2018-2019

REGULATIONS AND SYLLABUS

School of Fundamental and Applied Sciences

ASSAM
DON BOSCO UNIVERSITY

Tapesia Gardens | Azara, Guwahati - 781017
Sonapur - 782402 | Assam, India

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NOTE

This handbook contains important information to help guide and inform you during your programme of study. We recommend that you keep this handbook for the duration of your studies in the University so that you can refer to it as needed. Please note that the onus of ignorance of the regulations and information contained in this handbook will be on the student and will not be ground for any consideration.

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REGULATIONS

ASSAM DON BOSCO UNIVERSITY

ASSAM DON BOSCO UNIVERSITY

ASSAM DON BOSCO UNIVERSITY
REGULATIONS - GRADUATE DEGREE PROGRAMMES

The following are the regulations of the Assam Don Bosco University concerning the Graduate Programmes leading to the award of the Bachelor's Degree in various disciplines made subject to the provisions of its Statutes and Ordinances.

1.0 Academic Calendar

1.1. Each academic year is divided into two semesters of approximately 18 weeks duration: an Autumn Semester (July – December) and a Spring Semester (January – June). The Autumn Semester shall ordinarily begin in July for students already on the rolls and the Spring Semester shall ordinarily begin in January. However, the first semester (Autumn, for newly admitted students) may begin later depending on the completion of admission formalities.

1.2. The schedule of academic activities approved by the Academic Council for each semester, inclusive of the schedule of continuing evaluation for the semester, dates for the conduct of end-semester examinations, the schedule of publication of results, etc., shall be laid down in the Academic Calendar for the semester.

2.0 Duration of the Programme

2.1. The normal duration of the Graduate Programme shall be as given below:

Programme	Number of Semesters	Number of Years
Bachelor of Technology (BTECH)	8	4
Bachelor of Computer Applications (BCA)	6	3
Bachelor of Commerce (BCOM)	6	3
Bachelor of Arts (BA) Honours	6	3
Bachelor of Science (BSc) Honours	6	3

2.2 However, students who do not fulfil some of the requirements in their first attempt and have to repeat them in subsequent semesters may be permitted up to 4 more semesters (2 years) to complete all the requirements of the degree.

2.3 Under exceptional circumstances and depending on the merit of each case, a period of 2 more semesters (1 year) may be allowed for the completion of the programme.

3.0 Course Structure

3.1. The Choice Based Credit System (CBCS) shall be followed for the Graduate Degree Programmes. Credits are allotted to the various courses depending on the number of lecture/tutorial/laboratory hours per five-day cycle (one week) of classes assigned to them using the following general pattern:

- 3.1.1. Lecture : One hour per cycle/week is assigned 1 credit.
- 3.1.2. Tutorial : One hour per cycle/week is assigned 1 credit.
- 3.1.3. Practical : Two hours per cycle/week is assigned 1 credit.

3.2. The courses offered for the Graduate Degree Programmes are divided into two baskets – core courses and elective courses.

3.3. Core Courses: Core courses are those in the curriculum, the knowledge of which is deemed essential for students who are pursuing the said Degree Programme.

- 3.3.1 A student shall be required to take all the core courses offered for a particular programme.
- 3.3.2 The number of credits required from core courses shall be as prescribed by the competent academic authority.

3.4. Elective Courses: These are courses in the curriculum which give the student opportunities for specialisation and which cater to his/her interests and career goals. These courses may be selected by the student and/or offered by the department conducting the programme, from those listed in the curriculum according to the norms laid down by the competent academic authority.

- 3.4.1 The number of credits which may be acquired through elective courses shall be prescribed by the competent academic authority.

3.5. These categories of courses may further be subdivided into departmental, school or institutional, depending on the department which offers the course. The schema of categorisation of courses into baskets is as given below:

Core Courses	
Departmental Core **(DC)**	Core courses which are offered by the department conducting the programme
School Core **(SC)**	Core courses which are offered by a department other than the department conducting the programme, from within the same School
Institutional Core **(IC)**	Core courses which are offered by departments of the University from Schools other than the parent School
Elective Courses	
Departmental Elective **(DE)**	Elective courses which are offered by the department conducting the programme
School Elective**(SE)**	Elective courses which are offered by a department other than the department conducting the programme, from within the same School
Institutional Elective **(IE)**	Elective courses which are offered by departments of the University from Schools other than the parent School

3.6. In order to qualify for a Graduate Degree, a student is required to complete the minimum credit requirements as prescribed by the competent academic authority.

3.7. In addition to the prescribed credit requirement a student shall have to complete the requirements of Extra Academic Programmes (EAP) as may be prescribed by the School. Students shall be awarded P/NP grades for the EAP, which shall be recorded in the Grade sheet but not taken into account for computing the SGPA and the CGPA.

3.8. Students who secure a CGPA of at least 8 at the end of the 4th semester may opt to take one audit course per semester from any Department from the 5th semester onwards, provided the course teacher permits the auditing of the course. This shall be done under the guidance of the Departmental Faculty Advisor/mentor. The student is free to participate in the evaluation process for such courses. However, an attendance of 75% is necessary for obtaining a P grade for such courses. When auditing courses offered by other departments, it shall be the responsibility of the student to attend such courses without missing courses of one's own department and semester.

3.9. In addition, students may also opt for additional elective courses in consultation with their mentors. Students are required to participate in the evaluation process of such courses. The grades obtained for such courses shall be recorded in the grade sheet, but not taken into account for computing SGPA and CGPA.

3.10 It shall be the prerogative of the department to not offer an elective course which has less than 5 students opting for it.

3.11 The medium of instruction shall be English and examinations and project reports shall be in English.

3.12 The course structure and syllabi of the Graduate Degree Programmes shall be approved by the Academic Council of the University. Departmental Boards of Studies (DBS) shall discuss and recommend the syllabi of all the courses offered by the department from time to time before forwarding the same to the School Board of Studies (SBS). The SBS shall consider the proposals from the departments and make recommendations to the Academic Council for consideration and approval.

3.13 The curriculum may include industry training and /or fieldwork for a specified time. This is to be satisfactorily completed before a student is declared eligible for the degree. There shall be credit allocation for such industrial training or fieldwork. Normally these activities shall be arranged during convenient semester breaks as shall be determined by the School Board of Studies.

3.14 **Faculty Advisor/Mentor**: A faculty advisor/mentor (and a co-mentor to perform the duties of a mentor during the absence of the mentor) shall be assigned for groups of students. Generally the faculty advisor/mentor shall be assigned by the concerned department, in consultation with the Director of the School concerned. (For the first year students of the BTECH programme, the Director of the School of Technology shall assign the faculty advisor/mentor from departments belonging to other Schools teaching at the SOT). Faculty advisors/mentors shall help their mentees to plan their courses of study, advise them on matters relating to academic performance and personality development, and help them to overcome various problems and difficulties faced by them.

4.0 Admission

4.1 All admissions to the Graduate Degree Programmes of the University shall be on the basis of merit. There may, however, be provision for direct admission for a limited number of NRI/FN students.

4.2 Eligibility Criteria

4.2.1 To be considered for admission to a Graduate Degree Programme a candidate should have passed the Higher Secondary examination of a recognised Board of Higher Secondary Education or an equivalent examination of any University / Board securing grades/marks as specified in the table below.

4.2.2 A candidate must also obtain qualifying marks required by the University in entrance tests/ personal interview as the case may be. These marks shall be valid only for the academic year for which the test is held.

4.2.3 Admission will be on the basis of performance of the candidate at the qualifying examination, entrance test and/or personal interview.

Programme	**Grade /Marks requirement from qualifying examinations**	**Entrance Examinations / Personal Interview**
BTECH	Passed the qualifying examination in the Science Stream with 45% in the aggregate of all subjects and 45% in the aggregate of Physics, Chemistry and Mathematics	National Entrance Test such as JEE / State level entrance examination such as CEE or the ADBU Entrance Examination for Engineers
BCA, BCOM, BA Honours	Passed the qualifying examination in any stream with 45% marks in the aggregate of all subjects	Satisfactory performance in the Personal Interview
BSc Honours	Passed the qualifying examination in the science stream with 45% marks in the aggregate of Physics, Chemistry and Mathematics	Satisfactory performance in the Personal Interview

4.3 Reservation of seats for the programme shall be as per the guidelines laid out in the Statutes of the University.

4.4 Admissions shall ordinarily close after a specified period from the date of commencement of the first semester, through a notification. However, in exceptional cases, admission of a candidate after the last date may be recommended to the University with justification, by the School / Departments concerned. Under such an event, this period shall not exceed four weeks from the date of commencement of the first semester.

4.4.1 The attendance of such students shall be computed from the date of admission.

4.4.2 Such students may be offered the opportunity of taking part in in-semester assessment modules which may have already been completed.

4.5 All candidates shall be required to satisfy the norms prescribed by the University for medical fitness prior to admission.

4.6 Lateral Entry into the BTECH Programmes

4.6.1 Polytechnic diploma holders in different disciplines and B.Sc. Degree holders having Physics, Chemistry and Mathematics shall be eligible for admission to degree courses in Engineering and Technology in the third semester BTECH Programme against vacancies and/or seats in addition to the sanctioned intake in the first year.

4.6.2 Such diploma holders should have been bonafide students of polytechnics duly approved by the government and should have pursued an AICTE approved three-year diploma curriculum in an appropriate branch of Technology.

4.6.3 Only diploma holders who have secured a minimum of 60% marks in the aggregate in the relevant discipline and B.Sc. students who have secured a minimum of 50% marks in the aggregate shall be eligible for consideration for admission. The students belonging to B.Sc. Stream, would have to clear the subjects: Engineering Graphics/Engineering Drawing and Engineering Mechanics of the First Year Engineering Programme along with the Second year subjects.

4.6.4 Such admissions shall be on the basis of merit in the ADBU entrance test and a personal interview.

5.0 University Registration

5.1 Candidates shall have to register as bona-fide students with the University as per the University regulations within a period specified by the University, by a formal application routed through the Director of the School concerned.

6.0 Attendance

6.1. To be permitted to appear for the end-semester examination of a particular course, a student is required to have a minimum attendance of 75% for that course.

6.2 Deficiency in attendance up to 10% may be condoned by the Director of the School in the case of leave taken for medical and other grievous reasons, which are supported by valid medical certificates and other requisite documents (submitted at the time of returning to class).

6.3 Some students, due to exceptional situations like their own serious sickness and hospitalization or death of members of inner family circle (restricted to only father, mother, siblings), may have attendance below 65%. Such students may be given bonus attendance percentage for a particular course based on his/her attendance for that course during the remaining days of the current semester, as given in the following table:

Attendance during the remaining days of the current semester	**Bonus percentage available in the current semester**
95% or more	5
90% or more but less than 95%	4
85% or more but less than 90%	3
80% or more but less than 85%	2
75% or more but less than 80%	1

They shall be permitted to appear for the end-semester examination of the course if on the strength of this bonus attendance percentage, they obtain 65% attendance for that course.

6.4 If the sum of the credits of the courses for which a student is unable to appear at the end-semester examinations exceeds 50% of the total credits allotted for the semester, he/she shall not be permitted to appear for the entire end-semester examinations in view of clause 10.5 of these Regulations.

6.5 The School may propose to set aside a certain portion of the in-semester assessment marks for attendance. The number of marks and modalities of their allotment shall be made known to the students at the beginning of each semester.

6.6 Leave

6.6.1 Any absence from classes should be with prior sanctioned leave. The application for leave shall be submitted to the Office of the Director of the concerned School on prescribed forms, through proper channels, stating fully the reasons for the leave requested along with supporting documents.

6.6.2 In case of emergency such as sickness, bereavement or any other unavoidable reason for which prior application could not be made, the parent or guardian must promptly inform the office of the Director of the concerned School.

6.6.3 If the period of absence is likely to exceed 10 days, a prior application for grant of leave shall have to be submitted through the Director of the concerned School to the Registrar of the University with supporting documents in each case; the decision to grant leave shall be taken by the Registrar on the recommendation of the Director of the concerned School.

6.6.4 The Registrar may, on receipt of an application, also decide whether the student be asked to withdraw from the programme for that particular semester because of long absence.

6.7 It shall be the responsibility of the student to intimate the concerned teachers regarding his/her absence before availing the leave.

7.0 Grading System

7.1 Three types of courses are offered in the Graduate programmes:

- **Graded courses**: For the majority of the courses, students shall be assessed and given grades.
- **Pass/No-Pass courses**: There are some courses for which the students are expected to obtain a P grade to be eligible for the degree.
- **Audit Courses**: A third category of courses are audit courses. These are optional. However, students who opt for these courses must have the required attendance to obtain a P grade in the course.

7.2 Based on the performance of a student, each student is awarded a final letter grade in each graded course at the end of the semester and the letter grade is converted into a grade point. The correspondence between percentage marks, letter grades and grade points is given in the table below:

Marks (x) obtained (%)	Grade	Description	Grade Points
$90 \le x \le 100$	O	Outstanding	10
$80 \le x < 90$	E	Excellent	9
$70 \le x < 80$	A+	Very Good	8
$60 \le x < 70$	A	Good	7
$50 \le x < 60$	B	Average	6
$40 \le x < 50$	C	Below Average	5
$x < 40$	F	Failed	0

In addition, a student may be assigned the grades 'P' and 'NP' for pass marks and non-passing marks respectively, for Pass/No-pass courses, or the grade 'X' (not permitted).

7.2.1 A student shall be assigned the letter grade 'X' for a course if he/she is not permitted to appear for the end semester examination of that course due to lack of requisite attendance.

7.2.2 A letter grade 'F', 'NP' or 'X' in any course implies failure in that course.

7.2.3 A student is considered to have completed a course successfully and earned the credits if she/he secures a letter grade other than 'F', 'NP', or 'X'.

7.3 At the end of each semester, the following measures of the performance of a student in the semester and in the programme up to that semester shall be computed and made known to the student together with the grades obtained by the student in each course:

7.3.1 The Semester Grade Point Average (SGPA): From the grades obtained by a student in the courses of a semester, the SGPA shall be calculated using the following formula:

$$SGPA = \frac{\sum_{i=1}^{n} GP_i \times NC_i}{\sum_{i=1}^{n} NC_i}$$

Where GP_i = Grade points earned in the i^{th} course

NC_i = Number of credits for the i^{th} course

n = the number of courses in the semester

7.3.2 The Cumulative Grade Point Average (CGPA): From the SGPAs obtained by a student in the completed semesters, the CGPA shall be calculated using the following formula:

$$CGPA = \frac{\sum_{i=1}^{n} SGP_i \times NSC_i}{\sum_{i=1}^{n} NSC_i}$$

Where SGP_i = Semester Grade point average of i^{th} semester

NSC_i = Number of credits for the i^{th} semester

n = the number of semesters completed

7.3.3 The CGPA may be converted into a percentage, using the following formula:

for CGPA <= 9.0, Percentage marks = (CGPA x 10) – 5

for CGPA > 9.0, Percentage marks = (CGPA x 15) – 50

7.4 Both the SGPA and CGPA shall be rounded off to the second place of decimal and recorded as such. Whenever these CGPA are to be used for official purposes, only the rounded off values shall be used.

7.5 There are academic and non-academic requirements for the Graduate programmes where a student shall be awarded the ‘P’ and ‘NP’ grades. Non-credit courses such as Extra Academic Programmes belong to this category. No grade points are associated with these grades and these courses are not taken into account in the calculation of the SGPA or CGPA. However, the award of the degree is subject to obtaining a ‘P’ grade in all such courses.

7.6 In the case of an audit course, the letters “AU” shall be written alongside the course name in the Grade Sheet. A student is not required to register again for passing failed audit courses.

8.0 Assessment of Performance

8.1. A student’s performance is evaluated through a continuous system of evaluation comprising tests, quizzes, assignments, seminars, minor projects, major projects and end-semester examinations.

8.2. Theory Courses: Theory courses shall have two components of evaluation – in-semester assessment of 40% weightage and an end-semester examination having 60% weightage.

8.2.1. The modalities of the conduct of in-semester assessment and weightages attached to its various components shall be as published by the School at the beginning of each semester.

8.3. Lab Courses: Lab courses (Laboratory, Drawing, Workshop, etc.) shall be evaluated on the basis of attendance, assessment of tasks assigned and end semester test/viva voce. The weightage assigned for these components of the evaluation is given in the following table:

Component	Weightage
Attendance	10
Assessment of Tasks Assigned	50
End-semester test / viva voce	40

8.3.1. The modalities of the conduct of evaluation under the heading “Assessment of tasks assigned”, its components and the weightages attached to its various components shall be published by the department concerned at the beginning of each semester.

8.3.2. The evaluation of the end-semester test for a lab course may be done on the basis of criteria and weightage to be specified in the question paper, among which are included

- Organisation of the experiment
- Actual conduct of the experiment assigned and accuracy of the result
- Extent of completion
- A comprehensive viva-voce which examines the overall grasp of the subject

8.4 End-Semester examinations

8.4.1 End-semester examinations for the theory courses, generally of three hours’ duration, shall be conducted by the University. The Director of the concerned school shall make the arrangements necessary for holding the examinations.

8.4.2 In the end-semester examinations, a student shall be examined on the entire syllabus of the courses.

8.4.3 A student shall not obtain a pass grade for a course without appearing for the end-semester examination in that course.

8.5 Industry Training/Internship Programme

8.5.1 Departments may require students to undergo industry training/internship programmes. Students of the BTECH Programme are required to undergo an Industry Training/Internship programme after the sixth semester in any industry or reputed organisation. BCOM students are required to do internship at the end of 4th or 5th semester.

8.5.2 Such programmes shall generally be of duration not less than 70 hours.

8.5.3 After the Industry Training/Internship programme, the student shall furnish a certificate from the organisation where he/she underwent the programme as proof of successful completion.

8.5.4 The student shall submit a training/internship report to the department in a format to be laid down by the concerned department. He/she shall also give a seminar to present the learning outcomes of the programme in the presence of the faculty members and students of the department. The student shall be evaluated on the basis of the report, the seminar and interaction during the seminar and grades shall be assigned. These grades shall be given a weightage of two credits in the subsequent semester.

8.6 Major Project

8.6.1 Students of the BTECH programme and BCA programme shall undertake a Major Project during the course of their graduate studies. The BTECH major project work is normally conducted in two phases during the seventh and eighth semesters of the programme and is to be done individually or in groups within the campus. A department may substitute this with two independent projects in the seventh and eighth semesters with prior permission from the statutory authority. The BCA major project work is conducted during the sixth semester of the programme, and is to be done individually or in groups within the campus.

8.6.2 Each department shall constitute a Departmental Project Evaluation Committee (DPEC) consisting of the Head of the Department, Project Co-ordinator and two senior teachers from the department, with the Project Co-ordinator as the convenor. The DPEC shall co-ordinate the conduct and assessment of the project.

8.6.3 The DPEC shall notify the schedule and modalities for the following stages in the implementation of the project.

- Submission of the topic of the project.
- Notification for assignment of project supervisors.
- Submission of the synopsis.
- Schedule and modality for the submission of weekly activity reports.
- Schedule for the seminar presentation of synopsis.
- Schedule for Progress Seminars, submission of progress reports and viva voce examination.
- Date for the submission of the project report and a brief summary.
- Dates for the external evaluation of the project.

In the case of the BTECH project, some of these activities may be performed during semester VII (Phase I) and others during Semester VIII (Phase II) as shall be notified by the DPEC.

8.6.4 The DPEC may ask a student to resubmit a synopsis if the same does not get its approval.

8.6.5 The Convenor of the DPEC shall submit to the Controller of Examinations a panel of at least three names of external examiners at least three weeks before the external examination. The Controller of Examinations shall appoint the external examiner(s) from this panel. The project supervisor shall be the internal examiner.

8.6.6 Each student shall submit to the DPEC three bound, typed copies of the project report, prepared according to the prescribed format, after the pre-submission seminar, by the due date. The student shall also submit three copies of a brief summary of the project that shall be forwarded to the concerned examiners.

8.6.7 The DPEC shall make the arrangements necessary to conduct the external evaluation in consultation with the examiner(s) appointed by the University, during the dates notified.

8.6.8 Phase I of the project shall be evaluated through in-semester assessment only. The modality and components of the assessment and their weightages shall be determined by the School and the same shall be notified at the beginning of each semester.

8.6.9 Phase II of the project shall be evaluated through in-semester and end-semester assessments of equal weightage. The in-semester assessment shall be done by the DPEC and the project supervisor and the end-semester assessment shall be done by the external examiner(s) and the project supervisor, assisted by the DPEC. The modality and components of the in-semester assessment and their weightages shall be determined by the school and the same shall be notified at the beginning of each semester.

8.6.10 The DPEC shall forward the in-semester assessment marks to the Controller of Examinations by the date specified by the Examination Department.

8.6.11 The end-semester assessment shall have the following components:

- Project implementation : 40 marks
- Seminar presentation : 20 marks
- Viva voce examination : 20 marks
- Project documentation : 20 marks

8.6.12 Independent projects as envisaged in clause 8.6.1 shall be evaluated in the same manner as Phase II of the major project.

8.6.13 Those who obtain an 'F' grade for the major project shall be required to re-enrol for it in the subsequent semesters.

8.7 Minor and Mini Projects

8.7.1 Students may be assigned minor and mini projects by the department from the fourth semester onwards to ensure that their learning becomes a hands-on experience. These projects shall be executed by the students individually or in groups under the guidance of faculty members appointed by the department.

8.7.1.1 BCOM students shall undertake a Project (phase 1 & 2) spread across 5th and 6th semesters.

8.7.2 The mode of evaluation of these projects shall follow the pattern of evaluation of Lab Courses (vide clause 8.3) and the modalities for the conduct of evaluation, its components and the weightages attached to these components shall be published by the department concerned at the beginning of each semester.

8.7.3 The students may be required to submit project reports in the format specified. The evaluation of the Minor and Mini Projects shall take into consideration these project reports.

8.8 The evaluation of performance in Extra Academic Programmes shall be done by the authorities conducting them and they shall communicate the grades to the Director of the concerned School who shall forward them to the Controller of Examinations.

8.9 The Director of the concerned School shall forward the marks obtained in the in-semester evaluation to the Controller of Examinations within the prescribed time as may be notified.

8.9.1 All evaluated work in a course except the end semester answer scripts shall be returned to the students promptly.

8.10 Eligibility for appearing in the end-semester examinations: A student shall be permitted to appear for the end-semester examinations, provided that

8.10.1 A student has not been debarred from appearing in the end semester examinations as disciplinary action for serious breach of conduct.

8.10.2 He/she has satisfactory attendance during the semester according to the norms laid out in section 6 of these regulations.

8.10.3 He/she has paid the prescribed fees or any other dues of the university within the date specified.

8.11 Registration for end-semester Examinations

8.11.1 The University shall, through a notification, invite applications from students to register for the end-semester examinations.

8.11.2 Students who have registered with the University (vide clause 5) and those who have applied for such registration may apply to appear for the end-semester examinations of the university, in response to the notification issued by the University, provided that they fulfil the eligibility norms as laid down in clause 8.10.

8.11.3 All eligible candidates shall be issued an admit card for the relevant examination and for specified courses. A student who does not have a valid admit card may not be permitted to write the end-semester examinations.

8.11.4 A student who secures an 'F' or 'X' grade in any course in a semester may register for the end-semester examination for that course in a subsequent semester when that course is offered again, within a period of six years from his/her enrolment for the programme. The in-semester assessment marks obtained by him/her in the last semester in which the said course was attended by him/her shall be retained.

8.11.5 Similarly, in case of an 'NP' grade in Extra Academic Programmes the student shall have to re-register for it in the appropriate semester of the next academic session.

8.11.6 When a student re-registers for the end semester examination of a course, in accordance with clause 8.11.4 above, the better of the two grades obtained (the old and the new) shall be considered for the calculation of SGPA and CGPA.

8.12 Conduct of Examinations: The University shall conduct the end-semester examinations in accordance with the applicable regulations on such dates as are set down in the Academic Calendar or as notified.

8.13 Declaration of Results: The University shall declare the results of a semester and make available to the students their grade sheets within the time-frame prescribed by the relevant regulations of the university and specified in the academic calendar.

8.14 The University may withhold the results of a student for any or all of the following reasons

- he/she has not paid his/her dues
- there is a disciplinary action pending against him/her
- he/she has not completed the formalities for University Registration according to the requirement of section 5 of these Regulations.

8.15 Re-examining of answer scripts

8.15.1 If a student feels that the grade awarded to him/her in a course is not correct, he/she may apply to the University for the re-examining of his/her answer script.

8.15.2 Re-examining of scripts may be of two different categories – scrutiny and re-evaluation.

8.15.3 Scrutiny: The activities under this category shall ordinarily be confined to checking

- correctness of the total marks awarded and its conversion into appropriate letter grades
- whether any part/whole of a question has been left unevaluated inadvertently
- correctness of transcription of marks on the tabulation sheet and the grade sheet issued in respect of the course under scrutiny.

8.15.4 Re-evaluation: Re-evaluation of the answer script by independent experts in the concerned subject(s).

8.15.5 Application for re-examining of answer scripts

- A student may apply for scrutiny or re-evaluation for one or more courses of the just-concluded end-semester examinations within seven calendar days from the date of publication of its results in the application form prescribed for this purpose.
- He/she shall pay the prescribed fee to the University as notified.
- A student applying for scrutiny/re-evaluation shall expressly state on the application form whether the application made is for Scrutiny or for Re-evaluation. In each case, the student may also request to see his/her answer script.
- All applications for scrutiny/re-evaluation must be routed through the Director of the concerned School.

8.15.6 If in the process of re-examining, the grade obtained in a course changes, the better of the two grades shall be assigned to the course. If there is a change, the new grade shall be recorded and a new grade sheet shall be issued to the student.

8.15.7 Without prejudice to any of the clauses of section 8.15, a student who has been found to have used unfair means during an examination shall not be eligible to apply for scrutiny or re-evaluation of answer scripts.

8.16. Improvement Examination

8.16.1 After the completion of the entire programme of study, a student may be allowed the provision of improvement examinations. These are to be availed of only once each in the Autumn and Spring semesters that immediately follow the completion of the programme, and within the maximum number of years permissible for a programme.

8.16.2 A student who has taken migration from the University shall not be eligible to appear for Improvement Examination.

8.16.3 A student may not choose more than the number of courses specified below for improvement examinations.

Programme	Number of Courses for Improvement Examinations		
	Autumn Semester	Spring Semester	Total
BTECH	6	6	12
BCA	4	4	8
BCOM	4	4	8
BSc	4	4	8
BA	4	4	8

8.16.4 After the improvement examination, the better of the two grades obtained (the old and the new) shall be considered for the calculation of SGPA and CGPA.

8.16.5 If the student improves his/her grades through the improvement examination, new grade sheets and comprehensive transcripts shall be issued to the student.

8.17. Special Examination

8.17.1 The University shall conduct Special Examinations to benefit the following categories of students:

8.17.1.1 Students who, on the completion of the final semester, have some ‘F’ graded courses in the two final semesters, but no ‘F’ or ‘X’ graded courses in any of the previous semesters

8.17.1.2 Students who have only one ‘F’ graded course in a semester other than the two final semesters and do not have ‘F’ or ‘X’ graded courses in the two final semesters.

8.17.2 The Special Examinations shall ordinarily be conducted each year within a month of the declaration of the results of the Spring Semester.

8.17.3 Students who fail to secure 50% of the credits offered in the final semester shall not be eligible to appear for the special examinations. Such students will be governed by the provisions of clause 10.5 of these regulations. However, this restriction shall not apply in the case of students who are unable to appear in the end semester examinations due to exceptional situations like their own serious illness and hospitalisation or death of members of inner family circle (restricted to only father, mother, siblings).

8.17.4 Students who have ‘X’ graded courses only in the last two semesters shall be offered the opportunity for participating in a Tutorial Programme which may be conducted during the semester break immediately following the end-semester examinations of the final semester and students who earn 85% attendance for the programme shall be permitted to appear for the Special Examinations. Separate fees shall be charged for the Tutorial Programme.

8.17.5 Students who do not obtain pass grades in any course at the special examinations shall have to apply in the prescribed format and appear for the end-semester examination of these courses when they are scheduled by the University during subsequent relevant end-semester examinations.

9.0 Change of Branch (only for BTECH)

9.1 Normally a student admitted to a particular branch of the BTECH programme shall continue studying in that branch till completion. However, in special cases the university may permit a student to change from one branch of studies to another after the first two semesters.

9.2 Students shall be allowed a change in branch subject to the limitation that the strength of a branch should not fall below the existing strength by more than ten percent and should not go above the sanctioned strength by more than twenty percent.

9.3 Only those students shall be eligible for consideration of a change of branch, who have completed all the credits required in the first two semesters of their studies, in their first attempt.

9.4 Applications for a change of branch must be made by intending eligible students in the prescribed form. The Office of the Registrar shall call for applications at the beginning of the third semester and the completed forms must be submitted by the last date specified in the notification.

9.5 Students may enlist up to two choices of branch, in order of preference, to which they wish to change over. It shall not be permissible to alter the choice after the application has been submitted.

9.6 Change of branch shall be made strictly in order of merit of the applicants. For this purpose the CGPA obtained at the end of the second semester shall be considered. In case of a tie, the following shall be considered in the given order: the SGPA of the second semester, the SGPA of the first semester, grades obtained by the applicants in the courses of the second semester in an order to be determined by the Office of the Registrar.

9.7 A committee consisting of the Director and heads of departments of the concerned School, chaired by the Registrar shall examine the applications and consider them on the basis of the criteria laid out above.

9.8 The details of branch changes effected shall be notified to the students by the Registrar, within 7 days of the submission of applications.

9.9 All changes of branch shall be final and binding on the applicants. No student shall be permitted, under any circumstance, to refuse the change of branch offered.

9.10 All changes of branch made in accordance with the above rules shall be effective from the third semester of the applicants concerned. No change of branch shall be permitted after this.

10.0 Enrolment (for semesters other than the first)

10.1 Every student is required to enrol for the relevant courses before the commencement of each semester within the dates fixed for such enrolment and notified by the Registrar.

10.2 Students who do not enrol within the dates announced for the purpose may be permitted late enrolment up to the notified date on payment of a late fee.

10.3 Only those students shall be permitted to enrol who have

- cleared all University, Departmental, Hostel and Library dues and fines (if any) of the previous semester,
- paid all required University, Departmental and Hostel fees for the current semester, and
- not been debarred from enrolling on any specific ground.

10.4 No student may enrol for a semester if he/she has not appeared, for whatever reason, in the end semester examinations of the previous semester.

10.5 A student who fails to obtain 50% of the credits offered in a semester shall not be permitted to enrol for the next semester and shall have to re-enrol for and attend all the courses of the said semester in the following academic year.

11.0 Eligibility for the Award of the Graduate Degree

11.1 A student shall be declared to be eligible for the award of the Graduate Degree for which he/she has enrolled if he/she has

11.1.1 completed all the credit requirements for the degree with grade 'C' or higher grade in each of the mandatory graded courses and grade 'P' in all mandatory non-graded courses;

11.1.2 satisfactorily completed all the non-credit requirements for the degree viz., Extra Academic Activities, Industry Training, field work, internship programme, etc. (if any);

11.1.3 obtained a CGPA of 5.00 or more at the end of the semester in which he/she completes all the requirements for the degree;

11.1.4 no dues to the University, School, Department, Hostels; and

11.1.5 no disciplinary action pending against him/her.

11.2 The award of the Graduate Degree must be recommended by the Academic Council and approved by the Board of Management of the University.

12.0 Termination from the Programme

12.1 If more than the number of years permitted for the completion of a programme have elapsed since the student was admitted, and the student has not become eligible for the award of Degree, the student shall be removed from the programme.

12.2 A student may also be required to leave the Programme on disciplinary grounds on the recommendations of the Students' Disciplinary Committee of the concerned School.

ASSAM DON BOSCO UNIVERSITY
REGULATIONS - POST GRADUATE DEGREE PROGRAMMES

SCIENCE AND TECHNOLOGY

The following are the regulations of the Assam Don Bosco University concerning the Post-Graduate Programmes leading to the award of the Master's Degree in the disciplines of Science and Technology made subject to the provisions of its Statutes and Ordinances.

1.0 Academic Calendar

1.1 Each academic year is divided into two semesters of approximately 18 weeks duration: an Autumn Semester (July – December) and a Spring Semester (January – June). The Autumn Semester shall ordinarily begin in July for students already on the rolls and the Spring Semester shall ordinarily begin in January. However, the first semester (Autumn, for newly admitted students) may begin later depending on the completion of admission formalities.

1.2 The schedule of academic activities approved by the Academic Council for each semester, inclusive of the schedule of continuing evaluation for the semester, dates for the conduct of end-semester examinations, the schedule of publication of results, etc., shall be laid down in the Academic Calendar for the semester.

2.0 Duration of the Programme

2.1 The normal duration of the Post Graduate Programme shall be as per the table given below:

Programme	Number of Semesters	Number of Years
Master of Technology (MTECH)	4	2
Master of Computer Applications (MCA)	6	3
Master of Science (MSc)	4	2

2.2 However, students who do not fulfill some of the requirements in their first attempt and have to repeat them in subsequent semesters may be permitted up to 4 more semesters (2 years) to complete all the requirements of the degree.

2.3 Under exceptional circumstances and depending on the merit of each case, a period of 2 more semesters (1 year) may be allowed for the completion of the programme

3.0 Course Structure

3.1 The choice based credit system shall be followed for the Post Graduate Degree Programmes. Credits are allotted to the various courses depending on the number of lecture/tutorial/laboratory hours per five-day cycle (one week) of classes assigned to them using the following general pattern:

- 3.1.1 Lecture : One hour per cycle/week is assigned 1 credit.
- 3.1.2 Tutorial : One hour per cycle/week is assigned 1 credit.
- 3.1.3 Practical : Two hours per cycle/week is assigned 1 credit.

3.2 The courses offered for the Post Graduate Degree Programmes are divided into two baskets – core courses and elective courses.

3.3 **Core Courses:** Core courses are those in the curriculum, the knowledge of which is deemed Essential for students who are pursuing the said Degree Programme.

- 3.3.1 A student shall be required to take all the core courses offered for a particular programme.
- 3.3.2 The number of credits required from core courses shall be as prescribed by the competent academic authority.

3.4 **Elective Courses:** These are courses in the curriculum which give the student opportunities for specialisation and which cater to his/her interests and career goals. These courses may be selected by the student and/or offered by the department conducting the programme, from those listed in the curriculum according to the norms laid down by the competent academic authority.

- 3.4.1 The number of credits which may be acquired through elective courses shall be prescribed by the competent academic authority.

3.5 These categories of courses may further be subdivided into departmental, school or institutional, depending on the department which offers the course. The schema of categorisation of courses into baskets is as given below:

Core Courses	
Departmental Core **(DC)**	Core courses which are offered by the department conducting the programme
School Core **(SC)**	Core courses which are offered by a department other than the department conducting the programme, from within the same School
Institutional Core **(IC)**	Core courses which are offered by departments of the University from Schools other than the parent School
Elective Courses	
Departmental Elective **(DE)**	Elective courses which are offered by the department conducting the programme
School Elective **(SE)**	Elective courses which are offered by a department other than the department conducting the programme, from within the same School
Institutional Elective **(IE)**	Elective courses which are offered by departments of the University from Schools others than the parent School

3.6 In order to qualify for a Post Graduate Degree, a student is required to complete the minimum credit requirements as prescribed by the competent academic authority.

3.7 In addition to the prescribed credit requirements a student shall have to complete the requirements of Extra Academic Programmes (EAP) as may be prescribed by the School. Students shall be awarded P/NP grades for the EAP, which shall be recorded in the Gradesheet but not taken into account for computing the SGPA and the CGPA.

3.8 Students who secure a CGPA of at least 8 at the end of the first semester (third semester, in the case of MCA) may opt to take one audit course per semester from any Department from the second semester onwards (fourth semester, in the case of MCA), provided the course teacher permits the auditing of the course. This shall be done under the guidance of the Departmental Faculty Advisor/ mentor. The student is free to participate in the evaluation process for such courses. However, an attendance of 75% is necessary for obtaining a P grade for such courses. When auditing courses offered by other departments, it shall be the responsibility of the student to attend such courses without missing courses of one's own department and semester.

3.9 In addition, students may also opt for additional elective courses in consultation with their mentors. Students are required to participate in the evaluation process of such courses. The grades obtained for such courses shall be recorded in the gradesheet, but not taken into account for computing SGPA and CGPA.

3.10 It shall be the prerogative of the department to not offer an elective course which has less than 5 students opting for it.

3.11 The medium of instruction shall be English and examinations and project reports shall be in English.

3.12 The course structure and syllabi of the Post Graduate Degree Programmes shall be approved by the Academic Council of the University. Departmental Boards of Studies (DBOS) shall discuss and recommend the syllabi of all the courses offered by the department from time to time before forwarding the same to the School Board of Studies (SBOS). The SBOS shall consider the proposals from the departments and make recommendations to the Academic Council for consideration and approval.

3.13 The curriculum may include industry training and /or fieldwork for a specified time. This is to be satisfactorily completed before a student is declared eligible for the degree. There shall be credit allocation for such industrial training or fieldwork. Normally these activities shall be arranged during convenient semester breaks as shall be determined by the School Board of Studies.

3.14 Faculty Advisor/Mentor: A faculty advisor/mentor (and a co-mentor to perform the duties of a mentor during the absence of the mentor) to shall be assigned for groups of students. Faculty advisors/mentors shall help their mentees to plan their courses of study, advise them on matters relating to academic performance and personality development, and help them to overcome various problems and difficulties faced by them.

4.0 Admission

4.1 All admissions to the Post Graduate Degree Programmes of the University shall be on the basis of merit. There may, however, be provision for direct admission for a limited number of NRI/FN students.

4.2 **Eligibility Criteria**

4.2.1 To be considered for admission to a Post Graduate Degree Programme a candidate should have passed a Bachelor's Degree (or equivalent) programme of a recognised university securing grades/marks as specified in the table below.

4.2.2 Admission will be on the basis of the performance of the candidate at the graduate level, the Post Graduate Entrance Test conducted by the university and/or a personal interview. Candidates for MTECH who have a valid GATE score may be exempted from the entrance test.

Programme	Grade /Marks requirement from qualifying examinations	Entrance Examinations / Personal Interview
MTECH	Completed a Bachelor's Degree programme in the appropriate stream of technology from a recognised university successfully with a minimum CGPA of 6.5 (or equivalent). The Academic Council may establish other eligibility criteria for M Tech in a particular discipline.	Post Graduate Entrance Test of Assam Don Bosco University
MCA	Completed a Bachelor's Degree programme in any stream of a recognised university successfully with a minimum of 50 % marks in the aggregate. In addition, the candidate must have passed Mathematics or equivalent at the higher secondary level or above.	Post Graduate Entrance Test of Assam Don Bosco University
MSc	Completed a Bachelor's Degree programme in Science of a recognised university successfully with a minimum of 50 % marks in the aggregate, with the relevant discipline as a subject	Satisfactory performance in the Personal Interview

4.3 Reservation of seats for the programme shall be as per the guidelines laid out in the Statutes of the University.

4.4 Admissions shall ordinarily close after a specified period from the date of commencement of the first semester, through a notification. However, in exceptional cases, admission of a candidate after the last date may be recommended to the University with justification, by the School / Departments concerned. Under such an event, this period shall not exceed four weeks from the date of commencement of the first semester.

4.4.1 The attendance of such students shall be computed from the date of admission.

4.4.2 Such students may be offered the opportunity of taking part in in-semester assessment modules which may have already been completed.

4.5 All candidates shall be required to satisfy the norms prescribed by the University for medical fitness prior to admission.

4.6 Candidates may be required to furnish a certificate of good conduct from the institution last attended.

4.7 Lateral Entry into the MCA Programme

Students who have completed the BCA programme of Assam Don Bosco University shall be eligible for admission into the third semester of the MCA programme.

5.0 University Registration

5.1 Candidates shall have to register as bona-fide students with the University as per the University regulations within a period specified by the University, by a formal application routed through the Director of the School concerned.

6.0 Attendance

6.1 To be permitted to appear for the end-semester examination of a particular course, a student is required to have a minimum attendance of 75% for that course.

6.2 Deficiency in attendance up to 10% may be condoned by the Director of the School in the case of leave taken for medical and other grievous reasons, which are supported by valid medical certificates and other requisite documents.

6.3 Some students, due to exceptional situations like their own serious sickness and hospitalization or death of members of inner family circle (restricted to only father, mother, siblings), may have attendance below 65%. Such students may be given bonus attendance percentage for a particular course based on his/her attendance for that course during the remaining days of the current semester, as given in the following table:

Attendance during the remaining days of the current semester	Bonus percentage available in the current semester
95% or more	5
90% or more but less than 95%	4
85% or more but less than 90%	3
80% or more but less than 85%	2
75% or more but less than 80%	1

They shall be permitted to appear for the end-semester examination of the course if, on the strength of this bonus attendance percentage, they obtain 65% attendance for that course.

6.4 If the sum of the credits of the courses for which a student is unable to appear at the end-semester examinations exceeds 50% of the total credits allotted for the semester, he/she shall not be permitted to appear for the entire end-semester examinations in view of clause 9.5 of these Regulations.

6.5 The School may propose to set aside a certain portion of the in-semester assessment marks for attendance. The number of marks and modalities of their allotment shall be made known to the students at the beginning of each semester.

6.6 **Leave**

6.6.1 Any absence from classes should be with prior sanctioned leave. The application for leave shall be submitted to the office of the Director of the concerned School on prescribed forms, through proper channels, stating fully the reasons for the leave requested along with supporting documents.

6.6.2 In case of emergency such as sickness, bereavement or any other unavoidable reason for which prior application could not be made, the parent or guardian must promptly inform the office of the Director of the concerned School.

6.6.3 If the period of absence is likely to exceed 10 days, a prior application for grant of leave shall have to be submitted through the Director of the concerned School to the Registrar of the University with supporting documents in each case; the decision to grant leave shall be taken by the Registrar on the recommendation of the Director of the concerned School.

6.6.4 The Registrar may, on receipt of an application, also decide whether the student be asked to withdraw from the programme for that particular semester because of long absence.

6.7 It shall be the responsibility of the student to intimate the concerned teachers regarding his/her absence before availing the leave.

7.0 Grading System

7.1. Three types of courses are offered in the Post Graduate programmes:

- **Graded courses**: For the majority of the courses, students shall be assessed and given grades.
- **Pass/No-Pass courses**: There are some courses for which the students are expected to obtain a P grade to be eligible for the degree.
- **Audit Courses**: A third category of courses are audit courses. These are optional. However, students who opt for these courses must have the required attendance to obtain a P grade in the course.

7.2 Based on the performance of a student, each student is awarded a final letter grade in each graded course at the end of the semester and the letter grade is converted into a grade point. The correspondence between percentage marks, letter grades and grade points is given in the table below:

Marks (x) obtained (%)	Grade	Description	Grade Points
90 ≤ x ≤ 100	O	Outstanding	10
80 ≤ x < 90	E	Excellent	9
70 ≤ x < 80	A+	Very Good	8
60 ≤ x < 70	A	Good	7
50 ≤ x < 60	B	Average	6
40 ≤ x < 50	C	Below Average	5
x < 40	F	Failed	0

In addition, a student may be assigned the grades 'P' and 'NP' for pass marks and non-passing marks respectively, for Pass/No-pass courses, or the grade 'X' (not permitted).

7.2.1 A student shall be assigned the letter grade 'X' for a course if he/she is not permitted to appear for the end semester examination of that course due to lack of requisite attendance.

7.2.2 A letter grade 'F', 'NP' or 'X' in any course implies failure in that course.

7.2.3 A student is considered to have completed a course successfully and earned the credits if she/he secures a letter grade other than 'F', 'NP', or 'X'.

7.3. At the end of each semester, the following measures of the performance of a student in the semester and in the programme up to that semester shall be computed and made known to the student together with the grades obtained by the student in each course:

7.3.1. The Semester Grade Point Average (SGPA): From the grades obtained by a student in the courses of a semester, the SGPA shall be calculated using the following formula:

$$SGPA = \frac{\sum_{i=1}^{n} GP_i \times NC_i}{\sum_{i=1}^{n} NC_i}$$

Where GP_i = Grade points earned in the i[th] course
NC_i = Number of credits for the i[th] course
n = the number of courses in the semester

7.3.2. The Cumulative Grade Point Average (CGPA): From the SGPAs obtained by a student in the completed semesters, the CGPA shall be calculated using the following formula:

$$CGPA = \frac{\sum_{i=1}^{n} SGP_i \times NSC_i}{\sum_{i=1}^{n} NSC_i}$$

Where SGP_i = Semester Grade point average of i[th] semester
NSC_i = Number of credits for the i[th] semester
n = the number of semesters completed

7.3.3. The CGPA may be converted into a percentage, using the following formula:
for CGPA <= 9.0, Percentage marks = (CGPA x 10) – 5
for CGPA > 9.0, Percentage marks = (CGPA x 15) – 50

7.4. Both the SGPA and CGPA shall be rounded off to the second place of decimal and recorded as such. Whenever these CGPA are to be used for official purposes, only the rounded off values shall be used.

7.5. There are academic and non-academic requirements for the Graduate programmes where a student shall be awarded the 'P' and 'NP' grades. Non-credit courses such as Extra Academic Programmes belong to this category. No grade points are associated with these grades and these courses are not taken into account in the calculation of the SGPA or CGPA. However, the award of the degree is subject to obtaining a 'P' grade in all such courses.

7.6. In the case of an audit course, the letters "AU" shall be written alongside the course name in the Grade Sheet. A student is not required to register again for passing failed audit courses.

8.0 Assessment of Performance

8.1. A student's performance is evaluated through a continuous system of evaluation comprising tests, quizzes, assignments, seminars, minor projects, major projects and end-semester examinations.

8.2. **Theory Courses**: Theory courses shall have two components of evaluation – in-semester assessment of 40% weightage and an end-semester examination having 60% weightage.

8.2.1. The modalities of the conduct of in-semester assessment and weightages attached to its various components shall be as published by the School/Department at the beginning of each semester.

8.3. **Lab Courses**: Lab courses (Laboratory, Drawing, Workshop, etc.) shall be evaluated on the basis of attendance, assessment of tasks assigned and end semester test/viva voce. The weightage assigned for these components of the evaluation is given in the following table:

Component	**Weightage**
Assessment of Tasks Assigned	60
End-semester test / Viva voce	40

8.3.1. The modalities of the conduct of evaluation under the heading "Assessment of tasks assigned", its components and the weightages attached to its various components shall be published by the department concerned at the beginning of each semester.

8.3.2. The evaluation of the end-semester test for a lab course may be done on the basis of criteria and weightage to be specified in the question paper, among which are included

- Organisation of the program/experiment
- Coding, freedom from logical and syntactical errors, and accuracy of the result obtained / conduct of the experiment assigned and accuracy of the result
- Extent of completion
- A comprehensive viva-voce which examines the overall grasp of the subject

8.4. **End-Semester examinations**

8.4.1. End-semester examinations for the theory courses, generally of three hours' duration, shall be conducted by the University. The Director of the concerned school shall make the arrangements necessary for holding the examinations.

8.4.2. In the end-semester examinations, a student shall be examined on the entire syllabus of the courses.

8.4.3. A student shall not obtain a pass grade for a course without appearing for the end-semester examination in that course.

8.5. **Research Seminar**

8.5.1. During the course of the Post Graduate programme students may be required to conduct research seminars on a regular basis. The purpose of these research seminars is to encourage the students to conduct literature survey on the recent trends and developments in a chosen area of the discipline.

8.5.2. The literature survey conducted in preparation for these seminars may lead the students to the development of a project model to be executed during the final semesters of the programme.

8.5.3. The Research Seminars shall be evaluated on the basis of a presentation, a report and a viva voce examination.

8.6. **The Major Project / Research Project / Dissertation**

8.6.1 Students of the Post Graduate Programme shall undertake a Major Project / Research Project / Dissertation during the course of their Post Graduate studies. The Major Project / Research Project / Dissertation (to be referred to as Major Project henceforth) is normally conducted in two phases during the last two semesters of the programme.

8.6.2 The Major Project may be a software project, a research oriented project or research work which leads to a dissertation, as may be relevant to the discipline in which the work is undertaken. If it is a research oriented work, it should expose the students to the current state of research in a chosen area of the discipline and lead to new developments in the area.

8.6.3 The Major Project is to be undertaken individually in the campus or outside as may be specified by the department.

8.6.4 Each department shall constitute a Departmental Project Evaluation Committee (DPEC) consisting of the Director of the School (Chairperson), Head of the Department (Vice Chairperson), Project Co-ordinator and two senior teachers from the department, with the Project Co-ordinator as the convenor. The DPEC shall co-ordinate the conduct and assessment of the project.

8.6.4. The DPEC will notify the schedule and modalities for the following stages in the implementation of the project.

- Submission of the topic of the project.
- Notification for assignment of project supervisors.
- Submission of the synopsis
- Schedule for the seminar presentation of synopsis.
- Schedule for Progress Seminars, submission of progress reports and viva voce examination.
- Date for the submission of the project report and a brief summary.
- Dates for the end semester evaluation of the project.

8.6.5. The DPEC may ask a student to resubmit a synopsis if the same does not get its approval.

8.6.6. The project supervisor may be from outside the department or university. Such a supervisor should be approved by the DPEC and jointly supervise a project with a faculty member of the department.

