Group Theory
	DSE	2	2	TH	CHO-DSE-524 (B)	Applications of Nanotechnology
	DSC	2	4	PR	CHO-DSC-525	Advanced Analytical Chemistry Practicals
	DSE	2	4	PR	CHO-DSE-526 (A)	Applied Organic Chemistry Practicals
	DSE	2	4	PR	CHO-DSE-526 (B)	Practicals in Applied Inorganic Chemistry
	DSC	4	8	OJT	CHO-OJT-527	Intership/On Job Trainning
III	DSC	4	4	TH	CHO-DSC-611	Organic Reaction Mechanism
	DSC	4	4	TH	CHO-DSC-612	Stereochemistry
	DSC	4	4	TH	CHO-DSC-613	Physical Methods In Structure Determination
	DSE	2	2	TH	CHO-DSE-614 (A)	OrganicPhotochemistry
	DSE	2	2	TH	CHO-DSE-614 (B)	Nanochemistry
	DSC	2	4	PR	CHO-DSC-615	Separation of Ternary Mixtures
	DSE	2	4	PR	CHO-DSE-616 (A)	Two Stage Preparations
	DSE	2	4	PR	CHO-DSE-616 (B)	Green Chemistry Experiments
	DSC	4	8	RP	CHO-RP-617	Research Project-I
IV	DSC	4	4	TH	CHO-DSC-621	Natural Products
	DSC	4	4	TH	CHO-DSC-622	Advanced Synthetic Organic Chemistry
	DSE	2	2	TH	CHO-DSE-623 (A)	Heterocyclic Chemistry
	DSE	2	2	TH	CHO-DSE-623 (B)	Medicinal Chemistry
	DSC	2	4	PR	CHO-DSC-624	Three Stage Preparations
	DSC	2	4	PR	CHO-DSC-625	Synthesis of Drugs and Dyes
	DSE	2	4	PR	CHO-DSE-626 (A)	Spectral Identification of Organic Compounds
	DSE	2	4	PR	CHO-DSE-626 (B)	Isolation of Natural Products
	DSC	6	12	RP	CHO-RP-627	Research Project-II

DSC : Department-Specific Core course
DSE : Department-Specific elective
TH : Theory
PR : Practical
RP : Research project

M.Sc. II (Organic Chemistry)

Semester III

M.Sc. II (Chemistry)
Semester III
CHO-DSC-611: Organic Reaction Mechanism

Total Hours: 60 **Credits: 4**

Course objectives	• To impart knowledge of reactive intermediates, and reaction mechanisms • To study aromatic electrophilic substitution and elimination reactions • To study carbanion intermediate involving organic reactions • To study the concepts of umpolung	
Course outcomes	**After successful completion of this course, students are expected** • To apply the knowledge of reactive intermediates, and reaction mechanisms. • To learn aromatic electrophilic substitution and elimination reactions • To learn chemistry of carbanion intermediate and their reactions • To learn and apply the concepts of umpolung	
Unit	**Contents**	**Hours**
Unit I	**Electronic Effect and Reactive intermediates** **Effect of structure on reactivity**: Inductive effect, Electromeric effect, Resonance, Hyperconjugation, and steric effects, Hammett equation and linear free energy relationship, substituent and reaction constant, Taft equation. Thermodynamic and kinetic requirements for reactions, thermodynamically and kinetically controlled reactions,Hammonds postulate, transition states and intermediates, Kinetic &non kinetic methods of determining mechanisms, identification of products and determination of the presence of an intermediate, isotopic labeling, and kinetic isotope effects. **Reactive intermediates** Formation, structure, stability, and reactions of carbocations, carbanions, carbenes, nitrenes and free radicals.	**15**
Unit II	**Aromatic Electrophillic Substitution and Elimination Reactions** **Aromatic Electrophillic Substitution** The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The *o*/*p* ratio, *ipso* attack, orientation in benzene ring with more than one substituents, orientation in other ring system. Diazonium coupling, Gatterman-Koch reaction, Pechman reaction, and Houben–Hoesch reaction.	**15**

	Elimination Reactions The E^1, E^2 and E^1CB mechanisms and orientation of the double bond, Saytzeff and Hoffman‟s rule, Effect of substrate structure, attacking base, leaving group and medium, and Mechanism and orientation in pyrolytic elimination.	
Unit III	**Carbanion** **Carbanion**: related name reactions. Aldol Condensation, Benzoin Condensation, Michael addition, Mannich reaction, Reimer-Tiemann reaction, Knoevengal reaction, Dieckmann reaction, Perkin reaction, Stobbe reaction, Reformatsky reaction, Darzen Condensation reaction and Claisen Ester condensation. **Enamines:** Formation and Applications.	**15**
Unit IV	**Umpolung** **Umpolung Reactivity** Dipole inversion, generation of acyl anion, use of 1,3-dithiane, methylthiomethylsulphoxide, *bis*-Phenylthiomethane, Metallatedenol ethers, alkylidenedithiane, Ketone dithioacetals, and 2-propenethiobismethyl thioallyl anion. **Phosphorous, Nitrogen and Sulphur ylide** Preparation, Reactions, Applications and Stereochemistry. **Organoboranes** Preparation and properties of organoborane reagents (RBH_2, R_2BH, R_3B, 9-BBN, catechol borane, Thexylborane, hydroboration mechanism, stereo and regioselectivity, and uses of hydroboration in synthesis of primary, secondary, tertiary alcohols. **OrganoSilicon and Tin** Me_3SiCl, Peterson Olefination and Me_3SiH, TBTH and AIBN.	**15**

Study Resources	• Smith, M. B., (2015). March‟s Advanced Organic Chemistry – Reaction mechanism and structure, 7th edition, John Wiley. • Carey, F.A., and Sunberg R. J. (2008). Advanced Organic Chemistry, 5thedition, Springer. • Sykes, P., (2003). A Guidebook to Mechanism in Organic Chemistry, 6thedition, Pearson**.** • Morrison, R. T., Boyd R. N. and Bhattacharjee, S. K. (2003).Organic Chemistry, 7th Edition, Pearson. • Norman, R. O. C and Coxon, J. M., (2013). Principle of organic synthesis. • Warren, S., (2014). Organic synthesis, The disconnection approach, Wiley. • Carruthers, W., (2015). Modern methods of Organic Synthesis, Cambridge. • Zweifel, G. S., Nantz,M. H., Somfai. P., (2005). Modern Organic Synthesis: An Introduction, 2ndedition , Wiley.	

M.Sc. II (Chemistry)
Semester III
CHO-DSC-612: Stereochemistry

Total Hours: 60 **Credits: 4**

Course objectives	• To know the fundamentals of stereochemistry. • To study the stereochemistry involved in asymmetric synthesis. •To learn the stereochemistry of six membered rings and polycyclic compounds. • To know about CD and ORD.	
Course outcomes	**After successful completion of this course, students are expected** • To understand the fundamentals of stereochemistry. • To learn the stereochemistry involved in asymmetric synthesis. •To learn the stereochemistry of six membered rings and polycyclic compounds. • To analyse the compounds using CD and ORD.	
Unit	**Contents**	**Hours**
Unit I	**Fundamentals in Stereochemistry** Chirality, necessary condition for chirality, optical activity: working of polarimeter, optical activity due to stereoplane, Stereoaxis (eg.Allenes, Spiranes), Helicity(Hexahelicene), chirality centers other than carbon atom- Amine, Phosphine, sulfoxide, conformation & configuration, absolute configuration & relative configuration, Terms: meso compound, enantiomers and diastereomers, properties of enantiomers and diastereomers, D- and L-Designation, some weaknesses of D-L nomenclature, enantiomeric excess, Conformations of ethane and n-butane, Restricted rotation about single bond, Origin of conformational energy, and angle strain.	**15**
Unit II	**Asymmetric Synthesis and its Applications** **Prochirality:** Introduction, molecule with prochiral center, prochiral axis, prochiral plane, Re, Si-nomenclature: carbonyl compound, alkene.**Asymmetric synthesis**- Introduction, Principle of asymmetric synthesis, Principle categories of asymmetric synthesis- a) Use of chiral substrate b) Use of chiral auxiliaries c) Use of chiral reagents. **Models:** Cram's rule, FelkinAnh rule, Cram's chelate model, enantiomeric excess and optical purity. **Stereoselective Reactions:**Aldol reactions (Zimmermann traxler model), asymmetric hydrogenation (BINAP), asymmetric epoxidation	**15**

