CURRICULUM
&
SYLLABUS
Doctorial Program
(PhD – Basic Sciences)



ICFAI Foundation for Higher Education
(Deemed-to-be University under Section 3 of the UGC Act, 1956)

IcfaiTech
Faculty of Science & Technology (FST)

ICFAI FOUNDATION FOR HIGHER EDUCATION ★ HYDERABAD

REGISTRAR
ICFAI FOUNDATION FOR HIGHER EDUCATION
(Deemed-to-be University establishes under section 3 of UGC Act 1956.)

Contents

Item #	Description	Page#
1	Introduction	3
2	PhD Basic Science Program Structure	7
3	Course Descriptions	12
4	Handouts	14
5	Registration	20
6	Teaching & Evaluation	23
7	Grading	28

1. Introduction

1.1 The ICFAI Foundation for Higher Education

The ICFAI Foundation for Higher Education (IFHE) is declared as a Deemed-to-be University, under Section 3 of the UGC Act, 1956. It has evolved a comprehensive student-centric learning approach consisting of several stages, designed to add significant values to the learner's understanding in an integrated manner, covering relevant knowledge, practical skills and positive attitudes. IFHE comprises of:

- Faculty of Management (IBS Hyderabad),
- Faculty of Science and Technology (IcfaiTech), and
- Faculty of Law (FoL).

Vision and Mission of IFHE

The Vision of IFHE is to emerge as an Institution of Excellence known for research, teaching and practice.

The Mission of IFHE is 'Learning for Leadership'. It aims at developing a cadre of professionals possessing specialized skills having a sense of social and moral responsibility and the ability to address problems from a broader perspective.

1.2 Faculty of Science and Technology (IcfaiTech)

Faculty of Science and Technology (IcfaiTech), Hyderabad is a constituent of the ICFAI Foundation for Higher Education. It has been established to promote quality education in the field of Science andTechnology. IcfaiTech strives to acquire a reputation as a highly purposive, innovative institution setting the pace for workable reforms in professional education suitable and most relevant for the Indian cultural milieu.

VISION

The IcfaiTech campus shall become a leading institute for scientific research as well as innovative teaching and learning, keeping pace with evolving knowledge domains. It shall emerge as an attractive destination for the excellent students and the faculties. IcfaiTech aspires to be highly ranked amongst the group of other peer institutes.

MISSION

The mission of the IcfaiTech is to provide high quality teaching and learning experience through our first degree and higher degree programs.

• Teaching Excellence: IcfaiTech periodically reviews and redesigns existing courses and introduces new courses and programs geared towards current research and industry. It explores new dimensions in teaching and learning and uses various platforms and methodologies.

• Research Excellence: The faculty members of the department carry out research in almost all the major areas. The department is now vigorously scaling up its research activity and giving more visibility to it. The volume of research publications in peer reviewed journals of repute and the research funding received by the department has been increasing steadily.

• Faculty Leadership in Administration: The faculty members of the department make significant contribution to administrative leadership and various institute activities and initiatives.

1.3 Educational Philosophy

The core philosophy of education at IcfaiTech is empowering students with the right knowledge and modern skill sets in order that they are ready to face the challenges of the competitive world. IcfaiTech strives to provide its students with the fine edge that is required in the making of a successful professional. The programs at IcfaiTech have been uniquely designed by including courses drawn from varied areas like humanities, arts, and management combined with science, engineering and industry-based internships. IcfaiTech ensures that students gain exposure and knowledge across different disciplines; develop inter-personal skills and leadership qualities that takes them beyond traditional thinking and practice. Today's era of globalization and integrated economies presents talented professionals huge opportunities from across the world. The curriculum at IcfaiTech is truly global and modern in perspective and exposes its students to the latest practices and techniques. The curriculum offers a cafeteria approach allowing them to

choose courses from across the disciplines. This exposure also helps them to develop interests in tune with the current inter-disciplinary nature of research. The educational philosophy practices at IcfaiTech allow it to integrate into its learning system, an innovative and emerging body of knowledge. The highlights of the academic program are summarized below:

• Cutting-edge course curriculum with contemporary and effective pedagogic methods that lay emphasis on application-oriented learning.

• Encouraging students to not only articulate Science and Technology needs but also provide appropriate solutions.

• Developing appreciation for synthesized multidisciplinary learning by way of workshops, internships and other group learning assignments.

1.4 Objectives of IcfaiTech

• To provide high quality, cutting-edge and career-oriented education programs in Science and Technology.

• To offer practice-oriented, contemporary and flexible programs developed through regular assessment and consultation with leading institutions, academicians, professionals and practitioners.

• To turn out highly motivated and successful Science and Technology graduates to meet the current and projected needs of the knowledge workforce.

1.5 Flexibilities

A few of the flexibilities available to the students are mentioned below. The principle of merit, preference of the students and the facilities available at the Institute generally guide the decisions regarding flexibilities. Transfer: Every year, various branches of engineering are ranked based on the preferences and demands of the admitted batch of students. After two semesters of study (end of the first year), students can seek transfer across branches. Requests from students seeking transfer from a less preferred branch to the most preferred branch of B.Tech would be considered if they maintain a CGPA of not less than 9.00, by the end of the first year of degree program. For a branch transfer to the second most preferred branch, a student should have a CGPA of not less than 7.00 by the end of the first year of degree program. A branch transfer from a more preferred branch to a less preferred branch would be permitted without any restrictions on CGPA. Audit: Over the years of study at IcfaiTech, a student may develop interest in areas that go beyond the scope of his/her program of studies. IcfaiTech permits students to take such courses as audit courses. Certain courses like Foreign Languages, Music, etc. which are not the

part of a degree program could be opted for on an audit basis, on payment of additional fees. Audit courses do not count for the CGPA calculation.

Other Flexibilities: The Academic Regulations also provide flexibilities like choice of electives, number of electives, repetition of courses, departure from normal pace, withdrawal from or substitution of course(s).

2. PhD Sciences Program Structure

Programs at IcfaiTech

At IcfaiTech, the programs offered are divided into three tiers, namely the first degree programs, the higher degree programs and the doctoral programs falling into the first, second and the third tiers respectively. All the undergraduate, integrated programs fall under the first degree programs. The various masters programs fall under the category of the higher degree programs. The Ph.D. programs offered by various departments fall under the category of doctoral programs. The academic structures of each of these programs are discussed below.

First Degree Programs (First Tier)

There are three first degree programs being offered at IcfaiTech, the details of which are available in the prospectus/view book. Without going into the details of the regulatory processes, it is necessary to touch upon the subject to obtain a better understanding of these processes, which are controlled by these regulations in respect to operation.

There may be some restrictions from time to time in terms of flexibilities like transfer or dual degree concerning these degree programs. This will be notified in the prospectus/view book as per periodic decision of the Academic Council. All operational matters concerning this will be controlled by the PGC.

Program Courses

The various courses prescribed for a program of study may be categorized in terms of their academic affinity or their functional objectives. Depending on overall educational goals of programs, it is possible to have fixed named courses in a particular category, to have fixed number of electives; to have a range of named courses in a particular category and to have a number of electives within a range. Named courses are those indicated by course number and course title in the semester-wise- pattern prescribed for a program

For first degree students the named courses include all mandatory courses under the General Institutional Requirement and the Discipline Specific Core courses, known as Compulsory Discipline courses (CDCs), for the program(s). The Elective courses fall under three categories: Discipline Electives, Humanities Electives and Open Electives. Open Electives enable students to pursue courses that are neither part of the discipline requirement nor part of the humanities requirement. Normally any elective course will be treated as an Open Elective once the student's

requirement under Discipline Electives and Humanities Electives have been accounted for. Open elective requirement of Dual degree students is met by counting the Discipline Electives of one degree as Open Electives of the other degree. A first degree student may also choose, where permitted, up to a certain prescribed maximum of his/her elective courses from the offerings in the higher degree, subject to the approval by the DCA and the prerequisite requirements and clause 3.18 regarding over preparedness and under preparedness. Provided that, if such a student after graduation is admitted to a higher degree program his/her total requirement in the latter cannot ipso facto be reduced.

The prior preparation required of a student who intends to choose courses from a higher degree program of the Institute for the fulfillment of his/her elective requirement(s).

In a program all courses outside the elective categories are defined as named courses, in view of the fact that they have already been named in the semester-wise-patterns in the prospectus/view book or have been named by an appointed authority through subsequent operation on the basis of guidelines given in the prospectus/view book .The electives are, on the other hand, selected by the student himself/herself from outside the named courses in his/her program. The intended regions where he/she goes for the search will be designated as host regions. Certain specialized courses, Internship programs, Thesis etc., These courses are named courses for some specific programs and they are debarred to other students as electives in the same way as they are debarred to students who wish to take them on audit.

For each program the number of electives, under each of the categories, required to be taken by a student will be prescribed either through the prospectus/view book or through an appropriate committee. Over and above the prescribed number of electives, a student of an integrated first degree program will be allowed to take, on his/her own option, up to a maximum number of four electives. In extraordinary cases, the number may be increased by the DCA without violating limit. For the purpose of eligibility for degree(s),a student should get valid grades in at least the prescribed number of electives – under each of the categories, of his/her program(s). The student above a particular CGPA as prescribed by ACC will be allowed to register in maximum of one higher degree course per semester. This will be counted as open elective unless the course is listed in pool of discipline electives for his/her program.

Once a first degree student is declared to have fulfilled the requirements of graduation the student may be permitted to register for at most one additional semester with prior permission of his/her

Coordinator(s)of Department and Chairperson-Academics. Any first degree student who is interested in pursuing open elective(s) above the graduation requirements and/or completing a minor program he/she is pursuing and if that necessitates overstay, he/she should obtain permission from Chairperson- Academics at least one semester before the start of the overstay period. The overstay period can be at most one semester during which the student must register for at least three new courses of at least 9 units. In case a student withdraws from one or more of his/her courses or otherwise is found not to be pursuing his/her courses in all earnestness Chairperson-Academics in concurrence with the student's department Coordinator is authorized to get him/her graduated and evacuate the student from the campus.

The structure contains a category of courses such as Internship Program (IP)/Thesis (TS), which attempts a synthesis of earlier courses and gives a glimpse of the application of these courses. They carry a large number of units and are to be pursued when student can ensure sufficient time and attention throughout the allotted period. In particular, IP components are to be pursued exclusively full time throughout the allotted period. There is no provision for taking other courses along with an IP component. In case of a Thesis a student may choose between 12 units worth of thesis work or 20 units worth of thesis work with the concurrence of his/her supervisor. A student pursuing a 20 unit thesis must pursue it exclusively full time throughout the allotted period and there is no provision for taking other courses along with it. A student pursuing a 12 unit thesis may concurrently pursue at most 3 courses (totaling at most 9 units) and will not be allowed to pursue any other course/component.

The Higher Degree Programs (Second Tier)

At higher degree level, structure of the program is classified into courses, like, Research Methods, CDCs, electives, IP and thesis. Registration for the IP can be done only after all other required courses have been completed.

In the case of thesis, while normal registration can be done only after completion of all other courses, in extraordinary cases, the DCA may allow registration in Dissertation, spread over various semesters, along with other courses. A student of higher degree program can register up to a maximum of one elective more than those prescribed in a semester. This additional elective can be from the pool of electives of the concerned degree or named/electives courses from other disciplines' with the permission of DCAs – namely the DCA of the student's Department and the DCA of the Department offering the course that the student wants to pursue. The grade obtained in such additional electives will also be counted towards the CGPA. Each course in the Core

Requirement or in the List of Electives must be a graduate level (5th or 6th level) course or an advanced under-graduate course (4th level) with the restriction that a student may use at the most two 4th level courses to meet the requirements in above.

Ph. D Program (Third Tier)

The Ph.D. program is designed for the student to achieve a broad competence before research begins. He/she is required to clear certain course work, if not already cleared, and pass the Qualifying Examination to satisfy the institute that his/her spectrum of knowledge is such as to enable him to undertake the demands of interdisciplinary research. Working knowledge of a modern European language, wherever specified, Teaching Practice, Independent Study, Research Methodology and specified units of Thesis course and Seminar are significant components of the Ph.D. program. The pursuit of research through the Thesis-Seminar course will continue and terminate in a thesis which meets the standards and requirements of the committee of scholars.

The Academic Year

At IcfaiTech, the academic year is divided into two semesters (First Semester and the Second Semester) and a term called Summer Term. Each semester is of 18 weeks duration and summer term of 8 weeks duration.

The eligibility for a degree is determined on the basis of number of units completed. The minimum stipulated number of units for various degree programs are given below

Integrated First Degree (First tier)

B. Tech.	172
B. Sc.	133
B. Sc. – B. Tech Degree	209
B.Tech – B.Tech Degree	243

Higher Degree (Second tier)

M. Tech	90
Ph.D. (Thesis)	40

PhD Program Regulations:

The degree of Doctor of Philosophy (PhD) shall be awarded by IFHE University in the Faculties of Management, Science & Engineering and Law and in accordance with the provisions of these rules and regulations in present or amended form, and subject to the conditions laid down therein. These regulations are applicable to both full time and part time PhD Programs offered from the academic year 2016-17 onwards.

The following committees oversee the academic and administrative activities of the PhD Program:

I. **IFHE PhD Program Committee**: Chaired by the Vice Chancellor, this committee comprises the Directors, senior faculty members and the PhD Coordinators from all the three faculties of the University. The committee overseas the following activities:

1) The conduct of the program in all its aspects, including its design, admissions, academic and disciplinary matters;

2) Amendments and additions to the Rules and Regulations subject to approvals;

3) Performance evaluation of doctoral students;

4) Decisions on matters related to unsatisfactory academic performance, misconduct and moral turpitude.

II. **PhD Proposal Screening Committee:** This committee is appointed by the Vice Chancellor. Each faculty will have their own Proposal screening committee. This committee reviews the thesis proposals submitted by the students and approves the thesis topic of a student and appoints the PhD thesis supervisor after the student successfully defends his/her thesis proposal.

The Screening Committee would check the quality of the PhD Thesis Proposal of the student. Specifically, it will focus on the clarity of the objectives, thoroughness of the review of literature, proposed methodology and data analysis, and whether the thesis work makes a significant contribution to the existing body of knowledge. The Screening Committee, after deliberations, may decide on one of the following:

a. It accepts the proposal and recommends approval of the same.

b. It suggests the student to make revisions in the proposal and resubmit the proposal again to the Screening Committee.

c. It rejects the proposal, stating reasons.

1. Eligibility Criteria for Admission into PhD Programs

Candidates seeking admission in to the PhD Programs of all the Faculties (Management, Engineering, Science and Law) shall have:

1.1 A regular, full time Master's degree or a professional degree (declared equivalent to the master's degree by the corresponding statutory regulatory body), **with at least 55% marks** in aggregate or an equivalent grade in a point scale (wherever grading system is followed). (Candidates possessing master's degree in allied areas shall complete the pre-requisite courses as prescribed by the concerned Faculty).

(OR)

1.2 Qualified the UGC-NET/JRF/CSIR-NET/SLET/GATE examinations.

(OR)

1.3 A regular, full time M.Phil degree from any recognized University

(OR)

1.4 One year executive PG degree with relevant industry experience (at least 3 years)

(OR)

1.5 One year professional PG degree in Law

(OR)

1.6 A professional qualification like CFA / CA / ICWA / CS with 55% and above marks for management candidates.

2. Duration of the Program

2.1 PhD Program, both full time and part time, shall be for a minimum duration of 4 years, including the course work and a maximum of Eight years.