8.6.7. The minimum qualification of a project supervisor shall be laid down by the DPEC in consultation with the Director of the School and authorities of the University.

8.6.8. The Chairperson of the DPEC will submit to the Controller of Examinations a panel of at least three names of external examiners at least three weeks before the end semester examination. The Controller of Examinations will appoint the external examiner(s) from this panel.

8.6.9. Each student shall submit to the DPEC four bound, printed copies of the project report, prepared according to the prescribed format made available, by the due date. The student will submit also three copies of a brief summary of the project that will be forwarded to the concerned examiners.

8.6.10 The DPEC will make the arrangements necessary to conduct the end semester evaluation in consultation with the examiners appointed by the University, during the dates notified.

8.6.11 The project will be evaluated through in-semester and end-semester assessments of equal weightage. The in-semester assessment will be done by the DPEC and the project supervisor. The end-semester assessment will be done by the external examiner(s), the project supervisor and a member of the DPEC appointed by it for the purpose. The weightages attached to their respective evaluations shall be 60:20:20.

8.6.12 The DPEC will forward the in-semester assessment marks to the Controller of Examinations by the date specified by the Examination Department.

8.6.13 Given below are the suggested components of Internal assessment and respective marks assigned:

- Synopsis: 15 marks
- Seminar presentation of the synopsis: 15 marks
- Project implementation: 40 marks
- Pre-submission presentation: 15 marks
- Pre-submission viva voce: 15 marks

8.6.14 Given below are the suggested components of External assessment and respective marks assigned:

- Project implementation: 40 marks
- Seminar presentation: 25 marks
- Viva voce examination: 20 marks
- Project documentation: 15 marks

8.6.15 Publication of papers and registering of patents are encouraged during the Post Graduate programme. Papers published or patents obtained may be awarded extra weightage during the evaluation of the project.

8.6.16 Those who obtain an ‘F’ grade for the major project will be required to re-enrol for it in the subsequent semester and pay the prescribed fees.

8.7. The Director will forward the marks obtained in the in-semester evaluation to the Controller of Examinations within the prescribed time as may be notified.

8.8. All evaluated work in a subject except the end semester answer scripts will be returned to the students promptly.

8.9 Eligibility for appearing in the end-semester examinations: A student shall be permitted to appear for the end-semester examinations, provided that

8.9.1. A student has not been debarred from appearing in the end semester examinations as disciplinary action for serious breach of conduct.

8.9.2. He/she has satisfactory attendance during the semester according to the norms laid out in section 6 of these regulations.

8.9.3. He/she has paid the prescribed fees or any other dues of the university within the date specified.

8.10 Registration for end-semester Examinations

8.10.1 The University shall, through a notification, invite applications from students to register for the end-semester examinations.

8.10.2 Students who have registered with the University (vide clause 5) and those who have applied for such registration may apply to appear for the end-semester examinations of the university, in response to the notification issued by the University, provided that they fulfil the eligibility norms as laid down in clause 8.9.

8.10.3 All eligible candidates shall be issued an admit card for the relevant examination and for specified courses. A student who does not have a valid admit card may not be permitted to write the end-semester examinations.

8.10.4 A student who secures an ‘F’ or ‘X’ grade in any course in a semester may register for the end-semester examination for that course in a subsequent semester when that course is offered again, within the maximum period of time allotted for the completion of the programme. The in-semester assessment marks obtained by him/her in the last semester in which the said course was attended by him/her shall be retained.

8.10.5 Similarly, in case of an ‘NP’ grade in Extra Academic Programmes the student shall have to re-register for it in the appropriate semester of the next academic session.

8.10.6 When a student re-registers for the end semester examination of a course, in accordance with clause 8.10.4 above, the better of the two grades obtained (the old and the new) shall be considered for the calculation of SGPA and CGPA.

8.11 Conduct of Examinations: The University shall conduct the end-semester examinations in accordance with the applicable regulations on such dates as are set down in the Academic Calendar or as notified.

8.12 Declaration of Results: The University shall declare the results of a semester and make available to students their gradesheets within the time-frame prescribed by the relevant regulations of the university and specified in the academic calendar.

8.13 The University may withhold the results of a student for any or all of the following reasons

- he/she has not paid his/her dues
- there is a disciplinary action pending against him/her
- he/she has not completed the formalities for University Registration according to the requirement of section 5 of these Regulations.

8.14 Re-examining of answer scripts

8.14.1 If a student feels that the grade awarded to him/her in a course is not correct, he/she may apply to the University for the re-examining of his/her answer script.

8.14.2 Re-examining of scripts may be of two different categories – scrutiny and re-evaluation.

8.14.3 **Scrutiny:** The activities under this category shall ordinarily be confined to checking

- correctness of the total marks awarded and its conversion into appropriate letter grades
- whether any part/whole of a question has been left unevaluated inadvertently

- correctness of transcription of marks on the tabulation sheet and the gradesheet issued in respect of the course under scrutiny.

8.14.4 Re-evaluation: Re-evaluation of the answer script by independent experts in the concerned subject(s).

8.14.5 **Application for re-examining of answer scripts**

- A student may apply for scrutiny or re-evaluation for one or more courses of the just-concluded end-semester examinations within seven calendar days from the date of publication of its results in the application form prescribed for this purpose.
- He/she shall pay the prescribed fee to the University as notified.
- A student applying for scrutiny/re-evaluation shall expressly state on the application form whether the application made is for Scrutiny or for Re-evaluation. In each case, the student may also request to see his/her answer script.
- All applications for scrutiny/re-evaluation must be routed through the Director of the concerned School.

8.14.6 If in the process of re-examining, the grade obtained in a course changes, the better of the two grades shall be assigned to the course. If there is a change, the new grade shall be recorded and a new grade sheet shall be issued to the student.

8.14.7 Without prejudice to any of the clauses of section 8.14, a student who has been found to have used unfair means during an examination shall not be eligible to apply for scrutiny or re-evaluation of answer scripts.

8.15 **Improvement Examination**

8.15.1 After the completion of the entire programme of study, a student may be allowed the provision of improvement examinations. These are to be availed of only once each in the Autumn and Spring semesters that immediately follow the completion of the programme, and within the maximum number of years permissible for a programme.

8.15.2 A student who has taken migration from the University shall not be eligible to appear for Improvement Examination.

8.15.3 A student may not choose more than the number of courses specified in the table below for improvement examinations.

Programme	**Number of Courses for Improvement Examinations**		
	Autumn Semester	**Spring Semester**	**Total**
MCA	4	4	8
MSc	3	3	6
MTECH	2	2	4

8.15.4 After the improvement examination, the better of the two grades obtained (the old and the new) shall be considered for the calculation of SGPA and CGPA.

8.15.5 If the student improves his/her grades through the improvement examination, new grade sheets and comprehensive transcripts shall be issued to the student.

8.16 **Special Examination**

8.16.1 The University shall conduct Special Examinations to benefit the following categories of students:

8.16.1.1 Students who, on the completion of the final semester, have some 'F' graded courses in the two final semesters, but no 'F' or 'X' graded courses in any of the previous semesters

8.16.1.2 Students who have only one 'F' graded course in a semester other than the two final semesters and do not have 'F' or 'X' graded courses in the two final semesters.

8.16.2 The Special Examinations shall ordinarily be conducted each year within a month of the declaration of the results of the Spring Semester.

8.16.3 Students who fail to secure 50% of the credits offered in the final semester shall not be eligible to appear for the special examinations. Such students will be governed by the provisions of clause 9.5 of these regulations. However, this restriction shall not apply in the case of students who are unable to appear in the end semester examinations due to exceptional situations like their own serious illness and hospitalisation or death of members of inner family circle (restricted to only father, mother, siblings).

8.16.4 Students who have 'X' graded courses only in the last two semesters shall be offered the opportunity for participating in a Tutorial Programme which may be conducted during the semester break immediately following the end-semester examinations of the final semester and students who earn 85% attendance for the programme shall be permitted to appear for the Special Examinations. Separate fees shall be charged for the Tutorial Programme.

8.16.5 Students who do not obtain pass grades in any course at the special examinations shall have to apply in the prescribed format and appear for the end-semester examination of these courses when they are scheduled by the University during subsequent relevant end-semester examinations.

9.0 Enrolment (for semesters other than the first)

9.1 Every student is required to enrol for the relevant courses before the commencement of each semester within the dates fixed for such enrolment and notified by the Registrar.

9.2 Students who do not enrol within the dates announced for the purpose may be permitted late enrolment up to the notified date on payment of a late fee.

9.3 Only those students shall be permitted to enrol who have
- cleared all University, Departmental, Hostel and Library dues and fines (if any) of the previous semester,
- paid all required University, Departmental and Hostel fees for the current semester, and
- not been debarred from enrolling on any specific ground.

9.4 No student may enrol for a semester if he/she has not appeared, for whatever reason, in the end semester examinations of the previous semester.

9.5 A student who fails to obtain 50% of the credits offered in a semester shall not be permitted to enrol for the next semester and shall have to re-enrol for and attend all the courses of the said semester in the following academic year.

10.0 Eligibility for the Award of the Post Graduate Degree

10.1 A student shall be declared to be eligible for the award of the Post Graduate Degree for which he/she has enrolled if he/she has

10.1.1 completed all the credit requirements for the degree with grade 'C' or higher grade in each of the mandatory graded courses and grade 'P' in all mandatory non-graded courses.

10.1.2 satisfactorily completed all the non-credit requirements for the degree viz., Extra Academic Activities, Industry Training, field work, internship programme, etc. (if any);

10.1.3 obtained a CGPA of 5.00 or more at the end of the semester in which he/she completes all the requirements for the degree;

10.1.4 no dues to the University, School, Department, Hostels; and

10.1.5 no disciplinary action pending against him/her.

10.2 The award of the Post Graduate Degree must be recommended by the Academic Council and approved by the Board of Management of the University.

11.0 Termination from the Programme

11.1. If more than the number of years permitted for the completion of a programme have elapsed since the student was admitted, and the student has not become eligible for the award of Degree, the student shall be removed from the programme.

11.2. A student may also be required to leave the Programme on disciplinary grounds on the recommendations of the Students' Disciplinary Committee of the concerned School.

ASSAM DON BOSCO UNIVERSITY
REGULATIONS FOR MASTER'S DEGREE PROGRAMMES

HUMANITIES AND SOCIAL SCIENCES
COMMERCE AND MANAGEMENT

The following are the regulations of the Assam Don Bosco University concerning the Post-Graduate Programmes leading to the award of the Master's Degree in the disciplines of Humanities and Social Sciences & Commerce and Management made subject to the provisions of its Statutes and Ordinances:

The Master's Degree Programmes of Assam Don Bosco University consist of theory and practicum components, taught and learned through a combination of lectures, field work/field visit and research projects.

1.0 Academic Calendar

1.1 Each academic year is divided into two semesters of approximately 18 weeks duration: an Autumn Semester (July – December) and a Spring Semester (January – June). The Autumn Semester shall ordinarily begin in July for students already on the rolls and the Spring Semester shall ordinarily begin in January. However, the first semester (Autumn, for newly admitted students) may begin later depending on the completion of admission formalities.

1.2 The schedule of academic activities approved by the Academic Council for each semester, inclusive of the schedule of continuing evaluation for the semester, dates for end-semester examinations, the schedule of publication of results, etc., shall be laid down in the Academic Calendar for the semester.

2.0 Duration of the Programme

2.1 The normal duration of the Post Graduate Programme in the disciplines of Humanities and Social Sciences & Commerce and Management shall be 4 semesters (2 years).

2.2 However, students who do not fulfil some of the requirements in their first attempt and have to repeat them in subsequent semesters may be permitted up to 4 more semesters (2 years) to complete all the requirements of the degree.

2.3 Under exceptional circumstances and depending on the merit of each case, a period of 2 more semesters (1 year) may be allowed for the completion of the programme

3.0 Course Structure

3.1 The choice based credit system shall be followed for the Masters Degree Programmes. Credits are allotted to the various courses depending on the number of hours of lecture/practicum/Field work assigned to them using the following general pattern:

3.1.1. Lecture : One hour per cycle/week is assigned 1 credit.

3.1.2. Practicum/fieldwork : Two hours per cycle/week is assigned 1 credit.

3.2 The courses are divided into two baskets – core courses and elective courses.

3.3 **Core Courses:** Core courses are those in the curriculum, the knowledge of which is deemed essential for students who are pursuing the programme.

3.3.1 A student shall be required to take all the core courses offered for a particular programme.

3.3.2 The number of credits required from core courses shall be as prescribed by the competent academic authority.

3.4 **Elective Courses:** These are courses in the curriculum which give the student opportunities for specialisation and which cater to his/her interests and career goals. These courses may selected by the student and/or offered by the department conducting the programme, from those listed in the curriculum according to the norms laid down by the competent academic authority.

3.4.1 The number of credits which may be acquired through elective courses shall be prescribed by the Board of studies pertaining to the programme.

3.5 These categories of courses may further be subdivided into departmental, school or institutional, depending on the department which offers the course. The schema of categorisation of courses into baskets is as given below:

Core Courses	
Departmental Core **(DC)**	Core courses which are offered by the department which conducts the programme
School Core **(SC)**	Core courses which are offered by a department other than the department which conducts the programme, from within the same School
Institutional Core **(IC)**	Core courses which are offered by departments of the University from Schools other than the parent School
Elective Courses	
Departmental Elective **(DE)**	Elective courses which are offered by the department which conducts the programme
School Elective **(SE)**	Elective courses which are offered by a department other than the department which conducts the programme, from within the same School
Institutional Elective **(IE)**	Elective courses which are offered by departments of the University from Schools others than the parent School

3.6 In order to qualify for a Masters Degree, a student is required to complete the credit requirement as prescribed in the curriculum.

3.7 In addition to the prescribed credit requirement, a student shall have to complete the requirements of Extra Academic Programmes (EAP) as may be prescribed by the Department. Students shall be awarded P/NP grades for the EAP, which shall be recorded in the Gradesheet, but not taken into account for computing the SGPA and the CGPA.

3.8 Students who secure a CGPA of at least 7.5 at the end of the 2nd semester may opt to take one audit course per semester from any Department from the 3rd semester onwards, provided the course teacher permits the auditing of the course. This shall be done under the guidance of the Departmental Faculty Advisor/mentor. The student is free to participate in the evaluation process for such courses. However, an attendance of 75% percentage is necessary for obtaining a P grade for such courses. When auditing courses offered by other departments, it shall be the responsibility of the student to attend such courses without missing courses of one's own department and semester.

3.9 In addition, students may also opt for additional elective courses in consultation with their mentors. Students are required to participate in the evaluation process of such courses. The grades obtained for such courses shall be recorded in the gradesheet, but not taken into account for computing SGPA and CGPA.

3.10 It shall be the prerogative of the department to not offer an elective course which has less than 5 students opting for it.

3.11 The medium of instruction shall be English and examinations and project reports shall be in English.

3.12 The course structure and syllabi of the Post Graduate Degree Programmes shall be approved by the Academic Council of the University. Departmental Boards of Studies (DBOS) shall discuss and recommend the syllabi of all the courses offered by the department from time to time before forwarding the same to the School Board of Studies (SBOS). The SBOS shall consider the proposals from the departments and make recommendations to the Academic Council for consideration and approval.

3.13 The curriculum may include fieldwork / institutional visits / internship for a specified time. These are to be satisfactorily completed before a student is declared eligible for the degree. There shall be credit allocation for such activities. These activities may be arranged during the semester or during convenient semester breaks as shall be determined by the School Board of Studies.

3.14 Faculty Advisor/Mentor: A faculty advisor/mentor shall be assigned for groups of students. Faculty advisors/mentors shall help their mentees to plan their courses of study, advise them on matters relating to academic performance and personality development, and help them to overcome various problems and difficulties faced by them.

PROGRAMME SPECIFIC CURRICULAR ASPECTS

4.0 MASTER OF SOCIAL WORK (MSW)

4.1 Area of Concentration: The third and fourth semesters shall have courses from a chosen Area of Concentration (AoC) from among those offered by the department. The AoC is to be opted for at the end of the second semester and will be confirmed by the department depending on the availability of seats and the aptitude and ability of the student. An AoC will be offered by the department only if a minimum of six students opt for it. The fieldwork and research project of the third and fourth semesters will be based on the AoC.

4.2 Concurrent and Continuous Fieldwork

Fieldwork shall be an essential part of the course structure in all the semesters of the programme. The field work practice in the first semester shall consist of orientation visits, sessions for skills training and placement. In the first year, the focus of the field work shall be the community and in the second year the focus shall be based on the specialisation chosen by the students. In the first semester,, students shall be placed in communities, NGOs, service organizations and government agencies working with communities, and in those settings where they can be exposed to the community and community issues. The students get a close feel of the community and community settings, understand the dynamics and issues in the community and become aware of the sensitivities of people while working with them. They also get a firsthand experience of the programmes and projects implemented in the communities by NGOs and government agencies and the impact that these have on the community. They shall also interact with the personnel from organisations and the community members to understand the tension between tradition and change that the communities in the region are likely to experience, and how it is handled. They shall, with the help of the organisation and the field work supervisor, identify an issue and work on it following the principles of community organization. The students are expected to be creative and innovative in assisting the agency and community in whatever way possible.

The field work practice in the second semester will consist of lab sessions for skills training and placement. The focus will be on the practice of social case work and Group works. The students shall be placed in NGOs, and government service organizations and government agencies working with individuals and families, and in those settings where they can be exposed to issues related to individuals and groups. Normally a student spends fifteen hours over two days per week in field work.

4.2.1 Normally a student shall spend fifteen hours over two days per week in field work. However, keeping in mind the peculiar situation of transport and communications in the region and the expenses involved, the field work practice may be arranged in other convenient ways as the institution deems fit.

4.2.2. The student is required to submit the report on the field work and the field work diary to the field work supervisor, before the commencement of classes on the first day of class following the field work days. The supervisor shall conduct regular field work conferences

4.2.3. A student is expected to have 100 percent attendance in field work. Any shortage shall be compensated by him/her.

4.2.4 At the end of the semester the student shall submit a summary report of the field work for the semester and a viva voce examination shall be conducted.

4.3.5 The field work practice in the Third and Fourth Semesters shall focus upon the Area of Concentration chosen by the students. The students shall be placed in the field for twenty five days of consecutive field work. The field work settings shall be communities, NGOs, service organizations, hospitals, clinics and governmental agencies. Those students who are specializing in Community Development will either be placed in an urban or rural community setting that is identified by the Department. Students who are specializing in Medical and Psychiatric Social Work will be exposed to either a Medical or a Psychiatric setting.

4.3 Rural Camp

Students shall organise and participate in a rural camp during the first / second semester. The duration of the rural camp shall generally be ten days excluding days of travel.

4.3.1 The objectives of the rural camp are:

- To apply the acquired skills of group work and community organisation in communities.
- To understand and assess the problems faced by the rural population.
- To involve oneself positively in the communities to help to remove some of these problems.

4.3.2 At the end of the camp each student shall submit a written report to the department in a specified format. Performance at the Rural Camp shall be considered for the evaluation of the Field Work during the second semester.

4.3.3 The Rural Camp shall be credited along with the fieldwork of the semester along with which it can be conveniently coupled.

4.4 Study Tour

During the programme the students shall undertake a study tour of ten days along with the assigned faculty members to a place approved by the department. The places are to be so chosen as to be of educational benefit to students. During the tour, the focus shall be on visiting and interacting with as many NGOs/ state/national/international organisations involved in developmental work as possible. A report of the learning outcomes shall be submitted to the department at the end of the tour. The Study Tour shall be a Pass/No Pass course.

4.5 Block Placement

After the examinations at the end of the fourth semester, the students shall be placed with an NGO or Agency for a period of not less than one month for practical experience and application of their skills. While the Block Fieldwork is not credited, it is mandatory for the completion of the MSW programme. The student shall contact an agency of his/her choice and get the choice of agency approved by the department. Students shall endeavour to choose an agency that is primarily in tune with their AoC and which has credentials in the concerned field. At the end of every week the student shall send a brief report to the supervisor and at the end of the Block Field Work period a summary report shall be submitted. The summary report shall contain a short description of the Agency, the social service skills applied in his/her work and the student's learning outcomes. The report shall be submitted in a format prescribed by the department and shall be submitted together with a certificate from the agency confirming his/her field work, in a prescribed format.

4.6 Research Project Work

Every student shall undertake a research project work which has bearing on his/her AoC and present a written thesis on the research work under the supervision and guidance of a faculty member. The preliminary work may begin at the end of the second semester. The students are expected to complete the data collection before the fourth semester. The thesis is to be submitted to the department before the date notified. The student shall write a dissertation of the research thesis and appear for a viva voce examination on the research done. The mode and components of evaluation of the research work and the weightages attached to them shall be published by the Department/Institute at the beginning of the semester.

4.7 Assignments

Assignments are an essential part of learning. The faculty shall engage students in a minimum of one individual and one group assignment per course, per semester. A group assignment shall be accompanied by a common presentation.

5.0 MSC PSYCHOLOGY (PSYCHOLOGICAL COUNSELLING)

5.1 Field Work

Students shall take part in concurrent field work during the first three semesters in social service agencies, medical institutions, the criminal justice system, etc., where the student of psychological counselling can get a first hand experience of the application of the learning derived from the classroom. The field work shall be credited and shall be evaluated using norms laid down by the department.

5.2 Study Tour

During the programme the students shall undertake a study tour of ten days with the faculty members, to a place approved by the department. The places are to be so chosen as to be of educational benefit to students. During the tour, the focus shall be to visit and interact with NGOs, hospitals, state/national/international organisations involved in psychological counselling. A report of the learning outcomes shall be submitted to the department at the end of the tour. The Study Tour shall be a Pass/No Pass course.

5.3 Summer Internship

Students are required to undergo a summer internship of two weeks' during the semester break between the second and third semesters. It is a P/NP course and shall be recorded in the third semester. The Summer Internship gives students an opportunity to apply the theories and principles that they have learnt in class room courses to the "real world" of social service agencies, medical institutions, the criminal justice system, business, and industry. During the internship, students can explore career interests, develop professional skills, learn how community organizations work and expand their clinical and interpersonal skills. The summer internship enriches the students' academic experience while making a valuable contribution to the community and utilizing the vacation optimally.

5.4 Supervised Internship

Each student shall perform a supervised internship for a period of one semester in an organisation which offers counselling help to clients. The supervised internship shall ordinarily be organised during the last semester of the programme. It shall be the prerogative of the department to propose the number of institutions where a student is expected to perform supervised internship. Supervision shall be provided for by the university in collaboration with the organisation where the student performs the internship. Evaluation of the internship shall be based on the documentation, reports from the organisation, report of the supervisor and the presentation and the viva voce examination of the student at the end of the period of Internship.

5.5 Research Project Work

A research project shall be undertaken during the course of the third and the fourth semesters. The topic of the research shall be so chosen that it will be possible for the student to pursue and complete the research work in the institution/hospital where the student is placed for internship. The preliminary work may begin at the end of the second semester. The students are expected to complete the data collection before the fourth semester. The thesis is to be submitted to the department before the date notified. The student shall write a dissertation of the research thesis and appear for a viva voce examination on the research done. The mode and components of evaluation of the research work and the weightages attached to them shall be published by the Department/ Institute at the beginning of the semester.

5.6 Assignments

Assignments are an essential part of learning. The faculty shall engage students in a minimum of one individual and one group assignment per course, per semester. A group assignment shall be accompanied by a common presentation.

6.0 MA EDUCATION

6.1 Specialisations

The Masters Degree Programme in Education offers a number of specialisations, of which a student shall be required to choose a specialisation after the completion of the first semester. The department shall have the prerogative of not offering a specialisation if a sufficient number of students do not opt for it.

6.2 Educational Seminar

During the course of the programme, students are expected to present a series of seminars which will address fundamental intellectual, conceptual and practical issues in current educational philosophy and application. They may also deal with other relevant topics which may be suggested by the department. Students shall be assisted through guest lectures, discussions, field work in education related institutions and active engagement with faculty members. During these interactions students shall be provided with an opportunity to explore how best to bring new interdisciplinary scholarship, technology and critical thinking into the development of the chosen seminar area. They shall also consider alternative pedagogic strategies, teaching techniques and technologies. Students shall prepare and present a final paper based on these seminars. Students shall be evaluated on the basis of the seminars and the final paper.

6.3 Assignments

Assignments are an essential part of learning. The faculty shall engage students in a minimum of one individual and one group assignment per course, per semester. A group assignment shall be accompanied by a common presentation.

6.4 Research Project Work

Every student shall undertake a research project work which has bearing on his/her field of specialisation and present a written thesis on the research work under the supervision and guidance of a faculty member. The Research Project shall be undertaken individually, in two phases during the third and fourth semesters. Students are expected to make presentations to the department at different stages of the research work. The student shall write a dissertation of the research thesis, submit it to the department and appear for a viva voce examination at times to be notified by the department. The mode and components of evaluation of the research work and the weightages attached to them shall be published by the Department/Institute at the beginning of the semester.

6.5 School Visits and Audit

The students of the Masters Programme in Education shall be engaged in regular school visits with the purpose of understanding and evaluating the process of teaching, learning and evaluation as well as the exigencies of administration of the school. The students shall be trained in the principles and practice of performing a school audit and they shall undertake the audit of a school in groups during the course of the programme.

6.6 Internship

During the final semester of the programme, a student is required to undergo an internship for a period of one month. The internship provides an opportunity for students to experience the ground reality and connect it with the theoretical and methodological perspectives the student has studied and interiorized. During the internship the student will be monitored and guided by his/her supervisor and faculty members. The student will be required to maintain a journal and at the end of the period of internship, submit a written report and to make a presentation of his/her experiences and learnings at the internship. The student will be required also to submit a report from the head of the institution regarding his/her performance there.

The evaluation of the student shall be based on the level of his/her engagement during the internship in addition to his/her ability to communicate this engagement in the journal, the report and the presentation. The journal and the report are to be submitted within a month of the completion of the internship. The department shall specify the criteria for evaluating the journal, the report and the presentation.

7.0 MA MASS COMMUNICATION

7.1 Specialisations

The Master's Degree Programme in Mass Communication offers a number of specialisations, of which a student shall be required to choose a specialisation after the completion of the first semester. The department shall have the prerogative of not offering a specialisation if a sufficient number of students do not opt for it.

7.2 Media House Visits

During the course of the programme, students shall be required to visit a variety of Media Houses in small groups constituted by the department. The purpose of these Media House Visits shall be to gain exposure to the best practices among the day-to-day activities of the media house. A report of the visit is to be submitted in the format specified within two days of the visit. The Media House visit shall be a graded course and grades shall be awarded on the basis of the written reports of the media house visits.

7.3 Research Project Work

Every student shall undertake a research project work which has a bearing on his/her field of specialisation and present a written thesis on the research work under the supervision and guidance of a faculty member. The Research Project shall be undertaken individually, in two phases during the course of two semesters as shall be laid down in the course structure of the programme. Students are expected to make presentations to the department at different stages of the research work. The student shall write a dissertation of the research thesis, submit it to the department and appear for a viva voce examination at times to be notified by the department. The mode and components of evaluation of the research work and the weightages attached to them shall be published by the Department/Institute at the beginning of the semester.

7.4 Assignments

Assignments are an essential part of learning. The faculty shall engage students in a minimum of one individual and one group assignment per course, per semester. A group assignment shall be accompanied by a common presentation.

7.5 Internship

All students shall undergo an internship involving media related activities of four weeks' duration. The purpose of the internship is to give the students an opportunity to have a hands-on field experience to effectively put into practice the theoretical and practical learning from the programme in an area of interest. Students may undergo their internship in a media house of their choice. The student shall be required to discuss the choice of media house with the department and obtain its consent. Before going for the internship, a Letter of Consent from the concerned media house, in the prescribed format, shall be submitted by the student to the Department. After returning from the internship each student shall have to submit a detailed report in a prescribed format. Each student shall also make a presentation of the internship experience and learning in the Department and submit a certificate of successful completion of the internship from the designated authority of the concerned media house. The schedule of the conduct, report submission and evaluation of the internship shall be as notified by the Department. The components of evaluation of the Internship and their weightages shall be as notified by the department at the beginning of the semester.

7.6 Final Project

As a Final Project the students are required to create a Social Awareness and Community Development oriented multi-media project which shall culminate in a Media Event. The purpose of the final project is to showcase all the skills that the students have acquired during the course of the programme as well as demonstrate their Media and Event Management, and Media Entrepreneurship abilities and at the same time use these skills for the service and upliftment of the community. The Final Project shall essentially be a group project and the number of groups shall be specified by the department. The groups shall perform their activities under the guidance of faculty members who shall be assigned to guide each group. The last dates for the submission of the project proposal and the conduct of the event shall be notified by the Department well in advance. The components of evaluation of the Final Project and their weightages shall be as notified by the department at the beginning of the semester.

8.0 MASTER OF ARTS (MA) ENGLISH

8.1 Specialisations

The Master's Degree Programme in English offers a number of specialisations, of which a student shall be required to choose a specialisation after the completion of the second semester. The department shall have the prerogative of not offering a specialisation if a sufficient number of students do not opt for it.

8.2 Educational Seminar

During the course of the programme, students are expected to present a series of seminars related to English literature.They may also deal with other relevant topics which may be suggested by the department. Students shall prepare and present a final paper based on these seminars. Students shall be evaluated on the basis of the seminars and the final paper.

8.3 Assignments

Assignments are an essential part of learning. The faculty shall engage students in a minimum of one individual and one group assignment per course, per semester. A group assignment shall be accompanied by a common presentation.

8.4 Dissertation

Students will be required to write a dissertation in the 4th semester.

9.0 MASTER OF COMMERCE (MCOM)

9.1 Specialisations

The Master's Degree Programme in Commerce offers a number of specialisations, of which a student shall be required to choose a specialisation after the completion of the second semester. The department shall have the prerogative of not offering a specialisation if a sufficient number of students do not opt for it.

9.2 Project Work/Dissertation

The Master's Degree Programme in Commerce will require students to do Project work in the 3rd and 4th semesters. The mode and components of evaluation of the project work and the weightages attached to them shall be published by the department at the beginning of the semester.

9.3 Assignments

Assignments are an essential part of learning. The faculty shall engage students in a minimum of one individual and one group assignment per course, per semester. A group assignment shall be accompanied by a common presentation.

10.0 Admission

10.1 All admissions to the Post Graduate Degree Programmes of the University shall be on the basis of merit. There may, however, be provision for direct admission for a limited number of NRI/FN students.

10.2 Eligibility Criteria

10.2.1. To be considered for admission to a Post Graduate Degree Programme a candidate should have passed a Bachelor's Degree (or equivalent) programme of a recognised university securing 50% of the grades/marks.

10.2.2. Admission will be on the basis of the academic records of the candidate, and taking into consideration his/her performance in any or all of the following:

- Written test
- Group Discussion
- Personal Interview

10.3 Candidates whose results for the qualifying examination are not yet declared may be provisionally admitted provided she/he submits proof of fulfilment of the eligibility criteria by 31 October of the year of provisional admission.

11.0 University Registration

Candidates shall have to register as bona-fide students with the University as per the University regulations within a period specified by the University, by a formal application routed through the Director.

12.0 Attendance

12.1 To be permitted to appear for the end-semester examination of a particular course, a student is required to have a minimum attendance of 75% for that course.

12.2 Deficiency in attendance up to 10% may be condoned by the Director in the case of leave taken for medical and other grievous reasons, which are supported by valid medical certificates and other requisite documents.

12.3 Some students, due to exceptional situations like their own serious sickness and hospitalization or death of members of inner family circle, may have attendance below 65%. Such students may be given bonus attendance percentage for a particular course based on his/her attendance for that course during the remaining days of the current semester, as given in the following table:

Attendance during the remaining days of the current semester	Bonus percentage available in the current semester
95% or more	5
90% or more but less than 95%	4
85% or more but less than 90%	3
80% or more but less than 85%	2
75% or more but less than 80%	1

They shall be permitted to appear for the end-semester examination of the course if on the strength of this bonus attendance percentage, they obtain 65% attendance for that course.

12.4 If the sum of the credits of the courses for which a student is unable to appear at the end-semester examinations exceeds 50% of the total credits allotted for the semester, he/she shall not be permitted to appear for the entire end-semester examinations in view of clause 13.5 of these Regulations.

12.5 The School may decide to set aside a certain portion of the in-semester assessment marks for attendance. The number of marks and modalities of their allotment shall be made known to the students at the beginning of each semester.

12.6 Leave

12.6.1 Any absence from classes should be with prior sanctioned leave. The application for leave shall be submitted to the Office of the Director of the School on prescribed forms, through the Head of the Department, stating fully the reasons for the leave requested along with supporting documents.

12.6.2 In case of emergency such as sickness, bereavement or any other unavoidable reason for which prior application could not be made, the parent or guardian must inform the office of the Director promptly.

12.6.3 If the period of absence is likely to exceed 10 days, a prior application for grant of leave shall have to be submitted through the Director to the Registrar with supporting documents in each case; the decision to grant leave shall be taken by the Registrar on the recommendation of the Director.

12.6.4 The Registrar may, on receipt of an application, also decide whether the student be asked to withdraw from the programme for that particular semester because of long absence.

12.6.5 It shall be the responsibility of the student to intimate the concerned teachers regarding his/her absence before availing of the leave.

13.0 Grading System

13.1 Based on the performance of a student, each student is awarded a final letter grade in each graded course at the end of the semester and the letter grade is converted into a grade point. The correspondence between percentage marks, letter grades and grade points is given in the table below:

Marks (x) obtained (%)	Grade	Description	Grade Points
90 ≤ x ≤ 100	O	Outstanding	10
80 ≤ x < 90	E	Excellent	9
70 ≤ x < 80	A+	Very Good	8
60 ≤ x < 70	A	Good	7
50 ≤ x < 60	B	Average	6
40 ≤ x < 50	C	Below Average	5
x < 40	F	Failed	0

In addition, a student may be assigned the grades 'P' and 'NP' for pass marks and non-passing marks respectively, for Pass/No-pass courses, or the grade 'X' (not permitted).

13.1.1 A student shall be assigned the letter grade 'X' for a course if he/she is not permitted to appear for the end semester examination of that course due to lack of requisite attendance.

13.1.2 A letter grade 'F', 'NP' or 'X' in any course implies a failure in that course.

13.1.3 A student is considered to have completed a course successfully and earned the credits if she/he secures a letter grade other than 'F', 'NP', or 'X'.

13.2 At the end of each semester, the following measures of the performance of a student in the semester and in the programme up to that semester shall be computed and made known to the student together with the grades obtained by the student in each course:

13.2.1 **The Semester Grade Point Average (SGPA)**: From the grades obtained by a student in the courses of a semester, the SGPA shall be calculated using the following formula:

$$SGPA = \frac{\sum_{i=1}^{n} GP_i \times NC_i}{\sum_{i=1}^{n} NC_i}$$

Where GP_i = Grade points earned in the i^{th} course

NC_i = Number of credits for the i^{th} course

n = the number of courses in the semester

13.2.2 **The Cumulative Grade Point Average (CGPA)** : From the SGPAs obtained by a student in the completed semesters, the CGPA will be calculated using the following formula:

$$CGPA = \frac{\sum_{i=1}^{n} SGP_i \times NSC_i}{\sum_{i=1}^{n} NSC_i}$$

Where SGP_i = Semester Grade point average of i^{th} semester

NSC_i = Number of credits for the i^{th} semester

n = the number of semesters completed

13.2.3 The CGPA may be converted into a percentage, using the following formula:

for CGPA <= 9.0, Percentage marks = (CGPA x 10) – 5.

for CGPA > 9.0, Percentage marks = (CGPA x 15) – 50

13.3 Both the SGPA and CGPA will be rounded off to the second place of decimal and recorded as such. Whenever these CGPA are to be used for official purposes, only the rounded off values will be used.

13.4 There are academic and non-academic requirements for the programme where a student will be awarded the 'P' and 'NP' grades. All non-credit courses (such as Study Tour and Extra Academic Activities) belong to this category. No grade points are associated with these grades and these courses are not taken into account in the calculation of the SGPA or CGPA. However, the award of the degree is subject to obtaining a 'P' grade in all such courses.

14.0 Assessment of Performance

14.1 A student's performance is evaluated through a continuous system of evaluation comprising tests, quizzes, assignments, seminars, projects, research work, concurrent and block field work performance and end-semester examinations.

14.2 **Theory Courses**: Theory courses will have two components of evaluation – in-semester assessment of 40% weightage and an end-semester examination having 60% weightage.

12.2.1 The modalities of conduct of in-semester evaluation, its components and the weightages attached to its various components shall be published by the department concerned at the beginning of each semester.

14.3 **Practicum/Field Work/Lab:** These courses shall be evaluated on the basis of attendance, performance of tasks assigned and an end semester test/viva voce examination. The weightage assigned to these components of the evaluation is given in the following table:

Component	**Weightage**
Attendance	10
Performance of tasks assigned	50
end-semester test / viva voce examination	40

14.4 End-Semester examinations

14.4.1. End-semester examinations, generally of three hours' duration, shall be conducted by the University for the theory courses. However, the Director of the Institute shall make the arrangements necessary for holding the examinations.

14.4.2 In the end-semester examinations, a student shall be examined on the entire syllabus of the courses.

14.4.3 A student shall not obtain a pass grade for a course without appearing for the end-semester examination in that course.

14.5 The evaluation of performance in Co-curricular Activities will be done by the authorities conducting them and they will communicate the grades to the Director who will forward them to the Controller of Examinations of the University.

14.6 The Director will forward the marks obtained in the in-semester evaluation to the Controller of Examinations within the prescribed time as may be notified.

14.7 All evaluated work in a subject except the end semester answer scripts will be returned to the students promptly. They should be collected back after the students have examined them, and preserved for a period of one semester.

14.8 Eligibility for appearing in the end-semester examinations: A student will be permitted to appear for the end-semester examinations, provided that

12.8.1 A student has not been debarred from appearing in the end semester examinations as disciplinary action for serious breach of conduct.

12.8.2 He/she has satisfactory attendance during the semester according to the norms laid out in section 9 of these regulations.

12.8.3 He/she has paid the prescribed fees or any other dues of the university, institute and department within the date specified.

14.9 Registration for end-semester Examinations

14.9.1 The University shall, through a notification, invite applications from students to register for the end-semester examinations.

14.9.2 Students who have registered with the University and those who have applied for such registration may apply to appear for the end-semester examinations of the university, in response to the notification issued by the University, provided that they fulfil the eligibility norms as laid down in clause 14.8.

14.9.3 All eligible candidates shall be issued an admit card for the relevant examination and for the specified courses. A student who does not have a valid admit card may not be permitted to write the end-semester examinations.

14.9.4 A student who secures an 'F' or 'X' grade in any course in a semester may register for the end-semester examination for that course in a subsequent semester when that course is offered again, within a period of four years from his/her enrolment for the programme. The in-semester assessment marks obtained by him/her in the last semester in which the said course was attended by him/her shall be retained.

14.9.5 Similarly, in case of an 'NP' grade in Extra Academic Programmes the student shall have to re-register for it in the appropriate semester of the next academic session.

14.9.6 When a student re-registers for the end semester examination of a course, in accordance with clause 14.9.4 above, the better of the two grades obtained (the old and the new) shall be considered for the calculation of SGPA and CGPA.

14.10 **Conduct of Examinations**: The University shall conduct the end-semester examinations in accordance with the applicable regulations on such dates as are set down in the Academic Calendar or as notified.

14.11 **Declaration of Results**: The University shall declare the results of a semester and make available to the students their gradesheets within the time-frame prescribed by the relevant regulations of the university and specified in the academic calendar.

14.11.1 The University may withhold the results of a student for any or all of the following reasons

- he/she has not paid his/her dues
- there is a disciplinary action pending against him/her
- he/she has not completed the formalities for University Registration according to the requirement of section 6 of these Regulations.

14.12 **Re-examining of answer scripts**

14.12.1 If a student feels that the grade awarded to him/her in a course is not correct, he/she may apply to the University for the re-examining of his/her answer script.

14.12.2 Re-examining of scripts may be of two different categories – scrutiny and re-evaluation.

14.12.3 **Scrutiny**: The activities under this category shall ordinarily be confined to checking

- correctness of the total marks awarded and its conversion into appropriate letter grades
- whether any part/whole of a question has been left unevaluated inadvertently
- correctness of transcription of marks on the tabulation sheet and the gradesheet issued in respect of the course under scrutiny.

14.12.4 **Re-evaluation**: Re-evaluation of the answer script by independent experts in the concerned subject(s).

14.12.5 **Application for re-examining of answer scripts**

- A student may apply for scrutiny or re-evaluation for one or more courses of the just-concluded end-semester examinations within seven calendar days from the date of publication of its results in the application form prescribed for this purpose.
- He/she shall pay the prescribed fee to the University as notified.

- A student applying for scrutiny/re-evaluation shall expressly state on the application form whether the application made is for Scrutiny or for Re-evaluation. In each case, the student may also request to see his/her answer script.
- All applications for scrutiny/re-evaluation must be routed through the Director of the Institute.

14.12.6 If in the process of re-examining, the grade obtained in a course changes, the better of the two grades shall be assigned to the course. If there is a change, the new grade shall be recorded and a new grade sheet shall be issued to the student.

14.12.7 Without prejudice to any of the clauses of section 14.12, a student who has been found to have used unfair means during an examination shall not be eligible to apply for scrutiny or re-evaluation of answer scripts.

14.13 **Improvement Examination**

14.13.1 After the completion of the entire programme of study, a student may be allowed the provision of improvement examinations. These are to be availed of only once each in the Autumn and Spring semesters that immediately follow the completion of the programme, and within the maximum number of years permissible for the programme.

14.13.2 A student may choose no more than six courses (three in the Autumn semester and three in the Spring semester) for improvement examinations.

14.13.3 After the improvement examination, the better of the two grades obtained (the old and the new) shall be considered for the calculation of SGPA and CGPA.

14.13.4 If the student improves his/her grades through the improvement examination, new gradesheets and comprehensive transcripts shall be issued to the student.

14.14 **Special Examination**

14.14.1 The University shall conduct Special Examinations to benefit the following categories of students:

14.14.1.1 Students who, on the completion of the final semester, have some 'F' graded courses in the two final semesters, but no 'F' or 'X' graded courses in any of the previous semesters

14.14.1.2 Students who have only one 'F' graded course in a semester other than the two final semesters and do not have 'F' or 'X' graded courses in the two final semesters.

14.14.2 The Special Examinations shall ordinarily be conducted each year within a month of the declaration of the results of the Spring Semester.

14.14.3 Students who fail to secure 50% of the credits offered in the final semester shall not be eligible to appear for the special examinations. Such students will be governed by the provisions of clause 15.5 of these regulations. However, this restriction shall not apply in the case of students who are unable to appear in the end semester examinations due to exceptional situations like their own serious illness and hospitalisation or death of members of inner family circle (restricted to only father, mother, siblings).

14.14.4 Students who have 'X' graded courses only in the last two semesters shall be offered the opportunity for participating in a Tutorial Programme which may be conducted during the semester break immediately following the end-semester examinations of the final semester and students who earn 85% attendance for the programme shall be permitted to appear for the Special Examinations. Separate fees shall be charged for the Tutorial Programme.

14.14.5 Students who do not obtain pass grades in any course at the special examinations shall have to apply in the prescribed format and appear for the end-semester examination of these courses when they are scheduled by the University during subsequent relevant end-semester examinations.

15.0 Enrolment (for semesters other than the first)

15.1 Every student is required to enrol for the programme through the designated officer at the commencement of each semester on the days fixed for such enrolment and notified in the Academic Calendar.

15.2 Students who do not enrol on the days announced for the purpose may be permitted late enrolment up to the notified day in the Academic Calendar on payment of a late fee.

15.3 Only those students will be permitted to enrol who have

15.3.1 cleared all University, Institute, Department, Hostel and Library dues and fines (if any) of the previous semester,

15.3.2 paid all required University, Institute, Department and Hostel fees for the current semester, and

15.3.3 not been debarred from enrolling on any specific ground.

15.4 No student may enrol for a semester if he/she has not appeared, for whatever reason, in the end semester examinations of the previous semester.

15.5 A student who fails to obtain 50% of the credits offered in a semester shall not be permitted to enrol for the next semester and shall have to re-enrol for and attend all the courses of the said semester in the following academic year.

16.0 Eligibility for the Award of Degree

16.1 A student shall be declared to be eligible for the award of the degree if he/she has

16.1.1 completed all the credit requirements for the degree with grade ‘C’ or higher grade in each of the graded courses and grade ‘P’ in all the non-graded courses.

16.1.2 satisfactorily completed all the non-credit requirements for the degree (if any);

16.1.3 obtained a CGPA of 5.00 or more at the end of the semester in which he/she completes all the requirements for the degree;

16.1.4 no dues to the University, Institute, Department, Hostels; and

16.1.5 no disciplinary action pending against him/her.

16.2 The award of the degree must be recommended by the Academic Council and approved by the Board of Management of the University.

17.0 Termination from the Programme

17.1 If more than the number of years permitted for the completion of a programme have elapsed since the student was admitted, and the student has not become eligible for the award of Degree, the student shall be removed from the programme.

17.2 A student may also be required to leave the Programme on disciplinary grounds on the recommendations of the Students’ Disciplinary Committee of the concerned School.

SCHEME OF IN-SEMESTER ASSESSMENT: BACHELOR'S DEGREE PROGRAMMES

Theory Courses

For theory courses, in-semester assessment carries 40% weightage. Different components along with the weightage of each are given in the table below:

Component	Weightage	Remarks
Class Test (Two Class tests of one and a half hour duration)	20	Average of the two marks shall be considered
Assignment (Individual and Group)	10	Group assignments for two courses and individual assignments for the remaining courses
Non-formal evaluation	5	Based on response and interaction in class, quizzes, open book tests, etc.
Attendance	5	For norms regarding attendance cfr. clause 6 of the Regulations for Undergraduate Programmes

There shall be no re-test for In-semester assessment under any circumstance. The original marks of all the In-semester assessment components shall be retained for all further repeat examinations.

Attendance

Marks for attendance will be given according to the following scheme:

Attendance Percent (x)	Marks Allotted	
	Theory	Lab
75 <= x < 80	2	4
80 <= x < 90	3	6
90 <= x < 95	4	8
95 <= x 100	5	10

EVALUATION OF LABORATORY COURSES, DRAWING AND WORKSHOP

All Laboratory courses are evaluated on the basis of attendance, performance of tasks assigned and end semester test/viva voce examination. The distribution of marks within these components will be specified by individual departments along the lines of the break-up given below:

Component	Weightage
Attendance	10
assessment of tasks assigned	50
End Semester Test and/or Viva-Voce Examination	40
Total	100

In-Semester Evaluation of Minor and Mini Projects

The guidelines for the conduct and evaluation of Minor and Mini Projects shall be laid down by the Department. The components of evaluation and allotment of marks may be as follows:

In Semester Evaluation	Marks	End Semester Evaluation (weightage 40)	Marks
Synopsis	10	Project Implementation	16
Seminar presentation of synopsis (Analysis and Design)	15	Seminar Presentation	8
Progress Seminar (Implementation)	15	Viva Voce Examination	16
Project Documentation	10		
Attendance	10		
Total	**60**		**40**

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In-Semester Evaluation of BTECH Major Project Phase I and Phase II

The in-semester evaluation of Major Project Phase I and Phase II shall have 60% weightage. The modality and conduct of the in-semester evaluation of the Major Project Phase I, and their weightages shall be declared by the DPEC of each department at the beginning of the semester. The following aspects are to be assessed, among others:

- Synopsis presentation
- Progress seminars
- Progress reports
- Weekly activity reports

In-Semester BCOM Project Evaluation

The scheme of in-semester evaluation and the modalities along with the weightages will be specified by the department at the beginning of the semester.

SCHEME OF IN-SEMESTER EVALUATION - MASTER'S DEGREE PROGRAMMES

MCA, MSW, MSC (Psychology), MA English, MA Education, MCOM

Theory Courses

The different components of the scheme of in-semester Assessment and the weightages attached to them for the theory courses offered in the MSW, MSc-PC and MA-HR programmes are given in the table below:

Component	**Weightage**
Class Test (Two class tests of equal weightage)	20
Assignments, Group Presentations/Seminar	10
Non-formal evaluation	5
Attendance	5
Total	**40**

Non-formal Evaluation

Non-formal evaluation may be done using a combination of quizzes, unannounced tests, open book tests, library work reports, class room interaction and participation, etc. The scheme of non-formal evaluation shall be announced by every teacher in the beginning of the semester.

Attendance

Marks for attendance will be given according to the following scheme:

Attendance Percent (x)	**Marks Allotted**
75 <= x < 80	2
80 <= x < 90	3
90 <= x < 95	4
95 <= x 100	5

NB

There shall be no re-test for in-semester Assessment under any circumstance. The original marks of all the in-semester Assessment components shall be retained for all further repeat examinations.

MCA Minor Project

The guidelines for the conduct and evaluation of the MCA Minor Project shall be laid down by the Department . The components of evaluation and allotment of marks will be as follows:

In Semester Evaluation	**Marks**	**End Semester Evaluation (weightage 40)**	**Marks**
Synopsis	10	Project Implementation	16
Seminar presentation of synopsis (Analysis and Design)	15	Seminar Presentation	8
Progress Seminar (Implementation)	15	Viva Voce Examination	16
Project Documentation	10		
Attendance	10		
Total	**60**		**40**

In-Semester Evaluation of MCA Major Project

The in-semester evaluation of the MCA Major Project shall have 60% weightage. The Internal Evaluation of the Major project will be done through two seminar sessions:

Synopsis : 20
Seminar Presentation of Synopsis (Analysis and Design) : 30
Progress Seminar (Implementation) : 30
Project Documentation : 20

External Evaluation of all Major projects will follow the guidelines laid down in the Regulations.