	(+DET/-DET) and asymmetric dihydroxylation (DHQD).	
Unit III	**Stereochemistry of six membered rings** Conformational analysis of cyclohexane (structure associated with energy), Monosubstituted cyclohexane, Disubstituted with same substituent (e.g. 1, 2- Dimethylcyclohexane, 1, 3- Dimethylcyclohexane, 1, 4- Dimethylcyclohexane), Disubstituted with different substituents (e.g. 1-isopropyl-2- methylcyclohexane, 1, 3-cyclohexane dicarboxylic acid, 1-methyl-4-phenylcyclohexane). Conformations of common sugars andanomeric effect. **Stereochemistry of Polycyclic Compounds** Norboranes (exo, endo, syn and anti-nomenclature), Bicyclo [2.2.2] Octane, strained carbocycles-Bredts Rule, Fused ring – Decaline, Hydrindanes (Bicyclo [4.3.0] Nonane, Steroid nucleus, and bridge Alkaloids (Strychnine, Morphine).	**20**
Unit IV	**ORD and CD** Linearlypolarized light, circularly polarized light, circular birefringence, circular dichroism, ORD and CD curves, Cotton effect and its applications, Octant rule and the axial α–haloketone rule with applications.	**10**
Study Resources	• Kalsi P. S., (2022). Stereochemistry Conformation and Mechanism, 11th Edition, New Age International Publishers. • Kalsi P. S., (2017). Stereochemistry Conformation and Mechanism, 9th Edition, New Age International Publishers. •Clayden, J., Warren, S., Greeves, N. and Wother, P., (2001). Organic chemistry, Oxford University Press (Reprinted with corrections). • Singh, J. Yadav, L.D.S., Sing Jaya J. and Singh, S., (2020). Stereochemistry with Applications to Organic Reactions, New Age International Publishers. • Eliel, E. L. and Wilen, S. H., (2008). Stereochemistry of carbon compounds, Willey. •Carruthers,W., (1987). Some Modern Methods of Organic Synthesis, Cambridge Texts in Chemistry and Biochemistry. •Nasipuri, D., (2018). Stereochemistry of Organic Compounds: Principles and Applications, 3rd edition, New Age International Publishers.	

M.Sc. II (Chemistry)

Semester III

CHO-DSC-613: Physical Methods in Structure Determination

Total Hours: 60 **Credits: 4**

Course Objective	• To study the ^{1}H NMR and ^{13}C NMR data. • To study the two dimensional NMR spectroscopy. • To know the fragmentation mode depends on functional groups in Mass spectroscopy. • To study the structural elucidation based on spectroscopic data and spectra.
Course outcomes	**After successful completion of this course, students are expected** • To learn the principle and application of ^{1}H NMR and ^{13}C NMR spectroscopy. • To learn two dimensional NMR spectroscopy. • To learn fragmentation pattern to identify molecular mass and structure of compounds. • To elucidate the structure of compounds by using spectroscopic data.

Unit	Contents	Hours
Unit I	**^{1}H-NMR Spectroscopy** Principle of NMR, spin-spin coupling, (n+1) rule, coupling constant, vicinal and germinal coupling, long range coupling, factors affecting coupling constant, first order spectra, More complex spin-spin system like AB, AX, AX_2, ABX, AMX, ABC. Proton exchange reaction and hydrogen bonding, chemical exchange, rotation about single bond with partial double bond character, simplification of complex spectra-double resonance, shift reagents, Nuclear Over-Hauser effect (NOE), Deuterium exchange, solvent effects, Detection of solvent peaks in ^{1}H NMR spectra, NMR of intra and intermolecular hydrogen bond, C---H---N, C---H---O, Ar-HO=C. **Applications of ^{1}H NMR**: Magnetic Resonance Imaging (MRI). Problems Based on ^{1}H NMR spectroscopy.	**15**
Unit II	**^{13}C NMR spectroscopy** Elementary ideas, Instrumental difficulties, Proton decoupled spectra, off-resonance technique, chemical shifts of solvents, chemical shift of carbons, factors affecting on chemical shifts, calculations of chemical shifts of alkane, olefin, alkyne, aromatic, heteroaromatic, carbonyl carbons,chemical shift features of hydrocarbons, effect of substituents on chemical shifts. Problems based on ^{13}C NMR spectroscopy. NMR spectroscopy of Nuclei other than ^{1}H and ^{13}C. **Two dimensional NMR spectroscopy (2D NMR)** ^{1}H-^{1}H COSY, ^{13}C -^{1}H (HETCOR, HMQC, HMBC), and ^{13}C-^{13}C INADEQUATE.	**15**
Unit III	**Mass Spectrometry** Instrumentation, various methods of ionization (field ionization, field	**15**

	desorption, ESI, FAB, MALDI), different detectors [magnetic analyzer, ion cyclotron analyzer, Quadrupoule mass filter, time of flight (TOF)]. Mass spectral fragmentation of organic compounds containing common functional groups, Nitrogen rule, McLafferty rearrangement, Molecular ion peak,metastable peak, isotope peaks, and mass spectral fragmentation of organic compounds with respect of their structure determination. Problem based on Mass Spectrometry.	
Unit IV	**Problems based on U.V., I.R., NMR, CMR, Mass and 2D NMR spectroscopy** a) Problems based on joint application of U.V., I.R., NMR, CMR, Mass and 2D NMR spectroscopy b) Determination of structure of organic compounds from U.V., I.R., NMR, CMR, Mass and 2D NMR spectra.	**15**
Study Resources	• Kalsi, P.S., (2004). Spectroscopy of Organic compounds, 6th edition, New Age International publisher, Delhi. • Silverstein, R. M. and Webster, F. X., (2006). Spectrometric identification of organiccompounds, 6th edition, John Wiley and Sons. • Pavia, D. L. ,Lampman, G.M. and. Kriz, G. S., (2009). Introduction to Spectroscopy: Guide for students of organic chemistry, 4th edition, Brooks/Cole Cengage Learning. • Parikh, V. M., (1974). Absorption spectroscopy of organic molecules, 1st edition,Addition-WesleyPub. Co. • Rehman, A. U., (1986). Nuclear Magnetic Resonance Basic Principles, Springer-Verlag. • Rehman, A. U., (1989). One and Two dimensional NMR Spectroscopy, 1st edition, Elsevier. • Lambert B. and Lightner, S., (1998). Organic structural Spectroscopy-Joseph Cooks, Prentice-Hall. • Field, L.D., Sternhell, S. and Kalman, J.R., (2013). Organic structures from spectra, 5thedition, John Wiley and sons Ltd. • Dewan, S. K., (2019). Organic Spectroscopy (NMR, IR, Mass, and UV), 1st edition, CBS Publishers and Distributors Pvt. Ltd. • Sharma, Y. R., (2010). Organic Spectroscopy, S. Chand and company Ltd. • Banwell, C., Mccash, E., (2001). Fundamentals of Molecular Spectroscopy, 4th edition, Tata McGraw Hill.	