2.2 Extension beyond the above limits or early submissions (before 4 years) will be governed by the decision of the competent authority and ratification by the Academic Council.

3. Procedure for Admission

3.1 PhD Entrance Test shall be conducted by each Faculty. Each Faculty shall have its own modalities as approved by the competent authority.

3.2 M.Phil degree holders, UGC-NET/JRF/CSIR-NET/SLET/GATE qualified candidates are exempted from the entrance test.

3.3 In case of management stream, Candidates with GMAT® score of 500 & above, CAT percentile of 60 & above, IBSAT qualified are exempted from the entrance test.

3.4 Final selection process consists of Interview (which may include research aptitude test and micro presentation)

4. Semester Registration

4.1 PhD Students have to register for every semester at the beginning of each semester. If a student does not register for a semester without seeking exemption, his/her name may be removed from the rolls of PhD program.

5. PhD Program Structure

5.1 Each Faculty shall decide the structure of the courses, keeping in mind the basic program structure of the University, indicated in Table-1.

Table-1: The Ph. D Program Structure

Year	Semester I		Semester II	
	Course Title	**Credits**	**Course Title**	**Credits**
I	Research Methods-1	4	Research Methods-2	4
	Advanced Strategic Management	4	Doctoral Seminar -3	4
	Doctoral Seminar -1	4	Doctoral Seminar -4	4
	Doctoral Seminar -2	4	Doctoral Seminar -5	4
	Total credits	**16**	**Total credits**	**16**
Summer Research Project **PhD Qualifying Examination**				

5.2 Minimum credits required for Ph. D program is 32.

5.3 Upon successfully clearing the PhD qualifying exam, the full time PhD students are required to give at least one PhD Proposal preparation seminar in every semester. Upon successful thesis proposal defense, full time PhD students are required to give at least one PhD Thesis Progress Seminars in every semester until they submit the thesis for evaluation.

5.4 Upon successfully clearing the PhD qualifying exam, the part time PhD students are required to give one PhD Proposal preparation seminar in every 4 months. Upon successful thesis proposal defense, part time PhD students are required to give at least one PhD Thesis Progress Seminars in every 4 months until they submit the thesis for evaluation.

5.5 A PhD student is permitted to change from full-time mode to part-time mode and vice-versa, upon approval from the concerned competent authority.

6. Coursework and PhD Qualifying Examination

6.1 **Pre-PhD Courses**: Candidates joining the PhD program with a post graduation in allied disciplines of management are required to attend the 16 courses of MBA program offered during Semester-1 and Semester-2 as well as the Business Strategy course as a pre-requisite to proceed to the course work phase of the PhD Program. Candidate is also required to secure a CGPA of 7.5/10 as well as a grade not less than 'D' in all the courses at the end of Semester-2 of MBA. Also, candidate should maintain a GPA of 6.0 at the end of Semester-1 to proceed to Semester-2 of MBA. Candidate is also required to complete the 12 weeks summer internship program of MBA.

6.2 The objective of the coursework is to impart scholarship and to equip the student with the latest developments in the discipline, including the tools of research. In the first year the student takes **8 courses of 4 credits** each spread across two semesters.

6.3 Students who receive scholarships[1] are required to maintain a minimum CGPA of 7.5/10.0 at the end of the course work. Further, a student is also required to secure a minimum grade of 'C' in each course in order to be eligible to continue in the program. Method of calculating GPA/CGPA is illustrated in Appendix-A.

6.4 At the end of Semester-1, if the GPA falls within the range of 6.0 to 7.5, students may be allowed to proceed to Semester-2. However, they may have to improve the GPA of Semester-1 by taking up assignments/term papers/examinations in certain courses, in consultation with the faculty members who have handled the courses. However, the stipend would be stopped till they make up the GPA to 7.5 in both the semesters.

6.5 Students who successfully complete the coursework with a minimum CGPA of 7.5 are eligible to appear for PhD qualifying examination. The qualifying examination consists of written examination followed by a viva voce.

6.6 The qualifying viva voce would be conducted by a panel of examiners. Based on the overall performance, the result of the qualifying examination will be declared in terms of "Pass" or "Fail". The student may avail a maximum of two attempts for clearing the qualifying examination. If a student fails to qualify in two attempts, he/she will be discontinued from the program.

[1] As per University norms

7. Doctoral Advisory Committee

7.1 Upon successful completion of the PhD Qualifying exam, Doctoral Advisory Committee (DAC) will be constituted. The role of the DAC is to guide the student to sharply focus on the exact area of research and help in formulating the thesis proposal.

7.2 DAC comprises one convener and two members. DAC is appointed based on the following criteria:

a. The Convener and members should be from the broad area in which the student opts to pursue the PhD research.

b. The Convener and members should possess a PhD degree.

c. The proposed convener and members should have **at least four publications** in refereed journals or in journals recognized by the University.

d. However, a senior professional, holding a PhD degree in the relevant area (related to Management, Engineering, Science and Law), and having long professional experience in organizations of repute, may also be appointed as member of DAC.

The role of the DAC is:

a) To guide the student to sharply focus on the exact area of research and help in formulating the thesis proposal.

b) To periodically review and assist in the progress of the research work of the research scholar.

c) To guide the research scholar to develop the study design and methodology of research

d) The DAC is expected to submit a quarterly progress report of the student to the PhD Office.

The DAC exists till the approval of the Thesis Proposal by the University. The DAC convener invariably becomes the supervisor subject to approval by the screening committee.

8. Allocation of PhD Supervisor

8.1 Only a full time regular faculty member can act as a supervisor.

8.2 Number of research scholars that can be guided by a supervisor/convener/member at any given point in time is limited to 6 (six) for all the faculty members (Professor/Assoc. Professor/Asst. Professor) and 3 (three) for all the academic administrators (Directors/Deans/HODs).

8.3 In case of research topics which are inter-disciplinary in nature, apart from the supervisor, a co-supervisor may also be appointed from outside the Department/ Faculty/ College/Institution, on such terms and conditions as may be specified and agreed upon by the consenting Institutions/Colleges.

9. Preparation, Submission and Defense of Thesis Proposal

9.1 The student would prepare Thesis proposal document under the guidance of his/her DAC. The proposal approved by the DAC would be forwarded to the PhD Screening Committee for review.

9.2 The student is required to submit the first draft of the Thesis Proposal for review within two semesters after passing the Qualifying examination.

9.3 The proposal draft should not exceed 20 pages excluding the references. To ensure that all the relevant aspects of a PhD Thesis Proposal are covered, students are expected to prepare the draft based on the format presented in Table-2.

9.4 The Doctoral Advisory Committee of a student, after satisfying itself, will request the Convener to forward the proposal for approval. The Convener should forward the Thesis Proposal in the prescribed Performa (Refer Annexure-2) to the concerned PhD Coordinator along with the suggested name and CV of the proposed Supervisor for approval of the Screening Committee (consisting of senior faculty members appointed by the Vice Chancellor).

Table 2: PhD Thesis Proposal format

Section	Title
1	Introduction and Motivation (importance) for the proposed research
2	Literature survey (critical review of research papers related to the thesis topic) and
3	Identification of research gaps
4	Proposed Research Objectives, Model and Research Hypotheses
5	Research Methodology, sources of data and experimental resources
6	Expected contribution to the state of the art
7	List of references
8	Timeline (plan) of Research

9.5 The Screening Committee will check the quality of the PhD Thesis Proposal. Specifically, it will focus on the clarity of the objectives, thoroughness of the review of literature, proposed methodology, data analyses, and whether the thesis work makes a significant contribution to the existing body of knowledge. The Screening Committee, after deliberations, may decide on one of the following:

a) It accepts the proposal and recommends approval of the same.

b) It suggests the student to make minor revisions in the proposal and resubmit.

c) It suggests the student to make major changes in the proposal and resubmit and present the proposal again to the Screening Committee.

d) It rejects the proposal.

e) If the screening committee rejects the proposal the student has to work and resubmit the proposal again to the screening committee within a stipulated period of time.

9.6 By beginning of the third academic year, students are required to defend their theses proposals. Proposals cleared by the committee are scheduled for defense seminar, attended by the DAC, department faculty members, fellow PhD students and the Screening Committee.

9.7 Appointment of Supervisors would be done based on successful completion of the PhD Proposal Defense, by the Screening Committee.

10. PhD Thesis Preparation and Submission

10.1 In the fourth academic year students have to complete the Ph D thesis work and submit the thesis for evaluation.

10.2 Change of title of the thesis by the student is permitted in exceptional cases on taking necessary approvals from the Screening Committee. PhD Supervisor has to provide justifications for the change of title and request for the same in a prescribed format available in the PhD office (Refer Annexure-3).

10.3 Transfer of PhD students from one supervisor to another supervisor can be effected by the Screening Committee on the merit of the case.

10.4 PhD Supervisor has to verify, confirm and certify that the thesis data collected by his/her student is genuine.

10.5 While submitting the thesis for evaluation, the dissertation/thesis shall have an undertaking from the research scholar and a certificate from the PhD supervisor

attesting to the originality of the work, vouching that the thesis is free of plagiarism and that the work has not been submitted for the award of any other degree/diploma of the same institution or to any other institution.

10.6 Plagiarism percentage is fixed at 10%. Would be adjusted as per the UGC guidelines.

10.7 While submitting for evaluation, the dissertation/thesis shall have an undertaking from the PhD student and a certificate from the Supervisor attesting to the originality of the work, vouching that there is no plagiarism and that the work has not been submitted for the award of any other degree/diploma of this University or to any other institution.

10.8 PhD student must publish at least one research paper in a refereed journal, before submission of the thesis for adjudication, and produce evidence for the same in the form of acceptance letter and/or reprints.

10.9 PhD student must make two paper presentations in conferences/seminars, before submission of the thesis for adjudication and produce evidences for the same.

11. Progress Seminars

11.1 A PhD student is expected to give at least one progress seminar every semester in their respective department until he/she submits the thesis. The seminar tests the students for the following:

- ✓ Knowledge of basic concepts
- ✓ Ability to apply the knowledge of basic concepts
- ✓ Additional knowledge acquired
- ✓ Ability to analyze a given problem or situation
- ✓ Logical development of the subject
- ✓ Effective oral communication

11.2 After the successful defense of the PhD proposal, students are required to give one progress seminar exclusively on sampling design and data, computational and experimental procedures, where relevant.

11.3 Evaluation of progress seminars would be done by the respective Supervisors/DAC Conveners at the end of the seminar. (Refer Annexure - 4).

11.4 Two consecutive unsatisfactory grades will be viewed seriously and will not be permitted to continue in the PhD Program.

12. Research/Teaching Internship

12.1 After successfully defending their theses proposals, full time PhD students are required to involve in teaching, research or related academic activities.

13. Performance Monitoring and Feedback

13.1 The performance of students post PhD qualifying examination would be done on a quarterly basis.

13.2 The DAC Conveners/PhD Supervisors are expected to submit a quarterly Progress Report on the performance of their students in the prescribed format (Refer Annexure-5).

13.3 In case the progress of the PhD student is unsatisfactory, the DAC Convener/Supervisor has to record the reasons for the same and suggest corrective measures. If the student fails to implement these corrective measures, the DAC Convener/Supervisor may recommend to the concerned competent authority with specific reasons for cancellation of the PhD registration.

14. Appointment of Examiners

14.1 The Supervisor will submit a list of proposed examiners to the Registrar. Names and addresses along with the curricula vitae of at least six eminent persons in the field of research, should be proposed in the list (4 external examiners and 2 internal examiners).

14.2 The Vice Chancellor will select 3 examiners (2 external and 1 internal from the list submitted to him) and form a panel of examiners consisting of the Supervisor and the three selected ones.

14.3 The examiners may be from India or abroad. At least one examiner will be from outside the State.

14.4 The Vice Chancellor may ask the Supervisor or the Registrar to submit more names in the panel of proposed examiners if he so desires.

15. Examiner's Report on the Thesis

15.1 Invitations would be sent to the examiners selected by the Vice Chancellor. If they accept to evaluate the thesis, hard/soft copies of theses are sent to them, along with the recommendation forms. The Thesis Examiners have to complete and send their separate review reports on the Thesis along with the recommendation, in the approved format, to the concerned PhD Coordinator, within 10 weeks. An extension of maximum one month may be given for the purpose.

15.2 If the report is not received from an examiner within the stipulated period, the Thesis will be sent to another examiner chosen by the Vice Chancellor from the panel submitted by the Supervisor.

15.3 In case, all the examiners approve the thesis, it will be accepted and the student shall appear for the viva-voce examination.

15.4 In case, any one of the three examiners has not approved the thesis, the thesis shall be referred again to a fourth examiner, Indian or Foreign as the case may be. However, if the fourth examiner does not approve the thesis, the thesis shall be rejected and the registration will be cancelled.

15.5 If the examiner(s) suggest a revision and re-submission of the thesis, then the revised thesis duly certified by the supervisor shall be sent to all the examiners. If they all approve the revised thesis then the student shall appear for the viva-voce.

15.6 When a student is required to revise and resubmit his/her Thesis, his/her status will revert to what it was before the submission of the Thesis.

16. PhD Viva voce Examination

16.1 Upon approval of the thesis unanimously by all the 4 examiners, viva-voce examination for the student would be scheduled. Normally, the same panel of four examiners will conduct the viva-voce examination, which should be open to research scholars, faculty members and others.

16.2 If, due to some unforeseen circumstances, one of the examiners is unable to attend the viva-voce, the Vice-chancellor may permit to conduct the viva-voce with the remaining three examiners.

16.3 A student who is not successful at the viva-voce examination may be permitted to undergo the viva-voce examination for a second time, within a period of three months but not before one month after the first viva-voce.

17. Final Grade and Award of PhD Degree

17.1 Based on the total performance of the student, the panel of examiners would finally give one of the following grades: Excellent / Very good / Good / Unacceptable to the thesis.

17.2 Students who have achieved "Excellent", "Very Good" or "Good" grade in the thesis will be awarded PhD degree after approval of the results by the Academic Council.

18. Cancellation of PhD Registration

A student will not be permitted to continue in the PhD Program under any one of the following situations:

i) His/Her CGPA, wherever applicable, falls below the prescribed value

ii) He/She fails to pass the PhD Qualifying Examination within the prescribed time

iii) He/She accumulates two consecutive "Unsatisfactory" grades during the thesis work period, post qualifying examination.

iv) He/She fails to submit and defend the Thesis proposal/revised thesis proposal within the time prescribed for such submission as directed by the PhD screening committee

v) His/Her Thesis is rejected by the examiners

vi) His/Her Thesis does not receive unanimous final verdict from the examiners as required.

vii) Any proven indiscipline in the campus or outside.

19. University reserves the right to amend the regulations from time to time, if needed.

Annexure-1

Evaluation & Grading

a. The performance in most courses is spelt out in letter grades A, B, C, D, E. Each letter grade has qualitative meaning and a grade point value as given below:

Letter Grade	A	B	C	D	E
Qualitative Meaning	Excellent	Good	Fair	Poor	Exposed
Grade Point	10	8	6	4	2

b. In some courses, descriptive non-letter grades are awarded which carry no grade points. These are '***Satisfactory***' or '***Unsatisfactory***' grades.

CGPA

The up-to-date overall performance is reported by the Cumulative Grade Point Average (CGPA), which is a weighted average calculated as below:

$$CGPA = (u_1g_1 + u_2g_2 + u_3g_3 + ...) / (u_1 + u_2 + u_3 + ...)$$

Where u_1, u_2, u_3 ..... denote units associated with the courses taken by the student and g_1, g_2, g_3 ..... denote grade points of the letter grades awarded in the respective courses, provided that when a student repeats a course, the new grade replaces the earlier one in the calculation of the CGPA.