MSW, MSc Psychology Field Work

The components of evaluation and their weightages for the concurrent/continuous field work are as follows:

Component	Weightage
Field Work Diary	10
Agency Evaluation	15
Faculty Evaluation	20
Attendance	5
Viva Voce Examination	50
Total	**100**

Practicum

Field Report : 15
Presentation : 15
Administration of tests : 10
Faculty Evaluation : 10
Viva Voce Examination : 50

MSW, MSc Psychology Research Project

Phase I

Literature Survey Presentation : 40
Synopsis Presentation : 60

Phase II

Examination of Thesis : 50
Presentation and Viva Voce Exam : 50

MTECH, MSC (Physics, Chemistry, Mathematics, Life Sciences, Zoology)

Theory Courses

For theory courses, in-semester assessment carries 40% weightage. Different components along with the weightage of each are given in the table below:

Component	Weightage	Remarks
Class Test (Two Class tests of one and a half hour duration)	20	Average of the two marks shall be considered
Assignments	15	Written Assignments/Seminar on course Topics/ Technical Paper Review
Non-formal evaluation	5	Based on response and interaction in class, quizzes, open book tests, etc.
Total	40	

There shall be no re-test for In-semester assessment under any circumstance. The original marks of all the In-semester assessment components shall be retained for all further repeat examinations.

In-Semester Evaluation of Project (Phase I) / Research Project (Phase I) / Dissertation (Phase I)

The in-semester evaluation of Project Phase I / Research Project (Phase I) / Dissertation (Phase I) shall have 60% weightage. It shall be evaluated in the following seminar sessions having equal weightage:

Seminar 1: Presentation of the synopsis

Synopsis : 30%
Seminar presentation of the synopsis : 50%
Viva voce examination : 20%

Seminar 2: Progress Seminar

Progress report	:	30%
Progress seminar	:	50%
Viva voce Examination	:	20%

In-Semester Evaluation of Project (Phase II) / Research Project (Phase II) / Dissertation (Phase II)

The in-semester evaluation of Project Phase II / Research Project (Phase II) / Dissertation (Phase II)shall have 60% weightage. The in-semester evaluation will be done through two seminar sessions having equal weightage. Each seminar will be evaluated using the following components.

Progress Report	:	30
Progress Seminar	:	50
Viva Voce Examination	:	20

External Evaluation of the project / Research Project / Dissertation shall follow the guidelines laid down in the Regulations.

RULES, PROCEDURES AND BEHAVIOURAL GUIDELINES

1. Dress Code and Identity Card

1.1 The dress code of the University consists of shirt / top (of the prescribed colour and material), trousers (of the prescribed colour and material), shoes (black) and socks (dark grey), a belt (black/dark brown, if required) and a tie (blue, with diagonal stripes) Salvar, kurta and duppatta of the prescribed colour and material may also be used. Students are required to come to the University following this dress code. The tie will be required to be worn only on formal occasions. An apron (of the prescribed colour) is to be worn in the Chemistry Lab and during Workshop Practice. During winter, students may wear only a blazer and/or a sweater (full sleeve or sleeveless) of the prescribed colour and material.

1.2 The Student Identity Card is to be brought to the University every day and is to be produced whenever asked for. Entry to the University campus shall be only on production of the Identity Card. The Identity Card is also the Library Card.

1.3 All students should wear the ID card around the neck from entry in the morning to exit in the evening.

2. Morning Assembly

2.1 The morning assembly is a daily programme in the university on all class days during which all members, i.e., students, faculty, staff and management meet together. The assembly starts at 8:55 am. During the assembly, important announcements are made and a thought or insight is shared. The assembly is concluded with an invocation to God to bless the activities of the day. Note that any announcement made at the morning assembly is considered as being equivalent to notifying the same in the notice boards. All students should reach the assembly venue before 9:00 am. Immediately after assembly all should proceed to the classroom to start class at 9:10 am. Any change in procedures will be notified by the concerned School at the beginning of the Semester.

2.2 One of the following prayers may be used to conclude the Morning Assembly:

The Our Father

Our Father, who art in heaven,
Hallowed be thy name,
Thy kingdom come,
Thy will be done on earth as it is in heaven.
Give us this day, our daily bread
And forgive us our trespasses
As we forgive those who trespass against us.
And lead us not into temptation,
But deliver us from all evil, Amen.

Or

Prayer for Peace

Lord, make me an instrument of your peace,
Where there is hatred, let me sow love;
where there is injury, pardon;
where there is doubt, faith;
where there is despair, hope;
where there is darkness, light;
where there is sadness, joy;

O Divine Master, grant that I may not so much
seek to be consoled as to console;
to be understood as to understand;
to be loved as to love.

For it is in giving that we receive;
it is in pardoning that we are pardoned;
and it is in dying that we are born to eternal life. Amen

3. Punctuality in Attending Classes

3.1 All are expected to enter the university before 8:55 am. At the Azara campus, the University gates shall remain closed from 9:05 am to 9:20 am. Anybody entering the University after the gates open at 9:20 am shall not be given attendance for the first hour of class although he/she may be permitted to attend the class.

3.2 Normally no student shall leave the University before all the classes are over. In case of an emergency, a student may leave with proper written permission from the HOD of the concerned department.

3.3 While all students are encouraged to have their lunch in the University Canteens, students are permitted to take lunch outside the University.

4. Make-up Classes, Leave of Absence and Earned Attendance

4.1 If any student misses any laboratory class due to illness or other grievous problems, he/she is required to meet the concerned teacher for completing the experiments as soon as possible. Such make-up attendance will be taken into consideration at the end of the semester if attendance is less than 75%. At most two make-up attendances may thus be earned by any student.

4.2 Any student who is required to be engaged in a University activity or a pre-planned training and placement activity during class hours, may apply for the grant of an 'earned attendance' from the concerned HODs in the prescribed form available at the Reception. Such applications must be forwarded by the Activity In-Charge. For club related activities, Faculty Advisor of the concerned club will be the Activity In-Charge. In all other cases, Faculty In-Charge or Assistant Faculty In-Charge of Student Affairs will be the Activity In-Charge. Filled up forms shall be submitted preferably before or in case of emergency, immediately after the activity for which earned attendance is to granted.

4.3 Any student going to participate in any activity or competition outside the University must apply to the Faculty In-Charge of student Affairs using the prescribed form which must be forwarded by the Assistant Faculty In-Charge of Student Affairs in consultation with respective Club Advisers. On return, these students must report back to the Assistant Faculty In-Charge of Student Affairs for recording the outcome.

4.4 Any student who is not able to attend classes due to medical or other grievous reasons are required to apply for leave in the prescribed form along with valid medical certificates and other requisite documents, to the Faculty In-charge, students' affairs within seven days of joining back. Such applications must be signed by a parent of the student and forwarded by the mentor of the concerned student and the HOD of the concerned department. Only these students will be considered for condonement of deficiency in attendance.

5. Discipline

5.1 Personal, academic and professional integrity, honesty and discipline, a sense of responsibility and a high degree of maturity is expected of all students inside and outside the campus. Integrity calls for being honest in examinations and assignments, avoiding plagiarism and misrepresentation of facts.

5.2 Indulging in acts of violence, riotous or disorderly behaviour directed towards fellow students, faculty members or other employees of the institution/hostel in the campus or outside is considered to be a serious breach of discipline and will attract penalty.

5.3 **Respect for Common Facilities:** Care and respect for common facilities and utilities are an essential component of social responsibility. Any willful damage to University property must be made good by the persons concerned. Further, maintaining cleanliness of the classrooms and the entire campus is everyone’s responsibility.

5.4 **Substance Abuse:** Chewing of tobacco, betel nut and the likes, smoking and the use of other addictive substances and alcoholic drinks are strictly prohibited. These should not be brought into or used within the campus of the University. Violation of this norm will lead to stern action.

5.5 **Use of Cell Phones:** Cell phones may be used in the University lawns, canteens and other open areas. However, the use of cell phones in classrooms and labs are strictly prohibited except when used for teaching/learning purposes with the explicit permission of the teacher concerned. The cell phone of anyone found violating this rule shall be confiscated and his/her SIM card shall be taken away and retained in the University office for 7 days. If a person violates the norm for a second time, his/her mobile will be confiscated and retained in the University office till the end of the semester.

5.6 Use of Internet: The entire campus is wi-fi enabled and the students may use the Internet freely for educational purposes. Students may also use the Computing Centre for browsing the Net. However, the use of Internet to access unauthorized and objectionable websites is strictly prohibited.

5.7 All cases of indiscipline will be brought before the Students’ Disciplinary Committee and the decisions made by the Committee for dealing with such cases shall be final.

6. Class Tests and Examinations

6.1 The conduct of examinations will be governed by the norms of the University.

6.2 The Student Identity Card shall be the Admit Card for the class tests

6.3 During class tests, all students are expected to enter the venue of the class test 15 minutes before the scheduled time of commencement. However, no one will be permitted into the examination hall after 15 minutes of the commencement of the class test and No one will be allowed to leave the examination hall until an hour has elapsed from the commencement of the class test.

6.4 No one is to leave the hall during examination for any purpose, except in case of an emergency.

6.5 Malpractices during class tests and examinations will not be tolerated and will attract stern action.

7.0 **Ragging**:Ragging and eve-teasing are activities which violate the dignity of a person and they will be met with zero tolerance. Anti-ragging norms have been given to each student at the time of admission and all students and parents have signed the anti-ragging affidavit. Any case of ragging and eve-teasing must be reported to the anti-ragging squad. All cases of violation of anti-ragging norms will be taken up by the anti-ragging Committee and punished according to the norms.

8.0 **Grievance Redressal:** The University has constituted a Grievance Redressal Cell to redress any genuine grievance students may have. Any student having a genuine grievance may make a representation to the Grievance Redressal Cell through his/ her mentor. The representation should be accompanied by all relevant documents in support of the genuineness of the grievance.

9. School Association

9.1 The School Association is an association of the representatives of the various stake holders of the School – students staff, faculty and management. It is the responsibility of the School Association to take charge of organizing most of the co-curricular activities such as the annual festivals, quizzes, debates, competitions and social events.

9.2 A male and a female student are elected by the students of each class as "class representatives" to represent them in the School Association. Class representatives are expected to be outstanding students who are academically competent and having qualities of leadership.

10 Participation in University Activities

10.1 In order to provide opportunities for the holistic development of the human person, a large number of co-curricular and extra-curricular activities are designed and implemented under the banner of the University Association and student clubs. Three of the most important activities are D'VERVE & BOSCOSIADE (intra-University sports and cultural festival), PRAJYUKTTAM (the inter-University technical festival) and CREAZONE (the University magazine). All students are expected to take part actively in such activities to showcase their talents, to develop leadership qualities and to gain the experience of working in groups.

10.2 **Training and Placement Activities:** The training and Placement Cell of DBCET has been incorporated with the objective of minimizing the gap between industry and academia and giving the students training and exposure so that they can capitalize on every opportunity for placement. It is the prime responsibility of the cell to look after all matters concerning 'Training to enhance employability' and 'guiding students for placement'. In the first two semesters, students are trained for communication skills development under the department of Humanities and Social Sciences, and personal development programmes under the department of campus ministry. From the third semester onwards, in every semester, students are given systematic training in aptitude tests, communication skills, group discussion, etc. They are also made to undergo mock HR and Technical Interviews. These activities of the training and placement cell find a place in the curriculum as Extra Academic Programmes (EAP) and all students are required to get a P grade for these activities by taking active part in these activities regularly.

Other departments of the University offer customised services in training and placement of their students.

11. Free Time

Some hours without class may be available for some students during the day. Students are expected to use such 'free time' for visiting the library, meeting teachers and mentors, self-study, carrying out lab or project related activities, etc.

12. Faculty Performance Feedback

In order to improve the teaching and learning process in the University, students will be required to give feedback about the performance of their teachers from time-to-time. All students are expected to participate in the online feedback sessions concerning their teachers with sincerity and responsibility.

13. Mentoring

All students are assigned mentors from among the faculty members for their guidance. Directors of Schools in collaboration with the Heads of Departments will take care of assigning mentors. Mentors shall help the students to plan their courses of study, advise them on matters relating to academic performance and personality development, and help them to overcome various problems and difficulties faced by them. Although students should meet their mentors on a regular basis to get timely help, specific days have been set aside in the calendar for meeting mentors to ensure proper documentation of achievements, activities, shortcomings and problems faced by the students. Every student must meet the mentor during these days.

14. Interaction Meet With Parents

The University organises interaction meetings with parents once a year in which the parents are invited to interact with teachers and management to appraise themselves about the performance of their ward and also to offer their suggestions for the betterment of the institution. It is the responsibility of the students too to invite their parents to come and participate in the event and make the event meaningful.

SCHOOL OF FUNDAMENTAL AND APPLIED SCIENCES

DEPARTMENT OF PHYSICS

BACHELOR OF SCIENCE- HONOURS IN PHYSICS

Type of Course/Category	Course Code	Course Name	Credits	Page
Semester I				
Core Paper1 (Theory)/DC	PSMY0101	Mathematical Physics-I	4-0-0	84
Core Paper2 (Theory)/DC	PSMC0102	Mechanics	4-0-0	85
Core Paper1 (Lab)/DC	PSMY6101	Mathematical Physics-I Laboratory	0-0-2	93
Core Paper2 (Lab)/DC	PSMA6102	Mechanics Laboratory	0-0-2	94
Ability Enhancement compulsory Course -1/IC	LSEC0018	English Communication	2-0-0	157
General Elective –I (Maths)/SE	MACD0105	Calculus and Differential Equations	4-2-0	154
	MALG0106	Algebra		156
Total Credits			**20**	
Semester II				
Core Paper3 (Theory)/DC	PSEM0103	Electricity and Magnetism	4-0-0	86
Core Paper4 (Theory)/DC	PSWO0104	Waves and Optics	4-0-0	88
Core Paper3 (Lab)/DC	PSEM6103	Electricity and Magnetism Laboratory	0-0-2	95
Core Paper4 (Lab)/DC	PSWO6104	Waves and Optics Laboratory	0-0-2	95
Ability Enhancement compulsory Course –2/IC	CHES0002	Environmental Studies	2-0-0	156
General Elective –II (Maths)/SE	MAAL0107	Algebra and Numerical Methods	4-2-0	156
	MADV0108	Differential Equations, Vector Calculus and Geometry		157
Total Credits			**20**	
Semester III				
Core Paper5 (Theory)/DC		Mathematical Physics–II	4-0-0	
Core Paper6 (Theory)/DC		Thermal Physics	4-0-0	
Core Paper7 (Theory)/DC		Digital Systems and Applications	4-0-0	
Core Paper5 (Lab)/DC		Mathematical Physics–II Laboratory	0-0-2	
Core Paper6 (Lab)/DC		Thermal Physics Laboratory	0-0-2	
Core Paper7 (Lab)/DC		Digital Systems and Applications Laboratory	0-0-2	
Skill Enhancement Course 1 (Elective)/IE/SE/DE		Computational Physics Skills	2-0-0	
		Electrical circuits and Network Skills		
General Elective –III (Chemistry)/SE	CHAH0105	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	4-0-0	130
	CHCF0106	Chemical Energetics, Equilibria & Functional Organic Chemistry-I	4-0-0	132
General Elective –III (Chemistry) Lab/SE	CHAH6105	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons Lab	0-0-2	139
	CHCF6106	Chemical Energetics, Equilibria & Functional Organic Chemistry-I Lab	0-0-2	140
Total Credits			**26**	

Semester IV				
Core Paper8 (Theory)/DC		Mathematical Physics III	4-0-0	
Core Paper9 (Theory)/DC		Elements of Modern Physics	4-0-0	
Core Paper10 (Theory)/DC		Analog Systems and Applications	4-0-0	
Core Paper8 (Lab)/DC		Mathematical Physics III Laboratory	0-0-2	
Core Paper9 (Lab)/DC		Elements of Modern Physics Laboratory	0-0-2	
Core Paper10 (Lab)/DC		Analog Systems and Applications Laboratory	0-0-2	
Skill Enhancement Course 2 (Elective)/IE/SE/DE		Basic Instrumentation Skills	2-0-0	
		Radiation Safety		
		Applied Optics		
General Elective –IV (Chemistry)/SE	CHAB0101	Inorganic Chemistry - I: Atomic Structure and Chemical Bonding	4-0-0	
	CHSI0102	Physical Chemistry-I: States of Matter and Ionic Equilibrium		
General Elective –IV (Chemistry) – Lab/SE	CHAB6101	Inorganic Chemistry-I: Atomic Structure and Chemical Bonding Lab	0-0-2	
	CHIS6102	Physical Chemistry-I: States of Matter and Ionic Equilibrium Lab		
Total Credits			**26**	
Semester V				
Core Paper11 (Theory)/DC		Quantum Mechanics and Applications	4-0-0	
Core Paper12 (Theory)/DC		Solid State Physics	4-0-0	
Core Paper11 (Lab)/DC		Quantum Mechanics and Applications Laboratory	0-0-2	
Core Paper12 (Lab)/DC		Solid State Physics Laboratory	0-0-2	
Discipline Specific Elective I /DE		Embedded systems- Introduction to Microcontroller	4-0-0	
		Physics of Devices and Communication		
		Advanced Mathematical Physics-I		
		Embedded systems- Introduction to Microcontroller Laboratory	0-0-2	
		Physics of Devices and Communication Laboratory		
		Advanced Mathematical Physics-I Laboratory		
Discipline Specific Elective II/DE		Advanced Mathematical Physics-I	5-1-0	
		Classical Dynamics	5-1-0	
		Communication System	4-0-0	
		Communication System Lab	0-0-2	
Total Credits			**24**	
Semester VI				
Core Paper13 (Theory)/DC		Electromagnetic Theory	4-0-0	
Core Paper14 (Theory)/DC		Statistical Mechanics	4-0-0	
Core Paper13 (Lab)/DC		Electromagnetic Theory Laboratory	0-0-2	
Core Paper14 (Lab)/DC		Statistical Mechanics Laboratory	0-0-2	

Discipline Specific Elective III/DE		Nuclear and Particle Physics	5-1-0	
		Astronomy and Astrophysics	5-1-0	
		Nano Materials and Applications	4-0-0	
		Nano Materials and Applications Laboratory	0-0-2	
Discipline Specific Elective IV/DE		Digital Signal Processing	4-0-0	
		Digital Signal Processing Laboratory	0-0-2	
		Medical Physics	4-0-0	
		Medical Physics Laboratory	0-0-2	
		Plasma Physics	5-1-0	
		Dissertation	5-1-0	
Total Credits			**24**	
Total Programme Credits			**140**	

MASTER OF SCIENCE – PHYSICS

Semester	Category	Course Name	Course Code	Credits	Page
I	DC	Classical Mechanics	PSCM0020	4	63
	DC	Quantum Mechanics I	PSQM0021	4	64
	DC	Mathematical Physics	PSMP0022	4	65
	DC	Electronics I	PSEL0049	4	81
	DC	Physics Laboratory I	PSPL6009	4	89
Total Credits				**20**	
II	DC	Quantum Mechanics II	PSQM0024	4	65
	DC	Condensed Matter Physics	PSCP0025	4	66
	DC	Electrodynamics	PSED0026	4	67
	DC	Nanophysics I	PSNP0050	4	82
	DC	Physics Laboratory II	PSPL6003	4	89
Total Credits				**20**	
III	DC	Atomic and Molecular Physics	PSAM0028	4	68
	DC	Nuclear Physics	PSNA0029	4	69
	DC	Computer Oriented Numerical Methods	PSCN0030	2	70
	DC	Computer Oriented Numerical Methods Laboratory	PSCN6010	4	90
	DC	Project Phase I	PSPP6011	4	91
		Specialisation: High Energy Physics			
	DE	Particle Physics	PSPA0035	4	72
		Specialisation: Astrophysics			
	DE	Plasma Physics I	PSPL0036	4	73
		Specialisation: Plasma Physics			
	DE	Plasma Physics I	PSPL0036	4	73

		Specialisation: Electronics			
	DE	Electronics II	PSEC0037	4	74
		Specialisation: Nanophysics			
	DE	Nanophysics II	PSNS0041	4	75
Total Credits				**22**	
IV	DC	Statistical Mechanics	PSSM0034	4	71
	DC	Project Phase II	PSPR6012	6	91
		Specialisation: High Energy Physics			
	DE	Gauge Theories	PSGT0043	4	76
	DE	General Theory of Relativity and Cosmology	PSGR0044	4	77
		Specialisation: Astrophysics			
	DE	Astrophysics	PSAR0045	4	78
	DE	General Theory of Relativity and Cosmology	PSGR0044	4	
		Specialisation: Plasma Physics			
	DE	Plasma Physics II	PSPM0046	4	79
	DE	Plasma Physics Laboratory	PSPM6013	4	92
		Specialisation: Electronics			
	DE	Electronics III	PSER0047	4	79
	DE	Electronics Laboratory	PSEL6014	4	92
		Specialisation: Nanophysics			
	DE	Nanophysics III	PSNY0048	4	81
	DE	Nanophysics Laboratory	PSNY6015	4	72
Total Credits				**18**	
Total Programme Credits				**80**	

DEPARTMENT OF CHEMISTRY

BACHELOR OF SCIENCE- HONOURS IN CHEMISTRY

Type of Course/Category	Course Code	Course Name	Credits	Page
Semester I				
Core Paper1 (Theory)/DC	CHAB0101	Inorganic Chemistry-I: Atomic Structure & Chemical Bonding	4-0-0	124
Core Paper2 (Theory)/DC	CHSI0102	Physical Chemistry-I: States of matter & Ionic equilibrium	4-0-0	126
Core Paper1 (Lab)/DC	CHAB6101	Inorganic Chemistry-I: Atomic Structure & Chemical Bonding - Lab	0-0-2	136
Core Paper2 (Lab)/DC	CHIS6102	Physical Chemistry-I: States of matter & Ionic equilibrium - Lab	0-0-2	137
Ability Enhancement compulsory Course -1/IC	LSEC0018	English Communication	2-0-0	157
General Elective –I (Maths)/SE	MACD0105	Calculus and Differential Equations	4-2-0	154
	MALG0106	Algebra		155
Total Credits			**20**	
Semester II				
Core Paper3 (Theory)/DC	CHBH0103	Organic Chemistry-I: Basics & Hydrocarbons	4-0-0	127
Core Paper4 (Theory)/DC	CHCT0104	Physical Chemistry-II: Chemical Thermodynamics & its applications	4-0-0	128
Core Paper3 (Lab)/DC	CHBH6103	Organic Chemistry-I: Basics & Hydrocarbons	2	138
Core Paper4 (Lab)/DC	CHCT6104	Physical Chemistry-II: Chemical Thermodynamics & its applications - Lab	2	138
Ability Enhancement compulsory Course –2/IC	CHES0002	Environmental Studies	2	96
General Elective –II (Maths)/SE	MAAL0107	Algebra and Numerical Methods	4-2-0	156
	MADV0108	Differential Equations, Vector Calculus and Geometry		157
Total Credits			**20**	
Semester III				
Core Paper5 (Theory)		Inorganic Chemistry II: s- and p-Block Elements	4-0-0	
Core Paper6 (Theory)		Organic II: Oxygen Containing Functional Groups	4-0-0	
Core Paper7 (Theory)		Physical Chemistry III: Phase Equilibria & Chemical Kinetics	4-0-0	
Core Paper5 (Lab)		Inorganic Chemistry II: s- and p-Block Elements - Lab	2	
Core Paper6 (Lab)		Organic Chemistry II: Oxygen Containing Functional Groups - Lab	2	

Core Paper7 (Lab)		Physical Chemistry III: Phase Equilibria & Chemical Kinetics - Lab	2	
Skill Enhancement Course 1 (Elective)		Basic Analytical Chemistry	2	
		Chemo informatics		
		Chemistry of cosmetics and perfumes		
General Elective –III (Physics)			4-0-0	
General Elective –III (Physics) Lab			0-0-2	
Total Credits			**26**	
Semester IV				
Core Paper8 (Theory)		Inorganic Chemistry III: Coordination Chemistry	3-1-0	
Core Paper9 (Theory)		Organic Chemistry III: Heterocyclic Chemistry	3-1-0	
Core Paper10 (Theory)		Physical Chemistry IV: Electrochemistry	3-1-0	
Core Paper8 (Lab)		Inorganic Chemistry III: Coordination Chemistry - Lab	2	
Core Paper9 (Lab)		Organic Chemistry III: Heterocyclic Chemistry - Lab	2	
Core Paper10 (Lab)		Physica Chemistry l IV: Electrochemistry - Lab	2	
Skill Enhancement Course 2 (Elective)		Pesticide Chemistry		
		Fuel Chemistry		
		Intellectual Property Rights		
General Elective –IV (Physics)		Elements of Modern Physics	4-0-0	
		Analog Systems and Applications		
General Elective –IV (Physics) - Lab		Elements of Modern Physics Lab	0-0-2	
		Analog Systems and Applications Lab		
Total Credits			**26**	
Semester V				
Core Paper11 (Theory)		Organic Chemistry IV: Biomolecules	4-0-0	
Core Paper12 (Theory)		Physical Chemistry V: Quantum Chemistry & Spectroscopy	4-0-0	
Core Paper11 (Lab)		Organic Chemistry IV: Biomolecules - Lab	0-0-2	
Core Paper12 (Lab)		Physical Chemistry V: Quantum Chemistry & Spectroscopy - Lab	0-0-2	
Discipline Specific Elective I		Applications of computers in Chemistry	4-0-0	
		Analytical methods in Chemistry		
		Applications of computers in Chemistry Lab	0-0-2	
		Analytical methods in Chemistry Lab		
Discipline Specific Elective II		Novel Inorganic Solid	4-0-0	
		Polymer Chemistry		
		Novel Inorganic Solid Lab	0-0-2	
		Polymer Chemistry Lab		
Total Credits			**24**	

Semester VI				
Core Paper13 (Theory)		Inorganic Chemistry IV: Organometallic Chemistry	4-0-0	
Core Paper14 (Theory)		Organic Chemistry V: Spectroscopy	4-0-0	
Core Paper13 (Lab)		Inorganic Chemistry IV: Organometallic Chemistry - Lab	0-0-2	
Core Paper14 (Lab)		Organic Chemistry V: Spectroscopy - Lab	0-0-2	
Discipline Specific Elective III		Green Chemistry	4-0-0	
		Inorganic materials & Industrial Importance	4-0-0	
		Green Chemistry Lab	0-0-2	
		Inorganic materials & Industrial Importance Lab	0-0-2	
Discipline Specific Elective IV		Industrial Chemicals & Environment	4-0-0	
		Research methodology for Chemistry	4-0-0	
		Industrial Chemicals & Environment Lab	0-0-2	
		Research methodology for Chemistry Lab	0-0-2	
Total Credits			**24**	
Total Programme Credits			**140**	

MASTER OF SCIENCE – CHEMISTRY

Semester	Category	Course Name	Course Code	Credits	Page
I	DC	Fundamentals of Inorganic Chemistry	CHIC0003	4	97
	DC	Fundamentals of Organic Chemistry	CHOC0004	4	98
	DC	Fundamentals of Physical Chemistry	CHPC0005	4	99
	DC	Introduction to Quantum Chemistry and Group Theory	CHQG0006	3	100
	DC	Inorganic Qualitative and Quantitative Analyses and Preparations - Lab	CHIQ6002	3	134
Total Credits				**18**	
II	DC	Advanced Inorganic Chemistry I	CHIR0007	4	101
	DC	Advanced Organic Chemistry I	CHOG0008	4	103
	DC	Advanced Physical Chemistry I	CHAP0009	4	104
	DC	Fundamentals of Spectroscopy	CHFS0010	3	105
	DC	Introduction to Green and Environmental Chemistry	CHGC0011	3	106
	DC	Experimental Physical Chemistry - Lab	CHEQ6003	3	134
Total Credits				**21**	

III	DC	Advanced Inorganic Chemistry II	CHAI0012	4	107
	DC	Advanced Organic Chemistry II	CHAO0013	4	110
	DC	Advanced Physical Chemistry II	CHAP0014	4	111
	DC	Special Topics in Biochemistry	CHSP0015	3	112
	DC	Applied Spectroscopy	CHAS0016	2	113
	DC	Research Methodology for Chemistry	CHRM0017	3	114
	DC	Organic Qualitative Analysis and Synthesis Lab	CHQA6004	3	135
Total Credits				**23**	
IV	*One Elective Course (of the five offered) and two Specialisation Courses (either Physical or Organic Chemistry courses) to be selected*				
	Electives				
	DE	Materials Chemistry	CHMC0018	3	115
	DE	Computational Chemistry	CHCC0019		116
	DE	Food Chemistry	CHFC0020		117
	DE	Industrial Chemistry	CHIC0021		118
	DE	Medicinal Chemistry	CHMD0022		119
	Specialisation I - Physical Chemistry				
	DE	Recent Advances in Catalysis	CHRC0023	3	120
	DE	Biophysical Chemistry	CHBC0024		121
	Specialisation II - Organic Chemistry				
	DE	Heterocyclic Chemistry	CHHC0025	3	122
	DE	Natural Products Chemistry	CHNP0026		123
	DC	Research Project	CHRP6005	9	135
Total Credits				**18**	
Total Programme Credits				**80**	

DEPARTMENT OF MATHEMATICS

BACHELOR OF SCIENCE- HONOURS IN MATHEMATICS

Type of Course/Category	Course Code	Course Name	Credits (L-T-P)	Page
Semester I				
Core Paper1/DC	MACS0101	Calculus	4-2-0	151
Core Paper2/DC	MAAG0102	Algebra	4-2-0	152
Ability Enhancement compulsory Course -1/IC	LSEC0018	English Communication	2-0-0	157
General Elective –I//IE/ SE/DE (Physics)	PSMY0101	Mathematical Physics-I	3-1-0	84
	PSMC0102	Mechanics		85
	PSMY6101	Mathematical Physics-I Laboratory	0-0-2	93
	PSMA6102	Mechanics Laboratory		94
Total Credits			**20**	
Semester II				
Core Paper3/DC	MAER0103	Elementary Real Analysis	4-2-0	153
Core Paper4/DC	MADQ0104	Differential Equations	4-2-0	153
Ability Enhancement compulsory Course -1/IC	CHES0002	Environmental Studies	2-0-0	96
General Elective -II/IE/ SE/DE (Physics)	PSEM0103	Electricity and Magnetism	3-1-0	86
	PSWO0104	Waves and Optics		88
	PSEM6103	Electricity and Magnetism Laboratory	0-0-2	95
	PSWO6104	Waves and Optics Laboratory		95
Total Credits			**20**	
Semester III				
Core Paper5/DC		Theory of Real Functions	4-2-0	
Core Paper6/DC		Group Theory I	4-2-0	
Core Paper7/DC		Multivariable Calculus	4-2-0	
Skill Enhancement Course 1/IE		Programming in C/Logic and sets	2-0-0	
General Elective -III/IE/ SE/DE(Chemistry)	CHAH0105	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons	3-1-0	130
	CHCF0106	Chemical Energetics, Equilibria & Functional Organic Chemistry-I		132
	CHAH6105	Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons Lab	0-0-2	139
	CHCF6106	Chemical Energetics, Equilibria & Functional Organic Chemistry-I Lab		140
Total Credits			26	
Semester IV				
Core Paper8/DC		Partial Differential Equations	4-2-0	
Core Paper9/DC		Numerical Methods	4-2-0	
Core Paper10/DC		Mechanics	4-2-0	
Skill Enhancement Course 2/IE		Graph Theory /Computer Graphics	2-0-0	

General Elective –IV/IE/ SE/DE (Chemistry)	CHAB0101	Inorganic Chemistry - I: Atomic Structure and Chemical Bonding	3-1-0	
	CHSI0102	Physical Chemistry-I: States of Matter and Ionic Equilibrium		
	CHAB6101	Inorganic Chemistry-I: Atomic Structure and Chemical Bonding Lab	0-0-2	
	CHIS6102	Physical Chemistry-I: States of Matter and Ionic Equilibrium Lab		
Total Credits			**26**	
Semester V				
Core Paper11/DC		Metric Space and Complex Analysis	4-2-0	
Core Paper12/DC		Ring Theory and Linear Algebra I	4-2-0	
Discipline Specific Elective I/DE		Number Theory	4-2-0	
		Group Theory II		
Discipline Specific Elective II/DC		Probability and Statistics	4-2-0	
		Linear Programming		
Total Credits			**24**	
Semester VI				
Core Paper13/DC		Riemann Integration and Series of Functions	4-2-0	
Core Paper14/DC		Ring Theory and Linear Algebra II	4-2-0	
Discipline Specific Elective III/DE		Industrial Mathematics	4-2-0	
		Mathematical Finance		
Discipline Specific Elective IV/DE		Bio-Mathematics	4-2-0	
		Differential Geometry		
Total Credits			**24**	
Total Programme Credits			**140**	

MASTER OF SCIENCE – MATHEMATICS

Semester	Category	Course Name	Course Code	Credits	Page
I	DC	Real Analysis	MARA0014	4	142
	DC	Linear Algebra	MALA0015	4	143
	DC	Abstract Algebra	MAAB0016	4	144
	DC	Differential Equations	MADE0017	4	144
	DC	Mathematical Methods I	MAMT0018	4	155
Total Credits				**20**	
II	DC	Topology and Functional Analysis	MATF0019	4	146
	DC	Complex Analysis	MACA0020	4	147
	DC	Measure Theory and Probability Theory	MAMP0021	4	148
	DC	Mathematical Methods II	MAMD0022	4	149
	DC	Classical Mechanics	MACL0023	4	150

Total Credits				**20**	
		Research Methodology for Mathematical sciences and Mathematical tools		4	
		Research Seminar		2	
	Electives				
		Dynamical System		4	
		Fuzzy Mathematics			
		Algebra and Number Theory			
		Discrete Mathematics			
	Specialisations				
		Theoretical Mathematics			
		Field Theory		4	
		Number Theory			
		Mathematical Logic			
III		**Applicable Mathematics**			
		Advanced Partial Differential equations		4	
		Numerics for Partial differential equations			
		Fluid Dynamics			
		Computational Mathematics			
		Programming In C++		4	
		Algorithms and Complexity Theory			
		Computational Techniques			
		Interdisciplinary Mathematics			
		Mathematics in Applied Physics		4	
		Mathematics in Finance			
		Biomathematics			
Total Credits				**18**	
		Research Project		6	
	Specialisations				
		Theoretical Mathematics			
		Advanced Analysis		4	
		Multivariable Calculus			
		Advanced Graph Theory			
		Applicable Mathematics			
		Continuum Mechanics		4	
		Riemannian Geometry and Tensor Calculus			
		Finite Element Methods			
		Computational Mathematics			

		Theory of Computation		4	
		Computational Fluid Dynamics			
		Coding Theory and Cryptography			
		Interdisciplinary Mathematics			
		Mathematical Modelling		4	
		Statistical Methods			
		Mathematical Economics and Game Theory			
Total Credits				**18**	
Total Credits				**80**	

SCHOOL OF FUNDAMENTAL AND APPLIED SCIENCES

DEPARTMENT OF PHYSICS

PSCM0020: CLASSICAL MECHANICS
(4 credits-60 hours)

Objective: *The objective of the course in classical mechanics or Newtonian mechanics is to make the students familiar to the set of physical laws describing the motion of bodies under the action of a system of forces. Classical mechanics describes the motion of macroscopic objects, from projectiles to parts of machinery, as well as astronomical objects, such as spacecraft, planets, stars, and galaxies. Besides this, many specializations within the subject deal with solids, liquids and gases and other specific sub-topics. Emphasis shall be laid upon the solution of numerical problems.*

Module I (12 hours)

Hamilton's variational principle; derivation of Lagrange's equations; velocity dependent forces; dissipation. Charged particles in an electromagnetic field. Space time symmetries and conservation Laws. Varial theorem. Space transformation.

Module II (12 hours)

Two-body problem; central forces; classification of orbits; differential equation for orbits. Kepler problem; scattering in laboratory and centre of mass frames, transformation of cross sections, energies. Rutherford scattering. Kinematics of decay of particles (into two particles).

Module III (12 hours)

Rigid body motion: fixed and moving coordinate systems; orthogonal transformations. Euler angles; angular momentum; rotational kinetic energy. Principal axes transformation; Euler equations; force free motion of a rigid body symmetric top.

Module IV (12 hours)

Legendre transformation; Hamiltonian equations; Significance of the Hamilton function. Cyclic coordinates and conservation theorems. Poisson Brackets – Poisson Bracket of Angular momentum with coordinates. Canonical Transformation Theory. Contact transformation; integral invariants.

Module V (12 hours)

Special theory of relativity: Lorentz transformations. Four dimensional formulation. Force momentum and energy in relativistic mechanics. Properties of space-time in relativity. Two body decay of a particle.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Have a clear understanding of Hamilton's and Lagrange's equations and use them for solving problems in physics

CO2: Deal with two body problems

CO3: Understand rigid body problems

CO4: Get an idea of modern physics from Einstein's special theory of relativity

Suggested Readings

1. H. Goldstein, C. Poole and J. Safko, Classical Mechanics, Pearson Education Asia.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hills.
3. K. C. Gupta, Classical Mechanics of Particles and Rigid bodies, Wiley Eastern.
4. D. T. Greenwood, Principles of Dynamics, Prentice Hall.

PSQM0021: QUANTUM MECHANICS I

(4 credits-60 hours)

Objective: *The objective of this course in quantum mechanics is to make the students competent to understand the science of microscopic objects. It will help them to perceive the scientific principles that explain the behaviour of matter and its interactions with energy on the scale of atomic and subatomic particles. Emphasis shall be laid upon the solution of numerical problems.*

Module I (10 hours)

Introduction and revision: inadequacy of classical mechanics; basic postulates of quantum mechanics; ensemble and Copenhagen interpretation. Schrödinger equation; continuity equation; Ehrenfest theorem; admissible wave functions; stationary states. One dimensional problems; potential well and barriers; harmonic oscillator.

Module II (10 hours)

Equation of motion: Schrodinger, Heisenberg and Dirac representations; equation of motion in the respective representations. Application to linear harmonic oscillator.

Module III (10 hours)

Three dimensional problems: Separation of variables; orbital angular momentum; spherical harmonics. Harmonic oscillator in Cartesian and polar coordinates. A free particle and a particle in 3-D box in Cartesian and polar coordinates, Coulomb problem in spherical and parabolic coordinates - regular and irregular solutions.

Module IV (11 hours)

Spinors and their transformation properties. Pauli spin matrices. Identical particles and statistics. Addition of angular momenta. Clebsch-Gorden coefficients. Winger-Eckart Theorem.

Module V (8 hours)

Symmetry in quantum mechanics. Reflections, time reversal, space inversion, particle exchange. Displacement in space and time, space translation and rotational symmetry. Selection rule and conservation laws.

Module VI (11 hours)

Variational methods for bound states; lower and upper limits in simple cases. WKB approximation; connection with classical limits, validity of WKB approximation. Connection formulae; application to bound states, tunneling in one dimension. Application to radial Schrodinger equation.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understand different interpretation of quantum mechanics
CO2: Apply the concepts of quantum mechanics to different problems in physics
CO3: Appreciate the idea of symmetry in quantum mechanics
CO4: Get an idea of how to encounter spin
CO5: Comprehend variational method and WKB approximation

Suggested Readings

1. E. Merzbacher, Quantum Mechanics, John Wiley.
2. G. Ahruldhas, Quantum Mechanics, Prentice Hall.
3. L. I. Schiff, Quantum Mechanics, McGraw Hill.
4. V. K. Thankappan, Quantum Mechanics, New Age Int. Pub.
5. P. T. Mathews and Venkatesan, Quantum Mechanics, Tata McGraw Hill.
6. K. D. Krori, Principles of Non-Relativistics and Relativistic Quantum Mechanics, PHI.

PSMP0022: MATHEMATICAL PHYSICS

(4 credits–60 hours)

Objective: *The objective of the course in mathematical physics is to make students familiar with mathematical methods for application to problems in physics and the formulation of physical theories in different disciplines of physics. Emphasis shall be laid upon the solution of numerical problems.*

Module I (15 hours)

Functions of complex variable: Analytic functions; derivatives of an analytic function. Series of analytic functions: Taylor series, Laurent series; zeros and isolated singular points of analytic functions; the calculus of residues: theorem of residues; evaluation of integrals; Jordan's lemma; Principal value of an integral; multi-valued functions; Riemann surfaces; evaluation of an integral involving a multi-valued function; analytic continuation; dispersion relations.

Module II (13 hours)

Vectors and matrices: linear vector spaces; linear operators; matrices; coordinate transformations; eigen-value problems; diagonalisation of matrices; spaces of infinite dimensionality.

Module III (16 hours)

Special functions: associated Legendre differential equation and functions; generating functions; spherical harmonics; orthonormality. Bessel's equation; Bessel function; Spherical Bessel function, Neumann and Hankel functions; expansion of a plane wave into partial waves. Laguerre and associated Laguerre differential equation and functions; generating functions; recurrence relations; orthonormality. Hypergeometric and confluent hypergeometric functions.

Module IV (8 hours)

Integral transforms: general properties of Laplace transforms; inverse Laplace transform; application of Laplace transforms; convolution theorem; solution of differential equations using Laplace transform.

Module V (8 hours)

Probability and statistics: fundamental laws of probability; binomial, Poisson and Gaussian distributions; general properties of probability distributions.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Deal with function of complex variables
CO2: Have an advance knowledge of vectors and matrices
CO3: Learn about different differential equations and their solutions
CO4: Understand the concept of Laplace transform
CO5: Apply the concept of probability and statistics

Suggested Readings

1. G. Arfken, Mathematical Methods for Physicists, Academic Press.
2. J. Mathews and R. L. Walker, Mathematical Methods of Physics, The Benjamin-Cumminngs Publishing Company.
3. P. Dennery and A. Krzywicki, Mathematics for Physicists, Harper and Row.

PSQM0024: QUANTUM MECHANICS II

(4 credits – 60 hours)

Objective: *The objective of the course in quantum mechanics II is to provide a deeper knowledge in the subject. This will be extremely helpful for students intending to go for higher studies in theoretical physics, e.g., theoretical nuclear physics, theoretical condensed matter physics, theoretical high energy physics, etc. Emphasis will be laid on solution of numerical problems.*

Module I (11 hours)

Stationary perturbation theory: Non Degenerate case; first and second order of energy and wave functions, perturbation of one dimensional harmonic oscillator by potentials of the bx^2 and cx^3. Degenerate case; first order Stark effect in hydrogen; Zeeman effect without electron spin.

Module II (9 hours)

Time dependent perturbation theory; first order transition probabilities; constant perturbation. Transition to continuum; Harmonic perturbation; Fermi's golden rule; Sudden and adiabatic approximations.

Module III (10 hours)

Many Electron Atoms: Indistinguishable particles; Pauli's Principle; inclusion of spin; spin functions for two and three electrons; the Helium atom; central field approximation, Thomas-Fermi model of the atom; Hartree equation, Hartree- Fock equation.

Module IV (13 hours)

Scattering theory: asymptotic behaviour of scattering wave function; relation to cross sections, Green's function for scattering problem; Green's function with different boundary conditions; scattering integral equations; Born approximation and its validity criteria; scattering by screened Coulomb potential; Born series. Partial waves and phase shifts. Scattering amplitude; optical theorem; low energy scattering. Effective range; scattering length; resonance.

Module V (12 hours)

Relative wave equations: Klein-Gordon equation. Difficulty with probability interpretation. Dirac equation; four component solutions for free particle; negative energy solutions – particles and antiparticles. Covariant form of Dirac equation; 4-current density. Properties of γ-matrices. Dirac equation in the presence of electromagnetic field; non-relativistic reduction; spin and magnetic moment.

Module VI (5 hours)

Path integral approach to quantum mechanics: Feynman's Path Integral method, equivalence of Feynman and Schrödinger equations, Dirac-Feynman Action Principle.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn about perturbation theory
CO2: Comprehend advanced topics like Hartree- Fock equation
CO3: Apply the concept of quantum mechanics to the problems of scattering
CO4: Understand relativistic quantum mechanics
CO5: Have an idea of path integral approach to quantum mechanics

Suggested Readings

1. E. Merzbacher, Quantum Mechanics, John Wiley.
2. G. Aruldhas, Quantum Mechanics, Prentice Hall.
3. L. I. Schiff, Quantum Mechanics, McGraw Hill.
4. V. K. Thankappan, Quantum Mechanics, New Age Int. Pub.
5. P. T. Mathews and Venkatesan, Quantum Mechanics, Tata McGraw Hill.
6. K. D. Krori, Principles of Non-Relativistics and Relativistic Quantum Mechanics, PHI.

PSCP0025: CONDENSED MATTER PHYSICS

(4 credits – 60 hours)

Objective: *The objective of the course in condensed matter physics is to equip the students to deal with the physical properties of condensed phases of matter. Condensed matter physicists seek to understand the behaviour of these phases by using physical laws. Knowledge of condensed matter physics is required to pursue studies on specialised topic like electronics, nano-sciences, etc. Emphasis shall be laid upon the solution of numerical problems.*

Module I (11 hours)

Crystal structure. Diffraction of waves by crystal. Scattered wave amplitudes, Brillion zones. Fourier analysis of the basis. Crystal binding and elastic constants.

Module II (9 hours)

Phonons: quantisation of lattice vibrations, dispersion relation for acoustic and optical phonon, energy gap, density of states, heat capacity, thermal conductivity and thermal expansion.

Module III (8 hours)

Free electron Fermi gas: Fermi energy, density of states, heat capacity, thermal conductivity and electrical conductivity. Wiedemann-Franz law.

Module IV (10 hours)

Nearly free electron gas: Schrodinger equation of an electron in a periodic potential, Bloch theorem, energy gaps at the zone boundary, approximation solution near a zone boundary, energy bands and their role in properties of metals, insulators and semiconductors. Holes on energy bands. Hall effect.

Module V (12 hours)

Shape of fermi surfaces in the free electron and nearly free electron models. Tight binding approximations. Electron orbits, hole orbits and open orbits. Quantization of orbits in a magnetic field. De Hass-van Alphen effect and its role in experimental determination of Fermi surfaces.

Module VI (10 hours)

Plasmons, polaritons and polarons: dielectric functions of the electron gas, plasmons, electrostatic screening, Mott metal-insulator transition, polaritons, polarons. Peierls instability of linear metals.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn about crystal structure in details
CO2: Understand physics of phonons
CO3: Conceptualise free electron and nearly free electron models
CO4: Know about advanced topics like plasmons, polaritons, polarons, etc.

Suggested readings

1. C. Kittel, Introduction to Solid State Physics, John Wiley and Sons, Inc.
2. C. Kittel, Quantum Theory of Solids, John Wiley and Sons, Inc.
3. J. Callaway, Quantum Theory of the Solid State, Academic Press, New York.
4. H. Ibach and H. Luth, Solid State Physics, Narosa Pub. House.

PSED0026: ELECTRODYNAMICS

(4 credits – 60 hours)

Objective: *The objective of the course in electrodynamics (the science of charge and of the forces and fields associated with charge) to get an advanced understanding of electric charges, currents and magnetism. The curriculum provides an excellent description of electrodynamic phenomena which is also required in other disciplines of Physics. Emphasis shall be laid upon the solution of numerical problems.*

Module I (7 hours)

Maxwell's equations: review of Maxwell's equations; boundary conditions at interface between different media; Poisson's and Laplace's equations

Module II (8 hours)

Magnetostatics: introduction; Biot and Savart Law; Ampere's Law; vector potential; vector potential and magnetic induction for a circular current loop.

Module III (8 hours)

Electromagnetic waves: linear and circular polarisation; Stoke's parameters; Poynting theorem of complex field vectors; frequency dispersion (normal and anomalous); characteristics of dielectrics, conductors and plasma and their interaction with electromagnetic waves.

Module IV (15 hours)

a) Simple radiating systems: Gauge invariance; Green's function for the wave equation; concept of retarded potential, radiation from an oscillating dipole and its polarisation. Electric dipole fields, magnetic dipole and electric quadrupole fields; centre fed linear antenna, scattering at long wavelengths – viz. by dipoles induced in a small scatterer, scattering by a small dielectric sphere.

b) Diffraction: Scalar diffraction theory; vectorial diffraction theory, Scattering in a short wavelength limit.

c) Guided waves: waveguides, TE waves in a rectangular waveguide, coaxial transmission lines.

Module V (13 hours)

Radiation from accelerated charge: Lienard-Wiechart potentials; radiated power from accelerated charge at low velocities. Larmor's power formula. The fields of a point charge in arbitrary and uniform motion. Radiation from an ultra relativistic particle. Angular and frequency distribution of radiation from moving charges.

Module VI (9 hours)

Special theory of relativity: matrix representation of Lorentz transformation; infinitesimal generators; Thomas precession; invariance of electric charge; covariance of electrodynamics; transformation of electromagnetic fields

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Know electromagnetism in details
CO2: Understand physics of electromagnetic waves
CO3: Explain radiation emitted from accelerating charge
CO4: Have an understanding of advanced topics like retarded potential, waveguides, etc.