M.Sc. II (Chemistry)
Semester III
CHO-DSE-614 (A): Organic Photochemistry

Total Hours: 30 **Credits: 2**

Course objectives	• To study the basic principles of photochemistry. • To study and understand the chemistry of carbonyl compounds and alkenes under photochemical conditions. • To study basics of pericyclic reactions. • To study and understand electrocyclic, cycloaddition and sigmatropic reactions.	
Course outcome	**After successful completion of this course, students are expected** • To learn the basic principles of photochemistry. • To understand the chemistry of carbonyl compounds and alkenes under photochemical conditions. • To learn basics of pericyclic reactions. • To understand electrocyclic, cycloaddition and sigmatropic reactions.	
Unit	**Contents**	**Hours**
Unit I	**Basic Principles of Photochemistry** Introduction, Thermochemical vs Photochemical reactions, Electromagnetic radiation, Interaction of electromagnetic radiation with organic molecules, Spin multiplicity Electronic transitions, Laws of phtochemistry-GrothursDrapper Law, Einstein's Law of Photochemical Equivalence, Lambert-Beers Law, Jablonski diagram, Quantum yield, and Photosentization and Quenching.	**6**
Unit II	**Photochemistry of Organic Compound** **Carbonyl compounds** α-cleavage: Norrish Type I, Photochemistry of ß,γ-Unsaturated carbonyl compound, Photochemistry of α,ß-Unsaturated carbonyl compound, Intramoleculer Photo-rearangement of cyclohexadienone, Norrish Type II or ß-cleavage, ß-hydrogen abstraction, δ- hydrogen abstraction, Paterno-Buchi reaction, and the de Mayo reaction. **Photochemistry of alkenes** Geometrical isomerism, cyclization reactions, di-pi-methane rearrangement and aza-di-pi-methane reaarangement.	**8**

Unit III	**Pericyclic Reactions** Introduction, Charecteristic features, Classifications, construction of π MO orbitals of ethylene and 1,3-butadiene **Electrocyclic reactions:** Introduction, con-rotatory and dis-rotatory motions, FMO method for ring opening and closing of 4n and 4n+2 π system, Huckel Mobius Transition state theory.	**6**
Unit IV	**Cycloaddition and Sigmatropic Reactions** **CycloadditionReactions**: Introduction, classification, FMO Interaction for [2+2] and [4+2] cycloaddition, [2+2] cycloaddition, Diels-Alder reaction, and 1,3-dipolar cycloaddition. **SigmatropicReactions:** Introduction, Stereochemistry, FMO analysis,Cope rearrangement, Claisen rearrangements, and [2,3]-sigmatropic rearrangements.	**10**
Study Resources	• Dey, S.; Hazra, N. K., (2019). Pericyclic reactions & organic photochemistry-Through solved problems, Techno World, Kolkata. • Sankararaman, S., (2002). Pericyclic Reactions – A textbook. Wiley-VCH. • Fleming, I., (1999) Pericyclic Reactions, Oxford University Press. • Turro, N. J., Ramamurthy V. and Scaiano, J. C., (2010). Modern molecular photochemistry of organic compounds, University Science Books. • Hoffman R. and Woodward, R. B., (1967). The conservation of Orbital Symmetry. • GriesbeckA. G. and Mattay, J., (2005). Synthetic Organic Photochemistry, Marcel Dekker, New York. • Gilchrist T. L. and. Storr, R. C., (1979). 2nd edition, Cambridge University Press, New York. • Lehr, R.E., Merchant, A.P., (1972). Orbital Symmetry: A Problem Solving Approach, Academic Press Inc. • Singh J. and Singh, J. Photochemistry and Pericyclic Reactions, 3rd edition,New Age International Publishers.	

M.Sc. II (Chemistry)
Semester III
CHO-DSE-614 (B): Nanochemistry

Total Hours: 30 **Credits: 2**

Course Objectives:	• To learn the foundations of Nanochemistry. • To acquire knowledge about the different techniques in nanomaterials synthesis. • To acquire knowledge about characterization of nanomaterials. • To study the applications of Nanochemistry.	
Course Outcomes	**After successful completion of this course, students are expected** • To learn fundamentals of Nanochemistry. • To learn different techniques in nanomaterials synthesis. • To apply the knowledge of characterization techniques for various nanomaterials identification. • To understand the importance of nanochemistry and its real life applications.	
Unit No.	**Content**	**Hours**
Unit I	**Introduction to Nanotechnology and Nanomaterials** Introduction to Nanochemistry, Nanostructures, Nano size, History of nanoscience, different types of nanomaterials, Size Effects, and introduction to methods creating nanostructures.	**5**
Unit II	**Synthesis and Characterization techniques of Nanomaterials** A) **Synthesis:**Physical Vapour Deposition (PVD), Chemical Vapour Deposition (CVD), Pulse Laser Deposition (PLD), Ball Milling, Electro-deposition, Metal nanocrystals by reduction, Sol-gel, Solvothermal synthesis, hydrothermal, Photochemical synthesis, Electrochemical synthesis, Nucleation and growth of nano systems, self-assembly,. **B) Characterization Techniques:**Introduction to Optical microscopy, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), particle size determination using XRD, Atomic Force Microscopy (AFM) etc.	**11**
Unit III	**Carbon based Nanomaterials** Introduction –Carbon molecules, nature of the carbon bond, new carbonstructures, discovery of C60-structure of C60 and its crystal, from a Graphene Sheet toa Nanotube, Single wall and Multi walled Nanotubes, Zigzag and Armchair Nanotubes.	**6**

Unit IV	**Applications of Nanomaterials** **Electronics**: Single electron transistors, Nano capacitors, Nano-photonics, Nano electronic and Magnetic devices **Nanocatalysis**: Introduction, Chemical Reactions on Point Defects of Oxide Surfaces, Chemical Reactions and Catalytic Processes on Free and Supported Clusters, Catalytic Processes on Free Metal Clusters, Chemical Reactions and Catalytic Cycles on Supported Clusters, Single Atoms on Oxide Surfaces, Size-Selected Clusters on Oxide Surfaces, Turn-Over Frequencies of Catalytic Reactions on Supported Clusters.	**8**

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M.Sc. II (Chemistry)

Semester III

CHO-DSC-615: Separation of Ternary Mixtures

Total Hours: 60 **Credits: 2**

Course Objectives	• To learn organic qualitative analysis through separation of ternary mixture • Identification and purity confirmation of organic compounds using chromatography.	
Course Outcomes	**After successful completion of this course, students are expected** • To understand the organic qualitative analysis • To apply the knowledge of organic qualitative analysis for separation, and identification of organic compound	
	Contents	**Hours**
	Organic Qualitative Analysis **Ternary Mixture Separation (Any Ten)** Qualitative Analysis of Ternary Mixtures containing single/poly functional compounds by chemical and physical method. The mixture separation should be carried out on micro-scale using ether/dichloromethane. Purity of the separated component must be carried out using chromatography technique (TLC). Ternary Mixtures – 1) Three solids 2) Two solids and one liquid 3) One solid and two liquids 4) Three liquids	**60**
Study Resources	• Vogel, I. A., (1989). Vogel‟s Text book of practical organic chemistry, 5th edition, Wiley. • Clarke, H. T. Haynes, B., Brick, E. C. and Shone, G. G., (1975). A Handbook of Organic Analysis: Qualitative and Quantitative, Crane, Russak. • Silverstein, R. M., Webster, F. X., Kiemle, D. J. and Bryce D. L., (2015). Spectrometric identification of organic compounds, 8th edition, Wiley. • Kalsi, P. S., (2016). Spectroscopy of organic molecule, New Age International. • Williams, D. and Fleming, I., (2011). Spectroscopic methods in organic chemistry, McGraw Hill Education.	