Annexure – 2

Form No.1

The ICFAI Foundation for Higher Education

Declared as a Deemed-to-be-University Under Section 3 of the UGC Act, 1956

FORM FOR SUBMISSION OF THESIS PROPOSAL AND PROPOSED SUPERVISOR

Enclosed herewith is my Ph.D Thesis Proposal recommended by DAC for approval by the Screening Committee. The proposed Topic and Title of Ph.D Thesis are given as below:

Topic of Research: _____

_____

Title of the Thesis: _____

_____

Following are the details of the Proposed Supervisor

Name:

Dr./Prof./Shri._____

Designation_____

Organization_____

Address_____

Tel.No._____Email_____

Yours Sincerely

_____

(Signature of Candidate)

Full Name: _____

ID. No:_____

Place of Work _____

CONSENT OF THE PROPOSED SUPERVISOR

I have scrutinized the above Ph.D Thesis Proposal and I agree to act as Supervisor as per the provisions of the Academic Regulations of the University.

Date: _____

_____

(Signature of the Proposed Supervisor)

Forwarded, along with a copy of the Ph.D Thesis Proposal Approved by DAC.

Date: _____

_____

HoD/Dean/Director

Annexure – 3 **Form No.2**

The ICFAI Foundation for Higher Education

Declared as a Deemed-to-be-University under Section 3 of the UGC Act, 1956

FORM FOR THE REQUEST OF CHANGE OF THESIS TITLE / SUPERVISOR

The approved Ph. D Title and the name of Supervisor for my Thesis are:
(Title)

_____

_____

___

(Name of the
Supervisor)_____

Now I request that the title of my Ph. D Thesis / name of my Supervisor be changed to the following:

(Reason for change in Title / Supervisor should be appended)

New Title

_____

_____

___

New Supervisor

_____

Designation

_____

Organization

_____

Address

_____

Tel. No._____
Email_____

Yours sincerely,

_____
(Signature of the candidate)

Full Name: _____

Place of Work: _____ ID No. :

_____

RECOMMENDATIONS OF THE EXISTING SUPERVISOR

I have satisfied myself of the need to change the Title of the Ph. D thesis as mentioned above.

and / or

I will not be able to continue to act as his/her Supervisor and suggest that another Supervisor be appointed to supervise the Ph. D thesis work of this candidate.

Date: _____ (Signature of the existing Supervisor)

CONSENT OF THE PROPOSED SUPERVISOR

I have scrutinized the Ph. D thesis proposal and I agree to act as the Supervisor as per provisions of the Academic Regulations of the University.

Date: _____ (Signature of the proposed new Supervisor)

Annexure-4 **Form No.3**

The Icfai Foundation for Higher Education

FORM FOR EVALUATION OF RESEARCH SEMINAR

PhD Program

Section – 1

(To be filled by the candidate)

Name of the event: Research Seminar

Semester: _____ Year: _____

Name of the student: _____ _____Enrol. _____

E-Mail: _____ Phone: _____

Name of the Convener, DAC / Supervisor _____

Address: _____

Tel. No: _____ E-Mail: _____

Topic of the Seminar: _____

_____

Date of Seminar: _____

_____

Signature of the Candidate

The candidate must enclose a copy of the write up of the seminar presentation to depict the progress of the work done during semester. The candidate may mention Publications, if any, in the area of the thesis.

Section – II

(To be filled by the Convener, DAC / Supervisor)

Comments on the progress of Research work and the Seminar by the Convener of DAC / Supervisor: (Additional Sheet may be attached, if required)

☐ Recommended ☐ Not Recommended

Recommended Grade: Satisfactory / Unsatisfactory

_____ _____

Date

Signature of the Convener of DAC / Supervisor

Annexure-5 **Form No.4**

The Icfai Foundation for Higher Education

PhD Program

Quarterly Progress Report

Period from _____ to _____

1. **Name of the PhD Student:** .....

2. **Please tick (√) the current status of the Scholar:**

   a. Thesis Proposal stage

      i) Please give the tentative date for proposal submission: .....

   b. Thesis preparation stage

      i) Please give the tentative date of Thesis submission: .....

3. **How do you rate the quality of interaction with your student?**

   Satisfactory Unsatisfactory

4. **How do you rate the progress made by the student during this period?**

   Satisfactory Unsatisfactory

5. **Brief Report on the current status of the thesis work:**

.....
.....
.....
.....
.....
.....

PhD Supervisor/DAC Convener:

Date:

Contact #:

Email-id:

.....

Signature of the Supervisor/DAC Convener

The Icfai Foundation for Higher Education

Declaration Form

(To be signed by Full Time PhD Students)

I hereby declare that I have clearly read and understood the regulations of the PhD program and agree to abide by the same.

Signature of the student: .....

Name of the student: .....

Enrollment No.: .....

Place:.....

Date:.....

The Icfai Foundation for Higher Education

Declaration Form

(To be signed by Part Time Students of Faculty of Management)

Please read the clauses given below and sign the declaration form.

1. Semester Registration

PhD Students have to register for every semester and shall be done at the start of each semester. If a student does not register for a semester without seeking exemption, his/her name may be removed from the rolls of PhD program.

2. Fee for Part-time PhD Program

- An admission fee of Rs. 40,000 has to be paid to confirm the admission. This fee is non-refundable.
- The Program fee of Rs.60,000 per semester has to be paid for 8 semesters.
- The fee should be paid at the beginning of each semester.
- There is no fee waiver or fellowship/stipend for Part-time PhD Program students.

3. Duration of Part time PhD Program

The duration of the Part time PhD program is 4 years. However, part time PhD students who could not complete the theses within the stipulated period of 4 years would be granted an extension subject to satisfactory progress in the thesis work, as recommended by the Supervisor and approved by the Vice Chancellor. Nevertheless, the students are required to register for subsequent semesters and pay a tuition fee of Rs. 60,000/- per semester to protect the enrollment as well as to avail the academic and administrative services for the extended period or completion of PhD thesis, whichever is earlier. If a student is not able to complete the PhD thesis within 8 years, he/she ceases to be a student of the PhD Program forthwith.

Declaration by the student

I hereby declare that I have clearly read and understood the regulations of the PhD program and agree to abide by the same.

Signature of the student: .....

Name of the student: .....

Enrollment No.: .....

Place:.....

Date:.....

The Ph. D Program Structure

Year	Semester I		Semester II	
	Course Title	**Credits**	**Course Title**	**Credits**
I	Course - I	4	Course - I	4
	Course - II	4	Course - II	4
	Course -III	4	Course -III	4
	Course -IV	4	Course -IV	4
	Total credits	**16**	**Total credits**	**16**
PhD Qualifying Examination				

Students who successfully complete the coursework with a minimum CGPA of 7.5 are eligible to appear for PhD qualifying examination. The qualifying examination consists of written examination followed by a viva voce.

Upon successful completion of the PhD Qualifying exam, the Doctoral Advisory Committee is constituted to guide the student on the exact area of research and help in formulating the thesis proposal and monitor the progress. The proposal approved by the DAC would be forwarded to the PhD Screening Committee for review.

PhD Screening Committee reviews the thesis proposals submitted by the students and approves the thesis topic of a student and appoints the PhD thesis supervisor after the student successfully defends his/her thesis proposal.

A PhD student is expected to give at least one progress seminar every semester in their respective department until he/she submits the thesis.

The performance of students post PhD qualifying examination would be done on a quarterly basis.

The DAC Conveners/PhD Supervisors are expected to submit a quarterly Progress Report on the performance of their students.

In the fourth academic year students have to complete the Ph D thesis work and submit the thesis for evaluation.

Department of Chemistry

Ph.D. Course work (Semester -I)

S. No	Course Code	Course Title	LTP	Credits
1.	CH611	Research Methodology-I	400	4
2.	CH612	General Chemistry	400	4
3.	CH613	Advanced Inorganic Chemistry	400	4
4.	CH 617	Chemical and Electrochemical Kinetics	400	4

Department of Chemistry

Ph.D. Course work (Semester -II)

S. No	Course Code	Course Title	LTP	Credits
1.	CH 619	Research Methodology-II	400	4
2.	CH 614	Organic Synthesis & Synthine Mechanism	400	4
3.	CH 615	Advanced Physical Chemistry	400	4
4.	CH 618	Inorganic and Organometallic Chemistry	400	4

HANDOUTS

Course code	:	CH611
Course Title	:	Research Methodology-I
Number of Credits	:	4
Prerequisites	:	M.Sc
Course Type	:	Compulsory Course

Course Learning objectives

To impart the fundamentals of research methods.

To introduce the basic concepts in research, research methods and their approach that includes literature survey, research design, techniques, collection and analysis of data.

To develop an understanding of the ethical dimensions of conducting applied research.

Course contents

Module I - Introduction to research and research process overview: Research: Meaning of Research, research motivation and objectives, research and scientific method. **Research Approaches:** Descriptive vs. analytical research, applied vs. fundamental research, quantitative vs. qualitative research, conceptual vs. empirical research. Significance of research. **Research methodology:** An introduction. **Research Process:** Basic overview, Criteria of Good research, Formulating the research problem, Defining the research problem. Research questions, research methods vs. research methodology.

[10 Lect.]

Module II - Essence of research methodology: Stages of research problem: Selecting the research topic, defining the research problem, importance of literature survey and reference collection in defining a problem. **Literature review:** Primary and secondary sources, journals, patents, web as a source. Development of working methodology.

[8 Lect.]

Module III - Designing and planning of experiments, time management: Research design: Meaning of research design, need for research design, different research designs, Observation of Laws and theories, predictions and explanation. **Experimental design:** Basic principles of experimental designs, planning of experiments for achieving aims and objectives, Importance of reproducibility of research work.

[8 Lect.]

Module IV – Methods of data collection and analysis: Collection of data: Collection of primary data, secondary data, sampling merits and demerits of experiments, procedure and observation methods, sampling errors. **Statistical data analysis: Introduction to statistics:** Probability theories, Conditional probability, Poisson distribution, binomial distribution and normal distributions, estimates of means and proportions, Chi-Square Test, **Association of attributes:** t-test, standard deviation, coefficient of variations. **Types of analysis:** Correlation and regression analysis. Introduction to statistical packages, plotting of graphs.

[12 Lect.]

Module V – Interpretation, report and thesis writing: Meaning of interpretation and its precautions, significance of report writing, different steps in writing report- layout and structure, layout of research report. **Types of report writing**: research papers, thesis, research project reports, pictures and graphs, citation styles and oral presentation. **Application of results and ethics:** Research ethics, copy right, intellectual property right and patent law, reproduction of published material, plagiarism, citation and acknowledgement, reproducibility and accountability.

[10 Lect.]

REFERENCES

1. C. R. Kothari, Research Methodology: Methods and techniques, 2nd revised edition, New Age International Publishers (2004).
2. R. P. Baker, A. C. Howell, The preparation of reports, New York: Ronald Press (1938).
3. Edwards, L. Allen, Statistical methods, 2nd edition, New York: Holt, Rinehart and Winston (1967).
4. R. A. Fisher, Statistical methods for research workers, 13th edition, New York: Hafner Publishing Co., (1960).
5. R. A. Fisher, The design of experiments, 7th revised edition, New York: Hafner Publishing Co., (1960).
6. Harnett, L. Donald and Murphy, L. James, Introductory statistical analysis, Philippines: Addison Wesley Publishing Co., Inc., (1975).
7. Johnson, Ellen, The research report: A guide for the beginner, New York: Ronald Press (1951).
8. Ullman, R. Neil, Elementary Statistics, New York: John Wiley and Sons, Inc., (1978).
9. T. Yamane, Statistics: An Introductory Analysis, 3rd edition, New York: Prentice-Hall (1960).
10. John W. Creswell, Research design: Qualitative, Quantitative and Mixed methods approaches, 2nd edition, Sage publications (2003).
11. P. D. Leedy and J. E. Ormrod, Practical Research: Planning and Design, Prentice Hall (2004).
12. A. Fink, Conducting research literature reviews: From the internet to paper, Sage Publications (2009).
13. Chawla, Deepak and Sondhi, Neena, Research Methodology: Concepts and cases, Vikas Publishing House Pvt. Ltd. Delhi (2011).
14. Data collection and analysis, 2nd edition, Edited by Roger Sapsford and Victor Jupp, Sage publications (2006).
15. Yogesh Kumar Singh, Fundamental of Research methodology and statistics, New Age International Publishers (2006).

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required numerical skills necessary to carry out research.

General Chemistry

Course code	:	CH612
Course Title	:	General Chemistry
Number of Credits	:	4
Prerequisites	:	M.Sc Chemistry
Course Type	:	Discipline Oriented Course

Module-I: SYMMETRY OF MOLECULES & REACTION MECHANISMS OF TRANSITION METAL COMPLEXES

i) Symmetry of Molecules: Concept of Symmetry in Molecules – Symmetry Operations & Symmetry Elements: Rotational Axis of Symmetry and Types of Rotational Axes, Plane of Symmetry and types of Planes, Improper Rotational Axis of Symmetry, Inversion Center and Identity Element – More about Symmetry Elements – Molecular Point Groups: Definition and Notation of Point Groups, Classificationof Molecules in to C_1, C_s, C_i, C_n, C_{nv}, C_{nh}, C_{nv}, D_n, D_{nh}, D_{nd}, S_n (n = even), , T_d, O_h and I_h; Groups. Properties of a group-sub group.

ii) Reaction mechanisms of transition metal complexes:

Ligand substitution reactions: Energy profile of a reaction- Transition state of Activated complex. Types of substitution reactions (SE, SN, SN_1, SN_2).
Ligand substitution reactions in octahedral complexes: Acid hydrolysis reactions, Factors effecting Acid Hydrolysis, Base Hydrolysis, Conjugate Base Mechanism, Evidences in favour of SN_1CB Mechanism. Substitution reactions without Breaking Metal-Ligand bond. Ligand Substitution reactions in Square-Planar complexes: Mechanism of Substitution in Square-Planar complexes- Trans-effect, Grienberg's Polarization theory and π - bonding theory – Applications of Trans-effect in synthesis of Pt (II) complexes. Electron Transfer Reactions (or Oxidation-Reduction Reactions) in Coordination compounds: Mechanism of One-electron Transfer Reactions: Atom (or group) Transfer or Inner Sphere Mechanism, Direct electron Transfer or Outer Sphere Mechanism.

[8 Lect]

MODULE- II: STRATEGIES IN ORGANIC SYNTHESIS

i) Oxidations: Swern, Prevost and Woodward oxidations.
ii) Reductions: Birch reduction, Reduction with $LiAlH_4$, $NaBH_4$, BH_3, AlH_3, and tri-n-butyl tinhydride.
iii) Organo- metallic reagents: Use of Organo lithium, Silicon and boron reagents in Organic synthesis.
iv) Modern Organic Synthetic Reactions: Aza-Cope and Aza-Wittig reactions, Baylis-Hillman reaction, BINAL and BINAP assisted reactions, Buchwald-Hartwig coupling, Click

reaction, Grubb's catalyst and RCM olefin metathesis, Heck reaction, Julia- Lythgoe olefination, Mukayama aldol reaction, Mitsunobu reaction, McMurray reaction, Peterson's stereoselective olefination, Suziki coupling. [10 Lect]

MODULE - III: CHEMICAL KINETICS & PHOTO CHEMISTRY

CHEMICAL KINETICS: Structure-Reactivity relationships- Linear free energy relationships. Hammett equation – The substituent constant (□□) and exalted sigma values. The Reaction constant (□□) and the importance of rho value in arriving at the mechanism of reactions. Deviations from Hammett correlations. Taft equation and Taft four parameter equation. The Swain – Scott equation- Correlations for nucleophillic reactions. The Edward equation. The reactivity-selectivity principle and the iso-selectivty rule. The intrinsic barrier and Hammond's postulate.