Suggested Readings

1. J. D. Jackson, Classical Electrodynamics, John Wiley and Sons.
2. S. P. Puri, Classical Electrodynamics, Tata McGraw Hill Publishing Company Ltd..
3. S. L. Gupta, V. Kumar and S. P. Singh, Electrodynamics, Pragati Prakashan.
4. D. J. Griffiths, Introduction to Electrodynamics, Prentice Hall of India.

PSAM0028: ATOMIC AND MOLECULAR PHYSICS

(4 credits – 60 hours)

Objective: *The course intends to give a widespread knowledge of the physics of atoms and molecules and the spectroscopy to the students. The knowledge of this subject is indispensable to understand matter-matter and light-matter interactions. Its applications are wide. Typically, the theory and applications of emission, absorption, scattering of electromagnetic radiation (light) from excited atoms and molecules, analysis of spectroscopy, generation of lasers and masers in general, fall into these categories. Emphasis shall be laid upon the solution of numerical problems.*

Module I (15 hours)

Introduction of atomic spectrum; fine structure and hyperfine structure of energy levels. Angular momentum and magnetic moment. Doublet structure energy levels and single electron atom. Term symbols and fine structure of energy levels of two electron atoms using L-S coupling and j-j coupling schemes; identification of ground state. Interaction of nuclear and electronic magnetic moments and hyperfine structure with examples.

Module II (10 hours)

Interaction of radiation with atoms; spontaneous and stimulated emission; absorption; transition. Einstein's A and B coefficients. Working principles of He-Ne laser.

Module III (12 hours)

Theories of molecular bond formation; van der Waals bonding, ionic bonding, valance bond and molecular orbital models of covalent bonding. Homonuclear diatomic molecules and the term symbols and their ground states.

Module IV (8 hours)

Vibronic states of molecules and nature of vibronic spectra; harmonic and anharmonic vibrations and potential constants; rotational spectrum and moment of inertia of molecules.

Module V (15 hours)

Symmetry of molecules; symmetry elements and points group; proper and improper rotations and their matrix representation. Introduction to character table of point group; reducible and irreducible representation for simple molecules such as H_2O, NH_3, etc.Normal coordinates and normal modes of vibrations. Infrared absorption and Raman scattering form molecular vibrations and rotations, and selection rules.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain atomic and molecular spectroscopy in details
CO2: Understand interaction of radiation with atoms
CO3: Appreciate bond formation
CO4: Know about symmetry of molecules

Suggested Readings

1. H. E. White, Introduction to Atomic Spectra, Mc-Graw Hill.
2. Martin Karplus and Richard N. Porter; Atoms and Molecules, W. A. Benjamin.
3. G. Hertzberg, Spectra of Diatomic Molecules, Van Vostrand.
4. O. Svelto, Principles of Lasers, Plenum Press.

PSNA0029: NUCLEAR PHYSICS

(4 credits–60 hours)

Objective: *This course is mainly the study of the physics of elementary particles of the nature. The main of objective of the course is to give the students a comprehensive knowledge of the constituents and interactions of atomic nuclei which will find its applicability in nuclear power generation. Further, many fields, including magnetic resonance imaging, are the direct applications of the knowledge of nuclear physics. Elementary knowledge of particle physics and detectors is also provided in the course. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Conventional Units to be Adopted in Nuclear Physics (8 hours)

Properties of nucleons and pion, elements of nucleon and pion structure in terms of quark model. Basic properties of nuclei-charge, mass, binding energy, size, spin and statistics, parity, magnetic dipole moment, electric dipole moment with illustration examples.

Module II: Nuclear Two Body Problem and Nuclear Force (12 hours)

Properties of deuteron bound state and low energy n-p scattering in terms of scattering length and effective range, spin dependence, charge independence of nucleon force. Non-central part of nucleon force, isospin concept, exchange forces, magnetic moment and electric quadrupole moment of deuteron. Yukawa theory of nuclear force.

Module III: Nuclear Models (8 hours)

Magnetic number and single shell model using oscillator well, and l.s interaction, Schmidt lines, spin parity assignment, rotational model, vibrational model with examples.

Module IV: Nuclear Reactions (15 hours)

Conservation laws: Kinematics governing nuclear reactions, Q-value, cross section of nuclear reactions, neutron reactions at low energies, Coulomb effects in nuclear reactions, neutron reactions at low energies, Coulomb effects in nuclear reactions, neutron reactions, compound nucleus hypothesis, Breit Wigner one level formula for resonance reactions. Elements of direct reactions (qualitative), energies of fission and fusion, neutron induced fission, chain reaction, hydrogen burning in the sun.

Module V: Nuclear Decay (8 hours)

Fermi theory of decay, selection rules, non-conservative of parity. Gamma decay, electric and magnetic multipole transitions, selection rules, examples of beta and gamma decay.

Module VI: Interactions of Charged Particles and Gamma Radiation with Matter (9 hours)

Linear attenuation coefficients, Compton scattering, photoelectric absorption, and pair production. Stopping power and range energy relations.Semiconductor detectors for charged particles and scintillation detectors.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain nucleus and nuclear forces in details
CO2: Expound nuclear models
CO3: Understand nuclear reaction and origin of nuclear energy
CO4: Describe interactions of charged particles and gamma radiation with matter

Suggested Readings

1. S. N. Ghosal, Atomic and Nuclear Physics, Vol-II, S. Chand and company Ltd.
2. S. M. Wong, Introductory Nuclear Physics, Prentice Hall Inc.
3. B. L. Cohen, Concepts of Nuclear Physics, Tata McGraw Hill Publishing Company Ltd.
4. R. D. Evans, The Atomic Nucleus, Tata McGraw Hill Publishing Company Ltd.
5. S. S. Kapoor and V. S. Ramamurthy, Nuclear Radiation Detectors, Wiley Eastern Ltd.
6. W. N. Cottingham and D. A. Greenwood, An introduction to nuclear Physics, Cambridge University Press.

PSCN0030: COMPUTER ORIENTED NUMERICAL METHODS

(2 Credits – 30 hours)

Objective*: Most problems in physics benefit from numerical methods, and many of them resist analytical solution altogether. The objective of this course is to learn the principles of numerical techniques and apply them to problems of Physics. Knowledge of computer programming is given with FORTRAN language. Emphasis will be laid on the solution of numerical problems.*

Module I: Numerical Analysis (10 hours)

a) Introduction to numerical methods: approximate and significant figures, absolute and relative errors, general formula for errors, application of the error formula to the fundamental operations of arithmetic and to logarithms. The error of a sum, the error of a difference, the error of a product and number of correct digits, the error of quotients and number of correct digits, the relative error of a power, the relative error of a root, successive approximation, Taylor's series, principle of least square, law of error of residuals.
b) Matrices and linear equations: addition, subtraction and multiplication of matrices, inversion of matrices, Jacobi transformation of a symmetric motion, determinant of a matrix, transpose of a matrix, solution of equations by matrix method, Gauss-Jordan elimination Method, eigenvalues and eigenvectors.
c) The solution of numerical, algebraic and transcendental equations: Equations in one unknown: Finding approximate values of the roots, finding roots by repeated application of location theorem, bisection method, the Newton-Raphson method; their convergence and geometric significance.

Module II: Solutions of Ordinary Differential Equations (9 hours)

a) Equations of the first order: Euler's method and its modification, the Runge-Kutta method, checks, errors and accuracy.
b) Equations of the second order and systems of simultaneous equations: Milne's-predictor and corrector methods, boundary value problems, conditions for convergence.
c) Minimization or maximization of functions: golden selection search in 1-D, parabolic interpolation and Brent's method in 1-D, 1-D search with 1 derivatives, Downhill simplex method in multidimensions, Direction set (Powell's method in Multidimensions)

Module III (5 hours)

a) Numerical Integration: Classical formulae for equispaced abscissae: Simpson's rule, trapezoidal rule, Gaussian quadrature formula.
b) Computation of factorials, computation of square roots, recurrence relations.

Module IV: Review of FORTRAN Language I (6 hours)

a) Introduction to computer programming, Machine and High Level Languages.
b) Constants, variables, expressions, operations, statements and built in functions.
c) Conditional and looping structures, arrays, subprograms and subroutines.
d) File operations.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain the concept of numerical methods
CO2: Apply numerical techniques to solve different problems in Physics
CO3: Understand high level language through Fortran

Suggested Readings

1. Seymour Lipschutz and Arthur Poe, Theory and problems of Programming with FORTRAN, McGraw-Hill.
2. C. Xavier and R. Rajaraman, FORTRAN 77 and numerical methods, New Age International Publishers
3. V. Rajaraman, FORTRAN 77 Programming, Prentice Hall of India.
4. V. Rajaraman, Numerical Analysis, Wiley Eastern.
5. W. H. Press, S. S. Tenkulsky, W. T. Wettering and B. P. Flannery, Numerical Recepies in FORTRAN, Cambridge University Press.
6. S. Sastry, Introductory Methods of Numerical Analysis, Prentice Hall of India.
7. M. K. Jain et al., Numerical Methods for Scientific and Engineering Computation, New Age International Publications.
8. F. B. Hildebrand, Introduction to Numerical Analysis, McGraw-Hill Book Company Inc.

PSSM0034: STATISTICAL MECHANICS

(4 credits – 60 hours)

Objective*: The course intends to describe physical phenomena in terms of a statistical treatment of the behaviour of large numbers of atoms or molecules, especially as regards the distribution of energy among them. Emphasis will be laid on the solution of numerical problems.*

Module I: Essentials (17 hours)

a) Probability theory: the random walk problem, binomial, Poisson and Gaussian distributions, central limit theorem.
b) Classical equilibrium statistical mechanics: concept of equilibrium; Ergodic hypothesis; microcanonical, canonical and grand canonical Ensembles; partition functions and their relation to thermodynamics.
c) Classical nonequilibrium statistical mechanics: approach to equilibrium, Liouville's theorem, Boltzmann's H theorem

Module II: Quantum Statistics (15 hours)

a) Quantum statistical mechanics: Schrödinger and Heisenberg Picture; pure and mixed states, the density matrix, quantum mechanical Liouville's theorem; the fundamental postulates.
b) Quantum statistics: quantum gases of independent particles; partition functions; Bose Einstein's and Fermi Dirac's distributions; electrons in metals; black body radiation; Bose Einstein's Condensation

Module III: Phase Transitions (15 hours)

a) Phenomenology: first and second order phase transitions; elementary ideas of critical phenomena; universality of critical exponents; scaling of thermodynamic functions.

b) Theory: the Landau theory of phase transition with examples.
c) Exact solutions: Ising model in one dimension.

Module IV: Non Equilibrium Phenomena and Irreversible Processes (13 hours)

a) Non equilibrium phenomena: transport theory; Boltzmann equation; Maxwell-Boltzmann distribution.
b) Irreversible processes: fluctuations; Brownian motion; Langevin's equation; Wiener Khintchine relations, Nyquist theorem, Fluctuation-Dissipation theorem; Fokker Planck equation.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Appreciate the connection between statistical mechanics and thermodynamics
CO2: Conceptualise quantum statistical mechanics
CO3: Understand the physics of phase transition

Suggested Readings

1. Federick Reif, Fundamental of Statistical and Thermal Physics, McGraw Hill, Singapore.
2. Shang-Keng Ma, Statistical Mechanics, World Scientific, Singapore.
3. Richard E. Wilde, and Surjit Singh, Statistical Mechanics: Fundamental and Modern Applications, Wiley-Interscience, John Wiley and Sons Inc., New York.
4. Leo P Kadanoff, Statistical Physics: Statics, Dynamics and Renormalisation, World Scientific, River Edge, New Jersey.
5. K. Huang, Statistical Mechanics, John Wiley and Sons Inc., New York.
6. D. J. Amit and J. Verbin, Statistical Physics, World Scientific, Singapore.
7. L D Landau, E.M. Lifshitz, Statistical Physics, Butterworth-Heinemann.
8. R. K. Pathria, Statistical Mechanics, Academic Press.

PSPA0035: PARTICLE PHYSICS

(4 credits – 60 hours)

Objective*: The objective of the course in particle physics is to make the students learn about the most primitive, primordial, unchanging and indestructible forms of matter and the rules by which they combine to compose all the things of the physical world. Thus, it is the branch of physics that studies the nature of the particles that constitute matter (particles with mass) and radiation (massless particles). In principle, all physics (and practical applications developed there from) can be derived from the study of fundamental particles. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Relativistic Kinematics (5 hours)

Lorentz transformation, four vectors, relativistic collisions and their application.

Module II: Group theory and Tensors (10 hours)

Introduction to group theory, representation theory, Lie group and Lie Algebra, direct product group, Young tableau. Basics of tensors, covariant and contravariant tensors, covariant derivative.

Module III: Introduction to Elementary Particles and their Interactions (13 hours)

Classification of elementary particles, interactions and Feynman diagram, particle exchange, leptons and weak interactions, quarks and hadrons, quark model, space time symmetry, C, P, CP conservation, time reversal, conservation law in different interactions.

Module IV: Quantum Field Theory (17 hours)

Concept of field, canonical quantisation of classical system, second quantisation, Fock space quantisation of scalar, Dirac and electromagnetic fields, Noether theorem - conservation of energy, momentum and charge of the field, the vacuum in field theory; C, P, T transformation of scalar and E. M. fields.

Module V: Quantum Electrodynamics (15 hours)

Covariant perturbation theory, Wick's theorem, Feynman rule, Compton scattering, Mott's scattering, basics of renormalisation.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Use mathematical skills like group theory, tensors, kinematics, etc.
CO2: Explain quantum field theory
CO3: Explicate quantum electrodynamics

Suggested Readings

1. D. Griffiths, Introduction of Elementary Particle, Wiley-vch Verlag Gmbh.
2. F. Halzen and A. D. Martin, Quarks and Leptons : An Introductory Course in Modern Particle Physics, Wiley India.
3. L. H. Ryder, Quantum Field Theory, Cambridge University Press.
4. D. H. Perkins, Introduction to High Energy Physics, Addison-Wesley.
5. Brian R. Martin and Graham Shaw, Particle Physics, Wiley.
6. Michael E. Peskin and Daniel V. Schroeder, An introduction to Quantum Field Theory, Westview Press Inc.

PSPL0036: PLASMA PHYSICS I

(4 Credit – 60 hours)

Objective: *The objective of this course is to give a basic understanding of plasma physics. The course dealing with the knowledge of the fourth state of matter is not only important for taking up advanced studies in plasma physics but also in other branches of physics. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Introduction to Plasma Physics (12 hours)

Role of temperature in occurrence of plasma; definition of plasma: quasineutrality and collective behaviour of plasma; concept of temperature; Debye shielding; criteria for plasma; classification of plasma; occurrence of plasma in nature

Module II: Single Particle Motion (12 hours)

Uniform electric and magnetic fields; non-uniform magnetic field: grad-B drift, curvature drift, magnetic mirrors, the loss cone; non-uniform electric field; time-varying electric field; time-varying magnetic field; adiabatic invariants.

Module III: Plasma Diagnostics (14 hours)

Langmuir probe: I-V characteristics, measurement of plasma potential, floating potential, electron temperature and electron density; double probe; optical emission spectroscopy: radiation from plasma, plasma models, temperature measurement by Boltzmann plot and line intensity ratio method, line broadening in plasma, Doppler broadening and stark broadening, applications; absorption spectroscopy; calorimetric methods; laser and microwave interferometer.

Module IV: Laboratory and Space Plasma (10 hours)

Glow discharge plasma; production and stabilization of thermal plasma, principle of DC, AC and high frequency discharges, RF and ECR plasmas, dielectric barrier discharge plasma, laser produced plasmas; sun and solar winds, Van Allen belts, the ionosphere, formation of, accretion disks, dusty plasmas.

Module V: Applications of Plasma (12 hours)

Thermal plasma: nanoparticle synthesis, plasma spraying, waste management; plasma sputtering; plasma nitriding; plasma processing; plasma enhanced vapour deposition; plasma assisted surface engineering; biomedical applications; the magneto-hydrodynamic generator; plasma propulsion.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain theoretical concepts of plasma physics
CO2: Describe plasma diagnostic
CO3: Understand laboratory plasma
CO4: Explicate plasma in the universe
CO4: Know various applications of plasma

Suggested Readings

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Plenum.
2. J. A. Bittencourt, Fundamentals of plasma physics, Springer.
3. I. H. Hutchinson, Principles of plasma diagnostics, Cambridge University Press.

PSEC0037: ELECTRONICS II

(4 credits–60 hours)

Objective: *The course provides basic analog electronic circuit design techniques and analytical skills using diodes, op-amps, FETs, and BJTs. The student will develop ability to apply basic engineering sciences to the design, analyses and operation of electronics devices and circuits and problem solving skills of electronic circuits. Emphasis will be laid on the solution of numerical problems.*

Module I (20 hours)

a) Bipolar junction transistor: BJT biasing: fixed bias, emitter bias, voltage divider bias, D.C. collector feedback bias; DC and AC load line, Q- point, stability considerations. BJT modeling: two port representation of BJT with z, y, h-parameters; re and hybrid models of C-E, C-B, C-C configuration. Hybrid-pi model of C-E amplifier in voltage divider bias configuration, frequency response in low, mid and high frequency conditions, respective voltage gain, current gain, input and output impedances.
b) Field effect transistors: FET biasing: self bias, fixed bias, voltage divider bias, stabilization of Q-point. Small signal AC equivalent circuit of FET as amplifier, hybrid parameters. JFET amplifiers: CS, CD amplifiers; enhancement mode MOSFET amplifier, depletion mode MOSFET amplifiers; Introduction to CMOS, characteristics, structure of MOSFET, CMOS.

Module II (25 hours)

a) Thyristors: four layer diode, SCR, Photo SCR, gate controlled switch, silicon controlled switch, Diac, Triac, UJT;
b) Op-Amp - ideal operational amplifiers: Input impedance. DC offset parameters, frequency parameters, gain-bandwidth, CMRR, SVRR, SR. Op-Amp applications in constant gain multiplier, voltage summing, log - antilog amplifier, subtractor, comparator – zero crossing detector, Schmitt trigger, integrator, differentiator and controlled sources. instrumentation amplifier. Active filters: low, high and bandpass filters; ADC and DAC.
c) 555 timer: block diagram, monostable operation, astable operation, bistable operation, voltage controlled oscillator, ramp generator.

Module III (15 hours)

a) Feedback configurations: voltage series, voltage shunt, current series, current shunt.
b) Oscillators: introduction and classification, general form of LC oscillator, e.g. Hartley oscillator, Colpitts oscillator, RC phase shift oscillator, Wein Bridge oscillator, crystal oscillator.
c) Regulated power supply: voltage feedback regulation, current limiting characteristics, power supply characteristics, 3 terminal IC regulators, current boosters, switching regulators.
d) Characteristic of instruments: static characteristics, span, accuracy and precision, linearity, tolerance, error, repeatability, sensitivity, calibration, hysteresis, input impedance, resolution, bias and drift.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:
CO1: Know about different types of transistors
CO2: Describe devices like thyristors, operational amplifiers, oscillators, etc.

Suggested Readings

1. Robert L. Boylestad and Lowis Nashelsky, Electronic Devices and Circuit Theory, Pearson Education, New Delhi.
2. Jacob Millman, Christos C Halkias and Satyabrata Jit, Millman's Electronic Devices and Circuits, 2nd Edition, Tata McGraw Hill, New Delhi.

3. S. Salivahanan, N. Suresh Kumar and A. Vallavaraj, Electronic Devices and Circuits, Tata McGraw-Hill.
4. Streetman and Banerjee, Solid State Electronic Devices, Prentice Hall, New Delhi.
5. David A. Bell, Electronic Devices and Circuits, Prentice Hall of India, New Delhi.
6. Jacob Millman, Christos C Halkias, Integrated Electronics, McGraw Hill Int. students Edition.
7. Ramakant A. Gayakwad, Op-amps and Linear Integrated Circuits, PHI.

PSPT0038: PHYSICS FOR TECHNOLOGISTS

(4 Credits – 60 Hours) (L-T-P: 3-1-0)

Note: For details see pages 556-557 of *Regulations and Syllabus, School of Technology*

PSEP0039: ENGINEERING PHYSICS: MECHANICS

(4 Credits – 60 Hours) (L-T-P: 3-1-0)

Note: For details see pages 557-559 of *Regulations and Syllabus, School of Technology*

PSET0040: ENGINEERING PHYSICS: ELECTROMAGNETIC THEORY

(4 Credits – 60 Hours) (L-T-P: 3-1-0)

Note: For details see pages 559-560 of *Regulations and Syllabus, School of Technology*

PSNS0041: NANOPHYSICS II

(4 credits – 60 hours)

Objectives: *The aim of the course is to introduce the students to the world of nanomaterials and their synthesis and characterization process. Students will learn various kinds of nanomaterials and their potential use in the field of science and technology. The course will give scope of knowing about various methods of formation of nanostructures, surfaces and interfaces of nanostructures, natural nanomaterials and toxicology of nanomaterials. The common synthesis methods are also given emphasis as well as the characterization tools such as SEM, TEM, etc. will be discussed in detail. This course will help the students to take up practical work on nanotechnology. Emphasis will be laid on the solution of numerical problems.*

Module I (15 Hours)

Surfaces and interfaces in nanostructures; ceramic interfaces, superhydrophobic surfaces, grain boundaries in nanocrystalline materials, defects associated with interfaces; thermodynamics of nanomaterials, natural nanomaterials; toxicology of nanomaterials.

Module II (25 Hours)

Chemical routes for synthesis of nanomaterials: electrochemical synthesis, photochemical synthesis; synthesis in supercritical fluids. hydrothermal growth of nanoparticles and different nano structures. Ostwald ripening; zeta potential; fabrication of nanomaterials by physical methods: -inert gas condensation, arc discharge, plasma arc technique, RF plasma, MW plasma, ion sputtering, laser ablation, laser pyrolysis, ball milling, molecular beam epitaxy, physical and chemical vapour deposition method; electrodeposition. Core-shell quantum dots.

Module III (20 Hours)

Nanostructures: zero-, one-, two- and three- dimensional structure, size control of metal nanoparticles; properties: optical, electronic, magnetic properties; surface plasmon resonance, structural characterization X-ray diffraction, small angle x-ray scattering, optical microscope and their description, scanning electron microscopy (SEM), scanning probe microscopy (SPM), TEM and EDAX, SAED analysis, scanning tunneling microscopy (STM), atomic force microscopy (AFM). Spectroscopic characterizations: basic concepts of spectroscopy, operational principle and application for analysis of nanomaterials, UV-VIS-IR spectrophotometers, principle of operation and application for band gap measurement (Tauc plot).

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:
CO1: Explain different properties of nanomaterials
CO2: Know about different methods for the synthesis of nanomaterials
CO3: Appreciate the technology associated with characterisation of nanomaterials

Suggested Readings

1. G. L. Hornyak, J. Dutta and H. F. Tibbals, A. Rao Introduction to nanoscience, CRC Press.
2. T. Pradeep, Nano: The Essentials, McGraw Hill.
3. D. Maclurcan and N. Radywyl (Eds.) Nanotechnology and Global Sustainability, CRC Press.
4. G. W. Hanson Fundamentals of Nanoelectronics, Pearson.
5. R. Vajtai (Ed.), Springer Handbook of Nanomaterials, Springer.
6. B. Bhushan (Ed.), Springer Handbook of Nanotechnology, Springer.

PSGT0043: GAUGE THEORIES

(4 credits – 60 hours)

Objective: *The objective of this advanced course in physics is to use the knowledge of the earlier course in particle physics to understand the recent developments in high energy physics. The course mainly deals with Gauge theories which are fundamental for the understand of standard model and physics beyond standard model. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Introduction (10 hours)

Introduction to Gauge symmetries – global and local gauge transformations, abelian group U(1) (QED), Yang-Mills (Non-Abelian) groups – SU(2) (isospin), SU(3)C (QCD).

Module II: Spontaneous Symmetry Breaking (SSB) (12 hours)

Ground state with spontaneous symmetry breaking, some examples; global symmetry breaking and Goldstone bosons, proof of Goldstone theorem, local symmetry breaking and Higgs mechanism for giving masses to vector bosons, examples U(1), SU(2).

Module III: Standard Model (SM) (12 hours)

Standard model of electroweak unification, gauge bosons W^+, W^-, Z^0, charged weak current and neutral current, Higgs particle, experimental status.

Module IV: Beyond Standard Model (12 hours)

a) Introduction to Grand Unified Theories (GUTs) – SU(5) and SO(10), and proton decay predictions;
b) Minimal Supersymmetric Standard Model (MSSM) and its extension, its predictions;
c) Introduction to String Theories and Planck scale physics.

Module V: Neutrino Physics (14 hours)

Solar and atmospheric neutrino puzzles, theory of neutrino oscillations in vacuum and medium (MSW mechanism), neutrino masses and leptonic mixings, survey of various neutrino oscillation experiments, seesaw mechanism for small neutrino masses.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain gauge theories
CO2: Familiarise with physics of spontaneous symmetry breaking and Higg's mechanism
CO3: Expound standard model and physics beyond standard model
CO4: Understand neutrino physics

Suggested Readings

1. Ta-Pei Cheng and Ling-Fong Li, Gauge Theory of elementary particle physics, Oxford University Press.
2. Francis Halzen and Alan D. Martin, Quarks and leptons: An introductory Course in Modern Particle Physics, John Wiley & Sons.

3. David Griffiths, Introduction to Elementary Particles, John Wiley & Sons.
4. Barton Zwiebach, A First Course in String theory, Cambridge Univ. Press.
5. Graham G Ross, Grand Unified theories, Oxford University Press.
6. R. N. Mohapatra and P. B. Pal, Massive Neutrinos in Physics and Astrophysics, World Scientific, Singapore.

PSGR0044: GENERAL THEORY OF RELATIVITY AND COSMOLOGY

(4 credits – 60 hours)

Objective: *The course aims to provide the theoretical foundations of the general theory of relativity, and bring the student to the frontier of elementary cosmology, which would then enable the pursuit of future research in this area. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Theoretical Background of Relativity (15 hours)

a) Foundations of relativity: postulates of relativity, GR units, space-time intervals, proper time; special Lorentz transformations in Minkowski space-time; four-vectors.
b) Review of tensor calculus in Euclidean space; tensor calculus in Riemannian space: generalized N-dimensional spaces, covariant and contravariant tensors; Riemann-Christoffel curvature tensor, Christoffel symbols, Einstein's tensor, geodesics; metric tensor, covariant differentiation, Bianchi Identities, Ricci tensor.

Module II: General Theory of Relativity (30 hours)

a) Motion of a free particle in a gravitational field, equations of electrodynamics in the presence of a gravitational field; gravitational field equations – action for gravitational field, energy-momentum tensor, extremum principle, Einstein field equations, energy-momentum pseudotensor.
b) Field of gravitating bodies – Schwarzschild solution, Birkhoff's theorem, motion in a centrally symmetric gravitational field, precession of perihelion of Mercury, deflection of light, gravitational lensing; black holes – Schwarzschild black holes, Kruskal space, black hole thermodynamics; gravitational waves – plane waves, weak field approximation, gravitational radiation, transverse-traceless gauge.

Module III: Fundamentals of Cosmology (15 hours)

a) Cosmological principle, cosmological time; spaces of constant curvature, Hubble's constant, Hubble's Law, red-shift of galaxies, big bang, age and density of universe; cosmological constant – Einstein space, de Sitter space, anti-de Sitter space; Robertson-Walker metric, introduction to Friedmann-Robertson-Walker (FRW) universe.
b) The observed universe and its dynamics, Friedmann-Lemaitre-Robertson-Walker (FLRW) metric, Friedmann equation and its solutions; composition of the universe – origin of matter, big bang nucleosynthesis, abundance of light elements, dark matter and dark energy, cosmological constant as dark energy, origin of matter-antimatter asymmetry, baryogenesis.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Use mathematics necessary for understanding general theory of relativity
CO2: Explain general theory of relativity
CO3: Understand cosmology

Suggested Readings

1. D. F. Lawden, Introduction to Tensor Calculus, Relativity and Cosmology, Dover Publications.
2. B. Shutz, A First Course in General Relativity, Cambridge University Press.
3. B. Ryden, Introduction to Cosmology, Cambridge University Press.
4. C. W. Misner, K. S. Thorne and J. A. Wheeler, Gravitation, Princeton University Press.
5. L. D. Landau and E. M. Lifshitz, The Classical Theory of Fields, Butterworth-Heinmann.
6. A. Einstein, The Meaning of Relativity, Oxford & IBH.
7. P. A. M. Dirac, General Theory of Relativity, Prentice-Hall of India.
8. R. P. Feynman, F. B. Moronigo and W. G. Wagner, Feynman Lectures on Gravitation, Addison-Wesley.

9. S. Weinberg, Gravitation and Cosmology, Wiley.
10. J. V. Narliker, Introduction to Cosmology, Cambridge University Press.
11. S. Dodelson, Modern Cosmology, Academic Press.
12. V. Mukhanov, Physical Foundations of Cosmology, Cambridge University Press.

PSAR0045: ASTROPHYSICS

(4 credits - 60 hours)

Objective: *The objective of this course is to enable the students to apply basic physical principles from a wide spectrum of topics in physics to astronomical situations and formulate astrophysical problems and thereby, apply analytical and numerical methods towards its solution. This course seeks to develop competence in areas of astrophysical theory and experiment. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Fundamentals of Astronomy (12 hours)

Astronomy fundamentals: celestial coordinate systems, telescope and its operational principles and mounting, atmospheric extinctions, magnitude systems. Radiation mechanism, flux density and luminosity, specific intensity, (emission/absorption coefficients, source functions), basics of radiative transfer and radiative processes.

Module II: Stellar Parameters (18 hours)

Magnitudes, motions and distances of stars: absolute stellar magnitude and distance modulus, bolometric and radiometric magnitudes, colour-index and luminosities of stars, stellar positions and motions, velocity dispersion, statistical and moving cluster parallax, extinction, stellar temperature, effective temperature, brightness temperature, color temperature, kinetic temperature, excitation temperature, ionization temperature, spectral classification of stars, utility of stellar spectrum, stellar atmospheres. Binaries, variable stars, clusters, open and globular clusters, compact objects, shape, size and contents of our galaxy, normal and active galaxies.

Module III: Interstellar Medium (10 hours)

Neutral and ionized gas, gaseous nebulae, HII regions, supernova remnants, photo-dissociation regions, different phases of the interstellar medium: cold neutral medium, warm neutral and ionized medium, hot medium, diffuse clouds, dense clouds.

Module IV: Stellar Physics (20 hours)

Introduction to stars: HR diagram, a discussion on the variety of stellar phenomena, stellar structure, stellar opacities, stellar polytropes, energy generation in stars: calculation of thermonuclear reaction rates for non-resonant and beta-decay reactions, various reaction chains: pp-I, II, III, CNO, He-burning, C-burning, Si-burning, stellar degeneracy and equations of state: stellar degeneracy, Chandrasekhar mass, EoS of matter at near-nuclear and nuclear densities, final stages of stellar evolution: supernovae and neutron stars.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain fundamental ideas of astrophysics
CO2: Conceptualise the physics of interstellar medium
CO3: Describe in detail different stages of a star

Suggested Readings

1. P. Jain, An Introduction to Astronomy and Astrophysics, CRC Press.
2. B. Basu, An Introduction to Astrophysics, PHI Learning Pvt. Ltd.
3. K. D. Abhayankar, Astrophysics: Stars and Galaxies, Universities Press.
4. Erika Böhm-Vitense, Introduction to Stellar Astrophysics, Cambridge University Press.
5. J. B. Hartle, Gravity: Introduction to Einstein’s General Relativity, Pearson Education.
6. P. J. E. Peebles, Physical Cosmology, Princeton University Press.

PSPM0046: PLASMA PHYSICS II

(4 Credit – 60 hours)

Objective: *This advanced course in plasma physics provides a detailed description of physics of plasma. It further discusses various applications of plasma physics. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Plasma as fluids and Plasma Kinetic Theory (20 hours)

Introduction to fluid model; equation of motion; continuity equation; fluids drifts perpendicular to B; fluids drifts parallel to B; the plasma approximation; Introduction to kinetic theory; equations of kinetic theory; derivation of the fluid equation; plasma oscillation; Landua damping: meaning and physical derivation.

Module II: Waves in Plasma (10 hours)

representation of waves; group velocity; plasma oscillation; electron plasma waves; sound waves; ion waves; validity of plasma approximation; ion acoustic waves; Alfven waves.

Module III: Diffusion and Resistivity (10 hours)

Diffusion and mobility; plasma decay by diffusion; steady state solution; recombination; diffusion across a magnetic field; the single MHD diffusion equation; solutions of the diffusion equation.

Module IV: Instability and Non-linear Effects (10 hours)

Hydro-magnetic equilibrium; diffusion of magnetic field into a plasma; classifications of instability; two stream instability; plasma sheaths; ion acoustic shock waves; the ponderomotive force; parametric instabilities; plasma echoes; non-linear Landua Damping.

Module V: Controlled Fusion (10 hours)

Controlled fusion and problems; magnetic confinement: toruses, mirrors, pinches; laser fusion; plasma heating; fusion technology; tokamaks; ITER.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain plasma physics in details

CO2: Describe diffusion and resistivity in plasma

CO3: Appreciate a few advanced topics in plasma physics like waves in plasma, non-linear effects, controlled fusion, etc.

Suggested Readings

1. F. F. Chen, Introduction to Plasma Physics and Controlled Fusion, Plenum.
2. J. A. Bittencourt, Fundamentals of plasma physics, Springer.

PSER0047: ELECTRONICS III

(4 credits - 60 hours)

Objectives: *The objectives of this course are to introduce the concept of digital systems and give students the concept of digital electronics. The course also provides an in-depth understanding of the operation of microprocessors and basics of microcontrollers, assembly language programming and microprocessor interfacing techniques. The students will be able to design and implement microprocessor-based systems in both hardware and software and can apply this knowledge to more advanced structures. Emphasis shall be laid upon the solution of numerical problems.*

Module I (15 hours)

a) Number system: representation of signed integers, binary arithmetic on signed and unsigned integers and detection of overflow and underflow, weighted binary Codes: BCD, 2421, non-weighted codes: excess-3 codes, gray codes, error detecting codes, error correcting codes, alphanumeric codes: ASCII code, EBCDIC codes.
b) Boolean algebra and logic gates:, rules (postulates and basic theorems) of Boolean algebra, dual and complement of a Boolean expression, sum of products and product of sums forms.

canonical forms. Conversion between different forms, conversion between Boolean expression and truth table;, implementing logic expressions with logic gates (logic circuits).

c) Digital logic families: designing of basic logic gates with diode and transistor; elementary idea of DTL, TTL, RTL, ECL, I^2L logic family and characteristics.

Module II (15 hours)

a) Combinational circuit: Simplification of Boolean expressions using algebraic method, Karnaugh map method and Quine-McCluskey method, Don't Care conditions. Multiplexer, demultiplexer, encoder, decoder, half-adder, hull-adder, magnitude comparator, parity checkers: basic concepts, design of parity checkers, parity generation, code converters, binary –to- gray and gray-to-binary Code converter; concept of magnitude comparator.

b) Sequential circuit: simple R-S flip-flop or Latch, clocked R-S Flip-flop, D flip-flop. J-K flip-flop, T flip-flop, master-slave flip-flop, J-K Master-Slave flip-flop. Asynchronous preset and clear, edge triggering and level triggering. Registers: shift registers, parallel/serial in, parallel/serial out. Buffer counter design: different types of counters like asynchronous and synchronous, up and down, ring, Johnson etc. counter design using state diagram, state table and state equation.

c) Semiconductor memory: classification of memories, main memory and secondary memory, sequential access memory, static and dynamic memory, volatile and nonvolatile memory, concept of ROM, PROM, EPROM, RAM, DRAM, SDRAM, PSRAM, memory decoding.

Module III (30 hours)

a) History and evolution of microprocessor; introduction to CPU: components of CPU, block diagram, buses-data, control and address; ALU, control unit; main memory and secondary memory; I/O devices; memory addressing-memory mapped I/O and I/O mapped I/O; address decoding; memory and I/O interfacing;

b) Introduction to 8085; block diagram, registers, use of register pairs, PSW, accumulator; addressing modes; Instruction set of 8085: data transfer, arithmetic, logic, branch and machine control instructions; instruction cycle: fetch, decode and execute. Delay and counter; stack and its application; interrupt and its application; assembly level language programming of 8085.

c) Interfacing: Memory interfacing; I/O interfacing; interfacing small devices like keyboard, 7-segment display, relay, event counter etc.; idea of PPIs like 8251, 8255, 8257 and 8279 (block diagram and function only); serial communication standard (RS-232C).

d) Example of 16-bit processors (introduction to 8086); microcontroller (block diagram and application of 8051).

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Expound advanced topics of digital electronics
CO2: Describe microprocessor, microcontroller and assembly language
CO3: Apply this knowledge in advanced structures

Suggested Readings

1. M. Mano, Digital Logic and computer Design, PHI.
2. R. P. Jain, Modern Digital Electronics, TMGH.
3. Jain and Floyd, Digital Fundamentals, Pearson Education.
4. Malvino and Leach, Digital Electronics, Pearson Education.
5. Malvino, Digital Computer Electronics, TMGH.
6. Morris Mano, Digital Design, Principles and Practices, Pearson Education.
7. S. Salivahanan and S. Arivazhagan, Digital Circuits and Design, Vikash Publishing House Pvt. Ltd.
8. P. H. Talukdar, Digital Techniques, N. L. Publications.
9. Anand Kumar, Fundamentals of Digital Circuits, PHI.
10. Gaonkar, Introduction to Microprocessors, New age Publication.
11. B. Ram, Fundamentals of Microprocessor, Dhanpat Rai.
12. N. K. Srinath, 8085 Microprocessor Programming and Interfacing, PHI.
13. Slater, Microprocessor Based Design, PHI.
14. Gilmore, Microprocessors, McGraw Hill Publication.

PSNY0048: NANOPHYSICS III

(4 credits – 60 hours)

Objective: *This course will help students to understand the physics behind the different properties of nanoparticles and nanostructures. The quantum effect of nanostructures and their conduction and electronic behaviours are included in the course. Understanding of this course will build a strong base for pursuing theoretical and practical research in the field of nanoscience and nanotechnology. Emphasis shall be laid upon the solution of numerical problems.*

Module I (15 Hours)

Absorption and scattering of EM waves from nanoparticles based on bulk properties. Electronic phenomena in nanostructures: electronic structures and effective mass theory for bulk Si , Ge, GaAs; excitons. Boltzmann electron transport in bulk. Electron energy states in quantum confined systems, semiconductor heterojunctions.

Module II (20 Hours)

a) X-ray photoelectron spectroscopy (XPS): fundamentals: photoelectric effect, binding energy and chemical shift, ultraviolet photoelectron spectroscopy (UPS): information.
b) Extracted: band structure, occupied band states of clean solid surfaces as well as bonding orbital states of adsorbed molecules; fundamentals of Fourier transform infrared radiation (FTIR) and Raman spectroscopy.
c) 2-DEG systems, quantum wires, quantum dots. Transmission in nanostructures: tunneling in planar barrier, resonant tunnel diodes. Ballistic transport, Landauer formula, electron transport in quantum wave-guide structures.

Module III (15 Hours)

Single electron phenomena: electronic states in quantum dots, without and with magnetic fields, single electron tunneling and Coulomb blockade, single electron tunneling, elastic, inelastic, spin polarized tunneling, surface density of states for different dimensions, role of tip geometry, lithography and atomic manipulation; single electron transistor. Spin-orbit interaction and spin effects.

Module IV (10 Hours)

Nanomechanics: introduction to NEMS, CNT oscillation, nanoscale electrometer, bolometer. nanophotonics; science of Graphene.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain properties of nanomaterials in details
CO2: Understand quantum effects on nanostructures
CO3: Describe nanomechanics
CO4: Engage in higher studies and research in nanophysics

Suggested Readings

1. D. K. Ferry and S. M. Goodnick, Transport in Nano-Structures, Cambridge University Press, 1997.
2. S. Datta, Electronic Transport in Mesoscopic Systems, Cambridge University Press.

PSEL0049: ELECTRONICS I

(4 credits-60 hours)

Objective: *This course is intended to give a glimpse of the electronics world. The course is designed with a view of giving, students the knowledge of passive components, different electronic devices, digital electronics and introduction to communication so that it provides a motivation towards practical applications. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Passive Components and DC Networks (15 hours)

a) Passive components: resistors, capacitors and inductors-types, characteristics and applications;

b) DC networks: voltage and current sources, dependent sources, KCL, KVL, current division rule, voltage division rule, Y-Delta conversion, mesh analysis, node analysis, Thevenin's theorem, Norton's theorem, superposition theorem, maximum power transform theorem.

Module II: Electronic Devices and Circuits (20 hours)

a) Semiconductor concepts: semiconductor material, intrinsic semiconductor, extrinsic semiconductor, energy levels, concept of hole and electron, mobility, conductivity, n-type and p-type, majority and minority carriers, mechanism of current flow.

b) Semiconductor diode: PN junction and various biasing conditions, V-I characteristics, diode equation, diode resistance, equivalent circuit, transition capacitance and diffusion capacitance; rectifier circuit with filter, clipper, clamper, voltage multiplier.

c) Special purpose diodes: Zener diodes, LED, 7 segment display, photo diode, photo transistor, opto coupler, Schottky diode, varactor diode, tunnel diode

d) Transistor - BJT: construction, npn, pnp, operation and configuration, V-I characteristics, introduction to FET- JFET, MOSFET.

e) OP-AMP: block diagram, ideal op-amp equivalent circuit, ideal characteristics, transfer curve, open loop and closed loop configurations, op-amp as an inverting amplifier, non-inverting amplifier, adder, subtractor.

Module III: Digital Circuits (12 hours)

Number systems, Boolean algebra, De-Morgan's law, AND, OR, NOT, Universal gates, combinational logic circuits.

Module IV: Communication (13 hours)

a) Introduction: communication process, source of information, communication channels, modulation types and need, block diagram of communication systems, AM, FM, PAM, PWM, PPM.

b) Introduction to digital modulation: ASK, PSK, FSK.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Know about passive components and DC networks.
CO2: Students will be able to understand electronic devices and circuits.
CO3: Describe electronic communication.
CO4: Explain digital circuits.

Suggested Readings

1. S. Salivahanan, Electronic Devices and Circuits, McGraw Hill Publications.
2. R. D. Singh and S. D. Sapre, Communication System, TMGH.
3. D. Roy Choudhury, Networks and Systems, New Age International.
4. David A. Bell, Electronic Devices and Circuits, Oxford University Press.
5. Moris Mano, Digital electronics, EEE.

PSNP0050: NANOPHYSICS I

(4 credits – 60 hours)

Objective: *The objective of this course is to get students introduced to the new branch of science called Nanoscience and the technology associated with it. Nanotechnology can be considered as an interdisciplinary converging technology that brings together aspects of hitherto unrelated fields of studies. This course will deal with basic concepts laying more stress on the science rather than the technology. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Introduction (20 hours)

Distinction between nanoscience and nanotechnology, requisite definitions; historical perspectives; nanomaterials: overview, definitions, and examples; structurally confined materials: nanoparticles, islands, nanowires, thin films; metal nanoparticles: fundamentals and applications; self-assembled monolayers, semiconductor quantum dots: fundamentals and applications; ceramic nanomaterials: fundamentals and applications; carbon nanomaterials(Fullerenes and carbon nanotubes and nanofibers): fundamentals and applications; magnetic nanoparticles: fundamentals and applications; bionanomaterials, computational nanomaterials, composite nanomaterials and applications.

Module II: Characterization tools (10 hours)

Electron microscopy, atomic force microscopes, X-ray spectroscopy, surface enhanced Raman spectroscopy, lithography, computer modelling and simulation.

Module III: General Fabrication Methods (12 hours)

Background; top down fabrication: mechanical methods, thermal methods, high energy methods, chemical fabrication methods, lithographic methods; bottom up fabrication: gaseous phase methods, liquid phase methods, template synthesis

Module IV: Basic Properties of Nanomaterials (10 hours)

Importance of surface: natural, inorganic and the nano perspectives; particle shape and surface; surface: geometric surface to volume ratio, specific surface area; atomic structure: crystal systems.

Module V: Natural and Bio-nanoscience (8 hours)

Natural nanomaterials: inorganic natural nanomaterials, nanomaterials from the animal kingdom, nanomaterials derived from cell walls, nanomaterials in insects; Introduction to biomolecular nanoscience: history, biomolecular nanoscience, nano perspective

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain nanophysics
CO2: Describe properties of nanomaterials and natural nanomaterials
CO3: Know about characterization and fabrications of nanomaterials

Suggested Readings

1. G. L. Hornyak, J. Dutta and H. F. Tibbals, A. Rao Introduction to nanoscience, CRC Press.
2. T. Pradeep, Nano: The Essentials, McGraw Hill.
3. D. Maclurcan and N. Radywyl (Eds.), Nanotechnology and Global Sustainability, CRC Press.
4. E. Lichtfouse, J. Shwarzbauer and D. Robert, Environmental Chemistry for a Sustainable World, Vol.2, Springer Verlag.
5. G. L. Hornyak, J. Dutta, H. F. Tibbals and A.Rao Introduction to nanotechnology, CRC Press.
6. G. W. Hanson Fundamentals of Nanoelectronics, Pearson.

ENGINEERING PHYSICS: WAVES AND OPTICS

[L: 3; T: 1; P: 0 (3 credits – 45 hours)]/[L: 3; T: 1; P: 0 (4 credits – 60 hours)]

Objective: *The objective of the course is to impart the knowledge of oscillations and waves, geometrical and wave optics and fundamentals of laser structure, working and applications to the students of mechanical engineering. Emphasis shall be laid upon the solution of numerical problems.*

Module I: SHM and Oscillators (8 hours)/(11 hours)

Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator.

Module II: 1D Waves and Dispersion (8 hours)/(11 hours)

Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves and speed of sound, standing sound waves. Waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.

Module III: Light propagation and geometrical optics (12 hours)/(15 hours)

Fermat's principle of stationary time and its applications e.g. in explaining mirage effect, laws of reflection and refraction, Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster's angle, total internal reflection, and evanescent wave. Mirrors and lenses and optical instruments based on them, transfer formula and the matrix method.

Module IV: Wave Optics (8 hours)/(11 hours)

Huygens' principle, superposition of waves and interference of light by wave front splitting and amplitude splitting; Young's double slit experiment, Newton's rings, Michelson interferometer, Mach-Zehnder interferometer. Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power

Module V: Laser Fundamentals (9 hours)/(12 hours)

Einstein's theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO 2), solid-state lasers(ruby, Neodymium), dye lasers; Properties of laser beams: mono-chromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.

Suggested Readings

1. Ian G. Main, Oscillations and waves in physics.
2. H. J. Pain, The physics of vibrations and waves.
3. E. Hecht, Optics.
4. A. Ghatak, Optics.
5. W. T. Silfvast, Laser Fundamentals.
6. O. Svelto, Principles of Lasers.

PSMY0101: MATHEMATICAL PHYSICS-I

(4 credits–60 hours)

Objective: *The objective of the course is to make students familiar with basic mathematical methods for application to problems in physics and the formulation of physical theories in different disciplines of physics. Emphasis shall be laid upon the solution of numerical problems. The importance of course is on applications in solving problems of interest to physicists. The students are to be examined entirely on the basis of problems, seen and unseen.*

Module I: Calculus (21 hours)

Recapitulation: Limits, continuity, average and instantaneous quantities, differentiation. Plotting functions. Intuitive ideas of continuous, differentiable, etc. functions and plotting of curves. Approximation: Taylor and binomial series (statements only).

First Order and Second Order Differential equations: First Order Differential Equations and Integrating Factor. Homogeneous Equations with constant coefficients. Wronskian and general solution. Statement of existence and Uniqueness Theorem for Initial Value Problems. Particular Integral.

Calculus of functions of more than one variable: Partial derivatives, exact and inexact differentials. Integrating factor, with simple illustration. Constrained Maximization using Lagrange Multipliers.

Module II: Vector Calculus (27 hours)

Recapitulation of vectors: Properties of vectors under rotations. Scalar product and its invariance under rotations. Vector product, Scalar triple product and their interpretation in terms of area and volume respectively. Scalar and Vector fields.

Vector Differentiation: Directional derivatives and normal derivative. Gradient of a scalar field and its geometrical interpretation. Divergence and curl of a vector field. Del and Laplacian operators. Vector identities.

Vector Integration: Ordinary Integrals of Vectors. Multiple integrals, Jacobian. Notion of infinitesimal line, surface and volume elements. Line, surface and volume integrals of Vector fields. Flux of a vector field. Gauss' divergence theorem, Green's and Stokes Theorems and their applications (no rigorous proofs).

Module III: Orthogonal Curvilinear Coordinates (6 hours)

Orthogonal Curvilinear Coordinates. Derivation of Gradient, Divergence, Curl and Laplacian in Cartesian, Spherical and Cylindrical Coordinate Systems.

Module IV: Introduction to Probability (4 hours)

Independent random variables: Probability distribution functions; binomial, Gaussian, and Poisson, with examples. Mean and variance.

Dependent events: Conditional Probability. Bayes' Theorem and the idea of hypothesis testing.