M.Sc. II (Chemistry)

Semester III

CHO-DSE-616(A): Two Stage Preparations

Total Hours: 60 **Credits: 2**

Course Objectives	• To learn two stage organic preparations • To learn practical aspects of name reactions	
Course Outcomes	**After successful completion of this course, students are expected** • To apply the knowledge of two stage preparation for important organic conversions. • To apply the knowledge of name reactions in organic synthesis.	
	Contents (Any 15)	**Hours**
	• Phthalic acid - Phthalic anhydride - Phthalimide • Chlorobenzene- 2,4- dinitrochloro benzene - 2,4- dinitrophenol • Acetophenone -Oxime - Acetanilide • Nitrobenzene - m-Dinitrobenzene-m-Niroaniline • Acetophenone- Benzalacetophenone-Epoxide • Toluene- p-nitrotoluene- p-nitrobenzoic acid • Cyclohexanone – Cyclohexanoneoxime - Caprolactam • Benzophenone- Benzpinacol- Pinacolone • Benzaldehyde - Benzoic acid - Benzamide • Benzaldehyde –BenzylideneAcetophenone - 4,5-dihydro 1,3,5-triphenyl-1H-pyrazole • Nitrobenzene - n- Phenyl hydroxylamine – P- amino Phenol • Acetophenone–AcetophenonePhenylhydrazone - 2-Phenyl Indole • **Wittig Reaction** Anthracene - 9- anthraldehyde- Alkene • **Preparation of aromatic aldehyde by Vilsmeier-Haack reaction** Synthesis of acetanilide by green chemistry method 2-Chloroquinoline-3-carbaldehyde prepared from acetanilide via a Vilsmeier-Haack reaction • **Preparation of Acetophenone by Fries rearrangement.** Hydroquinone - Hydroquinonediacetate - 2,5-Dihydroxyacetophenone	**60**
Study Resources	• Bansal R. K.,Practical Organic Chemistry. • Vogel's, Practical Organic Chemistry. • AhluwaliaV. K., AggarwalR., Comprehensive Practical Organic Chemistry. • Monograph on Green Chemistry Laboratory Experiments. • SethiArun,Systematic lab experiment in Organic Chemistry. • Sitaramam, Govindachari, A Manual of Practical Organic Chemistry Day. • ShrinerP. L., FusonR. C., CurtinD.Y., Systematic Identification of Organic Compounds. • Fieser L. F. Organic Experiments • Monson R.S.,Advanced Organic Synthesis, Academic Press.	

M.Sc. II (Chemistry)

Semester III

CHO-DSE-616(B): Green Chemistry Experiments

Total Hours: 60 **Credits: 2**

Course objectives	• To learn the uses of green chemistry principles in organic synthesis • To learn the importance of green chemistry practices in modern organic synthesis •
Course outcomes	**After successful completion of this course, students are expected** • To understand uses of green chemistry principles • To apply green chemistry practices in modern organic synthesis

Unit	Green Chemistry Experiments (Any 15)	Hours
1	Pre-lab introduction to green chemistry	4
2	Synthesis of 1,4-dihydropyridines in aqueous ethanol in one-pot condensation (Hantzsch synthesis)	4
3	Synthesis of dihydropyrimidinone from ethyl acetoacetate, benzaldehyde and urea (Biginelli reaction)	4
4	Synthesis of Polyvinyl pyrrolidone (PVP)	4
5	Synthesis of N-Bromosuccinamide (NBS) using green brominating reagent	4
6	Photo-reduction of benzophenone to benzopinacol in presence of sun light using isopropanol and acetic acid	4
7	Oxidation alcohol to aldehyde using molybdenum based catalyst	4
8	Synthesis of 4-Bromoacetanilide using green brominating reagent	4
9	Bromination of acetanilide using cerric ammonium nitrate	4
10	Preparation of benzilic acid using NaOH/KOH under solvent –free conditions	4
11	Preparation of alkenes from alcohol dehydration	4
12	Rearrangement of diazoaminobenzene to p-aminoazobenzene using K10 montmorillonite	4
13	Clay catalyzed solid state synthesis of 7-hydroxy-4-methylcoumarin	4
14	One pot multicomponent synthesis of pyrazoles	4
15	Preparation of 1, 1-bis-2-naphthol(Radical Coupling Reaction)	4
16	Thiamine hydrochloride catalyzed synthesis of benzoin	4
17	Synthesis of Aspirin	4

18	The Diels-Alder Reaction of anthracene derivative	4
19	Friedel-Crafts Alkylation Reaction of xylene	4
20	Synthesis of 2-butoxynaphthalene from 1-iodobutane and 2-naphthol to are utilized in this S_N2 reaction	4
Study Resources	• Vogel's, Practical Organic Chemistry. • Bansal R. K., Practical Organic Chemistry. • Sethi A., (2003), Systematic lab experiment in Organic Chemistry,1st Edition, New Age International (P) Limited, Publishers. • Ahluwalia V.K., Aggarwal R., (2000), Comprehensive Practical Organic Chemistry,1stEdition,University press. • Monograph on Green Chemistry Laboratory Experiments. • A Manual of Practical Organic Chemistry Day Sitaramam&Govindachari • Fieser L.F., Organic Experiments. • Shriner P.L., Fuson R.C.& Curtin D.Y., Systematic Identification of Organic Compounds., • Monson R.S., Advanced Organic Synthesis, Academic Press • Springer Science Business Media B.V., Mol Divers (2010) 14:473–477 DOI 10.1007/s11030-010-9246-5 • Ranu B. C.,A Hajra A., and Dey S. S., Organic Process Research & Development ,2002, 6, 817−818 • Srivastava M., RaiP.,SinghJ. and SinghJ., New J. Chem., 2014, 38, 302,DOI: 10.1039/c3nj01149f • Tetrahedron Letters, Ghosh S.,Saikh F., DasJ., PramanikA. K., http://dx.doi.org/10.1016/j.tetlet.2012.10.079, • Scholars Research Library Der PharmaChemica, 2011, 3 (5):81-86 (http://derpharmachemica.com/archive.html), Samy A. El-Assaly • J. Org. Chem. Vol. 75, No. 24, 2010, pubs.acs.org/joc • Adimurthy S., Ramachandraiah G., Bedekar A. V., Ghosh S., Ranu B. C. and Ghosh P. K., Eco-friendly and versatile brominating reagent prepared from a liquid bromine precursor,Green Chem., 2006, 8, 916–922 ,DOI: 10.1039/b606586d. • Selective oxidation of benzyl alcohol to benzaldehyde with hydrogen peroxide over tetraalkylpyridiniumoctamolybdate catalysts, Green Chem., 2007, 9, 421-423. • Warnock, L., Coll, S., Githui, M. and Asonganyie, E ., Alternative Greener Method for Preparation of Alkenes from Alcohol, http://www.cs.gordon.edu/courses/organic/salem/Montmorillonite-alkene.pdf [Accessed January 2018]. • A Greener Alternative to Aluminum Chloride Alkylation of Xylene, Sereda, G.A.AndRajpara, V.B., J. Chem. Ed., 2007, 84(4), 692. • Greener Solutions for the Organic Chemistry Teaching Lab: Exploring the Advantages of Alternative Reaction Media, McKenzie, L.C., Huffman, L.M., Hutchison, J.E., Rogers, C.E., Goodwin, T.E., Spessard, G.O., J. Chem.	

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M.Sc. II (Chemistry)

Semester III

CHO-RP-617 Research Project I

Hours: 120 **Credits: 4**

Course Objectives

1. To give exposure to the students to research culture and technology
2. To introduce students to how to select a research topic, plan, perform experiments, collect and analyze the data
3. To foster self-confidence and self-reliance in the students as they learn to work and think independently

Course outcomes

After successful completion of this course, students are expected to:

- Conceive a problem based on published research and conduct a comprehensive literature survey.
- Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.
- Learn handling of instruments, use of chemicals and how to conduct the experiments
- Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

Credit distribution (1 credit for each unit)

- Identification of a research topic, formulation of research problem,objectives, sample size and hypothesis, etc
- Preparation of Outline
- Review of literature
- Bibliography

The systematic approach towards the execution of the project should be as follows: (Wherever applicable)

1. The complete tenure of the research project should be one year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 8 hours should be allotted to the research project in a regular timetable.
3. In the third semester, students will be evaluated based on a credit distribution mentioned above.In the fourth semester,students should perform further research work, collect and analyze the data, compile the resultsand prepare and submit the final dissertation.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with the literature survey and give them a fundamental understanding of designing and executing a research project.
5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.