PHOTO CHEMISTRY: Formation of excimers and exciplexes –Quantum yields. Electronically excited states- singlet and triplet states. Uni molecular decay of the excited state- internal conversion, inter system crossing, fluorescence and phosphorescence. Principles of energy transfer- photosensitization.
Flash photolysis and it's applications.

Organic photochemistry: Properties of (n, □*) and (□,□□) states. Photochemistry of alkenes: Cis-trans isomerisation, di□□ - methane rearrangement. Photochemistry of carbonyl compounds: i) Norrish type-I reactions. Photoreduction and photooxidation.ii); Norrish type-II reactions. Addition of carbonyl to carbon-carbon multiple bonds (Paterno-Buchi) reaction. Barton reaction. Singlet oxygen – photo oxidation and reactions with C=C compounds. $Ru(bpy)_{3}^{2+}$ as sensitizer for photo redox reactions. Photochemical cleavage of water.
[10 Lect]

MODULE-IV: PRINCIPLES OF SPETROSCOPY

i) IR Spectroscopy: Introduction, Principles, Characteristic vibrational frequencies of functional groups, Fermi resonance, Effect of hydrogen bonding on vibrational frequencies.

ii) Electronic spectroscopy: Introduction, Principles and Wood -Ward Fisher rules.
iii) NMR Spectroscopy (^{1}H NMR): Introduction, Principles, factors effecting the chemical shifts, spin-spin coupling, first order spectra
iv) Mass Spectrometry: Introduction, Principles, use of isotopic peaks, salient feature of fragmentation of organic compounds, McLafferty rearrangements, retro Diels-Alder fragmentation and ortho effects. Simple problems on structure determination based on the above spectral methods.
Atomic Absorption Spectroscopy (AAS): Principles of AAS– flame AAS and furnace AAS, sensitivity and detection limits in AAS, interferences – chemical and spectral, evaluation methods in AAS and applications in qualitative and quantitative analysis.
Atomic Emission Spectroscopy (AES): Principles of AES, Instrumentation, evaluation methods and application in quantitative analysis [10 Lect]

MODULE-V: COMPUTER APPLICATION

Introduction to Computers and Computing. Basic structure and Components of a computer. Evolution of computational machines, Memory devices. Secondary storage Computer languages. Number systems and some related numerical problems. Operating systems with DOS as an example Introduction to UNIX and WINDOWS. Principles of programming, Algorithms and flow-charts.

Programming in Chemistry. Developing of small computer codes using any one of the languages FORTRAN/C/BASIC involving simple formulae in Chemistry, such as Van der Waals equation. Chemical kinetics (determination of Rate constant) Radioactive decay (Half Life and Average Life). Determination Normality, Molarity and Molality of solutions. Evaluation Electronegativity of atom and Lattice Energy from experimental determination of molecular weight and percentage of element organic compounds using data from experimental metal representation of molecules in terms of elementary structural features such as bond lengths, bond angles.

Use of Computer programmes and Internet. Operation of PC. Data Processing. Running of standard Programs and Packages such as MS WORD, MS EXCEL-special emphasis on calculations and chart formations. X-Y plot. Simpson's Numerical Integration method. Programmes with data from physical and inorganic experiments. Application of Internet for Chemistry with search engines, various types of files like PDF, JPG, RTF and Bitmap. Scanning, OMR, Web camera.

Origin of Computational Software Models; Quantum Mechanics and its general applications in chemistry, Schrodinger's time dependant and time independent equations with derivations. Historical background of DFT approach, Thomas Fermi model and Kohn Sham Derivations.

Current Use of Software Packages in Chemical Research: Gaussian and Gauss View, Hartree-Fock Theory and Basis Sets, Semi empirical Methods, Electron Correlations, Density Functional Theory, Combined QM/MM Methods, Why and How to Combine QM and MM, Solvation and Solvent Effects, Polarization, Reaction profiles in solution, Protein-Ligand Interactions, Modelling Enzymatic Reactions [10 Lect]

Reference books:

MODULE - I: Symmetry of molecules & Reaction mechanisms of transition metal complexes

1. Chemical Applications of Group Theory, F. A. Cotton, 3rd edition, Wiley NY (1990)

2. Symmetry and Group Theory In Chemistry, Mark Ladd, Harwood Publishers, London (2000)

3. Symmetry Through the Eyes of a Chemist, I. Hargittai and M. Hargittai, 2nd Edition, Plenum Press, NY (1995)

4. Reaction mechanism in transition metal complexes .Basolo & Pearson

MODULE - II: Strategies in Organic Synthesis

1. Some modern methods of organic synthesis by W Carruthers

2. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken

3. Organic synthesis by O House

4. Organic synthesis by Michael B Smith

5. Reagents for organic synthesis, by Fieser & Fieser, Vol 1-11(1984)

6. Organic synthesis by Robert E Ireland

7. Organic Synthesis - The disconnection approach by S Warren

8. Organic Synthesis by C Willis and M Willis

9. Handbook of reagents for organic synthesis by Reich and Rigby, Vo I, IV

10. Problems on organic synthesis by Stuart Warren

11. Total synthesis of natural products: the Chiron approach by S.Hanessian

12. Organic chemistry Claydon and others 2005

13. Name Reactions by Jie Jack Li

14. Reagents in Organic synthesis by B.P.Mundy and others.

15. Tandem Organic Reactions by Tse-Lok Ho

MODULE - III: Chemical Kinetics & Photo Chemistry

1. Chemical Kinetics, K. J. Laidler, McGraw Hill

2. Kinetics and Mechanism, A. A. Frost & R. G. Pearson, John Wiley & sons

3. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman & J. Kuriacose, McMillan

4. Chemical Kinetics and Reaction Mechanisms, J. H. Espenson, McGraw Hill

5. Physical Organic Chemistry, N. S. Isaacs, ELBS

6. The Physical basis of Organic Chemistry, Howard Maskill, Oxford University Press

7. Molecular Photochemistry, N. J. Turro, W. A. Benzamin

8. Fundamentals of Photochemistry, Rohatgi-Mukherjee, Wiley Eastern

9. Essentials of Molecular Photochemistry, A. Gilbert & J. Baggott, Blackwell Science

10. Introduction to Molecular Photochemistry, C. H. J. Wells, Chapman and Hall

11. Molecular Reactions and Photo chemistry by Depuy and Chapman

MODULE -IV: Principles of Spectroscopy

1. Fundamentals of Molecular Spectroscopy, Banwell and McCash.
2. Introduction to Molecular Spectroscopy, G.M. Barrow
3. Absorption Spectroscopy of Organic Compounds, J.R. Dyer
4. Biochemistry: Hames and Hooper.
5. Spectroscopic identification of organic compounds by R.M.Silverstein. G.C.Bassler and T.E.Morrill
6. NMR-A multinuclear introduction by William Kemp
7. Spectroscopic identification of Organic compounds by RM Silverstein, G C Bassler and T B Morrill
8. Organic Spectroscopy by William Kemp
9. Spectroscopic methods in Organic chemistry by DH Williams and I Fleming
10 . Modern NMR techniques for chemistry research by Andrew B Derome
11. NMR in chemistry - A multinuclear introduction by William Kemp
12. Spectroscopic identification of organic compounds by P S Kalsi
13. Introduction to organic spectroscopy by Pavia
14. Carbon-13 NMR for organic chemists by GC Levy and O L Nelson
15. Principles of Instrumental Analysis, Skoog, Holler and Nieman.
16. Instrumental Techniques for Analytical Chemistry, Frank Settle.
17. Principles of Analytical Chemistry, M. Valcarcel.

MODULE-V: COMPUTER APPLICATION

1. Quantum Chemistry, 6th ed., Ira N. Levine, Pearson Education, Inc., New Delhi, 2012
2. Molecular Quantum Mechanics, 4th ed., P. W. Atkins, R. S. Friedman, Oxford University Press 2005
3. Essentials of Computational Chemistry, 2nd ed., C. J. Cramer, Wiley, 2005
4. Introduction to computational Chemistry, 2nd ed., F. Jensen, Wiley, 2007
5. Computational Chemistry, D. Young, Wiley 2001
6. Fundamentals of Computer: V. Rajaraman, Prentice Hall.
7. Computers in Chemistry: K.V. Raman, Tata Mc Graw Hill).

8. Computer Programming in FORTRAN IV-V Rajaraman, Prentice Hall.

9. Computers and Common Sense, R. Hunt and J. Shelley, Prentice Hall.

10. Computational Chemistry, A.C. Norris.

11. Microcomputer Quantum Mechanics, J.P. Killngbeck, Adam Hilger.

12. An Introduction to Digital Computer Design, V. Rajaraman and T. Radhakrishnan, Prentice Hall.

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Advanced Inorganic Chemistry (SDC)

Course code	:	CH613
Course Title	:	Advanced inorganic Chemistry
Number of Credits	:	4
Prerequisites	:	M.Sc Chemistry
Course Type	:	Discipline Oriented Course

MODULE -I: Bonding in metal complexes, Electron absorption Spectroscopy
Molecular Orbital Theory of Metal Complexes: Symmetry Classification of Metal and Ligand Orbitals in Cubic and Non-Cubic Environments: Octahedral, Tetrahedral, Square Planar, Square Pyramidal, Trigonal Bipyramidal Geometries – Concept of Ligand Group Orbitals – Construction of Molecular Orbital Energy Level Diagrams for Octahedral, Tetrahedral and Square Planar Metal
Complexes with Sigma (σ) and Pi (π) Bonding Contribution from the Ligands.
Electron absorption spectroscopy: Effect of weak cubic crystal fields on S,P,D and F terms-Orgel Diagrams. Selection Rules: Relaxation in Selection Rules – Nature of Electronic Spectral Bands: Band Widths, Band Intensities and Factors Influencing Band Shapes– Crystal Field Spectra of O_h and T_d metal Complexes of $3d_n$ Metal ions – Calculation of 10Dq Values, Racah Parameter. [10 Lect]

MODULE -II: IR, Raman, NMR and ESR, IR and Raman: Symmetry Based Selection Rules of Infrared and Raman – Symmetry Requirements for Overtone, Binary and Ternary Combination Bands - Fermi Resonance . Application of IR spectroscopy in the structural elucidation of inorganic compounds and metal complexes- Aquo, sulfato,
carbonato , nitro and carbonyl metal complexes.
Multinuclear NMR: Characteristic Nuclear Properties of $_1H$, $_{13}C$, $_{19}F$, $_{31}P$ and $_{15}N$ – Reference standards- Ranges of Chemical Shifts –Use of Chemical Shifts and Coupling Constants for the structure determination of simple inorganic and Coordination Compounds containing one or more of $_1H$, $_{13}C$, $_{19}F$, $_{31}P$ and $_{15}N$ nuclei.Examples; (1)$_1$H-NMR: Pt $HCl(PEt_3)_2$, Pt $(NH_3)_3(CH_3)_3$, BH_4^- , $[h_7C_7H_7Mo(CO)_3]^+$, B_2H_6; (2) $_{19}$F- NMR: PF_5, BF_4^-, SF_4; (3) $_{31}$P-NMR: H_3PO_2, H_3PO_3, H_3PO_4, [Rh $(PPh_3)_3$ Cl_3],[$Mo(CO)_3(PPh_3)_3$], [Rh $(PPh_3)_3$ Cl] , ATP. (4) $_{13}$C-NMR: [h_4 C_8H_8 $Ru(CO)_3$], $Fe(CO)_5$, $Fe_2(CO)_9$, $Fe_3(CO)_{12}$, [$_{13}$C $_{15}$N Co$(DH)_2$Pyridine].
ESR of Metal Complexes: Principle- Selection Rules –. g value and its significance, Interpretation of g in cubic , axial and rhombohedral geometries. Factors affecting g values. Calculation of g values with simple examples. Intensities of '$g_\parallel$ and $g_\perp$ peaks Evidence for Metal-Ligand Bond Covalency- Cu(II)- Bis –Salicylaldimine. $Co_3(CO)_9Se$, $[(NH_3)_5CoO_2$ Co $(NH_3)_5]^{5+}$, Cu(II)- diethyldithio phosphinate, Vanadyl dithio phsphinate, Copper(II) tetraphenyl porphyrin, Co(II)- phthalocyanine,
$K_2[IrCl_6]$. [10 Lect]

MODULE -III: Supramolecules and Organo metallic Catalysis

Supramolecular chemistryHost – Guest chemistry : Definition and different types of host and guests with examples – types of non covalent interactions – binding constants of host guest complex and thermo dynamics involved in it – designing principles of host. **Cation guest binding** – binding between metal cations and macro cycles – chelate and cryptate effects – relationship between cavity size of host
and cation radius and stability of resultant complexes – binding of macro cycles having secondary binding sites – **Anion guest binding** – different hosts for anionic guests capable of binding through electro static interactions, hydrogen bonds, lewis acidic hosts – enhancement of binding strength using more than non covalent interactions – **Neutral guest binding** – binding of neutral guest using hydrogen
bonding, π - π stacking, hydrophobic effect and charge transfer interactions – simultaneous binding of cation and anion guests – cascade approach, individual binding sites and zwitter ions approach –present and future applications – phase transfer agents – separation of mixtures – molecular sensors – switches
and molecular machinery.

Catalytic role of Organometallic Compounds: Oxidative addition and Reductive Elimination : Stereochemistry and Mechanism of Oxidative Addition – Insertion Reactions – Hydrogenation of Olefins –Transfer Hydrogenation – Hydrosilation of Olefins – Isomerisation of Olefins – Ziegler –Natta Polymerization of Olefins – Oligomerization of Butadiene . Alkene Metathesis. Oxidation of Olefins to Carbonyl Compounds – Oxidation of Hydrocarbons to Alcohols and Acids –Oxidation of Aldehydes. Reactions of Carbon monoxide and Hydrogen : Hydroformylation – Carbonylation –Syngas-Water gas
shift Reaction (WGS) – Reactions of Syngas. Applications of Metal Clusters in Catalysis :Hydroformylation of Ethylene using $[HRu_3(CO)_{11}]^-$, Hydrogenation of Olefins. Use of $[Fe_6C(CO)_{16}]$ as a model for Fischer – Tropsch process. [10 Lect]

MODULE -IV: Bio inorganic Chemistry (15 hrs)

Role of metal ions in biology – four basic principles in the biological selection of elements – brief survey of metal ions in biological system – effect of metal ion concentration and physiological effect.

Cobalt enzymes : chemistry, biochemistry and medicinal aspects of vit B_{12} – structure of vit B_{12} –various forms – Base 'On' and Base 'Off' and His 'On' or His 'Off' forms – complete and incomplete corrinoids – comparison of two biologically active forms of vit B_{12} – catalyzed reactions of vit B_{12} using coenzyme B and methyl cobalamin – biomethylation, methyl transfer to mercury and arsenic – vit B_{12} as drug transport vehicle – bio chemistry – functions of vit B_{12}, symptoms and causes of vit B_{12}
deficiency, absorption and storage of vit B_{12} – historical events in the discovery of vit B_{12}.