Module IV: Dirac Delta Function and its Properties (2 hours)

Definition of Dirac delta function. Representation as limit of a Gaussian function and rectangular function. Properties of Dirac delta function.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Describe advanced topics of calculus and vectors
CO2: Understand the concept of curvilinear coordinates
CO3: Explain probability
CO4: Describe Dirac delta function

Suggested Readings

1. G. B. Arfken, H. J. Weber and F. E. Harris, Mathematical Methods for Physicists, Elsevier.
2. E. A. Coddington, An introduction to ordinary differential equations, PHI learning.
3. George F. Simmons, Differential Equations, McGraw Hill.
4. James Nearing, Mathematical Tools for Physics, Dover Publications.
5. D. A. McQuarrie, Mathematical methods for Scientists and Engineers, Viva Book.
6. D. G. Zill and W. S. Wright, Advanced Engineering Mathematics, Jones and Bartlett Learning.
7. Goswami, Mathematical Physics, Cengage Learning.
8. S. Pal and S. C. Bhunia, Engineering Mathematics, Oxford University Press.
9. Erwin Kreyszig, Advanced Engineering Mathematics, Wiley India.
10. K. F. Riley and M. P. Hobson Essential Mathematical Methods, Cambridge Univ. Press.

PSMC0102: MECHANICS

(4 credits–60 hours)

Objective: *The objective of the course is to give a clear understanding of the motion of and forces on objects. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Fundamentals of Dynamics (6 hours)

Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Momentum of variable- mass system: motion of rocket. Motion of a projectile in Uniform gravitational field Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse.

Module II: Work and Energy (4 hours)

Work and Kinetic Energy Theorem. Conservative and non- conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Elastic potential energy. Force as gradient of potential energy. Work & Potential energy. Work done by non-conservative forces. Law of conservation of Energy.

Module III: Collisions (3 hours)

Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frames.

Module IV: Rotational Dynamics (12 hours)

Angular momentum of a particle and system of particles. Torque. Principle of conservation of angular momentum. Rotation about a fixed axis. Moment of Inertia. Calculation of moment of inertia for rectangular, cylindrical and spherical bodies. Kinetic energy of rotation. Motion involving both translation and rotation.

Module V: Elasticity (3 hours)

Relation between Elastic constants. Twisting torque on a Cylinder or Wire.

Module VI: Fluid Motion (2 hours)

Kinematics of Moving Fluids: Poiseuille's Equation for Flow of a Liquid through a Capillary Tube.

Module VII: Gravitation and Central Force Motion (9 hours)

Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and field due to spherical shell and solid sphere.

Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS).

Module VIII: Oscillations (7 hours)

SHM: Simple Harmonic Oscillations. Differential equation of SHM and its solution. Kinetic energy, potential energy, total energy and their time-average values. Damped oscillation. Forced oscillations: Transient and steady states; Resonance, sharpness of resonance; power dissipation and Quality Factor.

Module IX: Non-Inertial Systems (4 hours)

Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems.

Module X: Special Theory of Relativity (10 hours)

Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, frequency and wave number. Relativistic addition of velocities. Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Relativistic Kinematics. Transformation of Energy and Momentum.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain mechanics starting from basic concepts
CO2: Comprehend different properties of matter
CO3: Expound modern physics from Einstein's special theory of relativity

Suggested Readings

1. D. Kleppner, R. J. Kolenkow, An introduction to mechanics, McGraw-Hill.
2. C. Kittel, W. Knight, et.al. Mechanics, Berkeley Physics, vol.1, 2007, Tata McGraw-Hill.
3. Resnick, Halliday and Walker, Physics, Wiley.
4. G. R. Fowles and G. L. Cassiday, Analytical Mechanics, Cengage Learning.
5. R. P. Feynman, R. B. Leighton and M. Sands, Feynman Lectures, Vol. I, 2008, Pearson Education.
6. R. Resnick, Introduction to Special Relativity, John Wiley and Sons.
7. Ronald Lane Reese, University Physics, Thomson Brooks/Cole.
8. D. S. Mathur, Mechanics, S. Chand and Company Limited.
9. F. W. Sears, M.W. Zemansky and H. D. Young, University Physics, Addison Wesley.
10. J. W. Jewett and R. A. Serway, Physics for scientists and Engineers with Modern Phys., Cengage Learning.
11. M. R. Spiegel, Theoretical Mechanics, Tata McGraw Hill.

PSEM0103: ELECTRICITY AND MAGNETISM

(4 credits–60 hours)

Objective: *The course intends to provide a clear understanding and important concepts of the interactions between electric charges and currents using an extension of the classical Newtonian model. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Electric Field and Electric Potential (22 hours)

Electric field: Electric field lines. Electric flux. Gauss' Law with applications to charge distributions with spherical, cylindrical and planar symmetry.

Conservative nature of Electrostatic Field. Electrostatic Potential. Laplace's and Poisson equations. The Uniqueness Theorem. Potential and Electric Field of a dipole. Force and Torque on a dipole.

Electrostatic energy of system of charges. Electrostatic energy of a charged sphere. Conductors in an electrostatic Field. Surface charge and force on a conductor. Capacitance of a system of charged conductors. Parallel-plate capacitor. Capacitance of an isolated conductor. Method of Images and its application to: (1) Plane Infinite Sheet and (2) Sphere.

Module II: Dielectric Properties of Matter (8 hours)

Electric Field in matter. Polarization, Polarization Charges. Electrical Susceptibility and Dielectric Constant. Capacitor (parallel plate, spherical, cylindrical) filled with dielectric. Displacement vector D. Relations between **E, P** and **D**. Gauss' Law in dielectrics.

Module III: Magnetic Field (9 hours)

Magnetic force between current elements and definition of Magnetic FieldB. Biot-Savart's Law and its simple applications: straight wire and circular loop. Current Loop as a Magnetic Dipole and its Dipole Moment (Analogy with Electric Dipole). Ampere's Circuital Law and its application to (1) Solenoid and (2) Toroid. Properties of B: curl and divergence. Vector Potential. Magnetic Force on (1) point charge (2) current carrying wire (3) between current elements. Torque on a current loop in a uniform Magnetic Field.

Module IV: Magnetic Properties of Matter (4 hours)

Magnetization vector (M). Magnetic Intensity(H). Magnetic Susceptibility and permeability. Relation between B, H, M. Ferromagnetism. B-H curve and hysteresis.

Module V: Electromagnetic Induction (6 hours)

Faraday's Law. Lenz's Law. Self Inductance and Mutual Inductance. Reciprocity Theorem. Energy stored in a Magnetic Field. Introduction to Maxwell's Equations. Charge Conservation and Displacement current.

Module VI: Electrical Circuits (4 hours)

AC Circuits: Kirchhoff's laws for AC circuits. Complex Reactance and Impedance. Series LCR Circuit: (1) Resonance, (2) Power Dissipation and (3) Quality Factor, and (4) Band Width. Parallel LCR Circuit.

Module VI: Network theorems (4 hours)

Ideal Constant-voltage and Constant-current Sources. Network Theorems: Thevenin theorem, Norton theorem, Superposition theorem, Reciprocity theorem, Maximum Power Transfer theorem. Applications to dc circuits.

Module VII: Ballistic Galvanometer (3 hours)

Torque on a current Loop. Ballistic Galvanometer: Current and Charge Sensitivity. Electromagnetic damping. Logarithmic damping. CDR.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain electromagnetism

CO2: Understand physics of electricity

Suggested Readings

1. S. Mahajan and Choudhury, Electricity, Magnetism & Electromagnetic Theory, Tata McGraw.
2. Edward M. Purcell, Electricity and Magnetism, McGraw-Hill Education.
3. D. J. Griffiths, Introduction to Electrodynamics, Benjamin Cummings.
4. R. P. Feynman, R. B. Leighton and M. Sands, Feynman Lectures, Pearson Education.
5. M. N. O. Sadiku, Elements of Electromagnetics, Oxford University Press.
6. J. H. Fewkes & J. Yarwood, Electricity and Magnetism, Vol. I, Oxford Univ. Press.

PSWO0104: WAVES AND OPTICS

(4 credits–60 hours)

Objective: *The objective of this curriculum is to provide a clear concept of science of waves. This will make students obtain a comprehensive knowledge of optics. Emphasis shall be laid upon the solution of numerical problems.*

Module I: Superposition of Collinear Harmonic oscillations (5 hours)

Linearity and Superposition Principle. Superposition of two collinear oscillations having (1) equal frequencies and (2) different frequencies (Beats). Superposition of N collinear Harmonic Oscillations with (1) equal phase differences and (2) equal frequency differences.

Module II: Superposition of Two Perpendicular Harmonic Oscillations (5 hours)

Graphical and Analytical Methods. Lissajous Figures with equal an unequal frequency and their uses.

Module III: Wave Motion (5 hours)

Plane and Spherical Waves. Longitudinal and Transverse Waves. Plane Progressive (Travelling) Waves. Wave Equation. Particle and Wave Velocities. Differential Equation. Pressure of a Longitudinal Wave. Energy Transport. Intensity of Wave. Water Waves: Ripple and Gravity Waves.

Module IV: Velocity of Waves (6 hours)

Velocity of Transverse Vibrations of Stretched Strings. Velocity of Longitudinal Waves in a Fluid in a Pipe. Newton's Formula for Velocity of Sound. Laplace's Correction.

Module V: Superposition of Two Harmonic Waves (7 hours)

Standing (Stationary) Waves in a String: Fixed and Free Ends. Analytical Treatment. Phase and Group Velocities. Changes with respect to Position and Time. Energy of Vibrating String. Transfer of Energy. Normal Modes of Stretched Strings. Plucked and Struck Strings. Melde's Experiment. Longitudinal Standing Waves and Normal Modes. Open and Closed Pipes. Superposition of N Harmonic Waves.

Module VI: Wave Optics (3 hours)

Electromagnetic nature of light. Definition and properties of wave front. Huygens Principle. Temporal and Spatial Coherence.

Module VII: Interference (9 hours)

Division of amplitude and wavefront. Young's double slit experiment. Lloyd's Mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films. Fringes of equal inclination (Haidinger Fringes); Fringes of equal thickness (Fizeau Fringes). Newton's Rings: Measurement of wavelength and refractive index.

Module VIII: Interferometer (4 hours)

Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, and (5) Visibility of Fringes. Fabry-Perot interferometer.

Module IX: Diffraction (2 hours)

Kirchhoff's Integral Theorem, Fresnel-Kirchhoff's Integral formula. (Qualitative discussion only)

Module X: Fraunhofer diffraction (8 hours)

Single slit. Circular aperture, Resolving Power of a telescope. Double slit. Multiple slits. Diffraction grating. Resolving power of grating.

Module XI: Fresnel Diffraction (7 hours)

Fresnel's Assumptions. Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light. Theory of a Zone Plate: Multiple Foci of a Zone Plate. Fresnel's Integral, Fresnel diffraction pattern of a straight edge, a slit and a wire.

Module XII: Holography (3 hours)

Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:
CO1: Explain waves
CO2: Comprehend advanced geometrical optics
CO3: Conceptualise advanced topics like Holography

Suggested Readings

1. Francis Crawford, Waves: Berkeley Physics Course, vol. 3, Tata McGraw-Hill.
2. F. A. Jenkins and H.E. White, Fundamentals of Optics, McGraw-Hill.
3. Max Born and Emil Wolf , Principles of Optics, Pergamon Press.
4. Ajoy Ghatak, Optics, 2008, Tata McGraw Hill.
5. H. J. Pain, The Physics of Vibrations and Waves, John Wiley and Sons.
6. N. K. Bajaj, The Physics of Waves and Oscillations, Tata McGraw Hill.
7. A. Kumar, H. R. Gulati and D. R. Khanna, Fundamental of Optics, R. Chand Publications.

PSPL6003: PHYSICS LABORATORY II

(4 credits)

At least 10 experiments should be performed from the following

1. To study the characteristic of SCR using the breadboard.
2. To study resistivity of a semiconductor by probe method.
3. Determination of difference in wavelengths of Na using Fabry-Perot interferometer.
4. To verify the Beer-Lambert law using UV visible spectrometer.
5. Verification of inverse square law for gamma ray using GM counter.
6. To study attenuation of beta rays using GM counter.
7. To determine the activity of a gamma emitter.
8. To study gamma ray spectrum of Cs-137 source and determine the resolution of a gamma-ray spectrometer.
9. To calibrate the scintillation spectrometer and determine the energy of gamma rays from an unknown source.
10. To study attenuation of gamma-rays from Cs-137 source by using different absorbers.
11. To study decay curve for half-life components of irradiated 115In by a neutron source.
12. To study phonon dispersion of a monatomic chain of atoms using electronic analogue of the chain.
13. Experimental verification of Paschen law in a glow discharge system.
14. To find the floating potential of a plasma using Langmuir probe.

PSPL6009: PHYSICS LABORATORY I

(4 Credits)

At least 10 experiments should be performed from the following

1. Verification of KCL and KVL using discrete components.
2. Verification of Thevenins theorem.
3. VI characteristics of PN junction diode.
4. Series voltage regulaton using zener diode and transistor.
5. Design and study the clipper circuit.
6. Design and study the clamper circuit.
7. VI characteristics of Zener diode.
8. Design of Half wave and Full wave rectifier with and without filter.
9. RC low pass and high pass filter realization.
10. Static Characteristics of a Bipolar Junction Transistor (CE Mode).
11. Static Characteristics of a Bipolar Junction Transistor (CB Mode).
12. Design of voltage multiplier: voltage doubler / quadrupler.
13. Design BJT as a switch.
14. Op-Amp as Inverting and Non Inverting amplifier.

15. Realization of basic gates using discrete components.
16. To measure attenuation and bending losses of an optical fibre.
17. To study and verify the truth table of logic gates.
18. To realize half/full adder and half/full subtractor.

PSCN6010: COMPUTER ORIENTED NUMERICAL METHODS LAB

(4 Credits)

At least 10 experiments should be performed from the following
(All experiments are to be done using the Fortran Language)

1. Basic operations using a matrix A.
   a. To find the transpose of A.
   b. To find the inverse of A.
   c. To verify the accuracy of $AA^{-1} = I$.
   d. To diagonalise a given matrix.
   e. To find the eigenvalues and eigenvectors.
2. Numerical differentiation.
   a. To find the derivative of a given function f(x) using formula where h is the step size.
   b. To determine the second derivative of a given function f(x) using the formula.
   c. Plot the case (a) as a function of x.
   d. Plot the case (b) as a function of x.
   e. Compare the above cases (a) and (b) with the results obtained analytically in specific cases.
3. Numerical method of solving Schrödinger equation.
   a. Obtain numerical solution for the time independent Schrodinger equation in one dimension for a given potential using Runge-Kutta Method or Fox Godwin method.
   b. To plot the wave function obtained from above versus x.
   c. Obtain numerical solution for the time independent Schrodinger equation in three dimension for a given potential using Runge-Kutta method or Fox Godwin method.
   d. To plot the wave function obtained from above versus r.
   e. To evaluate the eigenvalues and eigenvectors for case (a).
   f. To evaluate eigenvalues and eigenvectors for case (b).
   g. To count the number of nodes of the function determined in (a) above and see if it is consistent with the theoretical expectation.
   h. To determine the boundary value problems for cases (a) and (c).
4. Spherical harmonics.
   a. To compute the Legendre polynomials.
   b. To plot spherical harmonics as a function of polar angles.
   c. To compute the spherical Bessel function (regular and irregular).
   d. To plot the case (c).
5. Numerical integration.
   a. To integrate a given function numerically by Simpson's Rule.
   b. To compare the results obtained form (a) with those obtained analytically.
   c. To integrate a given function numerically by Trapezoidal rule.
   d. To compare the results obtained from (b) with those obtained analytically.
   e. To integrate a given function numerically by Gauss-Legendre integration.
   f. To compare the results obtained form (c) with those obtained analytically.
6. Solution of algebraic equations.
   a. Solve a given equation numerically using Newton Raphson method.
   b. Compare the result of (a) with those obtained numerically.
   c. To solve a given equation using bisection method.
   d. Comparative study of (a), (b) and (c).
7. Solution of simultaneous equations.
   a. Using Gauss-elimination and Gauss Jordan elimination method.
   b. Compare (a) with solutions obtained analytically or algebraically.
8. Logistic systems.
   To explore the regions of (a) stable fixed points (b) periodic and (c) chaotic solution.

9. Radioactivity.
    a. Use Monte-Carlo method to simulate radioactive decay.
    b. Write a program for a radioactive series, when the daughter is also radioactive and so on.
    c. Plot N (number of nuclei) Vs time t.
    d. From the slope calculate the activity at different times.
10. LCR circuits.
    a. To compute the charge and discharge of RC circuit using DC source.
    b. To compute the charge and discharge of RC circuits using AC source.
    c. Analyse the energy in RL circuit using Runge-Kutta method.
    d. Study the energy dissipated in a series LCR circuit. Plot it versus time t.
11. Modelling of data.
    a. To compute for a given sample of data.
    b. To fit a given sample of data by least square method by a straight line.
    c. To fit by minimizing by straight line.
    d. To make a polynomial fit by least square method.
    e. To make a polynomial fit by minimizing.
12. Fourier transform special methods.
    a. To compute Fourier transform of discretely sampled data.
    b. To compute Fast Fourier transform of real functions and Sine and Cosine transformations.
    c. To compute Fourier transform of a given function in two or more dimensions.

Suggested Readings

1. R. C. Verma et al., Computational Physics An Introduction, New Age International.
2. C. Xavier, Fortran 77 and Numerical Methods, New Age International.
3. E. W. Schmid, G. Spitz and W. Losch, Theoretical Physics on the Personal Computer, Springer-Verlag.
4. W. H. Press, S. S. Teukolsky, W. T. Vetterling and B. P. Flanner, Numerical Recepies in FORTRAN, Cambridge University Press.
5. M. K. Jain et al., Numerical Methods for Scientific and Engineering and Computation, New Age Int. Pub.

PSPP6011: PROJECT PHASE I

(4 credits)

Objective: *During this phase the student will start a project applying the knowledge acquired during the first two semesters and also incorporating the recent trends in the chosen area. It should include phases of design, implementation and reporting. This project is to be executed individually within or outside the campus. The mode and components of evaluation and the weightages attached to them shall be published by the Department/Institute at the beginning of the semester.*

E-resource for learning:

LaTeX, www.spokentutorial.org

PSPR6012: PROJECT PHASE II

(6 credits)

Objective: *During this phase the student will complete the project started in the previous semester. The final implementation of the project and report writing shall be done in this semester. The student shall be required to make a number of presentations to report on the progress of the project. There will be a viva voce examination which shall follow the final submission of the project report. The mode and components of evaluation and the weightages attached to them shall be published by the Department/Institute at the beginning of the semester.*

PSPM6013: PLASMA PHYSICS LABORATORY
(4 Credits)

At least 10 experiments should be performed from the following

1. Experimental determination of minimum breakdown voltage in a glow discharge system.
2. To study the effect of variation in chamber pressure on different regions of a glow discharge.
3. To study the effect of variation in discharge voltage on different regions of a glow discharge.
4. To plot the I-V characteristics of a glow discharge plasma.
5. To find the variation in resistance of a glow discharge plasma with chamber pressure.
6. To find the variation in resistance of a glow discharge plasma with discharge voltage.
7. To find the variation in floating potential with discharge voltage of a plasma using Langmuir probe.
8. To find the variation in floating potential with chamber pressure of a plasma using Langmuir probe.
9. To find the plasma potential of a plasma using Langmuir.
10. To find the electron temperature of a plasma using Langmuir probe.
11. To find the electron density of a plasma using Langmuir probe.
12. Identification of different ions/atoms/molecules in plasma by optical emission spectroscopy (OES).
13. To find the plasma density by optical emission spectroscopy (OES) using Stark Broadening of hydrogen lines.
14. To find the plasma temperature by optical emission spectroscopy (OES) using line intensity ratio method.
15. To find the plasma temperature by optical emission spectroscopy (OES) using Boltzmann Plot method.

PSEL6014: ELECTRONICS LABORATORY
(4 Credits)

At least 10 experiments should be performed from the following

1. Design of amplifiers: Transistor amplifiers with and without feedback.
2. Design of Integrator and Differentiator using Op-amp.
3. Op-amp linear applications: adders, subtractors, comparator.
4. Op-amp based active filters.
5. 555 timer as monostable multivibrator.
6. 555 timer as astable multivibrator.
7. 555 timer as bistable multivibrator
8. To verify the truth table of MUX and DEMUX.
9. Realization of 2:4 decoder and 4:2 encoder design.
10. To verify the truth table of one bit and four bit comparators using logic Gates.
11. Truth table verification of Flip-Flops: (i) RS-Type, (ii) D- Type, (iii) T- Type, (iv) J-K Master Slave
12. To study shift register in all its modes i.e. SIPO/SISO, PISO/PIPO.

PSNY6015: NANOPHYSICS LABORATORY
(4 Credits)

At least 10 experiments should be performed from the following

1. Calculate molarity for different solutions. Learn to use the scientific balance (adjustments, taring, etc.).
2. Prepare stock solution of the following (100 ml)
   - 10mM $Zn(NO_3)_2 . 6H_2O$
   - 10mM 100ml $C_6H_{12}N_4$
   - 25 mM $Na_3C_6H_5O_7$
3. Synthesize ZnO nanoparticles using hydrothermal process.

4. Perform seeding of pre-synthesized ZnO nanoparticles on glass substrate. Also perform direct seeding of ZnO particles on glass substrate by thermal oxidation.
5. Grow ZnO nanorods on glass substrate hydrothermally.
6. Synthesize ZnS nanoparticles using hydrothermal process.
7. Synthesize manganese doped ZnS nanoparticles using hydrothermal process.
8. Make film of ZnO nanoparticles on glass substrate using the LBL machine.
9. Use Super-hydrophobicity testing machine to find out the roll-off and contact angle of a nanoparticle coated surface.
10. Synthesize CdS nanoparticles using hydrothermal process. Observe colour variations with size when illuminated with UV light.
11. Synthesize gold nanoparticles using Turkevitch process.
12. Sample preparation for different characterization techniques.
13. UV-vis spectroscopy to study optical properties of nanomaterials.
14. Tauc's plot to determine band gap of semiconductors.
15. Electron Microscopy Imaging of metallic and semiconducting nanoparticles.
16. Analyzing SAED patterns.
17. Measurement of lattice fringes in TEM images using ImageJ software.
18. Analyzing EDS plots.
19. Extracting information from XRD plots.
20. Measurement of WCA and ROA for different nanomaterial coated substrates.
21. PL spectroscopy on luminescent nanoparticles.

PSTC6016: PHYSICS LAB FOR TECHNOLOGISTS

(2 credits) (L-T-P:0-0-4)

Note: For details see page 560 of *Regulations and Syllabus, School of Technology*

PSEG6017: PHYSICS LAB FOR ENGINEERS

(1 credit) (L-T-P:0-0-2)

Note: For details see page 560 of *Regulations and Syllabus, School of Technology*

PSMY6101: MATHEMATICAL PHYSICS-I LABORATORY

(4 Credits)

At least 10 experiments should be performed from the following

Topics	**Description with Applications**
Introduction and Overview	Computer architecture and organization, memory and Input/output devices
Basics of scientific computing	Binary and decimal arithmetic, Floating point numbers, algorithms, Sequence, Selection and Repetition, single and double precision arithmetic, underflow &overflow- emphasize the importance of making equations in terms of dimensionless variables, Iterative methods
Errors and error Analysis	Truncation and round off errors, Absolute and relative errors, Floating point computations.
Review of C & C++ Programming fundamentals	Introduction to Programming, constants, variables and data types, operators and Expressions, I/O statements, scanf and printf, c in and c out, Manipulators for data formatting, Control statements (decision making and looping statements) (If-statement. If-else Statement. Nested if Structure. Else-if Statement. Ternary Operator. Goto Statement. Switch Statement. Unconditional and Conditional Looping. While Loop. Do-While Loop. FOR Loop. Break and Continue Statements. Nested Loops), Arrays (1D & 2D) and strings, user defined functions, Structures and Unions, Idea of classes and objects

Programs	Sum & average of a list of numbers, largest of a given list of numbers and its location in the list, sorting of numbers in ascending descending order, Binary search
Random number generation	Area of circle, area of square, volume of sphere, value of pi (π)
Solution of Algebraic and Transcendental equations by Bisection, Newton Raphson and Secant methods	Solution of linear and quadratic equation, solving ; in optics
Interpolation by Newton Gregory Forward and Backward difference formula, Error estimation of linear interpolation	Evaluation of trigonometric functions e.g. sin θ, cos θ, tan θ, etc.
Numerical differentiation (Forward and Backward difference formula) and Integration (Trapezoidal and Simpson rules), Monte Carlo method	Given Position with equidistant time data to calculate velocity and acceleration and vice versa. Find the area of B-H Hysteresis loop
Solution of Ordinary Differential Equations (ODE) First order Differential equation Euler, modified Euler and Runge-Kutta (RK) second and fourth order methods	First order differential equation • Radioactive decay • Current in RC, LC circuits with DC source • Newton's law of cooling • Classical equations of motion • Attempt following problems using RK 4 order method: • Solve the coupled differential equations for four initial conditions x(0) = 0, y(0) = -1, -2, -3, -4. Plot x vs y for each of the four initial conditions on the same screen for 0 t 15
	The differential equation describing the motion of a pendulum is . The pendulum is released from rest at an angular displacement , i. e. (0) = α and (0) = 0. Solve the equation for = 0.1, 0.5 and 1.0 and plot P as a function of time in the range 0 t 8. Also plot the analytic solution valid for small (sin() =

PSMA6102: MECHANICS LABORATORY

(4 Credits)

At least 10 experiments should be performed from the following

1. Measurements of length (or diameter) using vernier caliper, screw gauge and travelling microscope.
2. Study the random error in observations.
3. Determine the height of a building using a Sextant.
4. Study the Motion of Spring and calculate (a) Spring constant, (b) g and (c) Modulus of rigidity.
5. Determine the Moment of Inertia of a Flywheel.
6. Determine g and velocity for a freely falling body using Digital Timing Technique
7. Determine Coefficient of Viscosity of water by Capillary Flow Method (Poiseuille's method).
8. Determine the Young's Modulus of a Wire by Optical Lever Method.
9. Determine the Modulus of Rigidity of a Wire by Maxwell's needle.
10. Determine the elastic Constants of a wire by Searle's method.
11. Determine the value of g using Bar Pendulum.
12. Determine the value of g using Kater's Pendulum.

PSEM6103: ELECTRICITY AND MAGNETISM LABORATORY

(4 Credits)

At least 10 experiments should be performed from the following

1. Use a Multimeter for measuring (a) Resistances, (b) AC and DC Voltages, (c) DC Current, (d) Capacitances, and (e) Checking electrical fuses.
2. Study the characteristics of a series RC Circuit.
3. Determine an unknown Low Resistance using Potentiometer.
4. Determine an unknown Low Resistance using Carey Foster's Bridge.
5. Compare capacitances using De'Sauty's bridge.
6. Measurement of field strength B and its variation in a solenoid (determine dB/dx)
7. Verify the Thevenin and Norton theorems.
8. Verify the Superposition, and Maximum power transfer theorems.
9. Determine self inductance of a coil by Anderson's bridge.
10. Study response curve of a Series LCR circuit and determine its (a) Resonant frequency, (b) Impedance at resonance, (c) Quality factor Q, and (d) Band width.
11. Study the response curve of a parallel LCR circuit and determine its (a) Anti- resonant frequency and (b) Quality factor Q.
12. Measurement of charge and current sensitivity and CDR of Ballistic Galvanometer
13. Determine a high resistance by leakage method using Ballistic Galvanometer.
14. Determine self-inductance of a coil by Rayleigh's method.
15. Determine the mutual inductance of two coils by Absolute method.

PSWO6104: WAVES AND OPTICS LABORATORY

(4 Credits)

At least 10 experiments should be performed from the following

1. Determine the frequency of an electric tuning fork by Melde's experiment and verify λ2 –T law.
2. Investigate the motion of coupled oscillators.
3. Study Lissajous Figures.
4. Familiarization with: Schuster`s focusing; determination of angle of prism.
5. Determine refractive index of the Material of a prism using sodium source.
6. Determine the dispersive power and Cauchy constants of the material of a prism using mercury source.
7. Determine the wavelength of sodium source using Michelson's interferometer.
8. Determine wavelength of sodium light using Fresnel Biprism.
9. Determine wavelength of sodium light using Newton's Rings.
10. Determine the thickness of a thin paper by measuring the width of the interference fringes produced by a wedge-shaped Film.
11. Determine wavelength of (1) Na source and (2) spectral lines of Hg source using plane diffraction grating.
12. Determine dispersive power and resolving power of a plane diffraction grating.

SCHOOL OF FUNDAMENTAL AND APPLIED SCIENCES

DEPARTMENT OF CHEMISTRY

CHES0002: ENVIRONMENTAL STUDIES
(2 Credits - 30 Hours)

Objective: *This course is designed to enhance knowledge skills and attitude to environment. It will help a student to get a broad exposure to problems facing our environment.*

Module I: The Multidisciplinary Nature of Environmental Studies (3 hours)

Definition, scope and importance, need for public awareness.

Module II: Natural Resources (3 hours)

a. Different types of natural resources and associated problems - forest resources, water resources, mineral resources, food resources, energy resources, land resources.
b. Conservation of natural resources.

Module III: Ecosystems (4 hours)

a. Concept of an ecosystem, structure and function of an ecosystem, producers, consumers and decomposers, energy flow in the ecosystem, food chains, food webs.
b. Structure of following ecosystems - forest ecosystem, grassland ecosystem, desert ecosystem, aquatic ecosystems.

Module IV: Biodiversity and Its Conservation (4 hours)

Types of biodiversity – genetic, species and ecosystem, value of biodiversity, global biodiversity, India as a mega-diversity nation, threats to biodiversity, conservation of biodiversity - in-situ and ex-situ conservation.

Module V: Environmental Pollution (6 hours)

a. Definition, causes, effects and control measures of - air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards and e-pollution.
b. Solid waste management
c. Disaster management

Module VI: Social Issues and the Environment (6 hours)

a. From unsustainable to sustainable development, urban problems related to energy, water conservation, rain water harvesting, climate change, global warming, acid rain, ozone layer depletion.
b. Environment protection act.
v. Introduction to environmental impact assessment.

Module VII: Human Population and the Environment (4 hours)

Population growth and sex ratio; Population explosion - family welfare programme; Environment and human health; HIV/AIDS; Role of information technology in environment and human health.

Suggested Readings

1. Erach Bharucha; Textbook for Environmental Studies, UGC, New Delhi
2. S. Somvanshi and R. Dhupper; Fundamentals of Environmental Studies, S.K. Kataria and Sons Publisher.
3. A.K. De; Environmental Chemistry, New age publishers.
4. J.P. Sharma; Environmental Studies, University Science Press
5. K.G. Bhattacharyya and A. Sarma; Comprehensive Environmental Studies, Narosa Publishing House Pvt, Ltd.

CHIC0003: FUNDAMENTALS OF INORGANIC CHEMISTRY

(4 Credits - 60 Hours)

Objective: *This course is designed to deal with the concept of acids and bases, properties of transition metals and transition metal complexes.*

Module I: Concepts of Acids and Bases (10 hours)

Hard and soft acid-base concept, non-aqueous solvents, redox chemistry

Module II: Transition Metal Chemistry (8 hours)

Descriptive chemistry of transition metals including lanthanides and actinides, coordination chemistry - coordination number and geometry, isomerism, thermodynamic stability - successive and overall stability constants, Irving-William series, chelate and macrocyclic effects.

Module III: Bonding in Inorganic and Coordination Compounds (20 hours)

VBT (hybridization), CFT and their limitations, ligand field theory, d-orbital wave functions, d-orbital splitting in octahedral, square planar, square pyramidal, trigonalbipyramidal, and tetrahedral complexes; Jahn-Teller distortion, CFSE for d^1 to d^{10} systems, pairing energy, low-spin and high-spin complexes and molecular orbital (MO) theory of selected octahedral, tetrahedral complexes and other geometries, Walsh Diagram.

Module IV: Electronic Spectra of Transition Metal Complexes (12 hours)

d-d transition, charge transfer transition, color, intensity and origin of spectra, interpretation,term symbols and splitting of terms different geometries, selection rules for electronic transitions, correlation, Tanabe-Sugano and Orgel diagrams, calculation of Dq, B and C, nephelauxetic ratio.

Module V: Magnetic Properties of Transition Metal Complexes (10 hours)

Magnetic properties of free ions, types of magnetic behavior: dia-, para-, ferro- and antiferro-magnetism, temperature independent paramagnetism, magnetic susceptibility - Van Vleck equation, experimental measurement, magnetic moment - orbital contribution, quenching of contribution, effect of spin orbit coupling, spin crossover, temperature dependence of magnetic susceptibility, exchange coupling effects, magnetic properties of second and third transition series and lanthanides

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the fundamental concepts of Inorganic Chemistry that includes understanding the concept of hard and soft acids and bases, the behavior of inorganic nonaqueous solvents, the properties of transition metals and their complexes (*Knowledge*)

CO2: Have a conceptual understanding of the (i) periodic variation of the strength of acids and bases, their classification and applications (ii) general characteristics, structure, theory, reactivity and applications of coordination compounds (*Comprehension*)

CO3: Predict geometries of coordination complexes, the types of electronic transitions that take place giving rise to colour, they should be able to predict whether a transition metal complex will be dia-, para-, ferro- or antiferro magnetic (*Application*)

CO4: Explain why a certain transition metal complex will be ferro- or para- magnetic, or have tetrahedral or octahedral geometry (*Analysis*)

CO5: How to design transition metal complexes whose properties they can predict (*Synthesis*)

CO6: Students will have an overall understanding of acids and bases, on the properties of transition metal complexes such as the nature of bonding in coordination complexes, their electronic and magnetic properties and resultant applications (*Evaluation*)

Suggested Readings

1. J. E. Huheey, E. A. Keiter and R. L. Keiter; Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education.
2. B. N. Figgis, M. A. Hitchman; Ligand Field theory and its Applications, Wiley India.
3. G. L. Miessler, D Tarr; Inorganic Chemistry, Pearson Education.
4. P.W. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong; Shriver and Atkins: Inorganic Chemistry, Oxford University Press.

5. A.K. Das and M. Das; Fundamental Concepts of Inorganic Chemistry, Vols. 1-7, CBS Publishers and Distributors.
6. H.J. Arnikar; Essentials of Nuclear Chemistry, Wiley Eastern, New Delhi.
7. F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann; Advanced Inorganic Chemistry,Wiley.
8. C. E. Housecroft and A. G. Sharpe; Inorganic Chemistry, Prentice Hall.
9. F. A. Cotton; Chemical Applications of Group Theory, Wiley.
10. S. A. Cotton; Lanthanide and Actinide Chemistry, John Wiley.
11. G. Fridlander, J.W. Kennedy, E. S. Macias, and J. M. Miller; Nuclear and Radiochemistry, John Wiley, New York.
12. M. Weller, F. Armstrong, J. Rourke, T. Overton; Inorganic Chemistry, Oxford University Press.
13. R. L. Dutta, A. Syamal; Elements of Magnetochemistry, Affiliated East-West Press Pvt. Ltd.-New Delhi.
14. F. E. Mabbs, D. J. Machin; Magnetism and Transition Metal Complexes, Dover Pub.Inc.

CHOC0004: FUNDAMENTALS OF ORGANIC CHEMISTRY

(4 Credits - 60 hours)

Objective: *This course is designed to make the students familiar with reaction mechanisms, reactivity of organic compounds and the stereochemistry.*

Module I: Kinetics and Energetics of Reaction Mechanism (15 hours)

Transition state theory of reaction rates - kinetics and thermodynamics of activation, reaction profiles for multistep reactions, Hammond postulate, Curtin-Hammett Principle, kinetic and thermodynamic control, Linear free energy relationships (LFER), Hammett equation - substituent and reaction constants, the Taft treatment of polar and steric effects in aliphatic compounds, kinetic isotope effects in organic reactions, effects of conformation on reactivity, stereoelectronic effects, neighbouring group participation, anomeric effect.

Module II: Reaction Mechanisms and Intermediates (Structure and Reactivity) - I (15 hours)

a) Carbanions: enolates and enamines, kinetic and thermodynamic enolates, lithium and boron enolates in Aldol and Michael reactions, alkylation and acylation of enolates, name reactions under carbanion chemistry - Claisen, Dieckmann, Knoevenegal, Stobbe, Darzen, Acyloin condensations, Shapiro reaction, Julia olefination, Brook rearrangement, Sakurai reaction, Henry reaction, Kulinkovich reaction, Nef reaction, Baylis-Hillman reaction.
b) Ylids: Chemistry of phosphorous and sulfur ylids - Wittig and related reactions, Peterson olefination
c) Carbocations: structure and stability of carbocations, classical and non-classical carbocations, neighbouring group participation and rearrangements including Wagner-Meerwein, pinacol-pinacolone, semi-pinacol rearrangement, C-C bond formation involving carbocations, oxymercuration, halolactonisation,Tishchenko reaction, Ritter reaction, Prins reaction.

Module III: Reaction Mechanisms and Intermediates (Structure and Reactivity) - II (15 hours)

a) Carbenes and Nitrenes: Structure of carbenes, generation of carbenes, addition and insertion reactions, rearrangement reactions of carbenes such as Wolff rearrangement, generation and reactions of ylids by carbenoid decomposition (existence of O and N based ylids), Structure of nitrene, generation and reactions of nitrene and related electron deficient nitrogen intermediates, Curtius, Hoffmann, Schmidt, Beckmann rearrangement, structure and reactivity of benzynes.
b) Radicals: Generation of radical intermediates and its addition to alkenes, alkynes (inter AND intramolecular) for C-C bond formation and Baldwin's rules, name reactions involving radical intermediates such as Barton deoxygenation and decarboxylation, McMurry coupling.

Module IV: Stereochemistry (15 hours)

a) Classification of organic molecules into different Point Groups, R and S, E and Z nomenclature in C, N, S, P containing compounds, concept of absolute and relative
b) Configuration, chirality in molecules devoid of chiral centres - allenes, spiranes and biphenyls.

c) Concepts of stereogenic centres – chirotopic and achirotopic centres, homotopic and heterotopic ligands and faces, optical purity and enantiomeric excess, conformation of acyclic organic molecules, cyclohexane and decalins.

d) Dynamic stereochemistry, stereoselective synthesis, classification of stereoselective synthesis, diastereoselective, enantioselective and double stereo-differentiating reactions, nucleophilic addition to aldehyde and acyclic ketones, Prelog's rule, nucleophilic addition to cyclic ketones.

e) Enantioselective synthesis, use of chiral reagent, chiral catalyst and chiral auxiliary, stereospecific and stereoselective reactions

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Unique features of organic reactions mechanism, reaction intermediates, stereochemistry and reaction kinetics and principles involved in it (*Knowledge*)

CO2: Understand application of reaction mechanism and stereochemistry in different reactions as well as products (*Comprehension*)

CO3: Apply their skills for getting the stereochemistry of the product, mechanism of different reactions (*Application*)

CO4: Different problems related to organic reaction mechanisms, stereochemistry (*Analysis*)

CO5: Understanding of application of reaction mechanism of different types of reactions involving reactive intermediates like carbocation, carbanion, carbene etc and would be able to provide analytical solution towards their synthesis (*Synthesis*)

CO6: Demonstrate the unique features of organic reaction mechanism, reaction mechanism and stereochemistry (*Evaluation*)

Suggested Readings

1. F. A. Cary and R. I. Sundberg; Advanced Organic Chemistry, Part A and B,Springer.
2. A. J. Kirby; Stereoelectronic Effects,OUP.
3. W. Carruthers and I. Coldham; Modern methods of Organic Synthesis, South Asian Edition, Cambridge University Press.
4. T. H. Lowry, K. S. Richardson; Mechanism and Theory in Organic Chemistry.
5. J. Clayden, N. Greeves, S. Warren, Organic Chemistry.
6. E. V. Anslyn, D. A. Dougherty; Modern Physical Organic Chemistry, University Science Books.

CHPC0005: FUNDAMENTALS OF PHYSICAL CHEMISTRY

(4 Credits - 60 hours)

Objective: *This course is designed to give the students a basic understanding of equilibrium, non-equilibrium and statistical thermodynamics, polymer chemistry and some concepts of sampling and data analysis.*

Module I: Equilibrium and Non-equilibrium Thermodynamics (22 hours)

a) Laws of thermodynamics, state and path functions and their applications, Maxwell's relations, spontaneity and equilibria, Le Chatelier principle.

b) Non-ideal system - thermodynamics of real gases and gas mixtures, fugacity and its determination, non-ideal solutions, activity and activity coefficient, different scales of activity coefficient, electronic activity coefficients.

c) Phase equilibrium - thermodynamic criteria of phase equilibrium, Gibbs phase rule and its application to three component systems - triangular plots - water-acetic acid-chloroform system and ammonium chloride-ammonium sulphate-water system.

d) Non-equilibrium thermodynamics - forced flows and entropy of production, coupled flows and phenomenological relations, Onsager reciprocal relations, thermodynamic effects -Seebeck, Peltier and Thomson effects.

Module II: Statistical Thermodynamics (22 hours)

a) Statistical mechanics of systems independent particles - Maxwell Boltzmann distribution, entropy and probability, calculation of thermodynamic properties for independent particles, molecular partition functions, evaluation of translational, rotational and vibrational and nuclear partition functions.

b) Thermodynamic properties of monatomic and diatomic gases (Suckur Tetrode equation), calculation of partition functions, thermodynamic function, principles of equipartition, heat capacities (Einstein model and Debye modification), residual entropy, equilibrium constant.

Module III: Polymer Chemistry (8 hours)

Molecular weight of polymers, determination of molecular weight, kinetics of polymerization reaction, copolymerization, average dimension of polymer molecules, size exclusion chromatography.

Module IV: Sampling and Data Analysis: (8 hours)

Sampling of solid, liquid and gaseous samples, mean and standard deviation, absolute and relative errors, linear regression, covariance and correlation coefficient

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Recall the fundamental laws of thermodynamics, different thermodynamic functions, structure of polymer molecules and analysis of chemical data (*Knowledge*)

CO2: Understand application of thermodynamics in different field such as non- ideal system, phase equillibria, non- equilibrium system. They would also have some idea about the size of a polymer molecule as well as their mechanism of formation (*Comprehension*)

CO3: Apply thermodynamics in real gases, to some three component systems and to microsystem. They would also able to separate polymers molecules according to their sizes. (*Application*)

CO4: Analyse application of thermodynamics in both micro and macro system (*Analysis*).

CO5: Understanding of application of thermodynamics and polymerization process (*Synthesis*)

CO6: Apply thermodynamics to different systems, calculate size of polymer molecules and analyse results of different chemical experiment from the statistical point of view (*Evaluation*)

Suggested Readings

1. P. Atkins, J. Paula; Physical Chemistry,Oxford University Press.
2. I. R. Levine, Physical chemistry, Mcgraw Hill Education.
3. D. A. McQuarrie, J. D. Simon; Physical Chemistry: A Molecular Approach, Viva Student Edition.
4. R. S. Berry, S. A. Rice and J. Ross; Physical Chemistry, Oxford University Press.
5. D. A. McQuarrie; Statistical Mechanics, University Science Books, California.
6. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar, Vogel's Textbook of Quantitative Chemical Analysis, Pearson.
7. V. R. Gowarikar, N. V. Viswanathan, J. Sreedhar; Polymer Science, New age International Publishers.
8. G. Odian; Principles of Polymerization, Wiley Student Edition.

CHQG0006: INTRODUCTION TO QUANTUM CHEMISTRY AND GROUP THEORY

(3 Credits-45 hours)

Objective: *This course serves to introduce the concepts of quantum chemistry and group theory to students*

Module I: Quantum Chemistry I (15 hours)

Planck's theory, wave-particle duality, uncertainty principle, postulates of quantum mechanics, Schrodinger equation, free particle, particle in a box, degeneracy, harmonic oscillator, rigid rotator, the hydrogen atom, angular momentum, electron spin, spin-orbit coupling.

Module II: Quantum Chemistry II (15 hours)

Approximate methods in quantum mechanics - the variation theorem, linear variation principle and perturbation theory (first order and non-degenerate), application of variation method and perturbation theory to the Helium atom, antisymmetry, Slater determinant, term symbols and spectroscopic states

Module III: Chemical Applications of Group Theory (15 hours)

Symmetry elements and operations, equivalent symmetry elements and equivalent atoms, identification of symmetry point groups with examples, groups of very high symmetry, molecular dissymmetry and optical activity, systematic procedure for symmetry classification of molecules and illustrative examples, brief review of matrix representation of groups, reducible and irreducible representations, rules about irreducible representations as derived from great orthogonality theorem, relationship between reducible and irreducible groups, character tables.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understand fundamental concepts of quantum chemistry and group theory such as the postulates and theorems of quantum mechanics, complete solution of the Schrödinger equation for one electron systems, approximation methods for multi-electron systems, properties of symmetry groups, assigning symmetry point groups to molecules, irreducible representations of groups (*Knowledge*)

CO2: Explain the concepts of operators, eigenfunctions and eigenvalues and their uses in solving the Schrodinger equation for ideal systems, application of approximation methods applied to multi-electron atoms, symmetry classes and groups, degenerate and nondegenerate representations (*Comprehension*)

CO3: Apply the concepts they learn to calculate properties of simple systems e. g., calculating the probability of an electron occupying a certain energy state inside a well or a box, or the probability of finding an electron outside a potential well, and also determine the symmetry operations that can be applied to a molecule in group theory (*Application*)

CO4: Apply the concepts they learn to solve numerical problems such as writing the Schrodinger equation for a multi-electron atom or devising a trial variation wave function for a particle in a 1-D box (*Analysis*)

CO5: Differentiate between cases when an exact solution of the Schrodinger equation is possible and cases when an exact solution is not possible, they should be able to differentiate between applicability of different approximation methods in quantum chemistry and be able to assign point groups and calculate the character table for a particular point group in group theory (*Evaluation*)

CO6: Design simple problems in quantum chemistry and group theory by incorporating the different concepts they learn (*Synthesis*)

Suggested Readings

1. P. Atkins, R. Friedman; Molecular quantum Mechanics, Oxford University Press.
2. I. N. Levine, Quantum Chemistry, PHI Learning Pvt. Ltd.
3. David J. Griffiths; Introduction to Quantum mechanics, Pearson Education Ltd.
4. F. A. Cotton; Chemical Applications of Group Theory, Wiley India Pvt. Ltd.
5. R. L. Carter; Molecular Symmetry and Group Theory, John Wiley & Sons.

CHIR0007: ADVANCED INORGANIC CHEMISTRY I

(4 Credits-60 hours)

Objective: The objective of this course is to teach students core concepts of organometallic chemistry, inorganic reaction mechanisms, inorganic photochemistry, solid state chemistry, and structure and bonding in different inorganic compounds.

Module I: Descriptive Inorganic Chemistry (15 hours)

a) Structure and bonding in polyhedral boranes and carboranes, styx notation, Wade's rules, electron count in polyhedral boranes, synthesis of polyhedral boranes, isolobal analogy, boron halides, phosphine-boranes, boron heterocycles, borazine.
b) Silanes, silicon halides, silicates, silicones, silanols, zeolites, germanium, tin and lead organyls,silenes, germenes, stannenes, phosphorous halides, phosphazenes, sulphur halides, structural features and reactivity of S-N heterocycles.
c) Synthesis and reactivity of organo-lithium, -beryllium and -magnesium compounds,calixarines, cryptands and crown ethers in complexation chemistry.

d) Preparation and reactivity of aluminumorganyls, carbalumination, hydroalumination, chemistry of Ga (I) and In (I), reduction of Al, Ga and In organyls, Metal organic framework structures (MOFs)

Module II: Introduction to Solid State Chemistry (10 hours)

Structure of simple solids – metals, alloys and compounds; common structure types; synthesis of solid state compounds - ceramic method, microwave synthesis, sol-gel, precursor method, hydrothermal synthesis, CVD and intercalation; characterization of solids, bonding in solids – free-electron and molecular orbital theory; bands in solid state compounds, properties of solids – optical, magnetic and electrical properties of solids.

Module III: Organometallic Chemistry (10 hours)

a) Valence electron count (16/18 electron rules), synthesis, structure, bonding and reactivity of mono and polynuclear metal carbonyls, substituted metal carbonyls, vibrational spectra of metal carbonyls, metal-metal bonding.
b) Types of M-C bonds, synthesis and reactivity of metal alkyls, carbenes, alkenes, alkynes, and arene complexes, metallocenes and bent metallocenes, isolobal analogy.
c) Reactions of organometallic complexes: Substitution, oxidative addition, reductive elimination, insertion and deinsertion, catalysis, hydrogenation, hydroformylation, Monsanto process, Wacker process, alkene polymerization.

Module IV: Mechanism of Inorganic Reactions (7 hours)

Substitution in octahedral and square planar complexes, lability, trans-effect, conjugate base mechanism, racemisation, electron transfer reactions - inertness and lability, inner sphere and outer sphere mechanism, Marcus theory, solid state reactions – topotactic and epitactic mechanisms.