7. The student should select the topic relevant to priority areas of concern or allied subjects with the guidance of supervisor/ head of the department.
8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. At the beginning, students should submit the outline of the research work to be carried out in the project. (Writing in order: Title, Aim and objectives, Literature to be collected, Experimental plan or method design, expected outcome etc.)
10. Write and submit a Literature Review Reportand Research outline
    Tentative order for review: Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim of the Project, Materials and Methods, Bibliography/reference etc.
    Tentative order for research outline: Title page, introduction, background and significance of study, problems to be investigated, objective, hypothesis, chapter scheme, bibliography.
11. At the end of the third semester, each student should submit a detailed Literature Review Report and research outline.
12. An appropriate and essentialconclusive statement must be drawn at the end of the study.
13. Students should maintain lab notebooks, and the Supervisor may ask them to submit the mid-semester progress report.
14. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
15. Three copies of the Literature Review Report, research outline should be prepared (one copy for each department, guide, and student).
16. At the end of the semester, the candidate should prepare and present research work using a PowerPoint presentation with modern ICT toolsand present the same in front of his/ her respective department during the Internal Examination.
17. For external examination the candidate will have to present the research work and face viva voce.
18. Students may present their research work in Avishkar/Webinars/Conferences.
19. Students should note that plagiarism is strictly prohibited.

Internal examination (40 marks): Components of continuous internal assessment:

- Draft Research Outline (10 marks)
- Draft Review of literature (10 marks)
- Working Bibliography (10 marks)
- PowerPoint presentation, and oral examination (10 marks)

External examination (60 marks)and Components of external assessment:

- Final submitted review report, research outline in bound form at the time of examination **(40 marks)**
- Overall presentation reflecting the contribution of work, response to questions **(20 marks)**

M.Sc. II (Organic Chemistry)

Semester IV

M.Sc. II (Chemistry)
Semester IV
CHO-DSC-621: Natural Products

Total Hours: 60 **Credits: 4**

Course Objective	• To study the important aspects of terpenoids and alkaloids • To study the biosynthesis of natural products • To study the use of reagents in multistep synthesis of natural products • To learn the classification, and biological importances of vitamins and enzymes	
Course outcomes	**After successful completion of this course, students are expected** • To understand the chemistry of terpenoids and alkaloids • To understand the biosynthesis and stereochemistry of natural products • To apply the knowledge of reagents in multistep synthesis of biologically important compounds • To understand chemistry and biological importance of vitamins and enzymes.	
Unit	**Contents**	**Hours**
Unit I	**Terpenoids, and Alkaloids** **a) Biosynthesis of Terpenoids** Introduction to Terpenoids, Mevalonate pathway: Biosynthesis of mevalonic acid, Conversion of MVA into isopentyl pyrophosphate, Polymerisation of isopentyl pyrophosphate, monoterpenes–geranyl cation and its derivatives, sesquiterpenes–farnesyl cation and its derivatives, diterpenoids, tri and tetra terpenoids. **b) Biosynthesis of Alkaloids** Introduction, phenylethylamine group, pyrolidine group, pipyridine group, pyrolidine-pyridine group, tropane group and Indole group.	**15**
Unit II	**Chemistry of Natural Products** **Hardwickiicacid:**Structure, stereochemistry and biogenesis. **Prostaglandin**: General structure, Classification and Nomenclature, biological importance, Structure elucidation & total synthesis of PGE2, PGF1α. **Podophllyotoxins:**Structure, stereochemistry and reactions.	**10**
Unit III	**Multi-step synthesis of natural products** Synthesis of the following natural products with special reference to reagents used, stereochemistry and functional group transformations: i) Reserpine (Woodward synthesis) ii)Longifoline (Corey synthesis) iii) Estrone iv) Strychnine (Overman's synthesis) v) Fredericamycin.	**15**
Unit IV	**Vitamins and Enzymes** **a) Classification, sources and biological importance** of vitamin B1, B2, B6, folic acid, B12, C, D1, E (α-tocopherol), K1, K2, H (β- biotin). **b) Synthesis of the following:** Vitamin B1 including synthesis of pyrimidine and thiazole moieties	**20**

	Vitamin B2 from 3, 4-dimethylaniline and D(-)ribose Vitamin B6 from: Ethoxyacetylacetone and cyanoacetamide Vitamin E (α-tocopherol) from trimethylquinol and phytyl bromide Vitamin K1 from 2-methyl-1, 4-naphthaquinone and phytol. Vitamin Folic acid from Guanidine and ethyl cyano acetate. **Chemistry of enzymes:** Introduction, nomenclature and classification of enzymes. Properties of enzymes: i) Enzyme efficiency/catalytic power; ii) Enzyme specificity: a) stereospecificity b) reaction specificity c) substract specificity, Mechanism of enzyme action: a) Fischer's lock and key' b) Koshland induced fit hypothesis. Concept and identification of active site. Factors affecting enzyme kinetics: Substrate concentration, enzyme concentration, temperature, pH, product concentration etc. Reversible and irreversible inhibition	
Study Resources	• Mann, J., (1987). Secondary Metabolism, 2nd Edition, Oxford University. • Agrawal, O. P., (2008). Natural Product, Goel publishing house, Meerut, U.P. • Sing,J. Ali S. M. and Singh, J., (2017). Natural product Chemistry, 7th edition,PragatiPrakashan, • Mann, J., (1994). Chemical Aspects of Biosynthesis, Oxford University Press. • Manitto, P., (1981).Biosynthesis of Natural Products, John Willey and Sons. • Finar, I. L., (2002). Organic Chemistry-Vol.2, 5th edition, Pearson Education India. • Norman, R. O. C. and Coxon,J. M., (1993). Principles of Organic Synthesis by Chapmanand Hall, 3rd Edition, CRC Press. • Gilchrist, T. L. and Storr,R. C., (1979). Organic Reactions and Orbital Symetry, 2ndedition, Cambridge University Press, New York. • Nicolaou, K. C. and Sorensen, E. J., (1996). Classics in Total Synthesis: Targets,Strategies, Methods, Wiley VCH,. • Drauz, K. Groger, H. and May, O., (2012). Enzyme catalysis in organic synthesis, 3rdedition, Wiley-VCH.	