Nickel enzymes : Urease – active site – mechanism of degradation of urea to carbon dioxide and ammonia.**Copper enzymes :** Substrate specific antioxidants – Cu, Zn superoxide dismutase – structure and catalytic mechanism. **Zinc enzymes :** Role of zinc in catalytic activities of carbonic hydrase, carboxy peptidase and alkaline phosphate. **Vit B_6 :** Various forms – mechanism of catalysed reactions
– Dunothan hypothesis – role of metal ions in B_6 catalytic activity. [10 Lect]

MODULE-V: Bio inorganic Chemistry

Platinum complexes in cancer therapy: Discovery, applications and structure effect Relationships. Cis-platin(cis $Pt(NH_3)_2Cl_2$) mode of action. Drug resistance and DNA repair mechanism.

Physical effects of metal complex: DNA binding, unwinding, shortening and bending of the double helix. Biological consequences of platinum –DNA binding. Transition metal complexes as donor acceptor pairs. Non classical platinum antitumor+ agents.

[10 Lect]

REFERENCES & SUGGESTED BOOKS:

1. Chemical Applications of Group Theory, F. A. Cotton, 3rd edition, Wiley NY (1990)
2. Symmetry and Group Theory In Chemistry, Mark Ladd, Harwood Publishers, London (2000)
3. Symmetry Through the Eyes of a Chemist, I. Hargittai and M. Hargittai, 2nd Edition, Plenum Press, NY (1995)
4. Molecular Symmetry and Group Theory, Robert L. Carter, John Wiley & Sons (1998)
5. Group Theory for Chemists, G. Davidson, Macmillan Physical Science Series (1991)
6. Molecular Symmetry, Schoenland
7. Electronic Spectroscopy, A. B. P. Lever
8. Introduction to Ligand fields, B. N. Figgis Infrared and Raman Spectroscopy of Inorganic and Coordination Compounds, K. Nakamoto
9. Infrared spectroscopy of Inorganic Compound, Bellamy
10. Physical Methods in Chemistry, R. S. Drago, W.B. Saunders Co., 1977.
11. Chemical Structure and Bonding, R.L. Decock and H.B. Gray.
12. Physical Methods for Chemists, Russell S. Drago Second edition, Saunders ,College Publishing, 1992.
13. Comprehensive Coordination Chemistry, Vol 6.
14. Modern Coordination Chemistry, Lewis and Wilkins.
15. Organometallics-A Concise Introduction, Ch.Eischeinbroich and Salzer-VCH
16. Organotransition Metal Chemistry Fundamental Concepts and Applications, John Akio Yamamato, Wiley & Sons.
17. Homogeneous Catalysis by Metal Complexes, M M Taqui Khan and A E Martel
18. Applied Homogenous Catalysis with Organo Metallic Compounds Vol I & II, Boy Cornills and W A Herrmann – VCH
19. Homogenous catalysis, G W Parshall, John Wiley & Sons, New York
20. Inorganic elements in the Chemistry of life, Wolfgang Kaim & Brigette Schwederdki.
21. Bio inorganic Chemistry, Bertini, Lippard and Valentine, University Science Books, California USA, 1994
22. Principles Bioinorganic Chemistry., S J Lippard and Berg University Science Books, California USA, 1994
23. Biological Chemistry of Elements, J. J.R. Franstodasilva and R.J.P. Williams, aoxford University Press 1991
24. Metal ions in Biological Systems (series) Ed.H. Sigel Marcel Dekkar, New York
25. Inorganic Biochemistry, J.A. Cowan, VCH publishers 1993
26. Advances in Inorganic Biochemistry, edited by by G.L. Eichor

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Chemical and Electrochemical Kinetics (CH 617)

Course code	:	CH617
Course Title	:	Chemical and Electrochemical Kinetics
Number of Credits	:	4
Prerequisites	:	M.Sc Chemistry
Course Type	:	Elective Course

MODULE -I: Reaction Dynamics Factors affecting the chemical reaction rate: temperature, ionic strength of the solution, catalyst, pH and dielectric constant of the medium, micelle, reverse micelle & nano-particles; Determination of rate constant by stopped flow method & relaxation method; Flash photolysis & use of LASER; Ultra-fast reactions and introduction to diffusion controlled reactions. [8 Lect]

MODULE -II: Electrode-electrolyte interface : The electrical double layer. The Helmholtz-Perrin parallel-plate model, the Gouy-Chapman diffuse-charge model and the Stern model.

Corrosion : Electrochemical mechanism of corrosion . Types of corrosion, various methods of corrosion control.

D.C Palaeography : Dropping mercury electrode-polarography Instrumentation-polarogram.Types of limiting Currents : Adsorption, Diffusion, Kinetic. Ilkovic equation and its consequences. Applications of polarography. Determination of stability constant of complex.

Cyclic Voltammetry : Principle, instrumentation, reversible and irreversible cyclic voltammograms. Applications. Cyclic voltammetric study of insecticide parathion.

Electro-Organic synthesis **:** Electro chemical reduction of carboxylic acids, Electrochemical reduction of nitro compounds.

Anodic oxidation of metals **:** Characteristics of anodic oxide films. Instrumentation –break down voltage. Industrial applications of anodic oxide films.

Fuel cells; Solar cells (photochemical, photovoltaic); Batteries (solid-state & conventional)-single electrode and complete cell studies; Production of H2 and important chemicals of high energy; Corrosion & waste removal techniques. Electrochemical Techniques Polarog,raphy; Chronopotentiometry; Chronoamperometry, Chronocoulometry, Linear Potential Sweep Voltametry; Cyclic Voltametry, Impedance measurements; AC Voltametry.

[10 Lect]

MODULE -III: Bio-membranes (Structure and Function); Active transport and passive transport, Multiple equilibria, Specific examples of multiple equilibria, Transport processes; General features of transport processes; Optical systems for the study of transport processes, Self organizing systems (Micelles, Lipids. Cyclodextrins, Liquid crystals, Reverse micelles, coacervates, Proteins etc) their interactions and solutions properties. Preparation, Characterization and Application of nanoparticles Surface and Biophysical Techniques: CD, SEM, TEM, EDAX, DLS, Gel Electrophoresis, Radioactivity, XPS. [10 Lect]

MODULE -IV : HETEROGENEOUS CATALYSIS

Heterogeneous catalysis: Broad categories of catalysts – metals, bimetals, semiconductors, insulators, zeolites, oxides and nano materials.

Preparation of metal catalysts: Supported metal catalysts and non- metallic catalysts.
Characterization of catalysts: Surface area by BET method. Determination of pore volume and pore size distribution by BJH method. Pore size and specificity of catalysts. Surface acidity of catalyst & determination of surface acidity by indicator method, IR spectroscopic method and TPD method.

Steps in heterogeneous catalyzed reactions: Catalytic activity – the determining factors. Structure sensitive and structure insensitive catalysts. Mechanism of surface-catalyzed reactions. The Langmuir - Hinshelwood and the Eley- Rideal mechanisms. Rate constants and activation energies of surface reactions.

Introduction to Phase-transfer catalysis (PTC): Principles of phase-transfer catalysis. PTC classification. Role of water in phase-transfer catalyzed reactions. Factors influencing the rate of PTC reactions. Inverse phase transfer catalysis. [10 Lect]

MODULE -V: MOLECULAR MODELING

Molecular modeling: QSAR parameters – Physiochemical parameters- Lipophilicity – Electronic parameters, Steric parameters, effect of electronic and steric parameters on lipophilicity. Hansch analysis, significance of slopes and intercepts in Hansch analysis. QSAR-2D, 3D.

Case studies – on Pyranenamine. Achievements of QSAR – Forecasting biological activity, selection of proper substituents, bioisosterism, drug receptor interactions and pharmacokinetic information – Introduction to database similarity Search–Alignment ; Alignment methods, – Pair-wise alignment ; Multiple Sequence Alignment – Homology Modeling – Energy minimization methods – Active site Identification – Virtual Screening – Small molecule Building – Docking Algorithms – Docking Analysis [10 Lect]

References:

1. Chemical Kinetics, K. J. Laidler, McGraw Hill
2. Kinetics and Mechanism, A. A. Frost & R. G. Pearson, John Wiley & sons
3. Kinetics and Mechanism of Chemical Transformations, J. Rajaraman & J. Kuriacose, McMillan
4. Chemical Kinetics and Reaction Mechanisms, J. H. Espenson, McGraw Hill
5. Physical Organic Chemistry, N. S. Isaacs, ELBS
6. The Physical basis of Organic Chemistry, Howard Maskill, Oxford University Press
7. Modern Electrochemistry 2A & 2B, J. O. M. Bockris & A. K. N. Reddy, Plenum publishers
8. Introduction to Electrochemistry, S. Glasstone
9. Industrial Electrochemistry, D. Pletcher, Chapman & Hall
10. Fundamental principles of Modern Electroplating, Lowenheim, John Wiley
11. Principles of Polarography, Heyrovsky.
12. Principles of Polarography, Kapoor.
13. Modern Electroanalytical methods, edited by C.Charlot, Elsevier Company.
14. Principles of Instyrumental analysis, Skoog, Holler and Nieman, Harcourt Asia PTE Ltd.
15. Analytical Chemistry-An Introduction, Skoog, West, Holler and Crouch, Saunders College Publishing.
16. Principles of Instrumental Analysis, Skoog and Leary, Saunders College Publishing.
17. Principles of Heterogeneous Catalysis in practice, G. C. Bond, Oxford Publishing
18. Heterogeneous Catalysis, C. Satterfield, McGraw Hill
19. Catalysis, Principles and applications, edited by B. Vishwanathan, S. Sivasanker & A. V. Rama Swamy, Narosa Publishing House
20. Catalysis, J. C. Kuriacose, Macmillan

21. Phase Transfer Catalysis, Fundamentals, Applications and Industrial perspective, C. M. Stark, C. Liotta & M. Halpern, Academic Press
22. Phase Transfer Catalysis, E. V. Dehmlow & S. S. Dehmlow, Verlag Chemie, Weinheim
23. Phase Transfer Catalysis in Organic synthesis, W. P. Weber & G. W. Gokel, Springer
24. Drug design By E.J. Arienes
25. Jenkin's quantitative pharmaceutical chemistry By Knevel and Dryden
26. Recent advances in Bioinformatics By I. A. Khan and A Khanum
27. Computational chemistry By GH. Grant and WG. Richards
28. Molecular modelling By Hans Dieter Holtje and Gerd Folkers
29. Molecular modelling By Leach
30. Computational Chemistry by Jenson
31. Bio Informatics by Rastogi
32. The Science and practice of Pharmacy – Vol I and Vol II by Remington

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Research Methodology-II

Course code	:	CH 619
Course Title	:	Research Methodology-II
Number of Credits	:	4
Prerequisites	:	M.Sc
Course Type	:	Compulsory Course

MODULE-I: Spectroscopy and Asymmetric Synthesis 1H, 13C, 2D & other nuclei; Mass Spectrometry; Instrumental techniques: Basic principles and applications of instrumental techniques: Cyclic voltammetry, Gas chromatography, HPLC, IR, UV-Vis., ESR, 1H/C13-NMR, ESR, ENDOR & NQR, ESCA, XFAS, Mössbauer, TG/DTA/DSC, SEM, TEM, and XRD.

Conjoint Spectroscopy Problems: Application of UV, IR, Raman, NMR, ESR and Mass spectrometry for elucidation of structure of organic and inorganic compounds. [10 Lect]

MODULE -II: Advanced Organic Synthesis: Application of photochemistry and radical chemistry in Organic Synthesis; Pericyclic & Electrocyclic Reactions; Total synthesis with retro synthetic analysis. [8 Lect]

MODULE -III: Terminology, concepts of pro-chirality, enantio selectivity and diastereo selectivity. Methods for determination of enantiomer purity: Polarimeter, 1H-NMR and HPLC methods.

i) Asymmetric hydrogenation using chiral Wilkinson biphosphine and Noyori catalysts; approaches to L- DOPA and L-α- amino acids.

ii) Asymmetric aldol reaction and asymmetric Diels-Alder reaction.

iii) Chiron approach to stereo selective synthesis of (-) PGE2 and (-) shikimic acid. [10 Lect]

MODULE -IV Synthesis Methodology in Organometallic Chemistry; Green Chemistry; Combinatorial and Carbohydrate Chemistry. Introduction to Bio-organic Chemistry, Biomimetics; Peptides and Proteins Chemistry; Supramolecular Chemistry. [10 Lect]

MODULE -V

(a) Microwaves in organic synthesis. Non- thermal effects of microwaves in organic synthesis.

Origin of microwave effects. Specific microwave effects. Effect of the medium. Effects of reaction mechanisms. Selectivity in microwave assisted reactions. Advantages and limitations of microwave heating in organic synthesis.

(b) The Disconnection Approach. Basic principles, synthons, functional group interconversions. Order of events in organic synthesis. One group C-X disconnections and two group C-X disconnections. [10 Lect]

REFERENCES:

Spectroscopy:

1. Spectroscopic identification of organic compounds by RM Silverstein, G C Bassler andT B Morrill
2. Organic Spectroscopy by William Kemp
3. Spectroscopic methods in Organic chemistry by DH Williams and I Fleming
4. Modern NMR techniques for chemistry research by Andrew B Derome
5. NMR in chemistry - A multinuclear introduction by William Kemp
6. Spectroscopic identification of organic compounds by P S Kalsi
7. Introduction to organic spectroscopy by Pavia
8. Carbon-13 NMR for organic chemists by GC Levy and O L Nelson

Natural Product Chemistry:

1. Textbook of organic chemistry, Vol II by I L Finar
2. Chemistry of natural products, Vol 12, by Atta-Ur-Rahman
3. An introduction to the chemistry of terpenoids and steroids by William templeton
4. Systematic identification of flavonoid compounds by Mabry & Markham
5. Steroids by Fieser and Fieser
6. Alkaloids by Manske
7. Alkaloids by Bentley
8. The chemistry of terpenes by A Pinder
9. The terpenes by Simenson
10. Terpenoids by Mayo
11. Alkaloids by Pelletier
12. Total synthesis of Natural Products by Apsimon Vol 1-5
13. Biosynthesis by Geismann
14. Principles of organic synthesis 3rd Ed.R O C Norman and J M Coxen
15. One and two dimensional nmr spectroscopy by Atta Ur Rahman
16. Classics in total synthesis K C Nicolaou and E J Sorenson

Modern Concepts of Organic Chemistry and Green Chemistry:

1. Some modern methods of organic synthesis by W Carruthers
2. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken
3. Organic synthesis by O House
4. Organic synthesis by Michael B Smith
5. Reagents for organic synthesis, by Fieser & Fieser, Vol 1-11(1984)
6. Organic synthesis by Robert E Ireland
7. Organic Synthesis - The disconnection approach by S Warren
8. Organic Synthesis by C Willis and M Willis
9. Handbook of reagents for organic synthesis by Reich and Rigby, Vo I, IV
10. Problems on organic synthesis by Stuart Warren
11. Total synthesis of natural products: the Chiron approach by S.Hanessian
12. Organic chemistry by Claydon and others 2005
13. Name Reactions by Jie Jack Li
14. Reagents in Organic synthesis by B.P.Mundy and others.
15. Tandem Organic Reactions by Tse-Lok Ho
16. Organic synthesis in water. By Paul A. Grieco Blackie.
17. Green chemistry, Theory and Practical, Paul T.Anastas and John C.Warner.
18. New trends in green chemistry By V.K.Ahulwalia and M.Kidwai.
19. Organic Synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal

Synthetic strategies and Asymmetric synthesis.