Module V: Inorganic Photochemistry (3 hours)

Photosubstitution and photoredox reactions of chromium, cobalt and ruthenium compounds, Ligand field and charge transfer state (Thexi and DOSENCO states), cis-trans isomerization, photocatalysis and solar energy conservation by ruthenium complexes.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understand the concepts of organometallic chemistry, inorganic reaction mechanisms, inorganic photochemistry, solid state chemistry and structure and bonding in different inorganic compounds (*Knowledge*)
CO2: Interpret information based on their understanding of the concepts of bonding, structure, photochemistry and reaction mechanism of different inorganic compounds (*Comprehension*)
CO3: Solve problems which arise in different industrial and analytical fields by knowing the characteristics of the inorganic compounds (*Application*)
CO4: Apply their idea for using different inorganic compounds in different industrial fields (*Analysis*)
CO5: Identify the inorganic compounds for their suitable analytical and industrial use (*Synthesis*)
CO6: Judge and assess the inorganic compounds based on their structure and reactivity (Evaluation)

Suggested Readings

1. Cotton, F. A., Wilkinson, G., Murillo, C. A. and Bochmann, M., Advanced Inorganic Chemistry, Wiley.
2. Greenwood, N. N. and Earnshaw, E. A., Chemistry of elements, Butterworth-Heinemann.
3. Huheey, J. E., Keiter, E. A., . Keiter, R. L., Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education.
4. Miessler, G. L., Tarr, D., Inorganic.Chemistry, Pearson Education.
5. Atkins, P.W., Overton, T., Rourke, J., Weller, M., Armstrong, F., Shriver & Atkins: Inorganic Chemistry, Oxford University Press.
6. Douglas, B. E., McDaniel, D. H., Alexander, J. J. Concepts and Models of Inorganic Chemistry, John Wiley.
7. Wulfsberg, G., Inorganic Chemistry, University Science Books.
8. Smart, L., Moore, E. Solid State Chemistry: An Introduction, Nelson Thorns Ltd.

9. Das, A. K. and Das, M., Fundamental Concepts of Inorganic Chemistry, Vols. 1-7, CBS Publishers and Distributors
10. Crabtree, R. H., Organometallic Chemistry of the Transition Metals, John Wiley.
11. Basalo, F. and Pearson, R. G. Mechanisms of Inorganic Reactions, John Wiley

CHOG0008: ADVANCED ORGANIC CHEMISTRY I

(4 Credits- 60 hours)

Objective: This course will discuss nucleophilic, electrophilic and elimination reaction mechanisms along with various oxidation-reduction methods.

Module I (15 hours)

a) Nucleophilic Substitution: S_N1, S_N2 and related mechanisms; Factors influencing reaction rates; Neighbouring group participation by π- and σ-bond; Anchimeric assistance; Aromatic Nucleophilic Substitution: The SNAr, S_N1, benzyne and SR_N1 mechanisms. Reactivity; effect of substrate structure, leaving group and attacking nucleophile; The S_Ni mechanism.Nucleophilic substitution at an allylic, aliphatic trigonal and a vinyl carbon.Aromaticity, antiaromaticity and homoaromaticity.

b) Electrophilic Substitution: Aliphatic: Bimolecular mechanisms: SE1, SE2 and SEi. The SE1mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving group and the solvent polarity on the reactivity. Aromatic: The arenium ion mechanism, orientation and reactivity, energy profile diagrams. The ortho/para ratio, ipso attack, orientation in other ring systems.

Module II (15 hours)

a) Elimination reactions: Mechanism and stereochemistry of different types of elimination reactions; Effects of substrate structure, attacking base, leaving group and medium; Formation of other double bonds (C=N, C=O) and triple bonds by elimination reactions; Mechanism and orientation in pyrolytic elimination.

b) Miscellaneous Reactions: Biginelli reaction, Passerini reaction, Nazarov cyclisation, Pd-catalyzed reactions, Vilsmeier Hack reaction, Ugi reaction, Robinson annulations, Mitsonobu reaction, Appel reaction, Favoriskii rearrangement.

Module III Oxidation Reactions (15 hours)

Metal and non-metal based oxidations (Cr, Mn, Al, Ag, Os, Ru, Se, DMSO, hypervalent iodine), reagents (Fremy's salt, silver carbonate, peroxides/per-acids), Sharpless asymmetric epoxidation, Jacobsen epoxidation, Shi epoxidation, Sharpless asymmetric dihydroxylation, Baeyer-Villiger oxidation, Wacker oxidation, hydroboration-oxidation, Prevost reaction and Woodward modification.

Module IV Reduction Reactions (15 hours)

Catalytic hydrogenation (Pd/Pt/Rh/Ni), Wilkinson catalyst, Noyori asymmetric hydrogenation, metal based reductions using Li/Na/Ca in liquid ammonia, Sodium, Magnesium, Zinc, Titanium and Samarium (Birch, Pinacol formation, McMurry, Acyloin formation, dehalogenation and deoxygenations), Hydride transfer reagents from Group III and Group IV in reductions ($NaBH_4$triacetoxyborohydride, L-selectride, K-selectride, Luche reduction, $LiAlH_4$, DIBAL-H, and Red-Al, Trialkylsilanes and Trialkylstannane, Meerwein-Pondorff-Verley reduction), stereo/enantioselective reductions (Chiral Boranes, Corey-Bakshi-Shibata).

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Acquire the detailed knowledge on electrophilic substitution, nucleophilic substitution, elimination, organic oxidation and reduction reactions (*Knowledge*)

CO2: Understand how to apply the concept of mechanisms and different types of reactions in the synthetic organic chemistry research field (*Comprehension*)

CO3: Apply the knowledge of mechanisms and different types of reactions in the synthetic organic chemistry research field (*Application*)

CO4: Solve different problems related to organic reaction mechanisms (*Analysis*)

CO5: Understanding of application of reaction mechanism of different types of reactions (*Synthesis*)

CO6: Demonstrate the important features of basic organic reactions like electrophilic substitution reaction, nucleophilic substitution, elimination and oxidation-reduction reactions (*Evaluation*)

Suggested Readings

1. Cary, F. A., Sundberg, R. I., Advanced Organic Chemistry, Part A and B, Springer.
2. Smith, M. B., Organic Synthesis, Academic Press.
3. Carruthers, W. and Coldham, I., Modern Methods of Organic Synthesis, South Asian Edition, Cambridge University Press.
4. Clayden, J., Greeves, N., Warren, S., Organic Chemistry, Oxford University Press.
5. Pine, S. H., Organic Chemistry (5th edn.), McGraw-Hill Bool (1987).
6. March, J. Advanced Organic Chemistry: Reactions, Mechanisms and Structure ,Wiley Student Edition, John Wiley & Sons Asia Pte. Ltd. (2005).
7. House, H. O. Modern Synthetic Reaction, (W. A. Benjamin Inc. 1972).

CHAP0009: ADVANCED PHYSICAL CHEMISTRY I

(4 Credits - 60 hours)

Objective: This course is intended to give students a deep understanding of the kinetics and reaction dynamics of chemical reactions as well as an insight into the principles of electrochemistry

Module I Chemical Kinetics (15 hours)

Theories of unimolecular reactions: Lindemann theory, drawbacks of Lindemann theory- Hinshelwood modification, RRK theory, Slaters treatment, RRKM theory. Steady state approximation and its applications, oscillating reactions, chemical chaos, Belousov-Zhabotinski reaction, straight chain reactions - hydrogen-halogen reactions, alkane pyrolysis, Branching-chain reactions - the hydrogen-oxygen reaction, explosion limits, Enzyme catalyzed reactions, Michaelis-Menten mechanism-Lineweaver-Burk and Eadie plots, enzyme inhibiton. Photochemistry - kinetics of photophysical and photochemical processes, complex photochemical processes

Module II Study of Fast Reactions (5 hours)

Stopped flow technique, temperature and pressure jump methods, NMR studies in fast reactions, shock tube kinetics, relaxation kinetics, Linearized rate equation, relaxation time in single step fast reactions, determination of relaxation time.

Module III Molecular Reaction Dynamics (15 hours)

Collisions of real molecules- trajectory calculations, Laser techniques, reactions in molecular beam, reaction dynamics, estimation of activation energy and calculation of potential energy surface-the transition state theory (TST) of bimolecular gaseous reactions, statistical and thermodynamic formulations. Comparison between TST and hard sphere collision theory, theory of unimolecular reactions- Lindemann theory and its limitations, kinetics of reactions in solution-diffusion controlled and chemically controlled reactions, TST of reactions in solution- Bronsted and Bjerrum equation, effect of ionic strength, kinetic salt effect.

Module IV Electrochemistry - I (10 hours)

a) Ion-solvent interaction- the Born model, Thermodynamic parameters of ion solvent interactions-structural treatment, the ion-dipole model-its modifications, ion-quadrupole and ion-induced dipole interactions.
b) Primary solution- determination of hydration number, compressibility method and viscosity-mobility method, Debye-Huckel theory of ion-ion interactions, derivation, validity and limitations, extended Debye-Huckel-Onsager equation, random walk model of ionic diffusion-Einstein Smoluchowski reaction.

Module V Electrochemistry - II (15 hours)

a) Theories of Electrical Interface: Electrocapillary phenomena - Lippmann equation, electron transfer at interfaces, polarizable, non polarizable and nonpolaisable interfaces, Butler-Volmer equation, Tafel plot

b) Electro-analytical Techniques: Potential step methods, potential sweep methods, Polarography and Pulse voltammetry, controlled current techniques, techniques based on impedance.

c) Systems for Electro-chemical Energy Storage and Conversion: Types of Batteries, Lead- acid batteries, Nickel-cadmium batteries and Li-ion batteries, electrical double layer capacitor, pseudo-capacitor, fuel cells.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Recall about kinetics of different types of chemical reaction including unimolecular, bimolecular and chain reactions. They would also able to recall the theories of electrochemistry (*Knowledge*)

CO2: Understand the application of kinetic theories to different systems, interactions of ionic species with solvent molecules, different electrochemical techniques, different types of batteries (*Comprehension*)

CO3: Apply the knowledge of kinetic theories to some important types of reactions and to learn the use of different analytical techniques, and batteries (*Application*)

CO4: Analyse the application of reaction rate theories to different system and to analyse the application of electrochemistry in different fields (*Analysis*)

CO5: Understanding of kinetics of chemical reaction and application of electrochemistry (*Synthesis*)

CO6: Calculate rate of different types chemical reactions, compare reaction rate theories, apply the electrochemical techniques to analyse samples, construct different types of batteries (*Evaluation*)

Suggested Readings

1. Atkins, P. and Paula, J. Physical Chemistry, Oxford University Press, Oxford.
2. Levine, I. R., Physical chemistry, Mcgraw Hill Education.
3. Laidler, K. J., Chemical Kinetics, Pearson.
4. Bockris, J. O., Reddy, A. K. N., Modern Electrochemistry Part 1, 2A and 2B, Springer.
5. Bard, A. J., Faulkner, L. R., Electrochemical Methods Fundamentals and Applications, Wiley India.

CHFS0010: FUNDAMENTALS OF SPECTROSCOPY

(3 Credits-45 hours)

Objective: This course introduces students to the concepts of a range of spectroscopic techniques including rotational, vibrational, electronic, magnetic resonance and Mössbauer spectroscopies as well as to mass spectrometry.

Module I: Interaction of light with matter (5 hours)

Fundamental aspects of absorption and emission spectroscopy, probability of transition, oscillator strength, dipole strength, Spontaneous and stimulated emission, origin of selection rules

Module II: Rotational and Vibrational Spectroscopy (10 hours)

Degrees of freedom of molecules, rigid rotor model, rotational spectra of diatomics and polyatomics, effect of isotopic substitution and non rigidity, selection rules and intensity distribution, Vibrational spectra of diatomics, effect of anharmonicity, Morse potential, Vibrational-rotational spectra of diatomics, P,Q,R branches, normal modes of vibration, overtones, hot bands, Raman spectroscopy - Origin, rotational and vibrational Raman spectra of diatomics.

Module III: Electronic Spectroscopy (12 hours)

Electronic spectra of diatomic molecules, Frank-Condon principle, vibronic transitions, Spectra of organic compounds, $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transition, Photoelectron Spectroscopy - basic principle, photoelectron spectra of simple molecules, X-ray photoelectron spectroscopy (ESCA), Auger electron spectroscopy,Lasers - Laser action, population inversion,properties of laser radiation,examples of simple laser systems.

Module IV: Magnetic Resonance Spectroscopy (10 hours)

a) Nuclear Magnetic Resonance: Nuclear spin and nuclear spin states in magnetic field, resonance phenomenon, relaxation process, NMR line shapes and saturation, shielding and de-shielding of magnetic nuclei, chemical shift, spin-spin interactions, spectra of two-spin system (A_2, AB and AX cases),^{13}C,^{19}F and ^{31}P NMR spectroscopy.

b) Electron Spin Resonance: Basic principles, factors affecting g values, hyperfine coupling, spin densities and McConnell relationship, Zero field splitting

Module V: Mass spectrometry and Mössbauer spectroscopy (8 hours)

a) Mass spectrometry:Basic principles, ionization techniques, isotope abundance, molecular ion, fragmentation processes of organic molecules, deduction of structure through mass spectral fragmentation

b) Mössbauer spectroscopy: Principles, instrumentation and applications

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: The different spectroscopic and spectrometric techniques that can be used for determining the structure and properties of known or unknown molecules (*Knowledge*)

CO2: The concepts of different spectroscopic technique and their uses (*Comprehension*)

CO3: Differentiate one spectroscopic technique from another (*Application*)

CO4: Decide which technique would be best suited for determining a particular property of a molecule e.g. if the mass of an unknown compound is to be determined, they should know that mass spectrometry can be used (*Analysis*)

CO5: Decide the set of steps necessary for the analysis of properties or structure of a molecule that may be totally or partially unknown (*Evaluation*)

CO6: Devise a series of experiments to characterize a molecule using a range of spectroscopic techniques (*Synthesis*)

Suggested Readings

1. Hollas, J. M., Modern Spectroscopy, Wiley
2. Banwell, C. N., McCash, E. M. Fundamentals of Molecular Spectroscopy, Tata McGraw Hill.
3. Pavia, D.L., Lampman, G. M., Kriz, G. S., Introduction to Spectroscopy, Brooks/Cole Cengage Learning.
4. Drago, R.S., Physical Methods in Chemistry, Saunders, Thomson Learning
5. Silverstein, R.M., Webster, F. X., Kiemle, D. J., Bryce, D. L., Spectrometric Identification of Organic Compounds, Wiley India
6. Kemp, W., Organic Spectroscopy, Palgrave Macmillan.
7. Field, L. D., Sternhell, S., Kalman, J. R., Organic Structures from Spectra, John Wiley and Sons.
8. Rankin, D.W.H., Mitzel, N., Morrison, C. Structural Methods in Molecular Inorganic Chemistry, Wiley.

CHGC0011: INTRODUCTION TO GREEN AND ENVIRONMENTAL CHEMISTRY

(3 Credits - 45 hours)

Objective: The course is aimed at familiarizing students with the concepts and techniques of environmental chemistry and introduction to green chemistry.

Module I: Environmental pollution (15 hours)

Chemistry and environmental pollution: Chemical hazards, chemical disasters, Water pollution, air pollution and soil pollution; agricultural pollution, pollution by plastics; environmental biochemistry, toxicological chemistry, e-pollution and nuclear hazard.

Environmental analysis: Analysis of water and wastewater, solid-wastes and air pollution.

Module II: Environmental protection (10 hours)

Environmental protection: pollution prevention, green chemistry, biodegradation, water and wastewater purification – removal of arsenic, iron, fluoride, etc.; air purification, waste minimization, industrial and municipal waste treatment and soil remediation

Module III: Principles and concepts of Green Chemistry (10 hours)

Green chemistry: Principles of green chemistry, development of green chemistry; atom economy reactions – rearrangement reactions, addition reactions; atom uneconomic reactions–sublimation, elimination; toxicity measures, need of green chemistry in day to day life.

Module IV: Emerging Green Technology and alternative energy sources (10 hours)

Design for energy efficiency, photochemical reactions – advantages, disadvantages; microwave technology in chemistry - microwave heating, microwave assisted reactions, ultrasound assisted reactions, reactions in organic liquids, reactions in aqueous media, electrochemical synthesis-examples. Supercritical solvents, ionic liquids, green catalyst, auto-exhaust catalyst and clean technology. Real world examples.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Acquire knowledge on environmental chemistry and concepts of environmental friendly chemistry (*Knowledge*)

CO2: Understand principles of green chemistry, green solvent, energy efficiency, renewable source of energy, cause, prevention of all types of pollution (*Comprehension*)

CO3: Apply their knowledge of green chemistry and environmental chemistry in the applied research field (*Application*)

CO4: Aanalyze and solve the problems related to environment (*Analysis*)

CO5: Identify the cause of environmental degradation and able to find the solution for its protection (*Synthesis*)

CO6: Implement the green techniques for research and development in the future course of time (*Evaluation*)

Suggested Readings

1. Manahan, S. E., Environmental Chemistry, 9 th edn (CRC Press, Boca Raton, 2010).
2. Anastas, P. T. and Warner, J. C., Green Chemistry: Theory and Practice, (Oxford University Press, 1998).
3. Moore, J. W. & Moore, E. A., Environmental Chemistry, Academic Press, London (1976).
4. Lancaster, M., Green Chemistry: An Introductory Text, RSC.
5. Hutzinger, O., Handbook of Environmental Chemistry, Springer-Verlag, 1991.
6. Cann, M. C. & Connelly, M. E., Real World Cases in Green Chemistry, ACS, , 2000.

CHAI0012: ADVANCED INORGANIC CHEMISTRY II (FOR BATCH 2017-2019)

(4 Credits - 60 hours)

Objectives*: The objective of this course is to teach students core concepts of analytical techniques used in inorganic analysis, the role of metal ions in the function of biological macromolecules, supramolecular chemistry and nanomaterials*

Module I: Special Analytical Techniques (25 hours)

a) Principles and applications of Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS/EDX),Transmission Electron Microscopy (TEM), Selected Area (Electron) Diffraction (SAED), Thermal methods of analysis –thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Thermogravimetry (DTG), Differential Scanning Calorimetry (DSC), Powder X-ray Diffraction, Single crystal X-ray diffraction

b) Principles and applications of atomic absorption spectroscopy, atomic emission spectroscopy, Infrared and Raman Spectroscopy, Magnetic Resonance Spectroscopy- Electron Spin Resonance (ESR) of d^1 and d^9 transition metal ions in cubic and tetragonal ligand fields, applications of ^{31}P, ^{19}F, ^{119}Sn and ^{195}Pt nuclear magnetic resonance(NMR) spectrocopy

Module II: Bioinorganic Chemistry (15 hours)

Role of metal ions in biology and their toxic effects; Iron management in biological systems – siderophores, ferritin and transferrin; Dioxygen storage and transport – structure of myoglobin and haemoglobin, cooperativity of O_2 binding in haemoglobin, Bohr effect and Hill coefficients; Electron transfer proteins (structure and function) - Fe-S proteins, cytocchromes and plastocyanines; Structure of nitrogenase and its role in di-nitrogen fixation; Structure and function of vitamin B_{12} and mechanism of 1,2-shift reaction; Inorganic therapeutics - chelate therapy, metal based drugs.

Module III: Supramolecular Chemistry (10 hours)

a) Molecular recognition – Receptors, design and synthesis of co-receptors and multiple recognition, hydrogen bonds – strong, weak and very weak H-bonds, utilization of H-bonds to create supramolecular structures, use of H-bonds in crystal engineering and molecular recognition, chelate and macrocyclic effects.

b) Cation binding hosts, binding of anions, binding of neutral molecules, binding of organic molecules

c) Supramolecular reactivity and catalysis, transport processes and carrier design, supramolecular devices, supramolecular photochemistry

Module IV: Nanomaterials (10 hours)

General introduction to nanomaterials and emergence of nanotechnology; Moore's law; synthesis of nanoparticles of gold, rhodium, palladium, platinum, and silver; Synthesis of nanoparticle semiconductors, nanowires and nanorods; Techniques of synthesis: electroplating and electrophoretic deposition, conversion through chemical reactions and lithography; Thin films: Chemical vapor deposition and Atomic layer deposition techniques; Carbon fullerenes and nanotubes. Applications of nanoparticles.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Gain the concepts of analytical techniques used in inorganic analysis, the role of metal ions in the function of biological macromolecules and also the concepts of supramolecular chemistry and nanomaterials (Knowledge)

CO2: Understand (i) principles and application of various analytical techniques, (ii) biological uses of different metal ions, and (iii) Uses of nano materials in practical field. (Comprehension)

CO3. Apply the knowledge to proper use of various analytical techniques to characterize the chemical compounds which are synthesized in laboratories and industries.(Application)

CO4: Analyze the different uses of biomolecules, nano materials, supramolecules and various analytical techniques.(Analysis)

CO5: Apply their analytical skills for characterization of chemical compounds. (Synthesis)

CO6: Judge the need of different analytical techniques for characterization (Evaluation)

Suggested Readings

1. D. B. Murphy, M. W. Davidson, Fundamentals of Light Microscopy and Electronic Imaging, Wiley.
2. D. B. Williams, C. B. Carter, Transmission Electron Microscopy A Textbook for Materials Science, Springer.
3. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry (W. H. Freeman &Co.).
4. R. H. Abeles, P. A. Frey, W. P. Jencks, Biochemistry, Jones and Bartlett Publishers, Boston.
5. D. Voet, J. G. Voet, C. W. Pratt, Fundamentals of Biochemistry: Life at the Molecular Level.
6. I. Bertini, H. B. Gray, S. J. Lippard, J. S.Valentine, Bioinorganic Chemistry; Viva books Pvt. Ltd.
7. J. A. Cowan, Inorganic Biochemistry: An introduction, Wiley.
8. J. W. Steed and J. L. Atwood, Supramolecular chemistry John Wiley
9. J. M. Lehn Supramolecular Chemistry : Concepts and Perspectives Wiley-VCH
10. G.Zhong Cao. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press (2004)
11. G. R. Desiraju Ed. Perspectives in Supramolecular Chemistry and Molecular Recognition Wiley
12. M. Ratner & D. Ratner. Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson Education.

CHAI0012: ADVANCED INORGANIC CHEMISTRY II (FOR BATCH 2018-2020)

(4 Credits - 60 hours)

Objectives: *The objective of this course is to teach students core concepts of analytical techniques used in inorganic analysis, the role of metal ions in the function of biological macromolecules, supramolecular chemistry and nanomaterials*

Module I: Special Analytical Techniques (25 hours)

a) Principles and applications of Scanning Electron Microscopy (SEM), Energy Dispersive X-ray Spectroscopy (EDS/EDX),Transmission Electron Microscopy (TEM), Selected Area (Electron) Diffraction (SAED), Thermal methods of analysis –thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), Differential Thermogravimetry (DTG), Differential Scanning Calorimetry (DSC), Powder X-ray Diffraction, Single crystal X-ray diffraction

b) Principles and applications of atomic absorption spectroscopy, atomic emission spectroscopy, Infrared and Raman Spectroscopy, Magnetic Resonance Spectroscopy- Electron Spin Resonance (ESR) of d^1 and d^9 transition metal ions in cubic and tetragonal ligand fields, applications of ^{31}P, ^{19}F, ^{119}Sn and ^{195}Pt nuclear magnetic resonance(NMR) spectrocopy

Module II: Bioinorganic Chemistry (15 hours)

Role of metal ions in biology and their toxic effects; Iron management in biological systems – siderophores, ferritin and transferrin; Dioxygen storage and transport – structure of myoglobin and haemoglobin, cooperativity of O_2 binding in haemoglobin, Bohr effect and Hill coefficients; Electron transfer proteins (structure and function) - Fe-S proteins, cytocchromes and plastocyanines; Structure of nitrogenase and its role in di-nitrogen fixation; Structure and function of vitamin B_{12} and mechanism of 1,2-shift reaction; Inorganic therapeutics - chelate therapy, metal based drugs.

Module III: Introduction to Supramolecular Chemistry (5 hours)

Supramolecular chemistry: Definition, supramolecular host-guest compounds, macrocyclic effect, nature of supramolecular interactions.

Module IV: Introduction to Nanomaterials (5 hours)

Fabrication of nanomaterials – top-down and bottom-up approaches; solution-based synthesis of nanoparticles; other methods of nanomaterial synthesis – brief overview.Carbon fullerenes and nanotubes.Applications of nanoparticles.

Module V: Nuclear and Radiochemistry (10 hours)

Radioactive decay and equilibrium. Mass defect and binding energy, packing fraction, stability of nucleus, neutron-proton ratio, Artificial radioactivity. Nuclear reactions; Q value, cross sections, types of reactions, Chemical effects of nuclear transformations; fission and fusion, fission products and fission yields.Radioactive techniques; nuclear reactors, separation of isotopes; tracer technique, neutron activation analysis, counting techniques such as G.M. ionization and proportional counter. Application of radio-isotopes in agriculture, medicine and industry. Radiocarbon dating

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Gain the concepts of analytical techniques used in inorganic analysis, the role of metal ions in the function of biological macromolecules and also the concepts of supramolecular chemistry, nanomaterials and nuclear chemistry (*Knowledge*)

CO2: Have an understanding of (i) principles and application of various analytical techniques, (ii) nuclear reactions, (iii) biological uses of different metal ions, and (iv) uses of nano materials in practical field. (*Comprehension*)

CO3: The knowledge to proper use of various analytical techniques to characterize the chemical compounds which are synthesized in laboratories and industries (*Application*)

CO4: Analyze the different uses of biomolecules, nano materials, supramolecules and various analytical techniques (*Analysis*)

CO5: Apply their analytical skills for characterization of chemical compounds (*Synthesis*)

CO6: Judge the need of different analytical techniques for characterization (*Evaluation*)

Suggested Readings

1. D. B. Murphy, M. W. Davidson, Fundamentals of Light Microscopy and Electronic Imaging, Wiley.
2. D. B. Williams, C. B. Carter, Transmission Electron Microscopy A Textbook for Materials Science, Springer.
3. D. L. Nelson, M. M. Cox, Lehninger Principles of Biochemistry (W. H. Freeman &Co.).

4. R. H. Abeles, P. A. Frey, W. P. Jencks, Biochemistry, Jones and Bartlett Publishers, Boston.
5. D. Voet, J. G. Voet, C. W. Pratt, Fundamentals of Biochemistry: Life at the Molecular Level.
6. I. Bertini, H. B. Gray, S. J. Lippard, J. S.Valentine, Bioinorganic Chemistry; Viva books Pvt. Ltd.
7. J. A. Cowan, Inorganic Biochemistry: An introduction, Wiley.
8. J. W. Steed and J. L. Atwood, Supramolecular chemistry John Wiley
9. J. M. Lehn Supramolecular Chemistry : Concepts and Perspectives Wiley-VCH
10. G.Zhong Cao. Nanostructures and Nanomaterials: Synthesis, Properties and Applications, Imperial College Press (2004)
11. G. Friedlander, J.W. Kennedy, E. S. Macias, and J. M. Miller; Nuclear and Radiochemistry, John Wiley, New York.
12. G. R. Desiraju Ed. Perspectives in Supramolecular Chemistry and Molecular Recognition Wiley
13. M. Ratner & D. Ratner. Nanotechnology: A Gentle Introduction to the Next Big Idea, Pearson Education.

CHAO0013: ADVANCED ORGANIC CHEMISTRY-II

(4 Credits - 60 hours)

Objective: *This course will discuss organic photochemistry, pericyclic reactions, heterocyclic chemistry and Synthetic Strategies towards the synthesis of organic molecules.*

Module I: Organic Photochemistry (15 hours)

a) Introduction to organic photochemical-photophysical processes, chemiluminescence, photosensitization.
b) Photochemistry of carbonyl compounds - α-cleavage, β-cleavage, intramolecular H-abstraction, addition to π-systems- Paterno-Buchi reaction, electron transfer reactions, Photochemistry of olefins - photostereomutation of cis-trans isomers, optical pumping, cycloaddition, photochemistry of conjugated polyenes.
c) Photochemistry of enones, photo-rearrangement reactions- di-π-methane rearrangement, Photo-rearrangement of cyclohexadienones, Barton rearrangement, singlet oxygen photochemistry.

Module II: Pericyclic Reactions (15 hours)

Main features of pericyclic reactions; Woodward-Hoffman rules, correlation diagram and FMO approaches; Electrocyclic reactions – conrotatory and disrotatory motions for 4n and 4n+2 systems;. Cycloadditions – antarafacial and suprafacial additions, [2+2] and [4+2] reactions (hν and Δ), 1,3-dipolar cycloadditions and chelotropic reactions; Sigmatropic [i,j] shifts of C-H and C-C bonds; Sommelet-Hauser, Claisen, thio-Claisen, Cope and aza-Cope rearrangements.

Module III: Introduction to Heterocyclic chemistry (15 hours)

Nomenclature of heterocyclic compounds. Structure, reactivity, synthesis and reactions Pyridine, quinoline, Isoquinoline, Indole, Benzofuran, Benzothiophene, pyrazole, Imidazole, oxazole, Isoxazole, Thiazole, Isothiazole, pyridazine, pyrimidine and pyrazine.

Module IV: Synthetic Strategies (15 hours)

Synthons and synthetic equivalents, disconnection approach, functional group inter-conversions, importance of order of events in organic synthesis, one group and two group C-X disconnections, chemoselectivity, reversal of polarity, cyclisation reactions, amine synthesis.

One group C-C disconnections – alcohols and carbonyl compounds, regioselectiviity, alkene synthesis, use of acetylenes and aliphatic nitro compounds in organic synthesis.

Two group C-C disconnections – Diels-Alder reaction, 1,3-difunctionalised compounds, α, β-unsaturated carbonyl compounds, control in carbonyl condensations, 1,5-difunctionalised compounds, Michael addition and Robinson annelation. Principle of protection of alcohol, amine, carbonyl and carboxyl groups; Common protecting groups.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: The detailed knowledge on organic photochemistry, pericyclic reactions, heterocyclic chemistry and Synthetic Strategies towards the synthesis of organic molecules (*Knowledge*)

CO2: Have conceptual understanding of FMO approach, suprafacial antarafacial, conrotatory-disrotatory motion, Woodward Hoffmann rules, Electrocyclic reactions, Cycloaddition reactions, Sigmatropic rearrangement reactions, Chelatropic rection, Ene reaction and Correlation diagrams of different types of reactions (*Comprehension*)

CO3: Apply their knowledge of pericyclic reactions, photochemistry, heterocyclic and retrosynthesis in research and industrial field (*Application*)

CO4: Analyze problems related to pericyclic reactions, photochemistry, heterocyclic compounds and synthetic strategy (*Analysis*)

CO5: Understand heterocyclic compounds and would be able to provide analytical solution towards their synthesis (*Synthesis*)

CO6: Demonstrate different theories in pericyclic reaction and photochemistry in order to check feasibility of chemical reaction (*Evaluation*)

Suggested Readings

1. J.Clayden, N. Greeves, S. Warren; Organic Chemistry, Oxford University Press.
2. Norman, R. O. C., Coxon, J. M. Principles of Organic Synthesis, (Blackie Academic and Professional, 1993).
3. M. Harmata. Strategies and Tactics in Organic Synthesis 4 & 5, Academic Press (2004).
4. L. A. Paquette, Modern Heterocyclic Chemistry, John Wiley, (2007)

CHAP0014: ADVANCED PHYSICAL CHEMISTRY II

(4 Credits - 60 hours)

Objective: This objective of this course to make the students familiar with solid state chemistry, surface chemistry and catalysis.

Module I: Solid state (18 hours)

Structures of solids - crystal planes and Miller indices, Bragg's law and applications, Debye-Scherrer powder method, nanoparticles and nanotechnology, defects in solids, thermodynamics of Schottky and Frenkel defect formation, thin films, Langmuir-Blodget film. Electrical properties of solids, intrinsic and extrinsic semiconductors, doping of semiconductors, p-n junction, super conductors, conducting polymers, organic conductors, molecular electronic devices, nonlinear optical materials, optical reflectance, photoconduction, ionic conductors, Meissner effect, BCS theory.

Module II: Surface Chemistry (22 hours)

a) Electrical aspects of surface chemistry, Electro kinetic phenomena, the structure of electrical double layer, Zeta potential and colloidal stability, Measurement of zeta potential. Surfactants – definition and classification, micelle formation and determination of critical micelle concentration.Reverse micelle and its application, solubilization, microemulsion.

b) Adsorption of gases on solid surfaces – Langmuir's theory and its limitations. Derivation of BET equation – determination of surface area of an adsorbent, thermodynamics of adsorption processes. Capillary condensation – adsorption in micro pores, Kinetics of heterogeneous catalysis – Langmuir-Hinselwood model and Eley-Riedel mechanism.

Module III: Catalysis (20 hours)

Catalysts, classification of catalysts. Characterization of catalysts: Methods of surface analysis, surface area, pore size, void fraction, particle size, mechanical strength, surface chemical composition, surface acidity and reactivity.

Homogeneous catalysis: Atom transfer and electron transfer processes. Role of transition metal ions with special reference to Cu, Pd, Pt, Co, Ru and Rh, catalysis in non-aqueous media.Rates of homogeneously catalysed reactions, turnover number and frequency.Catalysis of isomerisation, hydrogenation, oxidation and polymerisation reactions. Metal clusters in catalysis, phase-transfer catalysis.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Recall the basic structure and properties of solids, different surface processes and types catalyst and catalytic processes (*Knowledge*)

CO2: Understand the electrical properties in terms of semiconductor, superconductor etc., classification of different surfactants, and process of adsorption gases on solid surfaces, types and characterization of catalyst (*Comprehension*)

CO3: Apply the knowledge solid chemistry to understand about different types of conducting materials, interpret the results of adsorption processes in terms of known isotherms, interpret the electro kinetic phenomena of surfaces, and explain the mechanism of different types of catalytic processes (*Application*)

CO4: Analyse the application of solid state chemistry in terms of electrical, magnetic and optical properties, classification of surfactants, process of surface adsorption and types catalysed reaction in terms of homogeneous and heterogeneous catalysis (*Analysis*)

CO5: Understanding of solid state chemistry, electro kinetic phenomena, colloids, surfactants, different types adsorption isotherms, different types of catalyst and catalytic process (*Synthesis*)

CO6: Apply the properties of solids to interpret the conducting behaviour of different types of materials, derive different adsorption isotherms, and interpret the different catalytic processes (*Evaluation*)

Suggested Readings

1. A. R. West. Solid State Chemistry and its Applications, John Wiley.
2. D.K. Chakrabarty. Solid State Chemistry, New Age Publishers.
3. New Directions in Solid State Chemistry- C N R Rao and J Gopalakrishnan
4. Catalytic Chemistry, B. C. Gates, John Wiley & Sons.
5. Fundamentals of Industrial Catalytic Processes C.H. Bartholomew, R. J. Furrauto, Wiley Interscience.
6. M. J. Rosen. Surfactants and Interfacial Phenomena, John Wiley.
7. Atkins, J. Paula; Physical Chemistry, Oxford University Press.

CHSP0015: SPECIAL TOPICS IN BIOCHEMISTRY

(3 Credits - 45 hours)

Objective: *The aim of this paper is to introduce properties of biomolecules, their roles in health and disease and chemical and biochemical methods of synthesizing them.*

Module I: Carbohydrates (9 hours)

Characteristics and properties of carbohydrates – nomenclature and stereochemistry of monosaccharides, typical carbohydrates, sweetening agents; chemistry of monosaccharides – cyclic structures, Haworth and conformational representations, oxidation, determination of ring size, structure of correlations, synthesis, glycosides; Oligosaccharides and Polysaccharides - sucrose and other oligosaccharides, starch, cellulose and other polysaccharides

Module II: Lipids (9 hours)

a) Glycerol derivatives- fats and oils, fatty acid biosynthesis, phospholipids, glycolipids, properties of lipid aggregates, micelles, bilayers, liposomes and biological membranes
b) Steroids – structural characteristics, synthesis and biosynthesis, steroid hormones; prostaglandins – structural characteristics, synthesis and biosynthesis;
c) Pheromones – structure and origin, synthesis

Module III: Nucleosides, Nucleotides and Nucleic acids (9 hours)

a) Nucleosides and Nucleotides: The structure of nucleosides, chemistry of nucleosides, nucleotides; sunlight, carbohydrates and energy – photosynthesis, glycolysis and metabolic energy;
b) Nucleic acids: Structure and function of DNA, RNA (m-RNA, t-RNA, r-RNA), an overview of gene expression (replication, transcription and translation), genetic code (origin, Wobble hypothesis and other features), genetic errors, carcinogenesis and recombinant DNA technology.

Module IV: Amino acids, Peptides and Proteins (9 hours)

a) Amino Acids – structural characteristics, acid-base properties, synthesis;
b) Peptides – amino acid analysis, terminal group analysis, the amino acid sequence, synthesis;
c) Proteins, enzymes and biosynthesis – the alpha-helix, other secondary and tertiary structural characteristics, enzymes; protein synthesis;

Module V: Vitamins (9 hours)

Vitamins: Classification; occurrence; chemistry of Vitamins – structure elucidation and synthesis; biochemical functions; deficiency syndromes.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain the different types of biomolecules present in living organisms, how they function, how they are synthesized biochemically and their modes of synthesis in the lab (*Knowledge*)
CO2: Understand the properties of biomolecules and their interplay of that takes place in living organisms for the sustenance of life (*Comprehension*)
CO3: Differentiate between different biological molecules based on their properties (*Application*)
CO4: Understand why certain biomolecules are needed for a particular set of processes (biomolecular pathways) to take place efficiently in a living system and will be able to compare it with the conditions under which those same processes take place outside a living system, in a lab. E.g., comparison of biochemical synthesis of a peptide or protein as compared to the chemical synthesis of the same (*Analysis*)
CO5: Have a working understanding of how certain biomolecular pathways function and have the knowhow to assess what the necessary components are for those pathways and processes. They will know how to recreate some of those processes in vitro (*Synthesis*)
CO6: Given a particular set of conditions and molecules, they will be able to tell whether a particular process can take place or not (*Evaluation*)

Suggested Readings

1. S. H. Pine, J. B. Hendrickson, D. J. Cram, G. S. Hammond Organic Chemistry McGraw Hill
2. J. Clayden, N. Greeves, S. Warren, P. Wothers, Organic Chemistry, Oxford University Press
3. J. M. Berg, J. L. Tymoczco, G. J. Gatto, L. Stryer Biochemistry W. H. Freeman & Co
4. D. Voet and J. G. Voet Biochemistry John Wiley and SonsBerg
5. D. L. Nelson and M. M. Cox, Lehninger Principles of Biochemistry, W. H. Freeman & Co.

CHAS0016:APPLIED SPECTROSCOPY

(4 Credits - 60 hours)

Objective: This course will discuss the application of various spectroscopic methods like IR, NMR, Mass spectrometry.

Module I (15 hours)

a) Infrared Spectroscopy: Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols, amines; Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acid anydrides, lactones, lactams, conjugated carbonyl compounds); Effects of H-bonding and solvent effect on vibrational frequency, extension to various organic molecules for structural assignment.
b) Mass Spectrometry: Mass spectral fragmentation of organic compounds, common functional groups; molecular peak, McLafferty rearrangements, examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Module II(15 hours)

a) Nuclear Magnetic Resonance Spectroscopy:
Approximate chemical shift values of various chemically non-equivalent protons and correlation to protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic); Protons bonded to other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides, SH); Chemical exchange, effect of deuteration; complex spin-spin interaction between two, three, four and interacting

nuclei (first order spectra); Complex interaction, virtual coupling, stereochemically hindered rotation, Karplus curve, variation of coupling constant with dihedral angle, nuclear magnetic double resonance, simplification of complex spectra using shift reagents, Fourier transform technique and nuclear Overhauser effect (NOE).

b) C-13 NMR Spectroscopy:
Chemical shift (aliphatic, olefinic, alkynes, aromatic, hetero-aromatic, carbonyl carbon); Coupling constants, two-dimensional NMR spectroscopy, NOESY, DEPT and INEPT terminologies.

c) Applications of IR, NMR and Mass spectroscopy for structure elucidation of organic compounds.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain different spectroscopic and spectrometric techniques like FT-IR, 1H NMR, 13C-NMR, Mass spectrometry etc(*Knowledge*)

CO2: Understand the concepts of each technique and the types of molecules that can be studied with each technique and the conclusions to draw from the analyses (*Comprehension*)

CO3: Apply their knowledge of different spectroscopic techniques in structure interpretation of unknown compounds (*Application*)

CO4: Analyze problems related to FT-IR, 1H NMR, 13C-NMR, Mass spectrometry (*Analysis*)

CO5: Identify the unknown compounds for their suitable analytical and industrial use (*Synthesis*)

CO6: Decide the set of steps necessary to elucidate the undefined molecular structure of various compounds (*Evaluation*)

Suggested Readings

1. R. M. Silverstein, G. C. Basseler & T. C. Morill.Spectroscopic Identification of Organic Compounds, John Wiley (1981).
2. W. Kemp. Organic Spectroscopy (3rd edn.), McMillan Press Ltd. (1991).
3. D Williams & I. Fleming.Spectroscopic Methods in Organic Chemistry, McGraw Hill (1989).
4. C. N. Banwell & E. M. McCash. Fundamentals of Molecular Spectroscopy, Tata McGraw-
5. Hill, New Delhi (2006).
6. D.L. Pavia, G. M. Lampman, G. S. Kriz Introduction to Spectroscopy, Harcourt College Publisher (2001) NY.

CHRM0017: RESEARCH METHODOLOGY FOR CHEMISTRY

(3 Credits - 45 hours)

Objectives: *To expose students to the methods of doing research, make them aware of safe procedures for handling chemicals, to train them to assimilate ideas from scientific articles through critical reading and to enable them to identify their topics for their fourth semester research projects.Mode of Assessment: Modules I-III will be assessed based on a written examination (2 credits) while Module IV will be assessed on the basis of a seminar (1-credit).*

Module I: Literature Survey, Methods of Scientific Research and Writing Scientific Papers (10 hours)

Print resources, digital resources, information technology and library resources, reporting practical and project work, writing literature surveys and reviews, organizing a poster display, giving an oral presentation, writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publication of scientific work; writing ethics – avoiding plagiarism

Module II Chemical Safety and ethical handling of chemicals (7 hours)

Safe working procedure and protective environment, protective apparel, emergency procedure and first aid, laboratory ventilation. Safe storage and use of hazardous chemicals, procedure for working with substances that pose hazards, flammable or explosive hazards, procedures for working with gases at pressures above or below atmospheric – safe storage and disposal of waste chemicals, recovery, recycling and reuse of laboratory chemicals, procedure for laboratory disposal of explosives, identification, verification and segregation of laboratory waste, disposal of chemicals in the sanitary sewer system, incineration and transportation of hazardous chemicals, overview of chemical regulations in India

Module III: Data Analysis (13 hours)

The Investigative Approach: Making and Recording Measurements. SI Units and their use.Scientific method and design of experiments.

Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics, Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis.

Module IV: Project Proposal Writing (15 hours) (Seminar Module)

In this module, students will be reviewing scientific articles, writing reports on the papers they have read and finally prepare a research proposal.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn about resources for research literature, they will learn how to work safely with chemicals, how to analyze data and to read scientific articles and gain information on research topics that are of interest to them (Knowledge)

CO2: Use print and digital resources, they will develop awareness on safety protocols they need to follow while using chemicals, understand principles of data analysis and understand underlying ideas on research topics they choose (Comprehension)

CO3: Apply their knowledge of print and digital resources to identify sources for research articles of interest to them, handle chemicals safely in the lab, dispose of chemicals the proper way, analyze data (Application)

CO4: Identify scientific articles that are of relevance to them, they should be able to choose the methods they need to analyze data, find out the flow of ideas and logic in papers they read (Analysis)

CO5: Review literature, analyze data, have a good estimate of where research on a topic of interest stands and come up with a workable research proposal (Synthesis)

CO6: Discern the loopholes and drawbacks of methods they come across in scientific articles, evaluate data - know which method works best for analyzing a given data set (Evaluation)

Suggested Readings

1. Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011) Practical skills in chemistry. 2nd Ed. Prentice-Hall, Harlow.
2. Hibbert, D. B. & Gooding, J. J. (2006) Data analysis for chemistry. Oxford University Press.
3. Topping, J. (1984) Errors of observation and their treatment.Fourth Ed., Chapman Hall, London.
4. Harris, D. C. Quantitative chemical analysis. 6th Ed., Freeman (2007) Chapters 3-5.
5. Levie,R. de, How to use Excel in analytical chemistry and in general scientific data analysis. Cambridge Univ. Press (2001) 487 pages.
6. Chemical safety matters – IUPAC – IPCS, Cambridge University Press, 1992.
7. OSU safety manual 1.01.

CHCM0018: MATERIALS CHEMISTRY

(3 Credits - 45 hours)

Objective: *This course aims to provide an understanding of how molecular structure affects the properties of materials and to predict and control material properties through an understanding of atomic, molecular, crystalline, and microscopic structures of engineering materials.*

Module I: Solid state ionic conductors (11 hours)

Structure, physico-chemical principles, applications of Ferrous alloys, Fe-C phase transformations in ferrous alloys, non-ferrous alloys, properties and applications of ferrous and non-ferrous alloys, magnetic alloy, metallic glass, ceramics, nano-materials and optical materials.

Module II: Polymeric materials and inorganic Polymers (12 hours)

a) Molecular shape, structure and configuration, crystallinity, stress-strain behaviour, thermal behaviour, polymer types and their applications, conducting and ferro-electric properties.

b) Polysiloxanes, polysilanes, polyphosphazenes, polymeric sulphur - synthesis, structure, properties and applications, co-ordination polymers and organometallic polymers.

Module III: Liquid crystals and high Tc materials (12 hours)

Nomatic, smectic, cholesteric - properties and applications, high Tc materials, defect perovskites, high Tc superconductivity in cuprates, 1-2-3 and 2-1-4 materials, anisotropy, temperature dependence of electrical resistance, optical phonon modes, superconducting state, heat capacity, coherence length, elastic constants, position lifetimes, micro-wave absorption pairing and multi gap structure in high Tc materials, applications of high Tc materials.

Module IV: Organic solids and molecular devices (10 hours)

a) Conducting organics, organic superconductors, magnetism in organic materials, fullerenes, doped fullerenes as superconductors.
b) Molecular rectifiers and transistors, artificial photosynthetic devices, sensors, clay -polymer and carbon composites, phosphor and laser materials.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Recall the knowledge of basic structure of materials like ionic solids, high Tc material, inorganic polymer, liquid crystals etc. (*Knowledge*)
CO2: Understand how molecular structure affects the properties of materials (*Comprehension*)
CO3: Explain the properties of different materials on the basis of their structures (*Application*)
CO4: Analyse the application of different types of materials in different field (*Analysis*)
CO5: Understanding of the structure and properties of different types of engineering materials useful in day to day life (*Synthesis*)
CO6: Predict and control material properties through an understanding of atomic, molecular, crystalline, and microscopic structures of engineering materials (*Evaluation*)

Suggested Readings

1. Keer, H.V. Principles of the Solid State, Wiley Eastern
2. Callister, W.D. Material Science and Engineering- An Introduction, Wiley, New York
3. Lever, K.D.; Alexander, J.M.; Rawlings, R.D. Materials Science , J.C. Sanderson, ELBS
4. Marck, J.E.; Allcock, H.R.; West, R. Inorganic Polymers, Prentice Hall
5. Solid State Physics, N.W. Ashcroft and N.D. Mermin, Saunders College.
6. Thermotropic Liquid Crystals, Ed., G.W. Gray, John Wiley.
7. Handbook oN Liquid Crystals, Kelker and Hatz, Chemie Verlag.

CHCC0019: COMPUTATIONAL CHEMISTRY

(3 Credits - 45 hours)

Objective*: To introduce computational methods to students to enable them to write simple programs, perform chemical calculations, simulate the dynamics of molecules and reactions as well as for them to learn how to identify and use databases relevant to chemists*

Module I: Programming and some numerical methods in chemistry (15 hours)

Introduction to Linux/UNIX and shell scripts; programming in C /python; Least squares fit; root finding; numerical differentiation; integration and solution of ODE; matrix multiplication, inversion and diagonalization; interpolation; pattern recognition techniques and molecular graphics

Module II: Molecular Mechanics (MM) Methods (10 hours)

Basic geometrical description of molecules; force field energy, force field parameterization, differences between force fields, computational considerations, validation of force fields, advantages and limitations of force field methods, transition structure modelling, hybrid force field – electronic structure methods

Module III: Electronic structure (or Quantum Mechanical, QM) Methods

Many electron systems, Hartree-Fock method, basis sets, electron correlation and its treatment, basics of density functional theory, DFT based reactivity descriptors. Introduction to popular softwares (like Gaussian, DMol, GAMESS).Applications to simple molecular systems. Monte Carlo and molecular dynamics simulations

Module IV: Combined QM/MM methods (15 hours)

Implications of the choice of QM and MM methods; Application of QM/MM methods in organic, inorganic and organometallic systems including bio-organic and bio-inorganic molecules.