M.Sc. II (Chemistry)

Semester IV

CHO-DSC-622: Advanced Synthetic Organic Chemistry

Total Hours: 60 **Credits: 4**

Course objectives	• To study industrially important catalysis processes and coupling reactions • To study various olefin and ring forming reactions • To study basics principles and applications of retrosynthesis • To study umpolung and protection and de-protection of organic functional groups	
Course outcomes	**After successful completion of this course, students are expected** • To learn importance of catalysis and coupling reactions • To learn various olefins and ring forming reactions • To understand the basics principles and applications of retrosynthesis • To understand umpolung and protection and de-protection of organic functional groups	
Unit	**Contents**	**Hours**
Unit I	**Catalysis and Coupling Reactions** **Catalysis:** Wilkinson catalyst, Oxo Process, Fischer-Tropsch, Synthetic Gasoline and Noyori asymmetric hydrogenation. **Coupling Reactions:** Tsuji-Trost, Mizoroki-Heck, Miyaura-Suzuki, Stille, Negishi, Sonagashira, Kumada, Hiyama, Buchwald-Hartwig amination, and Ullman coupling. Cross coupling reactions in aqueous media and Cross coupling reactions of organohalides with non organometallic and non-hetero atom based reagents.	**15**
Unit II	**Olefin and Ring Formation Reactions** **Olefin Formation Reactions:** Wittig, Shapiro, Bamford-Stevens, McMurry, and Cope reaction. Titanium carbene mediated alkene synthesis. **Alkene metathesis** **Ring Formation Reactions:** Pausan-Khand, Bergman and Nazerov cyclization. **Click chemistry**: criterion for click reaction, and Sharplessazides cycloadditions.	**15**
Unit III	**Retrosynthesis-I** Introduction, retrosynthesis, disconnection, synthons-nucleophilic and	**20**

	electrophilic, and synthetic equivalent. **Retrosynthetic steps**: disconnection-next to triple bond, at the benzylic/allylic or propargylic position, aromatic ring to stabilize adjacent positive or negative charge, use of organomettalics reagents, Functional Group Addition (FGA), and Functional Group Interconversion (FGI). Use of acetylide ion, Williamson ether synthesis, epoxide, pericyclic reactions, Wittig reaction, reaction of aromatic compounds, and reactions of benzene. 1,2-C-X disconnection, 1,2-diX relationship, 1,3-diX relationship, 1,1-diX relationship. **C-C Disconnections**: Disconnection of alkynes acetylides, 1,1-C-C disconnection in alcohols, and 1,2-C-C disconnection in alcohols. **Retrosynthetic analysis and synthesis of aldehydes and ketone**: Using acyl halide, nitrile, alkylation of enolate, acetoacetic ester, aldol condensation, Michael addition, enolate, enamine, hydration of alkynes, and Robinson Annulation. **Synthesis of Carboxylic acids, Esters, amide, ester, ether, and sulfides**.	
Unit IV	**Retrosynthesis-II** **Umpolung Synthons and Reagents:** Introduction, Use of dithiane, 1,3-Difunctionalized Compound-ß-hydroxy carbonyl, α,ß-unsaturated carbonyl, 1,3-dicarbonyl, 1,2-dicarbonyl compound, α-hydroxy carbonyl (Benzoin Condensation), 1,4-dicarbonyl, and 1,5-dicarbonyl. **Protection and De-protection of Organic Functional Groups** Protection and de-protection of aldehydes and ketones, alcohols, amino, carboxylic acid and examples of protecting groups in synthesis.	**10**
Study Resources	• Bates, R., (2012). Organic synthesis using transition metals, 2nd Edition, Wiley. • Clayden, J. Warren, S. Greeves,N. and Wother, P.,(2001). Organic chemistry, Oxford University Press. (Reprinted with corrections). • Warren, S., (2014). Organic synthesis, The disconnection approach, Wiley. • Carruthers, W., (2015). Modern methods of Organic Synthesis, Cambridge. • Kumar, A. (2021). Organomettalic and Bioinorganic Chemistry, 4th edition, Aaryush Education, Muzaffarnagar. • Gupta, B. D. and Elias, A. J., (2009). Basic Organometallic Chemistry-Concepts, Synthesis and Applications. 2nd Edition, Universities Press, Hyderabad.	

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- Carey F. A. and Sunberg R. J., (2008). Advanced Organic Chemistry, 5th edition, Springer.
- Mackie, R. Smith, D. M. and Atiken, R., (1990). Guidebook to organic synthesis, 2nd Edition, Longman.
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- Kurti, L. Kurti, Czako, B. Corey, E. J. and Nicolaou, K. C. (2005). Strategic Applications of Named Reactions in Organic Synthesis, Elsevier Science.
- Zweifel, G. Michael, S. Nantz, H. Somfai P., (2005). 2nd edition, Modern Organic Synthesis: An Introduction, Wiley.

M.Sc. II (Chemistry)
Semester IV
CHO-DSE-623(A): Heterocyclic Chemistry

Total Hours: 30 **Credits: 2**

Course objectives	• To learn synthesis of five membered heterocycles • To learn reactions of five membered heterocycles • To learn synthesis and reactions of condensed five member heterocycles • To learn synthesis and reactions of pyridine, quinoline and isoquinoline	
Course outcomes	**After successful completion of this course, students are expected** • To understand the synthesis of five membered heterocycles • To understand reactions of five membered heterocycles • To understand synthesis and reactions of condensed five member heterocycles • To understand synthesis and reactions of pyridine, quinoline and isoquinoline	
Unit	**Contents**	**Hours**
Unit I	**Synthesis of Five Membered Heterocycles** **Pyrrole Synthesis:** Paal-Knorr synthesis, Knorr synthesis, Hantzsch Synthesis, and from 1,3-dicarbonyl compounds **Furan Synthesis:** Paal-Knorr synthesis, Feist-Benary Synthesis, and from β-hydroxyα-β-unsaturated carbonyl compound **Thiophene of Synthesis:** from 1,4-dicarbonyl compounds, and Hinsberg synthesis.	**8**
Unit II	**Reactions of Five Membered Heterocycles** Resonance structure and aromaticity, and relative reactivity of pyrrole, furan and thiophene. **Reactions of Pyrrole, Furan and thiophene:** Nitration, Sulphonation, Halogenation, Acylation, Alkylation, Diazo coupling (**for pyrrole**), Reactions with nucleophilic reagents, Deprotection of N-hydrogen, condensation with aldehydes, ketones and imines, mercuration, and reactions with oxidizing and reducing agents.	**7**

Unit III	**Condensed five member heterocycles** **Indole** **Synthesis:** Fischer synthesis**,** Madelung synthesis, and Bartoli synthesis **Reactions:** Nitration, Sulphonation, Halogenation, Acylation, and Alkylation **Benzofuran and Benzothiophene** **Synthesis:** from 2-aryloxyaldehydes and ketones, from O-allylketoximes. **Reactions:** Substitution at carbon, addition to sulphur in benzothiophene, reactions with nucleophilic reagents and reactions with oxidizing and reducing agents. Orientation and reactivity in indole, benzofuran and benzothiophene	**7**
Unit IV	**Pyridine, Quinoline and Isoquinoline** **Pyridine synthesis:** from 1,5-dicarbonyl compounds and ammonia, Hantzsch synthesis, and 1,3-dicarbonyl compounds **Quinoline Synthesis:** Combes synthesis, Skraup Synthesis, and Friedlander Synthesis **Isoquinoline Synthesis:** Pomeranz-Fritsch synthesis, Bischler-Napieralski Synthesis, and Pictet-Spengler synthesis. **Reactions of pyridine, quinoline and isoquinoline:** Nitration, Sulphonation, Halogenation, Acylation, and Amination.	**8**
Study Reference	• Joules, J. A., Mills, K. and Smith, G. F., (1978). Heterocyclic Chemistry, 4th Edition, Blackwell Publications. • Paquette, L. A., (1978). Principles of Modern Heterocyclic Chemistry, Benjamin/Cummings Publications. • Bansal, R. K., (1999). Heterocyclic Chemistry, Third Edition, New Age International Publishers. • Morrison, R. T., Boyd, R. N. and Bhattacharjee, S. K.,(2003),7th Edition, Organic Chemistry, Pearson. • Finar, I. L., (2002). 5thedition, Vol.2,Organic Chemistry, Pearson.	