1. Stereochemistry: Conformation & Mechanism by P S Kalsi
2. Stereochemistry of Carbon compounds by Ernest L Eliel
3 . Stereo selectivity in organic synthesis by R S Ward.
4. Asymmetric synthesis by Nogradi
5. Asymmetric organic reactions by it) Morrison and HS Moscher
6. Stereo differentiating reactions by Izumi
7. Some modern methods of organic synthesis by W Carruthers
8. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken
9. Organic synthesis by Michael B Smith
10. Organic Synthesis by C. Willis & M. Willis
11. Total Synthesis of natural products: the Chiron approach by S. Hanessian
12. Organic Synthesis- The disconnection approach by S. Warren
13. Problems on Organic Synthesis by Stuart Warren
14. Organic Chemistry by Claydon

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Organic Synthesis & Synthine Mechanism (SDC)

Course code	:	CH614
Course Title	:	Organic Synthesis & Synthine Mechanism
Number of Credits	:	4
Prerequisites	:	M.Sc Chemistry
Course Type	:	Discipline Oriented Course

MODULE-I : NMR Spectroscopy

a) ^{13}C NMR (CMR) Spectroscopy: Principles involved and different types of CMR spectra, Chemical shifts and coupling in CMR. Applications of CMR spectroscopy to structure determination, stereochemistry, reaction mechanisms and dynamic processes in organic molecules. ^{13}C NMR spectral editing techniques. Principles and applications of APT, INEPT and DEPT techniques.

b) 2D- NMR Spectroscopy: Principles and applications of the following 2D- NMR experiments.
i) HOMO and Heteronuclear J resolved spectroscopy ii) HOMO COSY and TOCSY
iii) HETERO COSY , HMQC and HMBC iv) NOESY v) INADEQUATE [10 Lect]

MODULE -II: Natural Product Chemistry

a) IR, UV, ^{1}H, ^{13}C , 2D- NMR and mass spectral studies of the following classes of Natural Products:
i) Coumarins ii) Flavones iii) Isoflavones iv) Flavanones v) monoterpenes vi) Quinoline and isoquinoline alkaloids (cusparine and papaverine)
b) Structure elucidation, synthesis and stereochemistry of the following.
i) Taxol ii) Vincaleucoblastine iii) Reserpine iv) Rotenone. [8 Lect]

MODULE -III : Modern Concepts of Organic Chemistry and Green Chemistry

a) New Techniques and concepts in organic synthesis. i) Combinatorial synthesis ii) Phase transfer catalysis iii) Tandem synthesis iv) Mosher's method for configuration determination v) Baldwin rules vi)Kahne's glycosidation vii) Methods of oligonucleotide synthesis.

b) Green Chemistry: Introduction, principles of green chemistry, Different approaches to green synthesis: Microwave and Ultrasound assisted organic synthesis, Solid phase and aqueous phase organic synthesis. [10 Lect]

MODULE -IV: Synthetic strategies

a) Design of Organic synthesis: Terminology, Retrosynthesis, FGI, disconnection, synthon synthetic equivalent, protecting groups, chemoselectivity, regioselectivity and stereoselectivity. Linear and convergent strategies, Use of disconnection approach in the synthesis of multistriatin, Warfarin and α- bisabolene. [10 Lect]

MODULE -V: Asymmetric Synthesis: Terminology, concepts of prochirality, enantio selectivity and diastereo selectivity. Methods for determination of enantiomer purity: Polarimeter, ^{1}H-NMR and HPLC methods.

i) Asymmetric hydrogenation using chiral Wilkinson biphosphine and Noyori catalysts; approaches to L- DOPA and L-α- amino acids.

ii) Asymmetric aldol reaction and asymmetric Diels-Alder reaction.

iii) Chiron approach to stereoselective synthesis of (-) PGE_2 and (-) shikimic acid.

[10 Lect]

REFERENCES:

NMR Spectroscopy:

1. Spectroscopic identification of organic compounds by RM Silverstein, G C Bassler andT B Morrill
2. Organic Spectroscopy by William Kemp
3. Spectroscopic methods in Organic chemistry by DH Williams and I Fleming
4. Modern NMR techniques for chemistry research by Andrew B Derome
5. NMR in chemistry - A multinuclear introduction by William Kemp
6. Spectroscopic identification of organic compounds by P S Kalsi
7. Introduction to organic spectroscopy by Pavia
8. Carbon-13 NMR for organic chemists by GC Levy and O L Nelson

Natural Product Chemistry:

1. Textbook of organic chemistry, Vol II by I L Finar
2. Chemistry of natural products, Vol 12, by Atta-Ur-Rahman
3. An introduction to the chemistry of terpenoids and steroids by William templeton
4. Systematic identification of flavonoid compounds by Mabry & Markham
5. Steroids by Fieser and Fieser
6. Alkaloids by Manske
7. Alkaloids by Bentley
8. The chemistry of terpenes by A Pinder
9. The terpenes by Simenson
10. Terpenoids by Mayo
11. Alkaloids by Pelletier
12. Total synthesis of Natural Products by Apsimon Vol 1-5
13. Biosynthesis by Geismann
14. Principles of organic synthesis 3rd Ed.R O C Norman and J M Coxen
15. One and two dimensional nmr spectroscopy by Atta Ur Rahman
16. Classics in total synthesis K C Nicolaou and E J Sorenson

Modern Concepts of Organic Chemistry and Green Chemistry:

1. Some modern methods of organic synthesis by W Carruthers
2. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken
3. Organic synthesis by O House
4. Organic synthesis by Michael B Smith
5. Reagents for organic synthesis, by Fieser & Fieser, Vol 1-11(1984)
6. Organic synthesis by Robert E Ireland
7. Organic Synthesis - The disconnection approach by S Warren
8. Organic Synthesis by C Willis and M Willis

9. Handbook of reagents for organic synthesis by Reich and Rigby, Vo I, IV
10. Problems on organic synthesis by Stuart Warren
11. Total synthesis of natural products: the Chiron approach by S.Hanessian
12. Organic chemistry by Claydon and others 2005
13. Name Reactions by Jie Jack Li
14. Reagents in Organic synthesis by B.P.Mundy and others.
15. Tandem Organic Reactions by Tse-Lok Ho
16. Organic synthesis in water. By Paul A. Grieco Blackie.
17. Green chemistry, Theory and Practical, Paul T.Anastas and John C.Warner.
18. New trends in green chemistry By V.K.Ahulwalia and M.Kidwai.
19. Organic Synthesis: Special techniques. V.K.Ahulwalia and Renu Aggarwal

Synthetic strategies and Asymmetric synthesis.

1. Stereochemistry: Conformation & Mechanism by P S Kalsi
2. Stereochemistry of Carbon compounds by Ernest L Eliel
3 . Stereo selectivity in organic synthesis by R S Ward.
4. Asymmetric synthesis by Nogradi
5. Asymmetric organic reactions by it) Morrison and HS Moscher
6. Stereo differentiating reactions by Izumi
7. Some modern methods of organic synthesis by W Carruthers
8. Guidebook to organic synthesis, by R K Meckie, D M Smith & R A Atken
9. Organic synthesis by Michael B Smith
10. Organic Synthesis by C. Willis & M. Willis
11. Total Synthesis of natural products: the Chiron approach by S. Hanessian
12. Organic Synthesis- The disconnection approach by S. Warren
13. Problems on Organic Synthesis by Stuart Warren
14. Organic Chemistry by Claydon

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Advanced Physical Chemistry (SDC)

Course code	:	CH615
Course Title	:	Advanced physical Chemistry
Number of Credits	:	4
Prerequisites	:	M.Sc Chemistry
Course Type	:	Discipline Oriented Course

MODULE-I : HETEROGENEOUS CATALYSIS

Heterogeneous catalysis: Broad categories of catalysts – metals, bimetals, semiconductors, insulators, zeolites, oxides and nano materials.

Preparation of metal catalysts: Supported metal catalysts and non- metallic catalysts.
Characterization of catalysts: Surface area by BET method. Determination of pore volume and pore size distribution by BJH method. Pore size and specificity of catalysts. Surface acidity of catalyst & determination of surface acidity by indicator method, IR spectroscopic method and TPD method.

Steps in heterogeneous catalyzed reactions: Catalytic activity – the determining factors. Structure sensitive and structure insensitive catalysts. Mechanism of surface-catalyzed reactions. The Langmuir - Hinshelwood and the Eley- Rideal mechanisms. Rate constants and activation energies of surface reactions.

Introduction to Phase-transfer catalysis (PTC): Principles of phase-transfer catalysis. PTC classification. Role of water in phase-transfer catalyzed reactions. Factors influencing the rate of PTC reactions. Inverse phase transfer catalysis. [8 Lect]

MODULE -II: FUNCTIONAL POLYMERS

Smart materials –uses of smart materials in sensing devices and communication networks.
Conducting polymers: Electrically conducting polymers and their uses (polyanilines, polypyrrole, polyacetylene and polythiophene). Photoconductive polymers. Liquid crystal polymers – smectic, nematic and cholesteric structures.

Ionic exchange polymers: Cationic and anionic exchange polymers and their uses. Eco-friendly polymers. Poly lactide from corn derived dextrose, PHB etc.

Membrane separation. Filtration – micro, ultra and nanofiltration. Separation of gases – permeselectivity and gas permeability of representative polymers. Liquid separation – dialysis, electro osmosis and reverse osmosis.

Fire retarding polymers, photonic polymers. Inter penetrating networks (IPN), polymers in photo lithography

Polymers in biomedical applications – artificial organs and controlled drug delivery.

Emerging polymers: PTTC- (poly tri methylene tetra phthalate), Nylon 4,6 (Stanyl) – their structures, properties and uses. [10 Lect]

MODULE -III: ELECTRO CHEMISTRY

Electrode-electrolyte interface : The electrical double layer. The Helmholtz-Perrin parallel-plate model, the Gouy-Chapman diffuse-charge model and the Stern model.

Corrosion : Electrochemical mechanism of corrosion . Types of corrosion, various methods of corrosion control.

D.C Polarography : Dropping mercury electrode-polarography Instrumentation-polarogram.Types of limiting Currents : Adsorption, Diffusion, Kinetic. Ilkovic equation and its consequences. Applications of polarography. Determination of stability constant of complex.

Cyclic Voltammetry : Principle, instrumentation, reversible and irreversible cyclic voltammograms. Applications. Cyclic voltammetric study of insecticide parathion.

Electro-Organic synthesis : Electro chemical reduction of carboxylic acids, Electrochemical reduction of nitro compounds.

Anodic oxidation of metals : Characteristics of anodic oxide films. Instrumentation –break down voltage. Industrial applications of anodic oxide films. [10 Lect]

MODULE IV: MATERIALS SCIENCE AND MOLECULAR MODELING

Preparative methods of inorganic solids: Ceramic, co-precipitation, sol-gel, chemical vapor transport.

Characterization techniques of inorganic solids: X-ray powder diffraction (XRD), transmission electron microscopy (TEM) and X-ray photoelectron spectroscopy (XPES).

Composites: Classification, fiber reinforced composites- influence of fiber length.

Nanomaterials: preparation by sol-gel and hydrothermal methods, characterization by powder XRDScherer's equation and general applications.

Molecular modelling: QSAR parameters – Physiochemical parameters- Lipophilicity – Electronic parameters, Steric parameters, effect of electronic and steric parameters on lipophilicity. Hansch analysis, significance of slopes and intercepts in Hansch analysis. QSAR-2D, 3D. [10 Lect]

MODULE -V: CASE STUDY APPROACH

Case studies – on Pyranenamine. Achievements of QSAR – Forecasting biological activity, selection of proper substituents, bioisosterism, drug receptor interactions and pharmacokinetic information – Introduction to database similarity Search–Alignment ; Alignment methods, – Pair-wise alignment ; Multiple Sequence Alignment – Homology Modeling – Energy minimization methods – Active site Identification – Virtual Screening – Small molecule Building – Docking Algorithms – Docking Analysis [10 Lect]

REFERENCES:

Catalysis:

1. Principles of Heterogeneous Catalysis in practice, G. C. Bond, Oxford Publishing
2. Heterogeneous Catalysis, C. Satterfield, McGraw Hill
3. Catalysis, Principles and applications, edited by B. Vishwanathan, S. Sivasanker & A. V. Rama Swamy, Narosa Publishing House
4. Catalysis, J. C. Kuriacose, Macmillan
5. Phase Transfer Catalysis, Fundamentals, Applications and Industrial perspective, C. M. Stark, C. Liotta & M. Halpern, Academic Press
6. Phase Transfer Catalysis, E. V. Dehmlow & S. S. Dehmlow, Verlag Chemie, Weinheim
7. Phase Transfer Catalysis in Organic synthesis, W. P. Weber & G. W. Gokel, Springer

Functional Polymers:

8. Textbook of Polymer Science, F. W. Billmeyer Jr, John Wiley & sons
9. Polymer Science, V. R. Gowarikar, N. V. Viswanathan & J. Sreedhar, Wiley Eastern
10. Contemporary Polymer Chemistry, H. R. Alcock & F. W. Lambe, Prentice Hall
11. Physics and Chemistry of Polymers, J. M. G. Cowie, Blackie Academic and professional
12. Ploymer Chemistry, B. Vollmert
13. Physical Chemistry of Polymers, A. Tagers, Mir Publishers
14. Introduction to polymer Chemistry, By Charles E Carraher Jr (Taylor- Frncis)

Electro Chemistry:

15. Modern Electrochemistry 2A & 2B, J. O. M. Bockris & A. K. N. Reddy, Plenum publishers
16. Introduction to Electrochemistry, S. Glasstone
17. Industrial Electrochemistry, D. Pletcher, Chapman & Hall
18. Fundamental principles of Modern Electroplating, Lowenheim, John Wiley
19. Principles of Polarography, Heyrovsky.
20. Principles of Polarography, Kapoor.
21. Modern Electroanalytical methods, edited by C.Charlot, Elsevier Company.
22. Principles of Instyrumental analysis, Skoog, Holler and Nieman, Harcourt Asia PTE Ltd.
23. Analytical Chemistry-An Introduction, Skoog, West, Holler and Crouch, Saunders College Publishing.
24. Prinicples of Instrumental Analysis, Skoog and Leary, Saunders College Publishing.

Material Science:

25. Solid state and its applications by A.R. West.
26. New directions in solid state chemistry, J. Gopalakrishnan and C.N. R. Rao.
27. Principles of the solid state by HV Keer.
28. Materials science and engineering an introduction by W.D. Callister, Jr.

Molecular modelling:

29.Burger's medicinal chemistry and drug discovery. By Manfred E. Wolf.
30. Introduction to Medicinal chemistry. By Patrick.
31. Introduction to drug design. By Silverman
32. Comprehensive medicinal chemistry. Vol 1-5 By Hanzsch.
33. Principles of medicinal chemistry. By William Foye
34. Biochemical approach to medicinal chemistry. By Thomas Nogrady.
35. Pharmaceutical Chemistry and Drug synthesis By Roth and Kleeman
36. Drug design By E.J. Arienes
37. Jenkin's quantitative pharmaceutical chemistry By Knevel and Dryden
38. Recent advances in Bioinformatics By I. A. Khan and A Khanum
39. Computational chemistry By GH. Grant and WG. Richards
40. Molecular modelling By Hans Dieter Holtje and Gerd Folkers
41. Molecular modelling By Leach
42. Computational Chemistry by Jenson
43. Bio Informatics by Rastogi
44. The Science and practice of Pharmacy – Vol I and Vol II by Remington

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Inorganic and Organometallic Chemistry

Course code	:	CH618
Course Title	:	Inorganic and Organometallic Chemistry
Number of Credits	:	4
Prerequisites	:	M.Sc Chemistry
Course Type	:	Elective Course

MODULE- 1: Application of analytical Studies in Research

Advanced treatment of IR and UV-Visible Spectroscopy; Luminescence Spectral Studies; Mass Spectrometry at advanced level; NMR and ESR Spectrometric application; CD and ORD treatment at advanced level, neutron and electron diffraction technique. TG-DTA principles, instrumentation and use. [8 Lect]

References:

1. EAV Ebaworth, DWH Rankin and S. Cradock, Structural methods in inorganic chemistry by ELBS, 1988.
2. RK Harris & BE Mann, NMR and the Periodic tabled by Academic Press 1978.
3. R.S. Drago, Physical methods in inorganic chemistry, 2nd Edition, Chapman and Hall, 1977.
4. Molecular structure by diffraction methods spl. periodical report, Chem.Soc (Lon) Vol.1, 1973.
5. Physical methods in advanced inorganic chemistry Eds. HAO Hill and P. Day, Interscience, London, 1968.