Quantitative structure activity relation (QSAR): Early approaches, topological indices, fragmental models; quantum mechanical descriptors

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: A programming language to perform chemical calculations and simulations; they will learn about the similarities and differences between theoretical methods such as HF (Hartree-Fock), DFT(Density Functional Theory) and force field methods (*Knowledge*)

CO2: Describe the principles involved in the different theoretical methods used for simulations (*Comprehension*)

CO3: Apply QM or MM methods to simulate or model chemically related problems (*Application*)

CO4: Identify the advantages and disadvantages of the various methods they learn for simulations/modelling (*Analysis*)

CO5: Choose suitable methods for calculating electronic properties of simple molecules and crystals. (*Synthesis*)

CO6: Critically analyze the calculated properties of a chosen system (a molecule) after using a method for calculating its electronic properties (*Evaluation*)

Suggested Readings

1. Hinchcliffe, A. Modelling Molecular Structure, John Wiley and Sons
2. Holtje, H. D., Sippl, W., Rognan, D and Folkers, G. Molecular Modeling Basic Principles and Applications, Wiley-VCH
3. Leach, A. R. Molecular Modeling: Principles and Applications, Pearson Education
4. Jensen, F. Introduction to computational chemistry, John Wiley and Sons Press
5. W. H., Tenkolsky, S. A., Vetterling, W. T., and Flannery, B. P. Numerical Recipes in Fortran/C, Cambridge University Press
6. Dawson, M. Python programming for the absolute beginner, Course Technology, CENGAGE learning
7. Vine, M. C programing for the absolute beginner, Thomson Course Technology

CHFC0020: FOOD CHEMISTRY

(3 Credits - 45 hours)

Objective: *This course is aimed at familiarizing students with the importance of food and nutrition, deficiency diseases, its prevention and food additives/preservatives.*

Module I: Basic idea of food and nutrients (2 hours)

Relationship between food, nutrition and health; functions of food: physiological and social.

Module II: Major nutritional constituents (12 hours)

Functions, sources, deficiency/excess diseases of the following major nutrients:

(a) Carbohydrates; (b) Amino acids and proteins; (c) Lipids, sterols, metabolite; (d) Mineral;
(e) Vitamins: A, D, E, K

Module III: Different categories of food (7 hours)

Selection, nutritional contribution and changes during Cooking/Ripening/storage of the following categories of food:

(a) Cereals; (b) Pulses; (c) Fruits and vegetables; (d) Milk and milk products; (e) Egg, meat, poultry and fish; (f) Fats and oils.

Module IV: Nutritional needs during life cycle (6 hours)

Body composition, Influence of Nutrition, Physical Activity, Growth and Aging; Maternal Nutrition, Nutritional Requirement during Infancy, Childhood; Diet, Nutrition and Adolescence; Nutrition in the Elderly.

Module V: Prevention and management of deficiencies (6 hours)

Causes, symptoms, treatments and preventions of the following:
Protein-Energy malnutrition among children; Vitamin A deficiency; Iron deficiency; Fluorosis: Over nutrition, obesity, coronary heart diseases, Diabetes (Type I & II); Diet, Nutrition and cancer.

Module VI: Dietary goals & guidelines (10 hours)

National Perspectives; nutritional perspectives of vegetarian diets; Social Health Issues – Smoking, Alcoholism, Drug Addiction, AIDS and AIDS Control Programs; Food Preservation & Food Additives & Colorants.

Module VII: Entrepreneurship Development (2 hours)

Scope of Food based items for Entrepreneur Development in North East India & Identification of Resources; Development of a Project Plan.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Familiar with importance of food and nutrition, deficiency diseases, its prevention and food additives (Knowledge)
CO2: Have conceptual understanding of relationship between food, nutrition & health (Comprehension)
CO3: Apply their knowledge of food chemistry into personal life and food research field for societal development (Application)
CO4: Analyze and solve different problems related to food (Analysis)
CO5: Identify the cause of food borne illness and other food related diseases and be able to find a solution for its cure & prevention (Synthesis)
CO6: Explain/compare food as major dietary constituents, naturally occurring food, their energy/ nutritional values (Evaluation)

Suggested Readings

1. S. R. Mudambi, M. V. Rajagopal, Fundamentals of Foods, Nutrition and Diet Therapy, 5th Ed, New Age International.
2. B.Srilakshmi, Nutrition Science, New Age International.
3. Handbook of Food and Nutrition, 5th Edition, BAPPCO.
4. G. M. Wardlaw, J. S. Hanpl, Perspectives of Nutrition, McGraw Hill
5. S. Sari, A. Malhotra, Food Science, Nutrition and Food Safety, Pearson India Ltd
6. C. Gopalan, B. V. Rama Sastri, S. C. Balasubramanian, Nutritive Value of Indian Foods, NIN, ICMR,
7. M. S. Bamji et al., Textbook of Human Nutrition, Oxford & IBH Pub Co Pvt Ltd

CHIC0021: INDUSTRIAL CHEMISTRY

(3 Credits - 45 hours)

Objective: This course in Industrial Chemistry is designed to provide graduates with basic understanding of chemistry in the following sectors: Rubber, synthetic fibres, fertilizers and pesticides, Sugar, Tea and paints.

Module I: Elastomers (7.5 hours)

Rubbers: origin, importance, types of rubber, natural rubber, gutta percha, guayle rubber, balata. Refining of crude rubber, drawbacks of natural rubber, vulcanization, technique of vulcanization. Synthetic rubber, poly butadiene, buna –S or SBR rubber, neoprene, nitrile rubber, butyl rubber, silicone rubber, & poly urethane.

Module II: Synthetic Fibres (5 hours)

Introduction, natural and artificial fibres characteristics and limitations. Study of following synthetic fibres :- Rayon (nitro cellulose) cupra ammonium rayon, acetate rayon, nylon 66, nylon-6, terylene (Dacron) Teflon & Saran.

Module III: Fertilisers and Pesticides (10 hours)

a) Fertilizers: Plants nutrients, need for fertilizers, qualities of fertilizers, NPK ratio, classification of fertilizers, straight and mixed fertilizers. Nitrogenous fertilizers, manufacture of ammonium nitrate, urea, ammonium sulphate, phosphate fertilizers manufacture of triple phosphate and super phosphate, potassium fertilizers.

b) Pesticides: Introduction, classification, Study of the following types: - Organo chlorine pesticides like DDT, BHC and Aldrin. Organo phosphorous pesticides, malathion& parathion. Rodenticides, fungicides, herbicides, fumigants and repellants (one example each).

Module IV: Sugar and Fermentation Industries (10 hours)

a) SUGAR: Importance of sugar industry, manufacture of raw and refined sugar with flow sheet, estimation of sugar (physical and chemical methods)

b) FERMENTATION: Definition of fermentation, importance of various fermentation industries, basic requirements for fermentation, steps in fermentation process. Manufacture of alcohol from molasses, distillation, coffey still, preparation of absolute alcohol, various useful fractions and their uses, proof sprit, denatured spirit.

Module V: Tea Industry (7.5 hours)

Chemical composition - an overview, Polyphenols in tea- Mechanism of theaflavin formation, biochemistry of tea - Biosynthesis of caffeine, Cinnamate, flavonoids, Chemical properties of tea- Polyphenols as Antioxidants.

Module VI: Paints (5 hours)

Introduction, classification of paints, constituents of paints in brief. Manufacture of paints, qualities of good paint, emulsion paints, paint removers, varnishes enamels, lacquers, thinners in brief.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Distinguish various industries (*Knowledge*)

CO2: Get an in-depth knowledge about industries in the field of Synthetic fibre, Sugar, fertilizer, paint, Tea etc. (*Comprehension*)

CO3: Apply their chemical knowledge in industries (*Application*)

CO4: Compare and analyse different chemical reactions and compound behavior (*Analysis*)

CO5: Use their synthetic knowledge and apply in the synthesis of compounds required in different industries (*Synthesis*)

CO6: Valuate the challenges required in industries and would learn how to overcome various challenges (*Evaluation*)

Suggested Readings

1. Sharma, B. K. Industrial Chemistry, Goel Publishing House Meerut, India.
2. Austin, G. T. Shreeve's Chemical Process Industries, Mc Graw Hill
3. Finar, I. L. Organic Chemistry Vol I.
4. Finar, I. L. Organic Chemistry Vol II.

CHMD0022: MEDICINAL CHEMISTRY

(3 Credits - 45 hours)

Objective: *Students will be introduced to various types of drugs and medicines, their chemistry, modes of action and theoretical aspects of drug design*

Module I: Introduction and History of Drug Development (5 hours)

Definition of drug and prodrugs; need of drugs; germ theory of diseases; history of sulpha drugs and their mode of action; antibacterial agents

Module II: Mechanisms and Theoretical aspects of drug action, drug discovery, design and delivery (10 hours)

Receptors – two-state model of receptor theory, drug-receptor interaction and Clark's Occupancy Theory; physiological response; drug agonist and antagonist – classification; Need of quantification of drug action; definition of chemotherapeutic index and therapeutic index; factors affecting bioactivity of drugs; pharmacokinetics and pharmacodynamics; QSAR; Lead compounds in drug discovery; importance of SAR and molecular modification; importance of combinatorial library and molecular modelling in drug discovery; drug delivery – controlled drug delivery methods

Module III: Antibiotics, Antivirals and Antimalarials (15 hours)

a) General introduction to antibiotics – their sources and classification; causes and concerns of bacterial resistance to antibiotics; definition and need of broad Spectrum Antibiotics.
b) Mechanism of action of lactam antibiotics, non-lactam antibiotics and quinilones;
c) Antivirals – difficulty in developing clinical solutions to viral diseases, introduction to antiviral agents, AIDS –its cause and prevention;
d) Antimalarials – classification of human malaria and plasmodia responsible for human malaria; discovery of quinine and its structure-activity-relationship (SAR), importance of quinine as a lead to the discovery of low cost antimalarials, artemisinin and its derivatives – their SAR and importance in dealing with chloroquine resistant malaria, mode of action

Module IV: Neurotransmitters (5 hours)

Classes of neurotransmitters, drugs affecting cholinergic and adrenergic pathways

Module V: Miscellaneous topics (10 hours)

Antihistamines, anti-inflammatory drugs, antianalgesics, anticancer and antihypertensive drugs, gene therapy, anti-sense and anti-gene strategies and drug resistance

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Describe different types of drugs, drug-receptor interactions, drug-enzyme interactions, the mechanisms involved; topics related to drug discovery, drug design, structure activity relationships, molecular modeling of drugs, and methods of drug delivery (*Knowledge*)

CO2: Understand different aspects of drug-target interactions-specific and non-specific interactions, drug discovery, molecular modeling of drugs (*Comprehension*)

CO3: Compare the effectiveness of different drugs for a particular target, how a newly discovered or synthesized molecule is compared against an existing library of drugs and tested for its specificity against a target (*Application*)

CO4: Suggest reasons for differences in interaction of a drug with a range of targets or of a range of drugs with a target, or why certain targets inside a physiological system are hard to reach e. g., most drugs cannot cross the blood-brain-barrier, how to theoretically circumvent these difficulties (*Analysis*)

CO5: Tailor molecules (drugs) for optimal interactions with selected targets (*Synthesis*)

CO6: Compare and critically analyze drug-target interactions through designing drugs, SAR and molecular modelling of drugs (*Evaluation*)

Suggested Readings

1. Thomas, G. Medicinal Chemistry: An Introduction, John Wiley & Sons
2. Patrick, G. L. An Introduction to Medicinal Chemistry,Oxford University Press
3. Gringauz, A. Introduction to Medicinal Chemistry, Wiley India Pvt Ltd.
4. Sriram, D., Yogeeswari, P. Medicinal Chemistry, Pearson Education (Dorling Kindersley India)

CHRC0023: RECENT ADVANCES IN CATALYSIS

(3 Credits - 45 hours)

Objective: *To make the students understand structure, properties of different heterogeneous catalyst and mechanism of catalytic reactions for the design of processes involving catalytic reaction*

Module I: Kinetics of heterogeneous catalysis (10 hours)

Adsorption and catalysis, mechanism of heterogeneous catalysis, kinetics of heterogeneous catalytic reactions, volcano principle, shape and size selectivity of catalysts, characterization of catalysts and their surfaces, methods of surface analysis, surface area, pore size, void fraction, particle size, mechanical strength, surface chemical composition, surface acidity and reactivity.

Module II: Preparation and characterization of industrial catalysts (8 hours)

Catalyst design methods, catalyst support and preparation of industrial catalyst, supported and unsupported metal catalysts, bimetallic catalysts, Electron microscopy, XPS and PES, ESCA, IR and magnetic resonance spectroscopy, temperature programmed desorption (TDP), and DTA and TGA.

Module III: Zeolite and clays (15 hours)

a) Synthesis of some selected important zeolites, modification of zeolites, ion exchange, metals supported on zeolites, dealumination and desilication of zeolites, shape selective catalysis in zeolites.
b) Properties of pillared clays, use of coordination and organometallic compounds as pillaring, pillaring of acid activated clays, mesoporous materials, ordered mesoporous materials, synthesis of silica molecular sieve materials, characterization of mesoporous molecular sieves, catalytic properties of mesoporous materials, catalytic applications of zeolite, clays and mesoporous materials.

Module IV: Catalysis in petroleum industry and environmental catalysts (12 hours)

Design of catalytic reactors, promotion and promoters, catalytic processes in petroleum industry, reforming, cracking and hydrotreating, hydrogenation, hydrodesulphurization, Fischer-Tropsch process, Catalytic deactivation and reactivation, control of pollution from automobile exhaust, catalytic converters, abatement of nitrogen oxides and odours, cleaning of industrial effluents.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Recall their idea about structure and properties of different heterogeneous catalyst (*Knowledge*)
CO2: Understand structure, properties of different heterogeneous catalyst, mechanism of catalytic reactions, preparation and characterization of different types of catalyst (*Comprehension*)
CO3. Learn catalyst preparation and design methods to apply it different field like petroleum industry and for environmental remediation (*Application*)
CO4: Analyse the need of different catalyst for different application (*Analysis*)
CO5: Understanding recent advances of heterogeneous catalyst in terms of structure, properties, their characterization process and application in different field (*Synthesis*)
CO6: The preparation and characterization as well as the properties of different types of heterogeneous catalyst (*Evaluation*)

Suggested Readings

1. Bartholomew, C. H., Furrauto, R. J. Fundamentals of Industrial Catalytic Processes, Wiley Interscience
2. Chakrabarty, D. K., Viswanathan, B. Heterogeneous Catalysis, New Age Int.
3. Gates, B. C. Catalytic Chemistry, John Wiley & Sons
4. Augustine, R.L. Heterogeneous Catalysts for Synthetic Chemists, Marcel-Dekker
5. J. Weitkamp and L. Puppe, Catalysis and zeolites – fundamentals and applications, Springer-Verlag
6. G. Ertl, H. Knozinger, J. Weitkamp, Handbook of Heterogeneous Catalysis, Vol 4 and 5, Wiley-VCH

CHBC0024: BIOPHYSICAL CHEMISTRY

(3 Credits - 45 hours)

Objectives: *To teach the applications of physical chemistry methods for elucidation of the structure and properties of biological molecules*

Module I: Fundamentals of biological macromolecules (5 hours)

Chemical bonds in biological systems; properties of water; thermodynamic principles in biological systems; properties and classification of amino acids; protein structure and function; properties of nucleosides and nucleotides; composition of nucleic acids; structure of nucleic acids

Module II: Molecular modelling and conformational analysis (10 hours)

Complexities in modelling macromolecular structure; polypeptide chain geometries and internal rotation angles; Ramachandran plots; Molecular mechanics; stabilizing interactions in biomolecules; simulating macromolecular structure; energy minimization; molecular dynamics

Module III: Methods for separation of biomolecules (10 hours)

General principles, chromatography; sedimentation - moving boundary sedimentation, zonal centrifugation; electrophoresis, isoelectric focussing; capillary electrophoresis, MALDI-TOF

Module IV: Structural determinations: Physical Methods (10 hours)

Ultracentrifugation and other hydrodynamic techniques; light scattering – fundamental concepts, scattering from a number of small particles, Rayleigh scattering, scattering from particles that are not small compared to the wavelength of radiation, dynamic light scattering, low angle X-ray scattering, neutron scattering, Raman scattering

Module V: Optical Methods and Applications (10 hours)

Optical techniques in biological systems – absorption spectroscopy, fluorescence spectroscopy, linear and circular dichroism, single and multidimensional NMR spectroscopy

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Modeling biological macromolecules such as proteins and nucleic acids, they will learn about methods used to separate biological molecules in a mixture and methods to determine their structure (*Knowledge*)

CO2: Explain how to model proteins and nucleic acids, explain the methods used for separating these molecules if they are present in a mixture and also understand and explain the methods that can be used to determine their structures (*Comprehension*)

CO3: Identify conditions that are optimal for modeling a biological molecule, or to identify parameters that will enable separation of a particular protein from a mixture such as a cell or tissue homogenate and suggest optimal methods for determining its structure (*Application*)

CO4: Compare the advantages and disadvantages of the various methods that can be used to separate and purify a biological molecule from a mixture and determine its structure (*Analysis*)

CO5: Design the separation, purification and structure determination of a biological macromolecule from a mixture (*Synthesis*)

CO6: Critically analyze the conditions that will be best suited for the separation and purification of a biological macromolecule from a mixture, and also determine the best method for its structural elucidation (*Evaluation*)

Suggested Readings

1. Cantor and Schimmel Biophysical Chemistry Parts I-III, Macmillan
2. Lehninger, A. L., Nelson, D. L. and Cox, M. M. Lehninger Principles of Biochemistry W. H. Freeman
3. Cooper, A. Biophysical Chemistry The Royal Society of Chemistry, UK
4. Allen, J. P. Biophysical Chemistry Blackwell Publishing

CHHC0025: HETEROCYCLIC CHEMISTRY

(3 Credits - 45 hours)

Objective: *Students will be introduced to nomenclature, reactivity, and synthesis of different types of heterocyclic compounds including natural heterocycles.*

Module I: Introduction & Small Ring Heterocycles

Hantzsch-Widman nomenclature for monocyclic, fused and bridged heterocycles; General approaches to heterocyclic synthesis; Aliphatic and aromatic heterocycles; Basicity and aromaticity of heterocycles.

Syntheses of aziranes, oxiranes & thiiranes; Ring openings and heteroatom extrusion; Synthesis & reactions of azetidines, oxetanes & thietanes; Strain.

Module II: Azoles and condensed five membered Rings

Physical and chemical properties; Synthesis of pyrazole, isothiazole and isoxazole; Synthesis of imidazoles, thiazoles & oxazoles; Nucleophilic and electrophilic substitutions; Ring cleavages; Benzofused analogues.

Synthesis of indole, benzofuran and benzo-thiophene; Nucleophilic, electrophilic and radical substitutions; Addition reactions; Indole rings in biology.

Module III: Diazines, bicyclic heterocycles & seven membered heterocycles

Physical & chemical properties and synthesis of pyridazines, pyrimidines, pyrazines; Nucleophilic and electrophilic substitutions.

Synthesis of quinolines, isoquinolines, benzofused diazines, acridines, phenothiazines, carbazoles and pteridines; Substitution reactions.

Synthesis & reactions of azepines, oxepines, thiepines & diazepines.

Module IV: Natural heterocycles

Porphyrins: Classification and synthesis of porphin rings.

Nucleic Acids: Primary, secondary and tertiary structure of DNA; DNA replication and heredity; Structure and function of mRNA, tRNA and rRNA.

Proteins: Acid-base properties of amino acids; polypeptides; primary, secondary, tertiary and quaternary protein structures; classification of proteins on basis of structure and biological function; Merrifield peptide synthesis.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Describe structure, reactivity, and synthesis of different types of heterocycles (*Knowledge*)

CO2: Understand how to apply the concept of reactivity of hetrocyclic compounds in the synthetic organic chemistry research field (*Comprehension*)

CO3: Apply the knowledge of reactivity of different types of heterocycles in the synthetic organic chemistry research field (*Application*)

CO4: Solve different problems related to heterocyclic reaction mechanisms (*Analysis*)

CO5: Understanding of application of reactions of different types of heterocycles (*Synthesis*)

CO6: Demonstrate the important reactions like electrophilic substitution reaction, nucleophilic substitution, elimination reactions shown by different types of heterocycles (*Evaluation*)

Suggested Readings

1. L. A. Paquette. Modern Heterocyclic Chemistry, W. A. Benjamin
2. I. L. Finar. Organic Chemistry, Vol. II, ELBS
3. T. L. Gilchrist. Heterocyclic Chemistry, Longman
4. A. L. Lehninger. Biochemistry, Kalyani Publishers

CHNP0026: NATURAL PRODUCTS CHEMISTRY

(3 Credits - 45 hours)

Objective*: Students will be introduced to nomenclature, reactivity, and synthesis of different types of natural compounds.*

Module I: Natural Products and their Biosynthetic Pathways (15 hours)

General classification of natural products, sources and their isolation, characterisation and biosynthesis of common plant products; Extraction and Separation of Natural Products Biosynthesis pathways for natural products using co-enzymes and enzymes, general biogenesis and synthesis of cis-jasmone, methyl jasmonate, prostaglandins, exaltone and muscone.

Module II: Terpenoids and Alkaloids (15 hours)

Terpenes and the Isoprene Rule; General biosyntheses of mono- and sesquiterpenes, trans-chrysanthemic acid, cyclo-pentato monoterpene lactones; Synthesis of α-vetinone and total synthesis of β-eudesmol; Synthesis of hirsutene, abietic acid, cis juvenile hormone, trans annular cyclisation of caryophyllene; Synthesis of caryophyllene and isocaryophyllene; Rearrangements of santonic acid and thujospene; Synthesis and rearrangement of longifolene; Structure, synthesis and biosynthesis of common alkaloids: reticuline, yohimbine and tylophorine.

Module III: Steroids (15 hours)

Nomenclature of steroids and synthesis of squalene; Lanosterol and caretonoids; Synthesis of equlenins; Estrogens and total synthesis of non-aromatic steroids (progesterones); Corticosteroids; Degradation of diosgenin to progesterone and its synthesis; Miscellaneous transformations of steroid molecules.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Attain detailed knowledge about chemistry of medicinal compounds from natural origin (*Knowledge*)

CO2: Understand general methods of structural elucidation of medicinally active natural compounds (*Comprehension*)

CO3: Attain knowledge regarding isolation and purification of medicinal compounds from natural origin (*Application*)

CO4: Identify different types of natural products, their occurrence, structure, biosynthesis and properties (*Analysis*)

CO5: Know the use of natural products as starting materials (*Synthesis*)

CO6: Characterize products by physical and spectroscopic means including IR, NMR, GC, and MS (*Evaluation*)

Suggested Readings:

1. Nakanashi, K. Natural Products Chemistry, Vols. I and II, Academic Press, New York and London
2. Cooper R. and Nicola, G. Natural Products Chemistry, sources, separations and structures, CRC Press, Taylor & Francis Group
3. Bhat, S. V., Nagasampagi, B.A., Sivakumar, M. Chemistry of Natural Products, Springer Science & Business Media

CHAB0101: INORGANIC CHEMISTRY - I: ATOMIC STRUCTURE AND CHEMICAL BONDING

(4 Credits - 60 Hours)

Objectives: *To give students a sound understanding of the concepts of atomic structure, periodicity of elements, chemical bonding and redox reactions.*

Module I: Atomic Structure (14 hours)

Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ2. Quantum numbers and their significance. Normalized and orthogonal wave functions. Sign of wave functions. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Contour boundary and probability diagrams.

Pauli's Exclusion Principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.

Module II: Periodicity of Elements (16 hours)

s, p, d, f block elements, the long form of periodic table. Detailed discussion of the following properties of the elements, with reference to s & p-block.

a) Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.

b) Atomic radii (van der Waals)
c) Ionic and crystal radii.
d) Covalent radii (octahedral and tetrahedral)
e) Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy.
f) Electron gain enthalpy, trends of electron gain enthalpy.
g) Electronegativity, Pauling's/ Mulliken's/ Allred Rachow's/ and Mulliken-Jaffé's electronegativity scales. Variation of electronegativity with bond order, partial charge, hybridization, group electronegativity.Sanderson's electron density ratio.

Module III: Chemical Bonding (26 hours)

a) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its limitations. Packing of ions in crystals.Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy.Madelung constant, Born-Haber cycle and its application, Solvation energy.
b) Covalent bond: Lewis structure, Valence Bond theory (Heitler-London approach). Energetics of hybridization, equivalent and non-equivalent hybrid orbitals.Bent's rule, Resonance and resonance energy, Molecular orbital theory. Molecular orbital diagrams of diatomic and simple polyatomic molecules N2, O2, C2, B2, F2, CO, NO, and their ions; HCl, BeF2, CO2, (idea of s-p mixing and orbital interaction to be given). Formal charge, Valence shell electron pair repulsion theory (VSEPR), shapes of simple molecules and ions containing lone pairs and bond pairs of electrons, multiple bonding (σ and π bond approach) and bond lengths. Covalent character in ionic compounds, polarizing power and polarizability.Fajan's rules and consequences of polarization. Ionic character in covalent compounds: Bond moment and dipole moment. Percentage ionic character from dipole moment and electronegativity difference.
c) Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.
d) Weak Chemical Forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, Instantaneous dipole-induced dipole interactions. Repulsive forces, Hydrogen bonding (theories of hydrogen bonding, valence bond treatment) Effects of chemical force, melting and boiling points, solubility energetics of dissolution process.

Module IV: Oxidation-Reduction (4 hours)

Redox equations, Standard Electrode Potential and its application to inorganic reactions.
Principles involved in volumetric analysis to be carried out in class.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Describe the concepts of atomic structure, periodicity of elements and chemical bonding (*Knowledge*)
CO2: Explain the concepts they learn e.g., about quantum numbers and their significance, about properties of s and p-block elements such as electronegativity, electron gain enthalpy or electron affinity, concepts of different types of bonds etc. , in their own words (*Comprehension*)
CO3: Apply the concepts they learn to solve simple problems such as how atomic radii vary across a period or down a group, applying Heisenberg's uncertainty principle to calculate uncertainty in position or momentum of a particle in motion, calculate redox potentials of cells, balance redox reactions etc (*Application*)
CO4: Distinguish between periodic properties of elements such as ionization enthalpy from electron gain enthalpy, they should be able to explain the shapes of s, p, d, f orbitals, explain why certain redox reactions are favourable (*Analysis*)
CO5: Connect all the concepts they learn and apply them to predict shapes of molecules, the nature of bonding in different molecules, the polarizability of ions; calculate the redox-potentials of electrochemical cells (*Synthesis*)
CO6: Compare the advantages and disadvantages of the concepts they learn as well as their applications and limitations e.g., comparing the valence bond theory with that of the molecular orbital theory, the usefulness and limitations of valence shell electron pair repulsion theory etc. (*Evaluation*)

Suggested Readings

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
3. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
4. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.

CHSI0102: PHYSICAL CHEMISTRY-I: STATES OF MATTER AND IONIC EQUILIBRIUM

(4 Credits-60 hours)

Objectives: *To teach students the properties of the three states of matter and the concepts associated with ionic equilibria*

Module I: Gaseous state (18 hours)

a) Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

b) Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. Van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Module II: Liquid state (6 hours)

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity.Explanation of cleansing action of detergents.Temperature variation of viscosity of liquids and comparison with that of gases.Qualitative discussion of structure of water.

Module III: Solid state (16 hours)

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

Module IV: Ionic equilibria (20 hours)

a) Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).

b) Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body.

c) Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid – base titration curves (calculation of pH at various stages). Theory of acid–base indicators; selection of indicators and their limitations.Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: The properties of matter – the three states, solid, liquid and gaseous and the laws that govern them; they will also learn the principles of ionic equilibria (*Knowledge*)

CO2: Understand and explain the concepts they have learnt e.g., they should be able to explain the properties of the three states of matter and the principles of ionic equilibria in their own words (*Comprehension*)

CO3. Apply the principles they learn in this course to solve problems such as calculating the solubility product of an electrolyte in water, or calculating the pressure exerted by an ideal gas or calculate the surface tension or viscosity of a liquid (*Application*)

CO4: Differentiate between properties of ideal and real gases, liquids and gases or liquids and solids, strong and weak electrolytes etc. (*Analysis*)

CO5: Connect their understanding of the three states of matter and of ionic equilibria to construct an overview of these fundamental principles of physical chemistry - the applications of which they will encounter in subsequent courses in chemistry as well as in the laboratory and in everyday life (*Synthesis*)

CO6: Decide which laws to apply when solving problems dealing with states of matter and topics related to chemical equilibria (*Evaluation*)

Suggested Readings

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press
2. Ball, D. W. Physical Chemistry Thomson Press, India .
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

CHBH0103: ORGANIC CHEMISTRY- I: BASICS AND HYDROCARBONS

(4 Credits-60 hours)

Objectives: *To teach students the underlying principles of organic chemistry, stereochemistry and the chemistry of aliphatic and aromatic hydrocarbons*

Module I: Basics of Organic Chemistry (6 hours)

Organic Compounds: Classification, and Nomenclature, Hybridization, Shapes of molecules, Influence of hybridization on bond properties.

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids and bases; their relative strength.

Homolytic and Heterolytic fission with suitable examples.Curly arrow rules, formal charges; Electrophiles and Nucleophiles; Nucleophlicity and basicity; Types, shape and their relative stability of Carbocations, Carbanions, Free radicals and Carbenes.

Introduction to types of organic reactions and their mechanism: Addition, Elimination and Substitution reactions.

Module II: Stereochemistry (18 hours)

Fischer Projection, Newmann and Sawhorse Projection formulae and their interconversions; Geometrical isomerism: cis–trans and, syn-anti isomerism E/Z notations with C.I.P rules. Optical Isomerism: Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two or more chiral-centres, Distereoisomers, meso structures, Racemic mixture and resolution. Relative and absolute configuration: D/L and R/S designations.

Module III: Chemistry of Aliphatic Hydrocarbons (24 hours)

A. Carbon-Carbon sigma bonds Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. Carbon-Carbon pi bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene.

15 Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

C. Cycloalkanes and Conformational Analysis: Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Module IV: Aromatic Hydrocarbons (12 hours)

Aromaticity: Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Explain the principles that govern organic molecules such as their classification, nomenclature, electronic displacements, types of fission, types of organic reactions, stereochemistry, the chemistry of aliphatic and aromatic hydrocarbons (*Knowledge*)

CO2: Explain the principles e.g., the types and mechanisms of organic reactions, the principle of optical activity, different projection formulae etc. they learn, in their own words (*Comprehension*)

CO3: Apply their understanding to solve problems such as identifying whether a molecule will undergo an addition, elimination or substitution reaction under a certain given condition, finding out whether a molecule with a chiral centre has R or S configuration etc. (*Application*)

CO4: Distinguish between addition, elimination and substitution reactions, they should be able to distinguish between Fischer projection and Newman projection formulae, differentiate between chiral and achiral molecules, and differentiate enantiomers from diastereomers (*Analysis*)

CO5: Describe the classification, nomenclature, stereochemistry, and type of reaction an organic compound can undergo in a given set of conditions (*Synthesis*)

CO6: Decide under which conditions, for example, the elimination reaction converting an alkyl halide to an alkene will take place by the E1 or E2 or E1cb mechanism (*Evaluation*)

Suggested Readings

1. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds; Wiley: London
5. Kalsi, P. S. Stereochemistry Conformation and Mechanism; New Age International.

CHCT0104: PHYSICAL CHEMISTRY- II: THERMODYNAMICS AND ITS APPLICATIONS

(4 Credits-60 hours)

Objectives: *To teach students the concepts of classical thermodynamics, chemical equilbrium, properties of dilute solutions and colligative properties*

Module I: Chemical Thermodynamics (36 hours)

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics.

First law: Concept of heat, q, work, w, internal energy, U, and statement of first law; enthalpy, H, relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions.

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchhoff's equations) and pressure on enthalpy of reactions. Adiabatic flame temperature, explosion temperature.

Second Law: Concept of entropy; thermodynamic scale of temperature, statement of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes.

Third Law: Statement of third law, concept of residual entropy, calculation of absolute entropy of molecules.

Free Energy Functions: Gibbs and Helmholtz energy; variation of S, G, A with T, V, P; Free energy change and spontaneity. Relation between Joule-Thomson coefficient and other thermodynamic parameters; inversion temperature; Gibbs-Helmholtz equation; Maxwell relations; thermodynamic equation of state.

Module II: Systems of Variable Composition (8 hours)

Partial molar quantities, dependence of thermodynamic parameters on composition; Gibbs-Duhem equation, chemical potential of ideal mixtures, change in thermodynamic functions in mixing of ideal gases.

Module III: Chemical Equilibrium (8 hours)

Criteria of thermodynamic equilibrium, degree of advancement of reaction, chemical equilibria in ideal gases, concept of fugacity.Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient.Coupling of exoergic and endoergic reactions.Equilibrium constants and their quantitative dependence on temperature, pressure and concentration. Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants Kp, Kc and Kx. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

Module IV: Solutions and Colligative Properties (8 hours)

a) Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions.
b) Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] and amount of solute. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understand introductory concepts of thermodynamics, such as the laws of thermodynamics, chemical equilibrium, properties of dilute solutions and colligative properties (*Knowledge*)

CO2: Explain the laws of thermodynamics, the concept of free energy, concept of entropy, chemical equilibrium, etc. in their own words (*Comprehension*)

CO3: Apply the laws of thermodynamics, heats of reactions, free energy functions, reversible and irreversible processes, to solve simple problems (*Application*)

CO4: Differentiate between thermodynamic terms such as intensive and extensive properties; path independent and path-dependent functions; entropy, enthalpy, free energy, reversible and irreversible processes, etc. They should be able to decide the conditions that must be fulfilled, for a given chemical reaction to proceed spontaneously, etc. (*Analysis*)

CO5: Apply their understanding to design and solve analytical problems (*Synthesis*)

CO6: Evaluate conditions under which a system goes from one state to another reversibly and conditions that would make the transformation irreversible, they should understand the derivation of relations between equilibrium constants Kp, Kc, Kx etc. (*Evaluation*)

Suggested Readings

1. Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press .
2. Castellan, G. W. Physical Chemistry 4th Ed., Narosa

3. Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall.
4. McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S.
6. Commonly Asked Questions in Thermodynamics. CRC Press: NY.
7. Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill .
8. Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006)

CHAH0105: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS

(4 Credits-60 hours)

Objectives: *To give students an understanding of atomic structure, types of bonding, fundamentals of organic chemistry, stereochemistry and aliphatic hydrocarbons*

Module I: Inorganic Chemistry-1 (30 hours)

a) Atomic Structure (14 hours)

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de-Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to Atomic structure.

What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it.Significance of ψ and ψ2, Schrödinger equation for hydrogen atom. Radial an angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin - spin quantum number (s) and magnetic spin quantum number (m).

Rules for filling electrons in various orbitals, Electronic configurations of the atoms.Stability of half-filled and completely filled orbitals, concept of exchange energy.Relative energies of atomic orbitals, Anomalous electronic configurations.

b) Chemical Bonding and Molecular Structure (16 hours)

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding,lattice energy and solvation energy and their importance in the context of stability and solubilityof ionic compounds.Statement of Born-Landé equation for calculation of lattice energy,Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ioniccharacter in covalent compounds, bond moment, dipole moment and percentage ionic character.

Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

Module II: Organic Chemistry-1 (30 hours)

a) Fundamentals of Organic Chemistry (8 hours)

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles.

Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoids and Hückel's rule.

b) Stereochemistry (10 hours)
Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations.Concept of chirality (upto two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

c) Aliphatic Hydrocarbons (12 hours)
Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.
Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation.
Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. $KMnO_4$) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation.
Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.
Reactions: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alk. $KMnO_4$.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Concepts of inorganic chemistry such as atomic structure, chemical bonding and molecular structure; fundamentals of organic chemistry, stereochemistry such as electronic displacements, cleavage of bonds structure, shape, reactivity of organic molecules, stereochemistry, chemistry of aliphatic hydrocarbons (*Knowledge*)

CO2: Understanding of the concepts taught in this course, so as to be able to explain the concepts such as that of the wavefunction in quantum mechanics, the radial distribution function, principles of ionic and covalent bonding, valence bond theory, concepts of resonance MO approach etc. in their own words. Similarly they should be able to explain the concepts of organic chemistry such as electronic displacements, nucleophiles, electrophiles, Newman projection formula etc. (*Comprehension*)

CO3: Write electronic configurations of elements, predict the shapes of some inorganic molecules using the VESPR theory, calculate the strengths of organic acids and bases, predict whether a molecule is aromatic or not, draw the conformations of molecules such as ethane, butane, cyclohexane etc. (*Application*)

CO4: Compare concepts such as □ and □2, explain the Schrodinger equation for hydrogen atom and the resulting radial and angular parts of the hydrogenic wavefunctions, function, differentiate between conformation and configuration of a molecules, nucleophiles and electrophiles, bonding and antibonding orbitals, differentiate between properties of alkanes, alkenes, alkynes (*Analysis*)

CO5: Construct examples and arguments to explain concepts they learn. E.g. when describing enantiomers, they should be able to give appropriate examples, similarly while explaining resonance in inorganic and organic compounds. They should be able to devise problems based on the theories and concepts they learn (*Synthesis*)

CO6: Reflected in the ease with which they can explain and relate the different concepts they learn (*Evaluation*)

Suggested Readings

1. J. D. Lee: A new Concise Inorganic Chemistry, E L. B. S.
2. F. A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley.
3. Douglas, McDaniel and Alexader: Concepts and Models in Inorganic Chemistry, John Wiley.
4. James E. Huheey, Ellen Keiter and Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
5. T. W. Graham Solomon: Organic Chemistry, John Wiley and Sons.
6. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.

7. E. L. Eliel: Stereochemistry of Carbon Compounds, Tata McGraw Hill.
8. I. L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
9. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.

CHCF0106: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I

(4 Credits-60 hours)

Objectives: *To teach students the principles of chemical energetics, chemical and ionic equilibria and some concepts of organic chemistry*

Module I: Physical Chemistry-1 (30 hours)

Chemical Energetics (10 hours)

Review of thermodynamics and the Laws of Thermodynamics.

Important principles and definitions of thermochemistry.Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution.Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation.Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

Chemical Equilibrium (8 hours)

Free energy change in a chemical reaction.Thermodynamic derivation of the law of chemical equilibrium.Distinction between ΔG and ΔGo, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.

Ionic Equilibria (12 hours)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect.Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts.Buffer solutions.Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

Module II: Organic Chemistry-2 (30 hours)

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure.

Aromatic hydrocarbons (8 hours)

Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid.

Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene).Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl and Aryl Halides (8 hours)

Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions.

Preparation: from alkenes and alcohols.

Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution.

Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions.

Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3).

Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

Alcohols, Phenols and Ethers (Upto 5 Carbons) (8 hours)

Alcohols: Preparation: Preparation of 1o, 2o and 3o alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters.

Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate, conc. HNO_3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement.

Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer-Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction.

Ethers (aliphatic and aromatic): Cleavage of ethers with HI.

Aldehydes and ketones (aliphatic and aromatic) (6 hours)

(Formaldehye, acetaldehyde, acetone and benzaldehyde)

Preparation: from acid chlorides and from nitriles.

Reactions – Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Iodoform test.Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation.Clemensen reduction and Wolff Kishner reduction.Meerwein-Pondorff Verley reduction.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Theories of chemical energetics; chemical equilibria; aromatic hydrocarbons; alkyl and aryl halides; alcohols, phenols and ethers; aldehydes and ketones (*Knowledge*)

CO2: Explain concepts such as the free energy changes accompanying chemical reactions, Le Chatelier's principle, principles of electrolytes, preparation and reactions of organic molecules such as aromatic hydrocarbons, nucleophilic substitution reactions of alkyl halides etc. (*Comprehension*)

CO3: Calculate the change in free energy accompanying a chemical reaction, derive equations governing the dissociation of aqueous solutions of weak acids and bases, write out the methods of preparations of alcohols, phenols etc., and mechanisms of organic chemistry reactions such as that for nucleophilic substitution reactions, elimination reactions etc. (*Application*)

CO4: Explain spontaneity of a reaction based on the measure of free energy change accompanying the reaction; they should be able to explain whether a nucleophilic substitution reaction will take place by SN1 or SN2 or SNi mechanism etc. (*Analysis*)

CO5: Put together the methods of preparation of an organic compound such as a phenol and write out the possible reactions it can undergo along with detailed mechanisms (*Synthesis*)

CO6: Differentiate the concept of free energy change from standard free energy change; they should be able to explain how the equilibrium of a system changes when subjected to a change in pressure, temperature or concentration of a reactant; they should be able to compare the mechanisms that alkyl halides undergo with those of aryl halides or the reactions of alcohols with those of phenols etc. (*Evaluation*).

Suggested Readings

1. T. W. Graham Solomons: Organic Chemistry, John Wiley and Sons.
2. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
3. I.L. Finar: Organic Chemistry (Vol. I & II), E. L. B. S.
4. R. T. Morrison & R. N. Boyd: Organic Chemistry, Prentice Hall.
5. G. M. Barrow: Physical Chemistry Tata McGraw Hill .
6. G. W. Castellan: Physical Chemistry 4th Edn. Narosa .
7. J. C. Kotz, P. M. Treichel & J. R. Townsend: General Chemistry Cengage Lening India Pvt. Ltd., New Delhi.
8. B. H. Mahan: University Chemistry 3rd Ed. Narosa.
9. R. H. Petrucci: General Chemistry 5th Ed. Macmillan Publishing Co.: New York

CHIQ6002: INORGANIC QUALITATIVE AND QUANTITATIVE ANALYSIS - LAB
(3 Credits)

Objective: *This course aims to give an idea about the qualitative and quantitative analysis of binary mixtures, alloys and ores*

1. Qualitative analysis (tertiary mixtures, alloys, ores)
2. Quantitative analysis (binary mixtures, alloys, ores)
3. Inorganic preparation (crystallization, precipitation, calcination)
4. Coordination compounds through ligand synthesis and spectroscopic characterization, magnetic properties
5. Metal Nanoparticle synthesis and characterization

COURSE/LEARNING OUTCOMES

At the end of the Lab experiments students will be able to:

CO1: Gain complete understanding of various chemical processes and laboratory techniques (*Knowledge*)
CO2: Work in the laboratory with different chemicals and apparatus (*Comprehension*)
CO3: Learn the uses of different chemical compounds (*Application*)
CO4: Learn how to handle the apparatus and various instruments in the laboratory (*Analysis*)
CO5: Perform different reactions inside the laboratory (*Synthesis*)
CO6: Use practical concepts to understand the characteristics of various chemical compounds (*Evaluation*)

Suggested Readings

1. J. Mendham, R. C. Denney, J. D. Barnes, M. Thomas, B. Sivasankar; Vogel's Textbook of Quantitative Chemical Analysis, Pearson.
2. G. Svehla, S. Mittal; Vogel's Qualitative Inorganic Analysis, Pearson Education.

CHEQ6003:EXPERIMENTAL PHYSICAL CHEMISTRY - LAB
(3 Credits)

Objective: *This laboratory based course is designed to learn the applications of chemical kinetics, electrochemistry, spectrophotometry and pH-metric titrations.*

a) Chemical Kinetics based experiments
b) Electrochemistry based experiments
c) Spectrophotometry based experiments
d) pH-metric Titrations
e) Adsorption on porous materials - equilibrium, kinetic and thermodynamic studies

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: Recall fundamental concepts they got in the graduation level in physical chemistry that they applied in the practical field (*Knowledge*)
CO2: Understand the laboratory course which consists of experiments illustrating the principles of physical chemistry relevant to the study of Master of Science. (*Comprehension*)
CO3: Estimate rate constants of reactions from concentration of reactants/products as a function of time, measure activation energy, measure molecular/system properties such as surface tension, viscosity, conductance of solutions, pH of solution etc, adsorption of liquid in solid surfaces, distribution of solutes between two immiscible solvent, determination of unknown concentration of a given solution spectrophotometrically (*Application*)
CO4: Analyse practical utility of different theories chemical kinetics, surface tension, viscosity, conductance, pH meter, phase equillibria, adsorption etc. (*Analysis*)
CO5: Understanding of theories of the experiments they learned in the class by performing it in the laboratory class (*Synthesis*)
CO6: Apply the knowledge of practical classes such as estimation of rate constants of reactions from concentration of reactants/products as a function of time, measure activation energy, measure molecular/system properties such as surface tension, viscosity, conductance of solutions, pH of

solution etc, adsorption of liquid in solid surfaces, distribution of solutes between two immiscible solvent, determination of unknown concentration of a given solution spectrophotometrically etc in the practical field of chemistry to solve problems (*Evaluation*)

Suggested Reading

J. B. Yadav; Advanced Practical Physical Chemistry, Goel Publishing House.

CHQA6004:ORGANIC QUALITATIVE ANALYSIS AND SYNTHESIS LAB

(3 Credits)

Objective: *This course will introduce common laboratory techniques, instruments for carrying out organic synthesis, isolation and extraction of natural products and qualitative and quantitative analysis.*

1. Qualitative analysis of binary mixtures of organic compounds
   (a) Separation of binary mixture into individual components
   (b) Qualitative analysis of individual components by
      (i) Detection of extra elements N, S, Halogens
      (ii) Test for functional groups by systematic analysis
      (iii) Solubility, melting point
      (iv) Preparation of a derivative and determination of its melting point
2. Preparation of organic compounds by using single and multistep process.
3. Chromatographic techniques
   (a) Qualitative TLC separation and identification
   (b) Column chromatographic separation of a mixture of compounds.
4. Extraction of natural products.

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: Get idea about organic qualitative analysis, separation of binary mixtures of organic compounds, extraction of natural product, synthesis and different chromatographic techniques (*Knowledge*)

CO2: Synthesize and characterize organic compounds, perform qualitative analysis of simple as well as mixture of organic compounds and learn different chromatographic methods (*Comprehension*)

CO3: Apply different chromatographic techniques for the identification and purification of synthetic organic compounds as well as natural products (*Application*)

CO4: Analyse practical utility of different natural product extraction methods and chromatographic techniques (*Analysis*)

CO5: Understanding of separation of binary mixture of organic compounds by using the concept of solubility. They would be able to synthesize different organic compounds by using single and multistep synthesis (*Synthesis*)

CO6: Identify different types of natural products. They will be able to describe important methods of extraction and their synthesis (*Evaluation*

Suggested Readings

1. Vogel's Textbook of Practical Organic Chemistry, Including Qualitative Organic Analysis
2. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, Pearson.
4. Ahluwalia, V. K.; Dhingra, S. Comprehensive Practical Organic Chemistry, University Press.

CHRP6005: RESEARCH PROJECT

(9 Credits)

Objective*: To train students to carry out research on a topic that is of relevance to the chemical sciences*
In this course, each student undertakes research on a topic that he/she chooses in project phase I or on a topic assigned to him/her by the concerned mentor.

To this end, the student will first review the current status of research on the selected topic, state a hypothesis or a set of objectives and then carry out experiments (either wet-lab or theoretical) to gather data, which he/she will then analyse, draw conclusions and finally present in a dissertation at the end of the semester.

The format for the final dissertation will be as prescribed by the department. There will be a viva voce examination on the dissertation by an expert committee comprising external and internal members of the department. The mode and components of the evaluation and the weightages attached to them shall be published by the department at the beginning of the semester
This will be a research-based module, whereby, students will carry out either theoretical or wet lab experiments and present their findings in a thesis and perhaps as a paper in a conference or a journal.

COURSE/LEARNING OUTCOMES

At the end of the Research Project students will be able to:

CO1: Experiments to fulfil their research objectives and will in the process learn a wide range of techniques both scientific and statistical, and also probably add to the existing body of scientific knowledge (*Knowledge*)
CO2: Understanding of the methods they use to carry out their research and why a certain set of methods is chosen (*Comprehension*)
CO3: Apply their understanding to steer their research in the right direction (*Application*)
CO4: Troubleshoot when a chosen approach does not yield the expected result (*Analysis*)
CO5: Learn to choose a methodology or approach to fulfil a set of objectives or prove or disprove a hypothesis (*Synthesis*)
CO6: Critically analyse the results they obtain to decide whether the data obtained proves or disproves a stated hypothesis (*Evaluation*)

CHAB6101: INORGANIC CHEMISTRY-I: ATOMIC STRUCTURE AND CHEMICAL BONDING LAB

(2 Credits)

A) Titrimetric Analysis
(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants
B) Acid-Base Titrations
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents
C) Oxidation-Reduction Titrimetry
(i) Estimation of Fe(II) and oxalic acid using standardized KMnO4 solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe(II) with K2Cr2O7 using internal (diphenylamine, anthranilic acid) and external indicator.

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: How to carry out acid-base and oxidation-reduction titrations for the estimation of salts ions in mixtures or in a solution (*Knowledge*)
CO2: Understanding of the principles and procedures that they use in the laboratory to carry out titrations to estimate the concentrations of ions in solution (*Comprehension*)
CO3: Carry out estimations of ions present in unknown proportions in a mixture or estimate ions such as Fe(II) present in unknown concentrations in solution (*Application*)
CO4: Distinguish between procedures of acid-base titration used for estimating carbonate and hydroxide ions in a mixture from the procedure used to estimate concentration of Fe(II) ions in a solution. They should be able to interpret the data they obtain from their measurements (*Analysis*)

CO5: Set up the methods used for estimating an unknown mixture of ions and interpret the results they obtain. (*Synthesis*)

CO6: Compare and contrast the different principles and procedures that they follow to estimate ions whether present in mixtures or independently (*Evaluation*)

Suggested Readings

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.

CHIS6102: PHYSICAL CHEMISTRY-I: STATES OF MATTER AND IONIC EQUILIBRIUM LAB

(2 Credits)

1. Surface tension measurements.
   a. Determine the surface tension by (i) drop number (ii) drop weight method.
   b. Study the variation of surface tension of detergent solutions with concentration.
2. Viscosity measurement using Ostwald's viscometer.
   a. Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   b. Study the variation of viscosity of sucrose solution with the concentration of solute.
3. Indexing of a given powder diffraction pattern of a cubic crystalline system. pH metry
   a. Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   b. Preparation of buffer solutions of different pH
      i. Sodium acetate-acetic acid
      ii. Ammonium chloride-ammonium hydroxide
   c. pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   d. Determination of dissociation constant of a weak acid.