M.Sc. II (Chemistry)
Semester IV
CHO-DSE-623(B): Medicinal Chemistry

Total Hours: 30 **Credits: 2**

Course objectives	• To study chiron approach in various bio-active molecules • To study introductory medicinal chemistry • To study stages involved in drug development process • To study synthesis and pharmacological action of drugs	
Course outcomes	**After successful completion of this course, students are expected** • To understand chiron approach in various bio-active molecules • To learn introductory medicinal chemistry • To understand stages involved in drug development process • To understand synthesis and pharmacological action of drugs	
Unit	**Contents**	**Hours**
Unit I	**Chiron Approach** Introduction**,** Carbohydrates, amino acid, hydroxyl acids and terpenes. Chiral templates and chirones. Retro synthetic strategy and synthesis of- a) (-) Pentenomycin. b) (R) and (S) Epichlorohydrin, c) (-) Multistriatin.	**7**
Unit II	**Introductory Aspects in Medicinal Chemistry** Definition of drug, Classification, Concepts of prodrugs and soft drugs, Receptor, Therapeutic index, Bioavailability, Drug assay and Drug potency. Concept and definition of Pharmacophore. Pharmacokinetics: drug absorption, distribution, metabolism (biotransformation) and elimination. Drug targets: enzymes and receptors. Pharmacodynamics. Drug discovery and development. Competitive, non-competitive inhibitors, Physical and chemical parameters like solubility, lipophilicity, ionization, pH, redox potential, H-bonding, partition coefficient and isomerism in drug distribution and drug–receptor binding. Factors affecting Absorption, Distribution, Metabolism, Elimination and Toxicity.	**8**
Unit III	**Drug Discovery Design, and Development** **a) Procedures in drug design:** Drug discovery without a lead, Penicillin Lead discovery: random screening, non-random (or targeted) screening. **b) Lead modification:** Identification of the pharmacophore, Functional group modification, Structure activity relationship, Structure modification to increase potency and therapeutic index. Homologation, chain branching, ring-chain transformation, bioisosterism and combinatorial synthesis.	**8**

Unit IV	**Synthesis and Pharmacological Action of Drugs** Fluorouracil (Anticancer), Metaprolol (Antihypertensive), Ibuprofen(Antiinflammatory), Ampicilline (Antibiotics), and Troglitazone (Antidiabetics).	**7**
Study Reference	• Hanessin, S., (1983). Total Synthesis of Natural Products : Chiron Approach, Pergamon Press. • Ariens, E. J., (1972). Drug Design, Academic Press. • Lemke, T. L. L., Williams, D. A., Roche V. F. and Zito, S. W., (2012). Foye‟s Principles Medicinal Chemistry, Lippincott Williams and Wilkins. • Kar, A., (2018). Medicinal Chemistry, 7th Edition, New Age International. • Ahluwalia, V. K. and Chopra, M., (2008). Medicinal Chemistry, ANE books India. • Patrick, G. L., (2018). An Introduction to Medicinal Chemistry, Fifth Edition, Oxford University Press,	

M.Sc. II (Chemistry)
Semester IV
CHO-DSC-624: Three Stage Preparations

Total Hours: 60 **Credits: 2**

Course Objectives	• To learn three stage preparations and monitoring progress of the reaction • To learn techniques for the synthesis of compounds	
Course Outcomes	**After successful completion of this course, students are expected** • To understand multistep organic synthesis • To learn separation, purification, quantification and identification of intermediates and products	
	Contents	**Hours**
	• **Preparation of Benzanilide by Beckmann rearrangement** Benzene-Benzophenone - Benzophenone oxime- Benzanilide • **Preparation of Anthranilic acid** Phthalic acid - Phthalic Anhydride - Phthalimide- Anthranilic Acid • **Preparation of p-aminobenzoic acid** Toluene - p-nitrotoluene-p-Nitrobenzoic acid - p-Aminobenzoic acid • **Preparation of N-Bromosuccinamide** Succinic acid-Succinic anhydride -Succinimide-N-Bromo-succinimide • **Preparation of p-chloronitrobenzene by Sandmeyer reaction** Acetanilide - p-nitro acetanilide - p-nitroaniline to p-chloronitrobenzene • **Preparation of p-iodonitrobenzene by Sandmeyer reaction** Acetanilide - p-nitro acetanilide - p-nitroaniline to p-iodonitrobenzene • **Pinocol-pinacolone rearrangement** Benzene- Benzophenone - Benzepinacol- Pinacolone • **Synthesis of Acridone from Anthranilic acid** Anthranilic acid - o-chlorobenzoic acid - N-phenyl anthranilic acid - acridone • **Synthesis of Paracetamol from Nitrobenzene** Nitrobenzene - N-phenyl hydroxylamine - p-aminophenol - p-hydroxy acetanilide/paracetamol • **Synthesis of P-Nitro Aniline from Aniline** Aniline - Acetanilide - p-nitro acetanilide - p-nitroaniline • **Synthesis of m-chloronitrobenzene from m-Dinitrobenzene**	**60**

	m-dinitrobenzene - m-nitro aniline - m-nitro diazonium chloride- m-chloro-nitrobenzene • **Synthesis of p-bromoBenzanilide from Benzophenone** Benzophenone - benzophenone oxime - benzanilide - p-bromobenzanilid**e** • **Synthesis of Methyl Orange from Aniline** Aniline -Sulphanilic acid - Diazonium chloride -Methyl orange • **Synthesis of Benzilic acid from Benzaldehyde** Benzaldehyde - Benzoin - Benzil - Benzilic acid • **Synthesis of Benzylamine acid from phthalic anhydride** Phthalic anhydride -Phthalimide - N-Benzylphthalimide – Benzylamine	
Study Resources	• Bansal R. K., Practical Organic Chemistry. • Vogel's, Practical Organic Chemistry. • AhluwaliaV. K., AggarwalR., Comprehensive Practical Organic Chemistry. • Monograph on Green Chemistry Laboratory Experiments. • SethiArun, Systematic lab experiment in Organic Chemistry.. • Sitaramam, Govindachari, A Manual of Practical Organic Chemistry Day. • Shriner P. L., Fuson R. C., Curtin D.Y., Systematic Identification of Organic Compounds. • FieserL. F..Organic Experiments • Monson R.S., Advanced Organic Synthesis, Academic Press. • Mann, Saunders, Practical organic Chemistry, 4th edition.	

M.Sc. II (Chemistry)
Semester IV
CHO-DSC-625: Synthesis of Drugs and Dyes

Total Hours: 60 **Credits: 2**

Course objectives	• To study synthesis of drugs • To study synthesis of dyes	
Course outcomes	**After successful completion of this course, students are expected** • To acquired knowledge of drug synthesis • To acquired knowledge of dyes synthesis	
Unit	**Synthesis of Drugs**	Hours
1	Synthesis of Benzocaine (Anaesthetic drug).	**4**
2	Synthesis of 6-methyl uracil (Anticancer drug).	**4**
3	Synthesis of sulfanilamide (Antibiotic drug).	**4**
4	Synthesis of paraacetamol (Analgesic drug)	**4**
5	Synthesis of aspirin (Antiinflamatory drug)	**4**
6	Synthesis of Phenytoin (Anti-convulsant drug).	**4**
7	Synthesis of 2, 3-diphenyl quinoxaline (Antimalerial drug)	**4**
8	Synthesis of Naproxen	**4**
9	Synthesis of Metronidazole	**4**
10	Synthesis of Benzyl Benzoate.	**4**
	Synthesis of Dyes	
11	Direct dyes derived from Terephthalic and Isophthalic Acids.	**4**
12	Synthesis of azodye-Para amino azobenzene	**4**
13	Synthesis of Fluoresein.	**4**
14	Synthesis of Eosin.	**4**
15	Synthesis of Methyl orange II.	**4**
16	Synthesis of Malachite green	**4**
17	Synthesis of Magneson II	**4**

18	Synthesis of phenolphthaleine dye.	**4**
19	Synthesis of alizarin dye.	**4**
20	Synthesis of Rosaniline dye.	**4**
Study Resources	•Kar A., (2004). Advanced Practical Medicinal Chemistry, Theory – Methodology-Purification-Usage, New Age International (P) Limited, Publishers. •Alagarsamy V., (2010). Textbook Of Medicinal Chemistry Volume I, Elsevier. •Ali M.F., Ali B. M., Speight J. G., (2005). Handbook of Industrial Chemistry Organic Chemicals,McGraw-Hill Companies. •Mann, F. G. and Saunders, B. C. (2009). Practical organic chemistry, 4th edition, Pearson Education India. • Vogel, A. (1989). Vogel‟s Text book of practical organic chemistry, 5th edition, Wiley. •Bansal, R. K. (2008). Laboratory Manual of organic chemistry, 5th edition ,New Age International Publishers. •Ikan, R. (1991). Natural Products: A Laboratory Guide, 2nd edition, Academic Press. •Ahluwalia,V. K. and Aggarwal, R. (2000). Comprehensive practical organic chemistry: Preparation and Quantitative Analysis, Universities Press.	