MODULE- 2: Single Crystal X-Ray Structures, Supramolecular Chemistry and DFT Computation Crystal growth and data collection; Structure solution and refinement; Supramolecular Chemistry; DFT computation. [8 Lect]

References:

1. Structure Determination by X-ray Crystallography by: Mark Ladd and Rex Palmer (September 30, 2003)
2. Fundamentals of Powder Diffraction and Structural Characterization of Materials by: Vitalij Pecharsky and Peter Zavalij (March 3, 2005)
3. Supramolecular Chemistry, 2nd Edition, Jonathan W. Steed, Jerry L. Atwood, February 2009 ISBN: 978-0-470-51234-0

MODULE- 3:

Sensor; Cations and anions; Thin film semiconductors: synthesis and its application in As and Cd poisoning (as Sensors), solar cells. [6Lect]

References:

1. Physics of Solar Cells: From Basic Principles to Advanced Concepts, 2nd Edition, Peter Würfel, ISBN: 978-3-527-40857-3, March 2009.

MODULE- 4: Advanced Organometallic Chemistry

Definition, classifications and bonding in organometallics. Isolobal analogies. Structural aspects of organometallics. Preparative methods. Spectroscopic techniques in organometallics chemistry. Electronic and magnetic properties of organometallic compounds. Stoichiometric and catalytic reactions: Fundamental process in reactions of organotransition metal complexes. Application of transition metal complexes to catalysis. Organometallics directed towards organic synthesis. Enantioselective synthesis via organometallic compounds, importance of organometallic compounds in certain biological systems.Bio-organometallics, organometallics in environmental chemistry. Metal clusters and models for heterogeneous catalysis. Application of organometallics in industry. [12 Lect]

References:

1. Yamamoto, Organotransition metal in Chemistry, Fundamental concept and applications; John Wiley, 1986.
2. R. H. Crabtree, The organometallic Chemistry of the transition metals, John Wiley, 1994.

MODULE- 5: Developments in catalytic and surface science

Oxides:

Ceramics rare earth oxides, vanadia-based materials, micro-and mesoporous oxides, zeolites, sulphated-ZrO2 and layered materials - Architecture, synthetic methods, structure - property correlation and characterization, ion exchange, acidic and basic nature of these materials.

Clay chemistry:

Type and clays, kaolinites, hydrotalcites, clay polymers, clay colloids, and pillared clays. Structure, ion exchange and acidic properties of clays. Clays as supports and catalysts. Clay-mediated reactions.

Automotive emission catalysis:

Air pollution, development of three-way catalysts, principles and operation of exhaust catalysts, surface chemistry, use of zeolites in exhaust emission control.

Bimetallic catalysts:

Preparation, characterization and special catalytic properties.

Surface science view of catalysis:

Methods of surface science studies, chemical transformations related to catalysis on oxides, mono- and bimetal surfaces, monitoring surface reactions by in-situ spectroscopic methods.

Structure sensitive and insensitive reactions, oscillations in catalytic reactions, structure and bonding modifications, measuring heat of adsorption, single crystal adsorption calorimetry - a new development.

Active site - interpretation, surface frontier molecular orbitals, reaction kinetics, modelling of heterogeneous catalytic reactions. Catalytic reactors. [14 Lect]

References:

1. Heterogeneous Catalysis for the Synthetic Chemist, R.L. Augustine Marcel Dekker, 1996.
2. Insights into Inorganic Chemicals, Ed. D. Thompson, The Roayl Society of Chemistry, 1995.
3. Perspectives in Catalysis, Ed. J.M. Thomas & V.I. Zamaraev, Blackwell Scientific, 1992.
4. Studies in Surface Science and Catalysis volumes, Elsevier.
5. Inorganic Materials, 2nd Edition, Ed. D.W. Bruce and D. O'ttare John Wiley, 1996.
6. Reviews on these topics appear in various journals.

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code	:	PH612
Course Title	:	Quantum Mechanics-A Review
Number of Credits	:	4
Prerequisites	:	M.Sc Physics
Course Type	:	Discipline Oriented Course

Course Learning Objectives

Learn the fundamentals of quantum mechanics and then study the applications of the same in solid state and molecular physics.

Course Content:

Module 1 Wave mechanics in one dimension: We will begin with the axioms of quantum mechanics. We will then go on to one dimensional systems. Bound states as well as barrier problems. The bound state problems include harmonic oscillator, infinite square well potential, finite square well-potential, dirac delta potential. The barrier problems are the rectangular barrier, the triangular barrier and the Dirac delta. **[15 Lectures]**

Module 2 Three-dimensional systems: We continue with an in-depth look at the quantum mechanics of a single particle in three dimensions, emphasizing the special case of spherically symmetric systems in which angular momentum is conserved. The most important application will be to a particle trapped in a Coulomb potential, that is, the hydrogen atom. We will introduce the two and three dimensional oscillator also. **[10 Lectures]**

Module 3 Angular momentum: We will introduce the abstract angular momentum ladder operators. We will show the algebra associated with it is the su(2) algebra. The topic of angular momentum of a composite system will be introduced leading to the Clebsch-Gordan coefficients. Weill then take up the Wigner-Eckart theorem. **[10 Lectures]**

Module 4 Magnetic dipole moments , spin and Transition rates: We will introduce the concepts of orbital angular momentum. Stern-Gerlach experiment will be introduced. The very important notion of spin-orbit interaction will be explained. Transition rates will then be delineated. **[8 Lectures]**

Module 5 Quantum theory of solids: Band theory of solids via the periodic potentials. Kronig-Penny model.Semiconductors and semiconductor devices. **[5 Lectures]**

REFERENCES

1) Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles (Second Edition), R. Eisberg and R. Resnick, John Wiley and Sons, Singapore 2003.
2) Physics of Atoms and Molecules(Second Edition), B. H. Bransden and C. J. Joachain,Prentice Hall 2003.

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code	:	PH613
Course Title	:	Mathematical Physics-A Review
Number of Credits	:	4
Prerequisites	:	M.Sc Physics
Course Type	:	Discipline Oriented Course

Course Learning Objectives

Learn the fundamental and some advanced mathematical techniques which are essential at research level.

Course Content:

Module ILINEAR ALGEBRA –Introduction, Matrices; Row Reduction, Determinants; Cramer's Rule, Vectors,. Lines and Planes, Matrix Operations, Linear Combinations, Linear Functions, Linear Operators, Linear Dependence and Independence, Special Matrices and Formulas, Linear Vector Spaces, Eigenvalues and Eigenvectors; Diagonalizing Matrices, Applications of Diagonalization. VECTOR ANALYSIS -- Introduction, Applications of Vector Multiplication, Triple Products, Differentiation of Vectors, Fields, Directional Derivative; Gradient, Some Other Expressions Involving del (∇), Line Integrals, Green's Theorem in the Plane, The Divergence and the Divergence Theorem, The Curl and Stokes' Theorem [15 Lects]

Module IIFOURIER SERIES AND TRANSFORMS – Introduction, Simple Harmonic Motion and Wave Motion; Periodic Functions, Applications of Fourier Series, Average Value of a Function, Fourier Coefficients, Dirichlet Conditions, Complex Form of Fourier Series, Other Intervals, Even and Odd Functions, An Application to Sound, Parseval's Theorem, Fourier Transforms, Miscellaneous Problems [8 Lects]

Module IIIORDINARY DIFFERENTIAL EQUATIONS – Introduction, Separable Equations, Linear First-Order Equations, Other Methods for First-Order Equations, Second-Order Linear Equations with Constant Coefficients and Zero Right-Hand Side, Second-Order Linear Equations with Constant Coefficients and Right-Hand Side Not Zero, Other Second-Order Equations, The Laplace Transform, Solution of Differential Equations by Laplace Transforms, Convolution, The Dirac Delta Function, A Brief Introduction to Green Functions [8 Lects]

Module IVSPECIAL FUNCTIONS –Introduction, The Factorial Function, Definition of the Gamma Function; Recursion Relation, The Gamma Function of Negative Numbers, Some Important Formulas Involving Gamma Functions, Beta Functions, Beta Functions in Terms of Gamma Functions, The Simple Pendulum, The Error Function, Asymptotic Series, Stirling's Formula, Elliptic Integrals and Functions [8Lects]

Module VPARTIAL DIFFERENTIAL EQUATIONS –Introduction, Laplace's Equation; Steady-State Temperature in a Rectangular Plate, The Diffusion or Heat Flow Equation; the

Schr¨odinger Equation, The Wave Equation; the Vibrating String, Steady-state Temperature in a Cylinder, Vibration of a Circular Membrane, Steady-state Temperature in a Sphere, Poisson's Equation, Integral Transform Solutions of Partial Differential Equations [10Lects]

REFERENCES

1. Mathematical methods in the physical sciences Mary Boas, John Wiley & Sons, Inc. USA, 3rd Edition, (2006)
2. Mathematical Methods for Physicists, Arfken, Weber, and Harris, Elsevier Inc, USA, 7th Edition, (2013)
3. Mathematical Methods for Physics and Engineering", K.F. Riley, M.P. Hobson and S.J. Bence, Cambridge University Press, 3rd Edition, (2006)

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code	:	PH614
Course Title	:	Basic Solid State Physics & Materials Science
Number of Credits	:	4
Prerequisites	:	M.Sc Physics
Course Type	:	Elective

Course Learning objectives

To impart the fundamentals of Solid State Physics and Material Science, that will be required at the research level.

Course Content:

Module I Crystal structure and crystallography : Bravais lattice – Primitive vectors, Primitive unit cell, Conventional unit cell, Reciprocal lattice and Brillouin zone, Properties of X-rays, X-ray diffraction (geometry, intensity, real sample), Comparison with electron and neutron diffraction. [8 Lect.]

Module II Strength of materials : Cohesion in solids, Elasticity and plasticity, Defects in solids, Point defect, Line defect, Planar defects, 3D defects, Concept of dislocations, Role of dislocations in material behaviour, Interaction of dislocations with other defects. [8 Lect.]

Module III Electronic structure of solids : Band structure of solids, Introduction to many body problem, Single particle approximation, Hartree, Hartree-Fock methods, Modeling the ionic potential, Pseudo-potential method, Nearly free electron models, Bloch theorem, Tight binding method, Augmented plane wave method, Pseudo-potential plane wave method. Lattice vibrations: Phonons-Debye model for specific heat of solids-lattice dynamics-phonon spectrum. Electrical & thermal transport in solids, Role of electron-phonon interaction- Boltzmann transport equation. [14 Lect.]

Module IV Magnetism: Origin of magnetism, Quantum theory of diamagnetism and paramagnetism, Heisenberg's exchange interaction and ferromagnetism, Magnetism in metals, Magnetism in insulators, Introduction to super-exchange, Direct exchange and double exchange, Order disorder phase transition in magnetism. [9 Lect.]

Module V Dielectric properties of solids : Static dielectric constant metal and insulator using phenomenological theory (Maxwell's equations), Electronic and ionic polarization of molecules, Ferroelectricity- dipole theory, Inter-band transitions, Kramers-Kronig relations, Polarons, Excitons, Optical properties of metals and insulators. [9 Lect.]

REFERENCES

1. Solid State Physics, N. W. Ashcroft and N. D. Mermin. Thomson Learning (1976)
2. Introduction to Solid State Physics, C. Kittel, 8th Ed, Wiley Pub, (2004)

3. Principles of the Theory of Solids, J. M. Ziman, 2nd Ed., Cambridge University Press, (1972).
4. Condensed Matter Physics, M.P. Marder, 2nd Ed., WileyPub, (2010).
5. X-ray Diffraction, B. E. Warren, Dover Publications Inc., United States (*1991*).
6. Elements of X-ray Diffraction, B.D.Cullity and S.R.Stock,3rd Ed., New York Press, (2001).

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code : PH622

Course Title : Introduction to Numerical and Computational methods of Research

Number of Credits : 4

Prerequisites : M.Sc Physics

Course Type : Elective

Course content

Module I Introduction to Fortran -Declaration of a Variables, Arrays, functions, Subroutines etc. [10 Lect.]

Module II Interpolation, Least square fitting, finding mean , standard deviation, Matrix inversion, Numerical Differentiation,(i)Conjugate Gradient(ii) minimization of a function; Numerical Integration (i)Trapezoidal, (ii)Simpson, (iii)Gauss-Legendre (iv) Gauss-Chebyshev (v) Linear Analytic method [8 Lect.]

Module III Finding roots (i)bisection (ii) Secant (iii)RtNewton [5 Lect.]

Module IV Integral Transforms [5 Lect.]

Module V Solving Ordinary differential equations by Runga-Kutta method, application to Chaos problem [5 Lect.]

Module VI: Solving Partial Differential Equations (elliptic and parabolic)

(i) by Monte Carlo method [5 Lect.]

(ii)Finite difference scheme [5 Lect.]

Module VII: Miscelleneous [5 Lect.]

How to use (i)Latex,(ii)Power point(iii)Gnu-plot

REFERENCES

1.W. H Press et al, Numerical Methods in Fortran (Cambridge University Press)

2. Programming with Fortran 77 by Schaum's Series

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code	:	PH623
Course Title	:	Physics of Amorphous, Dielectric and ferroelectric materials
Number of Credits	:	4
Prerequisites	:	M.Sc Physics
Course Type	:	Elective

Course content

Module I Ionics and Superions:Superionic solids, classification of superionic solids, materials and structures, structural characterization. Thermodynamic properties, Ionic transport (microscopic nature), Ion dynamic, applications superionic solids with special reference to solid state batteries.

[9 lect.]

Module II Amorphous Materials: Introduction and preparation techniques, Glasses and glass transition, Structure of glass, atomic ordering in amorphous materials, Optical properties of amorphous materials, Applications of amorphous materials.Dielectrics:Dielectric polarization – Electronic – Ionic - Dipolar polarizations – local field – clausiusMosotti relation .

[9 Lect.]

Module III Single relaxation times, Debye"s equations and Cole-Cole plots, Distribution of relaxation times, Cole-Davidson plots, Random approximation, Variation of dielectric properties with frequency, temperature, pressure, and composition. (Dielectric properties of mixtures), Dielectric properties of glasses and polymers. [9 Lect.]

Module IV Measurement of dielectric properties, Scherring bridges, Q-meters and LCR meters and impedance analysers. Review of piezoelectricity and piezoelectric materials, lead based piezoelectric materials and applications. [9Lect.]

Module V Ferroelectrics:Review of types of ferroelectrics and their important features methods of preparation of bulk ceramic ferroelectrics. Characterization of ferroelectrics, small signal dielectric measurements, method of measuring spontaneous polarization, Hysteresis - pyroelectricity, polarization reversal. Theories offerrolectricity, Dipole theory, Devonshire theory and pseudospin theory. Application of ferroelectric materials, piezoelectric transducers, pyroelectric detectors, electro-optic application.Second harmonic generators, SAW devices and memory devices.[12 Lect.]