Any other experiment carried out in the class.

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: Measure properties such as surface tension, viscosity, pH of solutions, index a given powder diffraction pattern of a cubic crystalline system, prepare buffers etc. (*Knowledge*)

CO2: Understand the principles underlying the experiments they carry out and be able to explain the principles in their own words (*Comprehension*)

CO3: Measure surface tension, viscosity, pH of any given solution and the dissociation constant of unknown weak acids (*Application*)

CO4: Apply the right principles when measuring the property of a given solution be it surface tension, pH or dissociation constant (*Analysis*)

CO5: How to set up an experimental protocol for measuring the property of an unknown sample which may be a sugar solution whose viscosity they want to measure by varying its concentration (*Synthesis*)

CO6: Assess the advantages and limitations of the principles and procedures they learn in the lab for analyzing properties such as surface tension of a solution or the dissociation constant of an unknown weak acid (*Evaluation*)

Suggested Readings

1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).

CHBH6103: ORGANIC CHEMISTRY- I: BASICS AND HYDROCARBONS LAB

(2 Credits)

1. Checking the calibration of the thermometer
2. Purification of organic compounds by crystallization using the following solvents:
   a. Water
   b. Alcohol
   c. Alcohol-Water
3. Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
4. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
5. Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)
6. Chromatography:
   a. Separation of a mixture of two amino acids by ascending and horizontal paper chromatography
   b. Separation of a mixture of two sugars by ascending paper chromatography
   c. Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by
   thin layer chromatography (TLC)

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: Purify organic compounds by crystallization, to determine melting points of the purified compounds, to determine boiling point of liquid compounds and to use chromatography to separate out mixtures of two organic compounds (*Knowledge*)

CO2: Give the best crystals, how the melting point apparatus works, setting up a distaillation apparatus to determine the boiling of a liquid, and the significance of melting and boiling points of organic compounds, and the principle of chromatographic separation (*Comprehension*)

CO3: Crystallize an organic compound and determine its melting point or in the case of a liquid, determine its boiling point by distillation or the capillary method, they should be able to set up a chromatography experiment to separate a mixture of two organic compounds (*Application*)

CO4: Students should be able to assess the conditions required for crystallization and in the case of a liquid whether to use the distillation method or the capillary method for measuring the boiling point; they should be also determine optimal solvent compositions to use for chromatographic separation (*Analysis*)

CO5: Set up an experiment to separate a mixture of organic compounds using an appropriate chromatographic technique and identify the compounds based on their Rf values, they should be able to determine the melting point of an unknown organic compound (*Synthesis*)

CO6: Decide based on observations and acquired data, which chromatographic technique and solvent mixtures yield the best separation of a mixture of two organic compounds (*Evaluation*)

Suggested Readings

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi.

CHCT6104: PHYSICAL CHEMISTRY- II: THERMODYNAMICS AND ITS APPLICATIONS LAB

(2 Credits)

Thermochemistry

1. Determination of heat capacity of a calorimeter for different volumes using change of enthalpy data of a known system (method of back calculation of heat capacity of calorimeter from known enthalpy of solution or enthalpy of neutralization).
2. Determination of heat capacity of the calorimeter and enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Calculation of the enthalpy of ionization of ethanoic acid.

4. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) solution of salts.
5. Determination of basicity/proticity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
6. Determination of enthalpy of hydration of copper sulphate.
7. Study of the solubility of benzoic acid in water and determination of ΔH.

Any other experiment carried out in the class.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Measure properties such as surface tension, viscosity, pH of solutions, index a given powder diffraction pattern of a cubic crystalline system, prepare buffers etc.. (Knowledge)

CO2: Understand the principles underlying the experiments they carry out and be able to explain the principles in their own words. (Comprehension)

CO3: Measure surface tension, viscosity, pH of any given solution and the dissociation constant of unknown weak acids. (Application)

CO4: Apply the right principles when measuring the property of a given solution be it surface tension, pH or dissociation constant. (Analysis)

CO5: Set up an experimental protocol for measuring the property of an unknown sample which may be a sugar solution whose viscosity they want to measure by varying its concentration (Synthesis)

CO6: Assess the advantages and limitations of the principles and procedures they learn in the lab for analyzing properties such as surface tension of a solution or the dissociation constant of an unknown weak acid. (Evaluation)

Suggested Readings

1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi.
2. Athawale, V. D. & Mathur, P. Experimental Physical Chemistry New Age International: New Delhi.

CHAH6105: ATOMIC STRUCTURE, BONDING, GENERAL ORGANIC CHEMISTRY & ALIPHATIC HYDROCARBONS LAB

(2 Credits)

Section A: Inorganic Chemistry - Volumetric Analysis

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO4.
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
4. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator.
5. Estimation of Cu (II) ions iodometrically using Na2S2O3.

Section B: Organic Chemistry

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)
   (a) Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
   (b) Identify and separate the sugars present in the given mixture by paper chromatography.

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: Estimate inorganic salts such as sodium carbonate, sodium bicarbonate, Fe(II) ions, Cu(II) ions by volumetric analysis; Detect the presence of N,S, Cl, Br, I in organic compounds, separate mixtures of organic molecules by chromatography (*Knowledge*)

CO2: Explain the principles of the experiments they perform in this course in their own words (*Comprehension*)

CO3: Carry out estimations of mixtures of salts present in different proportions, estimate unknown quantities of Cu(II) or Fe(II) ions, determine the presence of N or S in unknown organic compounds, separate unknown mixtures by chromatography and identify them by comparing their Rf values with standard tables (*Application*)

CO4: Decide the best method for measuring the proportion of salts in a mixture by volumetric analysis; decide appropriate solvent ratios to use for chromatographic separation of organic molecules in a mixture (*Analysis*)

CO5: Design experiments to estimate for instance Cu(II) ions iodometrically, or design the solvent ratios in a chamber for optimal separation of organic molecules in a mixture by paper chromatography (*Synthesis*)

CO6: How to carry out elemental analysis of an organic molecule, know the best procedure for estimating salts in a mixture by volumetric analysis, and know why certain solvent ratios result in better separation of a pair of molecules in paper chromatography experiments, learn the shortcomings an advantages of the various experimental procedures they learn (*Evaluation*)

Suggested Readings

1. Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall
2. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall.
3. Textbook of Practical Organic Chemistry, A.I. Vogel , Prentice Hall.
4. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman.

CHCF6106: CHEMICAL ENERGETICS, EQUILIBRIA & FUNCTIONAL ORGANIC CHEMISTRY-I LAB

(2 Credits)

Section A: Physical Chemistry

Thermochemistry

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.
4. Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).
5. Determination of enthalpy of hydration of copper sulphate.
6. Study of the solubility of benzoic acid in water and determination of ΔH.
7. Ionic equilibria

pH measurements

1. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
2. Preparation of buffer solutions:
   i) Sodium acetate-acetic acid 82
   ii) Ammonium chloride-ammonium hydroxide
3. Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

Section B: Organic Chemistry

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed.
   Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
   (a) Bromination of Phenol/Aniline
   (b) Benzoylation of amines/phenols
   (c) Oxime and 2,4 dinitrophenylhydrazone of aldehyde/ketone

COURSE/LEARNING OUTCOMES

At the end of the Lab experimentsstudents will be able to:

CO1: Measure the heat capacity of a calorimeter for different volumes, the enthalpy of neutralization, ionization, hydration etc; they will learn to measure pH of aerated drinks, fruit juices etc., prepare buffers, purify organic compounds by crystallization, determine melting and boiling points of organic compounds, they will prepare organic compounds, carry out bromination of phenol/aniline etc. (*Knowledge*)

CO2: Understand the principles of the experiments they carry out as well as of the methodologies involved (*Comprehension*)

CO3: Measure enthalpy of neutralization of any given unknown salt, measure the pH of an unknown aqueous solution, prepare a buffer solution using any weak acid or base, determine the melting point or boiling point of an unknown organic compound (solid/liquid) etc. (*Application*)

CO4: Interpret the results they get of a set of measurements and draw relevant conclusions, they should be able to troubleshoot when results are not conclusive, they should be able to come up with mechanisms for the organic preparations they carry out, etc. (*Analysis*)

CO5: Design experiments to measure for instance, the enthalpy of solvation of a solute, or the method of preparation of an organic compound, measure its melting/boiling point, depending on whether it is a solid or a liquid etc. (*Synthesis*)

CO6: Deduce the optimal methods for measuring a property, analyze and interpret data correctly, describe mechanisms involved in preparation of organic compounds they synthesize etc. (*Evaluation*).

Suggested Books

1. A.I. Vogel: Textbook of Practical Organic Chemistry, 5th edition, Prentice-Hall.
2. F. G. Mann & B. C. Saunders, Practical Organic Chemistry, Orient Longman (1960).
3. B.D. Khosla, Senior Practical Physical Chemistry, R. Chand & Co.

SCHOOL OF FUNDAMENTAL AND APPLIED SCIENCES

DEPARTMENT OF MATHEMATICS

MARA0014: REAL ANALYSIS

(4 Credits - 60 hours)

Objective: *The objective of this course is to introduce to a student various algebraic properties of the real number system. Moreover, the present course also serves as an introductory course on principles of real analysis that undertakes all the key notion of any form of Mathematical analysis.*

Module I (14 hours)

Review of set theory, relations and functions, finite and infinite sets, countable and uncountable sets, Real number system as a complete ordered field, Archimedean property, supremum, infimum.

Sequence of real numbers, bounded sequence, limsup, liminf, Cauchy sequences, Series, convergence of series, root and ratio tests, absolute convergence.

Module II (8 hours)

Limit, Continuity, types of discontinuity, Intermediate value theorem, Fixed point theorem, uniform continuity, Monotonic functions.

Module III (12 hours)

Sequence and series of real valued functions, Point wise and uniform convergence, uniform convergence and continuity, uniform convergence and differentiation, uniform convergence and integration. Cauchy criteria for uniform convergence. Series of functions and convergence, Weierstrauss M-test.

Module IV (10 hours)

Riemann sums and Riemann integral, Riemann-Stieltjes Integrals, Improper Integrals

Functions of several variables, directional derivative, partial derivative, derivative as a linear transformation, inverse and implicit function theorems.

Module V (16 hours)

Metric spaces, open and closed sets, limit points, interior points, Euclidean space, compact spaces, Bolzano Weierstrass theorem, Heine Borel theorem.

Measurable sets and functions, Lebesgue outer measure, Lebesgue integral.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the fundamental concepts of mathematical analysis like algebraic and order properties of real numbers, continuity, differentiability, integration etc. (*Knowledge*)

CO2: Understanding of the already mentioned concepts, students will be able to have a systematic understanding of the interface among these concepts (*Comprehension*)

CO3: Formulate the problems involving numerous practical situations and will be able to solve such problems (*Application*)

CO4: Analyze roles played by each such concept in a certain problem and will be able to apply properties of the pertinent concept (*Analysis*)

CO5: Have a clear understanding of where the hypothesis of a given problem undertakes such concepts whence solving the problem (*Synthesis*)

CO6: Learn the fundamental distinction between various rules applied for the solution of a problem and also which method suits a certain problem the most (*Evaluation*)

Suggested Readings

1. Principles of Mathematical Analysis (5th edition) – W. Rudin, McGraw Hill Kogakusha Ltd., 2004.
2. Mathematical Analysis (5th edition) – T. Apostol, Addison-Wesley; Publishing Company, 2001.
3. Introduction to Real Analysis (3rd edition) – R. G. Bartle and D. R. Sherbert, John Wiley & Sons, Inc.,New York, 2000.
4. The Elements of Real Analysis (3rd edition) – R. G. Bartle, Wiley International Edition, 1994.

MALA0015: LINEAR ALGEBRA

(4 Credits - 60 hours)

Objective: *The objective of the present course is to introduce to a student the preliminaries of linear algebra. This course also intends to provide the students the knowledge of properties of matrices which is plays a key role in applicable as well as computational mathematics.*

Module I (10 hours)

Vector spaces, subspaces, quotient spaces, linear dependence, basis, dimension of a vector space, Linear Transformations.

Module II (20 hours)

Algebra of Matrices, trace of matrices, rank and determinant of matrices, system of linear equations. Eigenvalues and eigenvectors, relation between characterstic and minimal polynomial, Cayley-Hamilton theorem, Diagonalizability.

Module III (10 hours)

Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms.

Module IV (15 hours)

Inner product spaces, properties of inner products and norms, Cauchy-Schwarz inequality, Orthogonality and orthogonal complemants, orthonormal basis, Gram-Schmidt process.

Module V (5 hours)

Quadratic forms, reduction and classification of quadratic forms.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the fundamental concepts associated with linear algebra and the role played by the theory of matrices (*Knowledge*)

CO2: Understanding of the key concepts of linear algebra, students will have the knowledge of the various physical significance of these concepts (*Comprehension*)

CO3: Apply concepts like linear independence, basis in various engineering problems and will be able to handle such problems in an efficient manner (*Application*)

CO4: Analyze for instance, the solvability of a system of linear equations in the form of a matrix and can infer important results (*Analysis*)

CO5: Synthesize the class of system of linear equations as consistent and inconsistent systems (*Synthesis*)

CO6: Decide for example, under what condition a given linear transformation is diagonal and to what extent a given transformation can be diagonalized (*Evaluation*)

Suggested Readings

1. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall, 1984.
2. G.E. Shilov, Linear Algebra, Prentice Hall, 1998.
3. Linear Algebra, A Geometric Approach – S. Kumaresan, Prentice-Hall of India Pvt. Ltd., NewDelhi,2001.

MAAB0016: ABSTRACT ALGEBRA
(4 Credits - 60 hours)

***Objective**: The primary objective of the present course is to introduce to a student the basics of abstract mathematics, a notion that is inevitable in every branch of mathematics. Moreover, the present course also serves as the pre-requisite to topics like Galois theory and represent theory.*

Module I (20 hours)

Groups, subgroups, cyclic groups, permutation groups, Isomorphism's, cosets and Lagrange's Theorem, normal subgroups, quotient groups, group homomorphism's, fundamental theorem of finite abelian groups . Cayley's theorem, class equations, Sylow theorems, Direct products of groups, Solvable groups, Jordan-Holder theorem

Module II (20 hours)

Rings, ideals, prime and maximal ideals, quotient rings, Euclidean domain. principal ideal domain, unique factorization domain, Polynomial ring over a field, reducible and irreducible polynomials, irreducibility criteria.

Module III (15 hours)

Fields, finite fields, field extensions, Algebraic extensions, Galois Theory.

Module IV (5 hours)

Fundamentals of representation theory.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understanding of the basic concepts associated with abstract algebra for example group, ring, field etc. (*Knowledge*)

CO2: Relate these concepts to study the symmetries of a polygon, rotation of a cube etc. (*Comprehension*)

CO3: Use these concepts in various problems arising in mathematical physics and many other theoretical problems like insolvability of a quintic (*Application*)

CO4: Analyze the problem by analyzing the properties of the related structure (*Analysis*)

CO5: Classify the set of problems depending upon the underlying structure (*Synthesis*)

CO6: Infer about the possible outcomes of the problem (*Evaluation*)

Suggested Readings

1. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, New Delhi, 1975.
2. N. S. Gopalakrishnan, University Algebra, Wiley Eastern, 1991.
3. J. A. Gallian, Contemporary Abstract Algebra, Narosa, 1995.
4. Dummit & Foote, Algebra, John Wiley & Sons, 2005.

MADE0017: DIFFERENTIAL EQUATIONS
(4 Credits-60 Hours)

***Objective:** The present course aims to introduce to a student the theory of ordinary differential equation which plays a key role in almost every physical situation. Apart from that, the course can also be viewed as an introductory course on partial differential equation.*

Module I (12 hours)

Classification of Differential Equations, Their origin and solution; Exact differential equation and integrating factors, special integrating factors, linear equation and Bernoulli equations. existence and uniqueness for initial Value problem: Peano and Picard theorem

Module II (14 hours)

Second order Linear Differential equations , dimension of the solution space for homogeneous equations, general solution for non-homogeneous Equations.; method of undetermined coefficients, method of variation of parameters. Power series solution about an ordinary point, solution about singular points, Frobenius method

Module III (8 hours)

BVP, Sturm-Liouville Problem, Orthogonality of Characteristic functions, Fourier series exp.

Module IV (26 hours)

Origin of Partial Differential Equation, Linear and quasi-linear partial differential equation, method of characteristics, Lagrange's and Charpit's method to solve first order PDE, Cauchy problem for first order PDE, Classification of PDEs(second order), Method of separation of variables for Heat, Wave and Laplace equation.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the fundamental concepts associated with differential equations like linear and non linear differential equation, solution of a differential equation etc. (*Knowledge*)

CO2: Understanding of the above mentioned concepts, a student will also have a conceptual insight of the underlying mathematical analysis (*Comprehension*)

CO3: Formulate problems involving various physical situation and will be able to solve such problems (*Application*)

CO4: Analyze certain problems which are not solvable initially whereupon suggesting possible conditions for the solution of the same (*Analysis*)

CO5: Have a clear understanding of the necessity and sufficiency of the hypothesis related to a the solution of a certain problem (*Synthesis*)

CO6: Learn the fundamental distinction between various methods applied for the solution of the same problem and also when to apply which method (*Evaluation*)

Suggested Readings

1. S. L. Ross, Differential Equations, 3rd Edition, Wiley-India.
2. W. Strauss, Partial Differential Equations an introduction, 2nd Edition, John Wiley and Sons, Ltd.
3. Tye Myint U and L. Debnath; Linear PDE for scientist and engineers, Fourth edition,Birkhauser Boston

MAMT0018: MATHEMATICAL METHODS I

(4 Credits-60 hours)

Objective: *The present course basically deals with the various numerical and computational techniques of applied mathematics which are indispensable in other areas of Mathematics for instance, fluid dynamics, numerical linear algebra etc. Moreover, this course can also be viewed as an introduction to operation research.*

Numerical Analysis

Module I (10 hours)

Numerical solution of algebraic and Transcendental equations: Bisection method, Regula-Falsi methods and Newton-Raphson method; Error analysis; Rate of convergence of these methods. Solution of systems of linear algebraic equations: Gauss elimination method , Gauss-Jordan method, Gauss-Seidel methods, Error analysis.

Module II (6 hours)

Interpolation: Finite differences, Newton's forward and backward difference interpolations, Central difference interpolation, Lagrange's and Newton's divided difference interpolation, Hermite and spline interpolation.

Module III (15 hours)

Numerical differentiation and integration: Differentiation using interpolation formulae (Newton's forward and backward difference interpolation, Central difference interpolation, Lagrange's and Newton's divided difference interpolation), Numerical integration by trapezoidal and Simpson's 1/3 and 3/8 rule, Romberg method.

Module IV (14 hours)

Numerical solutions of ODE and PDE: Initial value problem for ODE of first and second order, Taylor series method, Picard's method, Euler and modified Euler methods, Runge-Kutta methods, Milne's and Adam's predictor and corrector methods, Finite difference solution of second order ODE and PDE.

Linear programming

Module V (15 hours)

Mathematical formulation of LPP, Solution of a LPP by graphical method, simplex method, Revised simplex method, Duality. Transportation and Assignment problem, Two person-zero sum games. Equivalence of Rectangular game and linear programming.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn and understand the basic methods associated with numerical integration and differentiation, linear programming problem etc. (*Knowledge*)

CO2: Gain the knowledge regarding the advantages and limitations of these methods (*Comprehension*)

CO3: Use these concepts in various engineering problems involving signal processing etc. to get the solution up to certain accuracy (*Application*)

CO4: Analyze various possible methods to obtain the solution (*Analysis*)

CO5: Predict the efficiency of one method over the other whereby relating various problems for which such methods are applicable (*Synthesis*)

CO6: Analyzing various methods of solution of a problem and predicting the degree of accuracy, a student will be able to determine the suitability of a certain method for a certain problem (*Evaluation*)

Suggested Readings

1. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods, Problems and solutions, NewAge International (P) Ltd., 1996.
2. S. D. Conte and Carl de Boor, Elementary Numerical Analysis - An Algorithmic Approach,3rd Edition, McGraw Hill, 1980.
3. K. E. Atkinson, Introduction to Numerical Analysis, 2nd Edition, John Wiley, 1989.
4. H. A. Taha, Operations Research: an Introduction, Macmillan, 1982.
5. Kanti Swarup, P. K. Gupta and M. M. Singh, Operations Research, Sultan Chand and Sons, 1985.

MATF0019: TOPOLOGY AND FUNCTIONAL ANALYSIS

(4 Credits-60 hours)

Objective: *The basic objective of the present course is to introduce to a student the notion of topology, the general framework under which every form of Mathematical analysis works. Apart from that, this course can also be treated as the beginner's course on functional analysis.*

Module I (11 hours)

Metric spaces, open and closed sets, limit points, interior points, convergence, Cauchy sequence, completeness, completion in metric spaces, separable spaces.

Module II (10 hours)

Topological Spaces, Basis for a topology, The order topology, The product topology, The subspace topology, Closed sets and limit points, convergent sequence, Continuous function, homeomorphism, metric topology.

Module III (8 hours)

Connected spaces, connected subspaces of real line, Components, local connectedness, Compact spaces, compact spaces of real line, limit point compactness, local compactness.

Module IV (8 hours)

The countability axioms, the separation axioms, Urysohn Lemma, Urysohn metrization theorem. Tychonoff's theorem, Stone-Cech Compactification.

Module V (8 hours)

Local finiteness, the Nagata Smirnov Metrization theorem, paracompactness, the Smirnov Metrization theorem, space of continuous function.

Module VI (15 hours)

Normed linear spaces, properties of normed linear spaces, Banach space, Hahn-Banach theorem, Open mapping theorem, Closed graph theorem, Principle of uniform boundedness, Hilbert spaces, Orthogonal complements, orthonormal sets, the Reisz representation theorem, Bessel's inequality, Parseval's identity, The dual space, self –adjoint, normal and unitary operators.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understand the basic concepts like open and closed sets, norm of a vector etc. (*Knowledge*)

CO2: Conceive the knowledge regarding for instance how to measure the distance between two vectors, length of a vector etc. (*Comprehension*)

CO3: Apply these concepts in various fields of engineering and applied sciences (*Application*)

CO4: Analyze different topological spaces depending upon various properties possessed by these spaces (*Analysis*)

CO5: Understand criteria behind the classification of topological spaces and the necessity to have such classification (*Synthesis*)

CO6: Depending upon the classification of topological and normed spaces, a student will be determine which space to consider while dealing with a certain problem (*Evaluation*)

Suggested Readings

1. G. F. Simmons, Introduction to topology and modern analysis, 2nd Edition, Tata-Mcgraw-Hill,
2. J. R. Munkres, Topology, 2nd Edition, Prentice Hall.
3. E. Kreyszig, Introductory functional analysis with application, John Willey and Sons.

MACA0020: COMPLEX ANALYSIS

(4 Credits-60 Hours)

Objective: *The basic objective of the present course is to familiarize a student about another form of Mathematical analysis called complex analysis. Apart from being one of the most important branches of analysis at its own, the notion of complex analysis is crucial for those who intends to pursue research in the field of Operator theory.*

Module I (10 hours)

Complex numbers and their properties, Complex Plane, Polar form of complex numbers, Powers and roots, set of points in the complex plane. Complex function, Special power functions, Reciprocal function.

Module II (15 hours)

Limits and Continuity, differentiability and analyticity, Cauchy-Reimann equations, Harmonic functions, Exponential and Logarithmic functions, complex powers, Trigonometric and Hyperbolic functions.

Module III (20 Hours)

Complex integrals, Cauchy-Goursat Theorem, Cauchy's integral formula and their consequences, Taylor and Laurent series, Zeroes and poles, Residues and residue theorem and consequences, evaluation of real improper integrals.

Module IV (15 hours)

Entire function, Liouville's theorem, Maximum modulus principle, Schwarz Lemma, Schwarz-Pick Lemma, Open Mapping theorem. Conformal Mapping, Linear Fractional Transformations, Cross Ratio.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Understanding of the basic concepts associated with complex analysis like analytic function, complex integration etc. (*Knowledge*)

CO2: Have the conceptual understanding regarding the difference between real and complex function theory (*Comprehension*)

CO3: Use these concepts in various engineering problems involving circuit problems, fluid flow to name a few whereby solving these problems (*Application*)

CO4: Analyze different complex functions defined over certain domains (*Analysis*)

CO5: Synthesize complex functions satisfying common properties (*Synthesis*)

CO6: Evaluate various physical problems by means of the properties of complex functions and the associated domain (*Evaluation*)

Suggested Readings

1. S. Ponnusamy, Foundation of Complex Analysis, 2nd Edition, Alphascience International.
2. J. B. Conway, Functions of one Complex variable I, 2nd Edition, Springer.
3. Schaum's outlines, Complex variable, 2nd Edition.

MAMP0021: MEASURE THEORY AND PROBABILITY THEORY

(4 Credits-60 hours)

Objective: *The prime objective of this course is to introduce to a student the fundamentals of measure theory both as a general subject and as a framework of probability theory. Apart from that, this course may also be viewed as the introductory course on probability theory.*

Module I (12 hours)

Algebra of sets, Borel set, extension of measures, Lebesgue measure on : outer measure, measurable sets and Lebesgue measure.Extension of measure, Lebesgue-Stieltjes measures and distribution functions.

Module II (18 hours)

Measurable functions and Integration: Lebesgue integral, Monotone convergence theorem, extended monotone convergence theorem, Fatou's Lemma, dominated convergence theorem, Comparison of Riemann and Lebesgue integral. Radon-Nikodym Theorem and related results

Module II (10 hours)

Probability axioms, sample spaces, events, law of total probability, conditional probability, Bayes' theorem and independence.

Module IV (20 hours)

Random Variables, types of random variables, distribution functions, function of random variables, standard univariate discrete and continuous distributions and their properties; expectations, moments, moments generating functions; Chebyshev's inequality, joint, marginal and conditional distributions; covariance, correlation; Random vectors, functions of random vectors, strong and weak law of large numbers, central limit theorem.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn and understand the fundamental of measure theory like measurable sets and functions etc. (*Knowledge*)

CO2: Gain the knowledge regarding how the axioms of measure theory provides a framework of probability theory (*Comprehension*)

CO3: Apply concepts of measurable spaces to define and understand random variables, probability density function (*Application*)

CO4: Analyze how the notion of measure to explain some famous paradox such as Banach Tariski paradox (*Analysis*)

CO5: Synthesize different measure spaces depending upon certain axioms (*Synthesis*)

CO6: Formulate necessary framework while dealing with certain problems of probability theory depending upon axioms of measure (*Evaluation*)

Suggested Readings

1. R.B.Ash and C.Doleans Dade; Probability and Measure Theory, Academic press
2. W. Feller, An Introduction to Probability Theory and its Applications, Vol. 1, 3rd Edn., Wiley, 1968.
3. V. K. Rohatgi and A. K. Md. E. Saleh, An Introduction to Probability and Statistics, 2nd Edn., Wiley, 2001.
4. Royden, H.L. and Fitzpatrick, P. M., Real Analysis, 4th Edition, Pearson, 2010
5. Halmos, P. R. Measure Theory (Springer-Verlag, 1974).

MAMD0022: MATHEMATICAL METHODS II

(4 Credits - 60 hours)

Objectives: *The basic idea of this course is to introduce to a student the concepts pertaining advanced mathematical techniques. The notion of Laplace and Fourier transform not only constitute transform calculus but also play a key role in other branches of science like Mathematical physics and signal processing.*

Module I (10 hours)

Linear functional, minimal functional theorem, general variation of a functional, Euler- Lagrange equation, Necessary and sufficient conditions for extrema, strong extremum and weak extremum, broken extremum; Weirstras Erdmann corner conditions

Module II (8 hours)

Linear integral equation of the first and second kind of Fredholm and Volterra type Reduction of ordinary differential equations into integral equations, Solution of integral Equations with separable kernels, Characteristic numbers and eigen functions, resolvent kernel.

Module III (12 hours)

Fourier Transform. Properties of Fourier Transform, Fourier sine and cosine transform, Inverse Fourier Transform, Application of Fourier transform to ordinary and partial differential equations of initial and boundary value problems.

Module IV (12 hours)

Laplace Transform and its properties, Convolution theorem, Inverse Laplace Transform, Application of Laplace Transform to solution of ordinary and partial differential equations of initial boundary value problems.

Module V (18 hours)

General solution of Bessel equation, Recurrence relations, Orthogonal sets of Bessel functions, Modified Bessel functions, Applications. General solution of Legendre equation, Legendre polynomials, Associated Legendre polynomials, Rodrigues formula, Orthogonality of Legendre polynomial, Concept and calculation of Green's function, Approximate Green's function, Green's function method for differential equations.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn and understand the fundamental methods associated with calculus of variation and integral equation etc. (*Knowledge*)

CO2: Gain the knowledge regarding the efficiency of such methods to tackle various practical problems (*Comprehension*)

CO3: Use concepts like Laplace and Fourier transform in numerous problems occurring various disciplines of Engineering sciences (*Application*)

CO4: Analyze and classify differential equations (*Analysis*)

CO5: Synthesize different physical models depending upon the classification of the associated differential equations (*Synthesis*)

CO6: Evaluate for instance which class of differential equation is be solvable by applying transform calculus (*Evaluation*)

Suggested Readings

1. Gelfand and Fomin: Calculus of Variation (Dover Publications,2000)
2. A.S. Gupta: Calculus of Variation with Applications, Prentice-Hall of India (1999).
3. R.P. Kanwal: Linear Integral Equations, Theory and Techniques, Academic Press, New York, 1971.
4. S.G. Mikhlin: Linear Integral Equations, (Trans.) Hindustan Book Agency, 1960..
5. M.R. Spiegel: Theory and Problems of Laplace Transform
6. F.B. Hilderbrand: Methods of Applied Mathematics, (Dover Publications,1992)
7. N.N. Levedev, Special functions and their applications, (Dover Publications,1972)
8. G.E. Andrews, R.A. Askey, and R. Roy: Special Functions (Cambridge University Press,1999).

MACL0023: CLASSICAL MECHANICS

(4 Credits - 60 Hours)

Objective: *The fundamental objective of this course to familiarize a student with the notion of classical mechanics. Moreover, this course provides a much needed framework for those who intend to pursue research in other branches of Mathematics and Physics.*

Module I (20 hours)

Introduction to the ideas of constrained motion, Different classifications of constrains of motion, Holonomic and nonholonomic constraints, rhenomic and scleronomic dynamical constraints, Concept of degree of freedom.

Introduction to generalized coordinates, generalized velocities, Total Kinetic energy of a system of particles in terms of generalized velocity. Introduction to generalized momenta and generalized force. D"Alemberts principle and Lagrangian form of equation motion of a dynamical system of N particles. Calculus of variations, Euler-Lagrange equation, application of calculus of variations in dynamical problems,

Module II (12 hours)

Two dimensional motion of rigid bodies, Euler's dynamical equations of motion for a rigidbody, Motion of a rigid body about an axis, motion about revolving axis, Eulerian angles, Eulers theorem on the motion of a rigid body, infinitesimal rotations, rate of change of a vector, Coriolis force, Euler's equations of motion, force free motion of a rigid body.

Module III (18 hours)

Hamilton's principle, Lagrange's equations from Hamilton's principle, extension of Hamilton's principle to non-conservative and non-holonomic systems, conservation theorems and symmetry properties. Hamilton's equations of motion, conservation theorems and physical significance of Hamiltonian, Hamilton's equations from variational principle, principle of least action.

Module IV (10 hours)

Hamilton Jacobi Method : Hamilton - Jacobi equation, Time independent Hamilton - Jacobi equation, canonical transformation generated by Hamilton characteristic function, application of Hamilton - Jacobi equation in solving problems of mechanics.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn and understand the fundamentals of classical mechanics (*Knowledge*)

CO2: Gain the conceptual understanding of such notions (*Comprehension*)

CO3: Apply concepts of classical mechanics to model various practical situations (*Application*)

CO4: Analyze various physical motion by first forming the mathematical model and then studying the properties of such model (*Analysis*)

CO5: Synthesize different motion possessed by rigid bodies depending upon the properties of various motions like Lagrangian and Hamiltonian (*Synthesis*)

CO6: Evaluate various practical situation by discussing the properties of existing models (*Evaluation*)

Suggested Readings

1. Classical Mechanics (3rd edition) – H. Goldstein, Addison Wesley Publications, Massachusetts, 2002.
2. Lagrangian and Hamiltonian Mechanics by M.G. Calkin, World Scientific, Singapore. 1996
3. Takwale, R. G. & Puranik, P. S. Classical Mechanics (Tata-McGraw Hill, 1979, 41st reprint, 2010).
4. Yung-Kuo, L. Problems and Solutions on Mechanics (World Scientific, 1994)

MACS0101: CALCULUS

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The objective of the present course is to introduce to a student the fundamental notions of calculus, for instance, integration and differentiation in case of function of a single variable. Apart from that, analogous notion in case of vector valued function will also be introduced.*

Module I (18 + 7 hours)

Hyperbolic functions, higher order derivatives, Leibniz rule and its applications to problems of type, concavity and inflection points, asymptotes, curve tracing in Cartesian coordinates, tracing in polar coordinates of standard curves, L'Hospital's rule, applications in business, economics and life sciences.

Module II (16 + 7 hours)

Reduction formulae, derivations and illustrations of reduction formulae of the type , volumes by slicing, disks and washers methods, volumes by cylindrical shells, parametric equations, parameterizing a curve, arc length, arc length of parametric curves, area of surface of revolution.

Module III (12 + 6 hours)

Techniques of sketching conics, reflection properties of conics, rotation of axes and second degree equations, classification into conics using the discriminates, polar equations of conics.

Module IV (14 + 10 hours)

Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions, tangent and normal components of acceleration, modeling ballistics and planetary motion, Kepler's second law.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the fundamental concepts and principles of differential and integral calculus (*Knowledge*)

CO2: Understanding of the already mentioned concepts, students will be able to have some idea on curve tracing, conics and vector function with properties (*Comprehension*)

CO3: Apply these mathematical concepts in various physical problems and will be able to solve such problems (like application of integration in finding volumes) (*Application*)

CO4: Analyze certain problems which are not solvable initially whereupon suggesting possible conditions for the solution of the same (*Analysis*)

CO5: Have a clear understanding of the necessity and sufficiency of the hypothesis related to a the solution of a certain problem (*Synthesis*)

CO6: Learn the fundamental distinction between various methods applied for the solution of the same problem and also when to apply which method (*Evaluation*)

Suggested Readings

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi, 2005.
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi, 2007.

3. H. Anton, I. Bivens and S. Davis, Calculus, 7th Ed., John Wiley and Sons (Asia) P. Ltd., Singapore, 2002.
4. R. Courant and F. John, Introduction to Calculus and Analysis (Volumes I & II), Springer-Verlag, New York, Inc., 1989.

MAAG0102: ALGEBRA

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The objective of this course is to familiarize a student with the fundamentals of complex numbers and arithmetic inequalities. This course also introduces to a student the basic properties of matrices along with their application in various physical situations.*

Module I (12 + 5 hours)

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.

Module II (12 + 7 Hours)

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Module III (14 + 8 hours)

Inequalities involving arithmetic, geometric and harmonic means, Cauchy Schwarz inequality, relations between roots and coefficients of polynomial equation of degree n, roots of symmetric functions, Cardon's methods solution of cubic equation.

Module IV (22 + 10 hours)

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of Rn , dimension of subspaces of Rn and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn and understand the fundamental concepts associated with complex number, set theory, number theory, linear algebra (*Knowledge*)
CO2: Recognize the various physical significance of these concepts (*Comprehension*)
CO3: Apply these concepts in various problems and will be able to use the basic properties of matrices along with their application in various physical situation (Application)
CO4: Analyze methods to obtain the solution (*Analysis*)
CO5: Solve those problems by using the basic concept and logical thinking (*Synthesis*)
CO6: Decide which method of solution is applicable to what type or class of problems and the advantages and demerits of other methods leading to the solution of the same problem (*Evaluation*)

Suggested Readings

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser, 2006.
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint, 2005.
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint, 2007

MAER0103: ELEMENTARY REAL ANALYSIS

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The objective of this course is to introduce to a student various algebraic properties of the real number system. Apart from that, the present course also serves as an introductory course on principles of Mathematical analysis and their application in various other discipline.*

Module I (20 + 10 hours)

Review of Algebraic and Order Properties of R, neighbourhood of a point in R, Idea of countable sets, uncountable sets and uncountability of R. Bounded above sets, Bounded below sets, Bounded Sets, Unbounded sets, Suprema and Infima, The Completeness Property of R, The Archimedean Property, Density of Rational (and Irrational) numbers in R, Intervals. Limit points of a set, Isolated points, Illustrations of Bolzano-Weierstrass theorem for sets.

Module II (20+ 10 hours)

Sequences, Bounded sequence, Convergent sequence, Limit of a sequence. Limit Theorems, Monotone Sequences, Monotone Convergence Theorem. Subsequences, Divergence Criteria, Monotone Subsequence Theorem (statement only), Bolzano Weierstrass Theorem for Sequences. Cauchy sequence, Cauchy's Convergence Criterion.

Module III (20 + 10 hours)

Infinite series, convergence and divergence of infinite series, Cauchy Criterion, Tests for convergence: Comparison test, Limit Comparison test, Ratio Test, Cauchy's nth root test, Integral test, Alternating series, Leibniz test, Absolute and Conditional convergence.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Learn and understand the basic concept associated with real number system, fundamental and principles of mathematical analysis (*Knowledge*)

CO2: Interpret these concepts in a practical manner apart from having conceptual understanding of the already mentioned concepts (*Comprehension*)

CO3: Use these concepts in various other disciplines (*Application*)

CO4: Analyze various possible methods to obtain the solution (*Analysis*)

CO5: Solve those problems by using the basic concept and logical thinking (*Synthesis*)

CO6: Predict which method suits a certain problem the most (*Evaluation*)

Suggested Readings

1. R.G. Bartle and D. R. Sherbert, Introduction to Real Analysis, 3rd Ed., John Wiley and Sons (Asia) Pvt. Ltd., Singapore, 2002.
2. Gerald G. Bilodeau , Paul R. Thie, G.E. Keough, An Introduction to Analysis, 2nd Ed., Jones & Bartlett, 2010.
3. Brian S. Thomson, Andrew. M. Bruckner and Judith B. Bruckner, Elementary Real Analysis, Prentice Hall, 2001.
4. S.K. Berberian, A First Course in Real Analysis, Springer Verlag, New York, 1

MADQ0104: DIFFERENTIAL EQUATIONS

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The present course aims to introduce to a student the theory of ordinary differential equation which plays a key role in almost every physical situation. The course focuses not only at how to formulate a physical problem using differential equation but also at different methods of solution.*

Module I (18 + 10 hours)

Differential equations and mathematical models. General, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Module II (20 +10 hours)

Introduction to compartmental model, exponential decay model, lake pollution model (case study of Lake Burley Griffin), drug assimilation into the blood (case of a single cold pill, case of a course of cold pills), exponential growth of population, limited growth of population, limited growth with harvesting.

Module III (22 + 10 hours)

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

Equilibrium points, Interpretation of the phase plane, predatory-prey model and its analysis, epidemic model of influenza and its analysis, battle model and its analysis.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the theory of differential equation (*Knowledge*)

CO2: Understanding of the already mentioned concepts, students will be able to have a systematic understanding of the relationship among these concepts (*Comprehension*)

CO3: Formulate a physical problems using differential equation and find solution (*Application*)

CO4: Analyze certain problems which are not solvable initially whereupon suggesting possible conditions for the solution of the same (*Analysis*)

CO5: Have a clear understanding of the necessity and sufficiency of the hypothesis related to a the solution of a certain problem (*Synthesis*)

CO6: Learn the fundamental distinction between various methods applied for the solution of the same problem and also when to apply which method (*Evaluation*)

Suggested Readings

1. Belinda Barnes and Glenn R. Fulford, Mathematical Modeling with Case Studies, A Differential Equation Approach using Maple and Matlab, 2nd Ed., Taylor and Francis group, London and New York, 2009.
2. C.H. Edwards and D.E. Penny, Differential Equations and Boundary Value problems Computing and Modeling, Pearson Education India, 2005.
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India, 2004.
4. Martha L Abell, James P Braselton, Differential Equations with MATHEMATICA, 3rd Ed., Elsevier Academic Press, 2004

MACD0105: CALCULUS AND DIFFERENTIAL EQUATIONS

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The objective of this course is to familiarize a graduate student with techniques in multivariable calculus and differential Equations. It aims to equip the students with standard concepts and tools from an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.*

Module I (17 + 10 hours)

a) Derivatives, higher order derivatives, successive differentiation and Leibnitz's rule and its applications; Mean value Theorem, Taylor's Theorem, tangents and normals, concavity and inflection points, curvature, L' Hospital's rule

b) Partial differentiations, partial derivative as a slope, partial derivative as a rate, higher order partial derivatives (two and three variables), Euler's theorem on homogeneous functions. Maxima, minima and saddle points; Method of Lagrange multipliers.

Module II (11 +5 hours)

Standard methods of integration, integration of irrational function, reduction formulae,derivations and illustrations of the type

Module III (7 + 5 hours)

Applications of Integrals: Area of plane curves, volume and surface area of solids of revolution, parametrization of a curve, arc ength of parametric curves.

Module IV (12+5 hours)

Differential equations; general, particular, explicit, implicit and singular solutions of a differential equation. Exact differential equations and integrating factors, separable equations and equations reducible to this form, linear equation and Bernoulli equations, special integrating factors and transformations.

Module V (13 + 5 hours)

General solution of homogeneous equation of second order, principle of super position for homogeneous equation, Wronskian: its properties and applications, Linear homogeneous and non-homogeneous equations of higher order with constant coefficients, Euler's equation, method of undetermined coefficients, method of variation of parameters.

COURSE/LEARNING OUTCOMES

At the end of this course students will be able to:

CO1: Systematically understand the fundamental concepts like limits, continuity, differentiability, integrability and theory of differential equation (*Knowledge)*

CO2: Understanding of the already mentioned concepts, students will be able to have a systematic understanding of the relationship among these concepts (*Comprehension*)

CO3: Apply these mathematical concepts in various physical problem and will be able to solve such problems. (like application of integration in finding volumes. Students also will be able to formulate a physical problems using differential equation and find solution (*Application*)

CO4: Analyze certain problems which are not solvable initially whereupon suggesting possible conditions for the solution of the same (*Analysis*)

CO5: Have a clear understanding of the necessity and sufficiency of the hypothesis related to a the solution of a certain problem (*Synthesis*)

CO6: Learn the fundamental distinction between various methods applied for the solution of the same problem and also when to apply which method (*Evaluation*)

Suggested Readings

1. G.B. Thomas and R.L. Finney, Calculus, 9th Ed., Pearson Education, Delhi
2. M.J. Strauss, G.L. Bradley and K. J. Smith, Calculus, 3rd Ed., Dorling Kindersley (India) P. Ltd. (Pearson Education), Delhi
3. S.L. Ross, Differential Equations, 3rd Ed., John Wiley and Sons, India

MALG0106: ALGEBRA

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective*: The objective of this course is to familiarize a student with the fundamentals of complex numbers and arithmetic inequalities. This course also introduces to a student the basic properties of matrices along with their application in various physical situations.*

Module I (12 + 5 hours)

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications.

Module II (12 + 7 hours)

Equivalence relations, Functions, Composition of functions, Invertible functions, One to one correspondence and cardinality of a set, Well-ordering property of positive integers, Division algorithm, Divisibility and Euclidean algorithm, Congruence relation between integers, Principles of Mathematical Induction, statement of Fundamental Theorem of Arithmetic.

Module III (14 + 8 hours)

Inequalities involving arithmetic, geometric and harmonic means, Cauchy Schwarz inequality, relations between roots and coefficients of polynomial equation of degree n, roots of symmetric functions, Cardon's methods solution of cubic equation.

Module IV (22 + 10 hours)

Systems of linear equations, row reduction and echelon forms, vector equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, linear independence. Introduction to linear transformations, matrix of a linear transformation, inverse of a matrix, characterizations of invertible matrices. Subspaces of Rn , dimension of subspaces of Rn and rank of a matrix, Eigen values, Eigen Vectors and Characteristic Equation of a matrix.

Suggested Readings

1. Titu Andreescu and Dorin Andrica, Complex Numbers from A to Z, Birkhauser
2. Edgar G. Goodaire and Michael M. Parmenter, Discrete Mathematics with Graph Theory, 3rd Ed., Pearson Education (Singapore) P. Ltd., Indian Reprint
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint

MAAL0107: ALGEBRA AND NUMERICAL METHODS

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The objective of the present course is to introduce to a student the fundamentals of algebra and the basic properties of matrices along with their application in various physical situation. Also, this course gives a complete procedure for solving different kinds of problem that occur in their discipline numerically.*

Module I (14 + 5 hours)

Polar representation of complex numbers, nth roots of unity, De Moivre's theorem for rational indices and its applications; expansion of cosx , sin x and tan x in positive integral powers of x, exponential and trigonometric function of a complex variable, Euler's expansion for cosine and sine; Gregory's series; Hyperbolic functions

Module II (13 + 7 hours)

Matrices, elementary matrices, row reduction and echelon forms, rank of matrix, linear independence, inverse of matrix, system of linear equations, the matrix equation Ax=b, solution sets of linear systems, applications of linear systems, characteristic equation of a matrix. Eigen values, Eigen Vectors, Diagonalzing matrices

Module III (17 + 10 hours)

Binary operations, associative and commutative binary operations; Groups; elementary properties of groups; subgroups and examples of subgroups, permutation groups, cyclic groups and properties of cyclic groups, cosets, order of groups, Lagrange's theorem of finite group, normal subgroups, quotient groups, homomorphism and isomorphism of groups.

Module IV (16 + 8 hours)

Transcendental and Polynomial Equation: Bisection method, Regula Falsi method, Newton's method; Interpolation: Lagrange and Newton's methods, finite difference operators, Gregory forward and backward difference interpolation; Numerical Integrations: Trapezoidal rule, Simpson's rule , Simpson 3/8th rule, finding eigenvalues by iteration.

Suggested Readings

1. J. A. Gallian: Contemporary Abstract Algebra, Brooks Cole.
2. J. B. Fraleigh, A First Course in Abstract Algebra, 7th Ed., Pearson
3. David C. Lay, Linear Algebra and its Applications, 3rd Ed., Pearson Education Asia, Indian Reprint
4. K. Hoffman and R. Kunze, Linear Algebra, Prentice Hall
5. M. K. Jain, S. R. K. Iyengar, R. K. Jain, Numerical methods for Scientific and Engineering Computation, 6th Ed. NewAge International (P) Ltd.

MADV0108: DIFFERENTIAL EQUATIONS, VECTOR CALCULUS AND GEOMETRY

(6 Credits- 60 hours Theory + 30 hours Tutorial)

Objective: *The objective of the present course is to introduce to a student the theory of partial differential equation, vector calculus and geometry. It aims to equip the students with standard concepts and tools from an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.*

Module I (20 + 10 hours)

Transformation of coordinate axis, pair of straight lines

Parabola, parametric coordinates, tangent and Normal, Ellipse and conjugate diameters with properties; general conics: tangents, condition of tangency, pole and polar, centre of a conic, equation of pair of tangents, reduction to standards forms, central conics, equation of axes and length of the axes, polar equation of a conic.

Module II (20 +10 hours)

Scalar triple product, vector triple product; Introduction to vector functions, operations with vector-valued functions, limits and continuity of vector functions, differentiation and integration of vector functions; partial derivatives of vector point function, gradient, curl and divergence

Module III (20 +10 hours)

Simultaneous linear differential equations, total differential equations.

Partial differential equations of first order, Lagrange's solutions, some special types of equations which can be solved by methods other than the general method, Charpit's general methods of solution.

Suggested Readings

1. Differential Equation, H.T.H. Piaggio Differential Equations G.Bell & Sons Ltd. 1921
2. Analytical Geometry of two and three dimension and vector calculus , R.M.Khan
3. Ordinary and partial differential equations, M.D.Raisinghania, S.Chand and Co.

LSEC0018: ENGLISH COMMUNICATION

(2 Credits- 30 Hours)

Objective: *The purpose of this course is to introduce students to the theory, fundamentals and tools of communication and to develop in them vital communication skills which should be integral to personal, social and professional interactions. The present course hopes to address some of these aspects through an interactive mode of teaching-learning process and by focusing on various dimensions of communication skills.*

Module I: Introduction

Theory of Communication, Types and modes of Communication

Module II: Language of Communication:

Verbal and Non-verbal (Spoken and Written)
Personal, Social and Business
Barriers and Strategies
Intra-personal, Inter-personal and Group communication

Module III: Speaking Skills

Monologue, Dialogue, Group Discussion
Effective Communication/ Mis- Communication
Interview, Public Speech

Module IV: Reading and Understanding

Close Reading, Comprehension, Summary, Paraphrasing
Analysis and Interpretation

Translation (from Indian language to English and vice-versa)
Literary/Knowledge Texts

Module V: Writing Skills

Documenting, Report Writing, Making notes, Letter writing

Suggested Readings

1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul,Dr Brati Biswas

Our Vision

"To mould intecllectually competent, morally upright, socially committed and spiritually inspired persons at the service of India and the world of today and tomorrow, by imparting holistic and personalized education."

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