M.Sc. II (Chemistry)

Semester IV

CHO-DSE-626(A): Spectral Identification of Organic Compounds

Total Hours: 60 **Credits: 2**

<table>
<tr><td>Course Objectives</td><td colspan="2">• To learn useful guidelines for solving the structures based on the different spectroscopic data.
• To learn the identification of organic compound structure from given the spectral data</td></tr>
<tr><td>Course Outcomes</td><td colspan="2">After successful completion of this course, students are expected
• To apply their knowledge of various spectroscopic techniques to solve the structure of organic compound.
• To analyze and identify the correct structure of organic compound from given spectral data.</td></tr>
<tr><td></td><td>Contents</td><td>Hours</td></tr>
<tr><td>1.</td><td>Revision of basic principles of important spectroscopy techniques and characterization data tables (IR, NMR, Mass, UV-visible).</td><td rowspan="3">60</td></tr>
<tr><td>2.</td><td>Discussion on solved practice problems (2-3 examples)</td></tr>
<tr><td>3.</td><td>Provides spectral practice problems (15-20 examples) to solve and identify the organic compound structure.</td></tr>
<tr><td>Study Resources</td><td colspan="2">• Spectral identification of organic compounds by Silverstein and Basilar. III, V and VI addition.
• Organic Spectrosopy by William Kemp.
• Elementary organic spectroscopy by Y. R. Sharma.
• Application of absorption spectroscopy of organic compounds by John. R. Dyer.</td></tr>
</table>

M.Sc. II (Chemistry)

Semester IV

CHO-DSE-626(B): Isolation of Natural Products

Total Hours: 60 **Credits: 2**

Course Objectives	• To familiarize the students with isolation and extraction of natural products. • To familiarize the students with natural products present in various food material and plants.	
Course Outcomes	**After successful completion of this course, students are expected** • To understand and apply the principles of isolation and extraction of natural products. • To understand the use of various chromatographic techniques and soxhlet extractions.	
Sr. No.	**Contents**	**Hours**
1	Isolation of clove oil from cloves.	**4**
2	Isolation of Nicotine dipicrate from tobacco.	**4**
3	Isolation of Caffeine from Tea/coffee (Solvent Extraction).	**4**
4	Isolation of Piperine from Pepper (Soxhlet Extraction).	**4**
5	Isolation of Lycopene from Tomato.	**4**
6	Isolation of Eugenol from Cloves/ Cinnamon.	**4**
7	Isolation of Carvone from Spearmint.	**4**
8	Isolation of Stigmasterol From Soyabean oil.	**4**
9	Isolation of Hesperidine from orange peel.	**4**
10	Isolation of Curcumin from turmeric	**4**
11	Isolation of Essential oils from herbs and plants.	**4**
12	Isolation of Camphor from Spearmint.	**4**
13	Isolation of Cymene from cumin.	**4**
14	Isolation of Thymol from tulsi leaves.	**4**
15	Isolation of Linalool from tulsi leaves.	**4**
16	Isolation of Casein from milk.	**4**
	References: 1. Natural Product isolation by J. P Cannell. 2. Natural Product isolation methods and protocols by Satyajit D. Sarkar and LutfunNahar. 3. Natural Products a Practical Manual by Praveen Kumar. 4. Bioactive natural products Detection, Isolation & Structural determination by Steven M. Colegate, Russell J. Molyneux 5. Isolation of Natural Products by Y. Tsuda.	

M.Sc. II (Chemistry)
Semester IV
CHO-RP-627 Research Project II

Hours: 180 **Credits: 6**

Course Objectives

1. To give exposure to the students to research culture and technology
2. To introduce students to how to select a research topic, plan, perform experiments, collect data and analyze the data
3. To foster self-confidence and self-reliance in the students as they learn to work and think independently
4. To learn how to present the project in PowerPoint etc.

Course outcomes

After successful completion of this course, students are expected to:

1. Conceive a problem based on published research and conduct a comprehensive literature survey.
2. Plan and carry out the tasks in the given framework of the dissertation and present the work in writing and viva.
3. Learn handling of instruments, use of chemicals and how to conduct the experiments
4. Learn how to present the project in PowerPoint and answer the queries to examiners and the science of writing.

The systematic approach towards the execution of the project should be as follows:
(Wherever applicable)

1. The complete tenure of the research project should be one academic year. It should be allotted during the third semester and completed in the fourth semester.
2. Weekly 12 hours should be allotted to the research project in a regular timetable.
3. In the fourth semester, students should perform further experimental work, analyze the data and compile the results.
4. Students may be given an opportunity to participate in ongoing research activities in the respective Departments/Schools/Supervisors' laboratories. This will familiarize them with

the literature survey and give them a fundamental understanding of designing and executing a research project.

5. Students may work individually or in groups (not more than 3 students) to be decided by the concerned department/supervisor.
6. Each research group should have a different research topic with some possible level of novelty.
7. The student should select the topic relevant to priority areas of concern or allied subjects.
8. Students are encouraged to work on multidisciplinary and applied projects, but it is not mandatory criteria.
9. Students are expected to work in line with the research outline and literature review,which was submittedin the third semester.
10. Students are expected to learn how to execute the research work systematically and overcome the hurdles. Students will get the opportunity to learn about practical aspects of many characterization techniques or models and further how to effectively employ them in the research work. Students should be able to critically evaluate the literature on the topic, identify the research gaps, plan and perform the experiments, interpret the results, understand the limitations of the work and draw conclusions.
11. At the end of the semester, each student should submit a detailed ResearchReport.
12. The format of the final research report shall be as per the guidelines of respective department. (**Example**:Title of the Project, Certificates, Acknowledgment, Abstract and Keywords, Contents, Introduction, Literature Review, Aim and objective, Materials and Methods, Result, Data analysis and Discussions, conclusion, limitations, suggestion, future scope,Bibliography, Appendix etc.)
13. An appropriate and essential conclusive statement must be drawn at the end of the study.
14. Students should maintain lab notebooks, and the supervisor may ask them to submit the mid-semester progress report.
15. For documents related to project submission: Font- Times New Roman, Heading Font Size-14, Normal Text Size-12, spacing-1.5, both sides justified and 1 inch margin on all side, both side printing on A-4 size.
16. Three copies of the dissertation should be prepared (one copy for each department, guide, and student).

17. At the end of the semester, the candidate should prepare and present research using a PowerPoint presentation using modern ICT tools during the Internal and External Examination.
18. Besides writing a dissertation, students are encouraged to write a manuscript/patent if the results obtained are worthy of publication.
19. Students may present their research work in Avishkar/Webinars/Conferences.
20. Students should note that plagiarism is strictly prohibited.

Internal examination (60 marks): Components of continuous internal assessment:

- Literature collected, methodological planning, analysis of data, design and work, progress reports etc(30 marks)
- Presentation in Webinars/Conferences/publication and departmental presentationetc(20 marks)
- Oral examination (10 marks)

External examination (90 marks)and Components of external assessment:

- Evaluation of dissertation submitted in bound form at the time of examination **(60 marks)**
- Presentation (PPT format) **(15 marks)**
- Overall presentation reflecting the contribution of work, Response to questions **(15 marks)**