REFERENCES

1. Materials science and engineering by V.Raghavan PHI learning, 5th Ed. (2004).
2. Solid state physics by Kittel 8th Ed, Wiley Pub. (2004)
3. Materials science and Engineering by W.D.Callister9th Ed Wiley Pub.(2013)

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code	:	PH624
Course Title	:	Material Preparation and Characterization
Number of Credits	:	4
Prerequisites	:	M.Sc Physics
Course Type	:	Elective

Course content

Module I Synthesis of materials: Bulk Synthesis: Solid State Route, Sol Gel, Co- precipitation, Combustion methods, Thin film fabrication: spin coating, dip coating, evaporation methods, Vacuum techniques, vacuum pumps (Rotary and Diffusion pumps), vacuum gauges.

Module II Structural and composition characterization: Basics of X – ray diffraction (XRD), grazing incidence and powder XRD, Scanning Electron Microscope, Energy dispersive X – ray analysis, X – ray photoelectron Spectroscopy, Atomic Force Microscopy (AFM), Scanning Tunneling Microscopy (STM) and Transmission Electron Microscope.

Module III Optical spectroscopy and Raman Spectroscopy: Review of molecular and vibrational spectroscopy, Basic principle, instrumentation, advantages and limitations, Fourier Transform Infrared Spectroscopy (FTIR), UV- Vis. Spectroscopy, and Raman Spectroscopy, analysis of spectrum

Module IV Electric and thermal measurements: a.c. and d.c.electrical conductivity measurements as a function of temperature and frequencies. Magnetoresistance measurements, specific heat measurements, Impedance spectroscopy: A.C. impendence spectroscopy, Thermo Gravimetric analysis (TGA),differential thermal analysis (DTA) and differential scanning calorimetric (DSC) analysis.

Module V Magnetic characterization: Characterization of magnetic materials, ferromagnetic, multiferroic, spin glass materials and underlying principles, Vibrating Sample Magnetometer (VSM), SQUID magnetometer, a.c. susceptibility and d.c. magnetization measurements

REFERENCES

1. Materials Science and Engineering (John Wiley & Sons, Inc.) By William D. Callister, Jr.
2. Introduction to Ceramics, W.D. Kingery
3. Introduction to Nanoscience and Nanotechnology, K.K. Chattopadhyay and A.N.Banerjee
4. Materials Science of Thin films, M. Ohring
5. Handbook of Vacuum Technology, Karl Jousten
6. Fundamentals of Molecular Spectroscopy, C.N. Banwell
7. Elements of X – ray diffraction, B.D. Cullity
8. A SQUID hand book, Ed. John Clark, and A.I. Braginskii

9. Magnetic sensors and magnetometers, PavelRipka

10. Callister's Materials Science and Engineering, R. Balasubramaniam (II Ed)

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Course code : PH625

Course Title : Nano Science and Technology

Number of Credits : 4

Prerequisites : M.Sc Physics

Course Type : Elective

Course content

Module I Introduction: Importance of Nano science &technology, Emergence of Nano-technology, Types of Nano materials, Bottom-up and Top-down approaches,, Applications of NanoTechnology in Science and technology. [9 Lect.]

Module II Zero Dimensional Nano-structures: Nano particles through homogenous nucleation;Growth of nuclei, synthesis of metallic nano particles, Nano particles through heterogeneous nucleation; Fundamentals of heterogeneous nucleation and synthesis of nano particles using micro emulsions and Aerosol.[9 Lect.]

Module III One Dimensional Nano-structure, Nano wires and nano rods: Spontaneous growth: Evaporation and condensation growth, Casting method, vapor-liquid-solid growth, Electrochemical deposition and Electro spinning. [10 Lect.]

Module IV Two dimensional nano-structures: Fundamentals of film growth. Physical vapourDepostion(PVD): Chemical VapourDepostion (CVD) Characterization of nanomaterialsby using spectroscopic and microscopic techniques-XRD,FTIR, DSC, SEM and TEM. Electrical measurements of nano composite materials by using fourprobe method. [12 Lect.]

Module V Introduction to Carbon Nano Tubes(CNTs), Properties, Preparation of CNTs-Laser ablation method, Arc method, chemical vapor deposition (CVD), Sol-Gel method, Carbon nanotube Polymer Nano composites ,Applications of Nano in drug delivery system.[10 Lect.]

REFERENCES

1. Introduction to Nano technologyby Charles P.Poole.Jr.& Frank J.ownes John Wiley&sons Inc. Publishers (2006)
2. Nano structures and Nano materials: Synthesis, properties and applications Guozhong Cao- 2nd Ed, Imperial College press (2004).
3. Nano structured Materials by Jackie Ying academic press, (2001)

Evaluation Components

Component	Duration	Weightage %	Marks
Mid-Semester Examination	3 Hours	50	50
End-Semester Examination	3 Hours	50	50

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Number Theory- (MA612) Total: 40Hrs (5*8hrs)

UNIT-I

Divisibility-Greatest Common Division (GCD)-Prime numbers- Fundamental Theorem of Arithmetic-The series of reciprocals of the Primes- the Euclidean algorithm.

UNIT-II

Congruences- Linear Congruences- Residue classes and complete residue systems.

UNIT-III

The Chinese Remainder Theorem- Euler's-Fermat's Theorem.

UNIT-IV

Finite Abelian group-Elementary properties of groups-Characters of finite Abelian group.

UNIT-V

Quadratic Residues- The Legendre Symbol- Quadratic Reciprocity- The Jacobi Symbol

Text Book :

1. Tom Apostol, Introduction to Analytic Number Theory, Springer 1976

References:

1. David M.Burton, Elementary Number Theory, 2nd Ed, Universal book stall, New Delhi.
2. Thomas Koshy, Elementary Number Theory with applications 2nd Ed., Elsevier.

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required experimental skills necessary to carry out research.

Abstract Algebra –(MA613)

Unit-I: (8 Lectures)

Groups: basic concepts, groups acting on sets, stabilizers, orbits, the counting formula. Actions of a group on itself, left and right multiplication, conjugation, the Sylow theorems. Symmetric and alternating groups: cycle decomposition, conjugacy classes. Simplicity of the alternating groups. Free groups, generators and relations.

Unit-II: (10 Lectures)
Rings: basic concepts, the Chinese remainder theorem for rings, applications to modular arithmetic. Integral domains and fraction fields. Factorization in integral domains: unique factorization domains, principal ideal domains, Euclidean domains. Primitive polynomials, Gauss' lemma, Factorization of integers, of polynomials, of Gaussian integers. Irreducible polynomials, Eisenstein's criterion. Commutative rings: prime and maximal ideals, polynomial rings.

Unit-III: (6 Lectures)
Modules: Artinian and Noetherian modules, Hilbert basis theorem. Structure of finitely generated modules over a PID, with applications to abelian groups and linear transformations

Unit-IV: (8 Lectures)
Fields: field extensions, algebraic and transcendental elements. Finite extensions and degree. Adjunction of roots. Finite fields. Galois theory: the main theorem of Galois theory. Symmetric functions. Primitive elements. Roots of unity, the cyclotomic equation

Unit-V: (8 Lectures)

Category theory: the basic language of categories, functors and natural transformations, products, co-products, free constructions, inductive and projective limits.

References: Most of the material can be found in any one of the following three books:

1. M. Artin, Algebra, Prentice-Hall (1991).
2. T.W. Hungerford, Abstract Algebra: An Introduction, Saunders (1990).
3. N. Jacobson, Basic Algebra I, Freeman and Company (1989).

For certain topics detailed below, the following books may be consulted:

1. T.W. Hungerford, Algebra, Springer-Verlag (1974).
2. S. Lang, Algebra, Addison-Wesley (1993).
3. N. Jacobson, Basic Algebra II, Freeman and Company (1989).

The simplicity of the alternating groups is an exercise in ARTIN (p. 233); the Chinese remainder theorem for rings is not in ARTIN; both these topics are exercises in JACOBSON I. Both topics are done in detail in the other books except JACOBSON II.

For Galois theory, the little HUNGERFORD is not adequate. For cyclic and solvable extensions and the computation of Galois groups of polynomials, any one of the last three books should be used.

In category theory, LANG does not have natural transformations, and the big HUNGERFORD does not have inductive and projective limits; otherwise, any one of the last three books is adequate

.Magazines:

1. Current Science (Indian Academy of Science).
2. The Mathematics Student (Math Student) (Indian Mathematical Society).
3. Mathematical Spectrum (The University of Sheffield).
4. Mathematics Magazines (Mathematical Association of America).
5. +Plus Magazines (University of Cambridge).
6. Ganithavahini (Ramanujam Mathematical Society).

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required skills necessary to carry out research.

Journals:

1. Ganita Sandesh.
2. Journal of Rajasthan Academy of Physical Sciences.
3. Bulletin of Calcutta Mathematical Society.
4. Algebra Colloquium.
5. Applicable Algebra in Engineering, Communication and Computing.
6. Contributions to Algebra and Geometry.
7. Communications in Algebra.
8. Journal of Algebra.
9. Journal of Pure and Applied Algebra.

Linear Algebra-(MA614)

Total-40 Hours (5 units each of 8hrs)

Unit-I: Review of Linear Equations, Vector Spaces, Linear Transformations, Polynomials and Determinants.Elementary Canonical Forms, Characteristic Values, Annihilating Polynomials

Unit-II: Invariant subspaces, Simultaneous triangulation, Simultaneous Diagonalisation, Direct-sum Decompositions, Invariant Direct Sums, The Primary Decomposition Theorem

Unit-III: The Rational Jordan Forms, Cyclic Subspaces and Annihilators, Cyclic Decompositions and the Rational form, The Jordan Form, Computation of Invariant Factors, Summary; Semi-Simple Operators

Unit-IV: Inner Product, Inner Product spaces, Linear Functionals and Adjoints, Unitary Operators, Normal Operators

Unit-V: Bilinear Forms, Symmetric Bilinear Forms, Skew-Symmetric Bilinear Forms, Groups Preserving Bilinear Forms

Text Book : Linear Algebra by Kenneth Hoffman and Ray Kunze,PHI,(2010), (Chapters: 6,7,8,10).

Reference Book: Algebra by M. Artin, Prentice Hall,(1991).

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required skills necessary to carry out research.

Computational Number Theory (MA 622)

Unit I:

Algorithms for integer arithmetic: Divisibility, gcd, modular arithmetic, modular exponentiation, Montgomery arithmetic, congruence, Chinese remainder theorem.

Unit II:

Hensel lifting, orders and primitive roots, quadratic residues, integer and modular square roots, prime number theorem, continued fractions and rational approximations.

Unit III:

Primality testing algorithms: Fermat test, Miller-Rabin test, Solovay-Strassen test, AKS test.

Unit IV:

Integer factoring algorithms: Trial division, Pollard rho method, p-1 method, CFRAC method, quadratic sieve method, elliptic curve method.

Unit V:

Computing discrete logarithms over finite fields: Baby-step-giant-step method, Pollard rho method, Pohlig-Hellman method, index calculus methods, linear sieve method, Coppersmith's algorithm.

Text Book: H Cohen-A Course in Computational Algebraic Number Theory, Springer, 2007.

Reference Book: Christof Paar and Jan Pelzl, Understanding Cryptography, Springer, 2010.

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required skills necessary to carry out research.

COURSE OUTCOMES:

COURSE OUTCOME	EXPLANATION
CO1	Study of Divisibility, Modular arithmetic and Chinese Reminder Theorem
CO2	Knowledge of Integer, modular square roots and continued fractions.
CO3	Ability to apply elliptic curve method, p-1 method and Solo wave, Solovay-Strassen test
CO4	Study Baby-step-giant-step method and Coppersmith's algorithm

LATTICE THEORY (MA-623)

Unit I:

Lattices: Algebra of lattices, the lattice theoretic duality principal, lattices as partly ordered sets, diagrams of lattices, sub-lattices, ideals, atoms, complements, relative complements, semi complements, irreducible and prime elements of a lattice and homeomorphisms of a lattice.

Unit II:

Complete Lattices: Complete lattices, complete sub-lattices of complete lattice, conditionally complete lattice, and subalgebra, lattices of an algebra, closure operations, Galois connection, Dedekind cuts, and partly ordered sets as topological spaces.

Unit III:

Modular lattices: Modular lattices, characterization of modular lattices by their sub lattices, the isomorphism theorem of modular lattices, the covering condition, meet representations in modular lattice.

Unit IV:

Distributive Lattices: Distributive lattices, infinite distributive and completely distributive lattices, Boolean algebra, characterization of distributive lattices by their sub lattices.

Unit V:

Special Subspaces of the Class of Modular Lattices: Modular lattices of locally finite length, the valuation of a lattice, metric and quest metric lattices, complemented modular Lattices.

Text Book:

1. Introduction to Lattice Theory by G. Szasz. Ch. IV- X, Academic Press, NY

Reference Books:

1. Lattice Theory by G. Birkhoff , AMS, Colloquium, 1967.
2. Introduction to Lattices theory, D. E. Rutherford, Oliver & Boyd, 1965.

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required skills necessary to carry out research.

COURSE OUTCOMES:

COURSE OUTCOME	EXPLANATION
CO1	Familiarity with lattices
CO2	Understanding of Galois connection, Dedekind cuts and Topological sorting
CO3	Characterization of Modular and Distributive lattices

Generalized inverses Theory and Applications (MA 624)

Unit- I :
The Moore-Penrose or generalized inverse
Basic definitions, Basic properties of the generalized inverse, Computation of A*, Generalized inverse of a product

Unit-II:
Least squares solutions
What kind of answer is A* b?, Fitting a linear hypothesis, Estimating the unknown parameters An application to curve fitting .

Unit-III:
Sums, partitioned matrices and the constrained generalized inverse
The generalized inverse of a sum, Modified matrices, Partitioned matrices, Block triangular matrices, The fundamental matrix of constrained minimization, Constrained least squares and constrained generalized inverses

Unit-IV:
The generalized inverse in electrical engineering
n-port networks and the impedance matrix, Parallel sums, Shorted matrices

Unit-V:
The Drazin inverse
Introduction, Basic properties of the Drazin inverse, Spectral properties of the Drazin inverse, The Drazin inverse of a partitioned matrix, Applications of the Drazin inverse to linear systems of differential equations, Applications of the Drazin inverse to difference equations.

Text book :

1. S. L. Compbell and C. D. Meyer, Generalized Inverses of Linear Transformations, Society for Industrial and applied Mathematics, 2009.

Reference Book:

1. A. Ben-Israel and T. N. E. Greville, Generalized Inverses: Theory and Applications, Springer, 1974.

COURSE OUTCOMES:

COURSE OUTCOME	EXPLANATION
CO1	Moore- Penrose and Generalized inverse of a product
CO2	application to curve fitting and , Estimating the unknown parameters
CO3	Block triangular matrices, The fundamental matrix of constrained minimization
CO4	n-port networks and the impedance matrix, Drazin inverse

Skill Development:

1. Different methodologies and techniques used in research work.
2. Assess the basic function and working of analytical instruments used in research.
3. Propose the required skills necessary to carry out research.

S. Vijayalakshmi.

ICFAI FOUNDATION FOR HIGHER EDUCATION HYDERABAD

REGISTRAR
ICFAI FOUNDATION FOR HIGHER EDUCATION
(Deemed-to-be-University establishes under section 3 of UGC Act 1956.)