INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH THIRUVANANTHAPURAM

An autonomous institution under the Ministry of Human Resource Development, Government of India

GUIDE BOOK OF CURRICULUM AND REGULATIONS FOR INTEGRATED BS-MS DUAL DEGREE PROGRAMME

2010 - 11
www.iisertvm.ac.in

The Indian Institute of Science Education and Research (IISER) is an Institution conceived and established by the Ministry of Human Resources Development (MHRD) of the Government of India. The mission of the Institute is to offer postgraduate level teaching of the highest international standards to school leaving (+2) students and also to conduct frontline research leading to Ph.D. Degree, in basic sciences like Biology, Chemistry, Physics, Mathematics and other Interdisciplinary Science subjects.

The five IISERs established by MHRD are at Kolkata, Pune, Mohali, Bhopal and Thiruvananthapuram.

IISER THIRUVANANTHAPURAM CAMPUS

IISER TVM started functioning in August 2008 at the transit campus in the Department of Computer Science of the College of Engineering,Thiruvananthapuram(CET). The Institute is residential. This means all students will reside in the Institute hostels. The permanent campus of IISER TVM is coming up at Vithura, about 40 km from Thiruvananthapuram City, at the foothills of the Ponmudi Hills.

Contents

Regulations

The BS-MS Programme

The basic philosophy of IISER TVM is that modern Science is a knowledge enterprise without barriers among the traditional disciplines. Accordingly, IISER TVM BS-MS dual degree curriculum is designed to be dominantly interdisciplinary.

- The BS-MS programme is of 10 semesters duration
- Each academic year has 2 semesters of roughly 17 weeks each.

  (a) Varsha Semester : August- December.
  (b) Vasanth Semester : January- May.

- The first 2 years (i.e. the first 4 semesters) will consist of CORE courses common to all students.
- 3rd and 4th year courses will be specialized in one Major (Biology, Chemistry, Physics or Mathematics) and one or more Minors.
- The 5th year will be devoted to a thesis by research.
- Students undertake summer research projects at IISERs and other institutions

Admission

Joint admissions to all five IISERs is currently through three channels

1. KVPY (Kishore Vaigyanik Protsahan Yojana): SX, SA, SB, SP
2. IIT-JEE Merit List
3. DIRECT ADMISSION: Students with specified percentage of marks in both X and XII board exams: Selection based on merit and performance in science aptitude and interaction-discussion.

For more details please refer to `http://www.iiser-admissions.in`

Registration

- Every student must register for the courses of a semester on the first day (registration day) of the semester.
- The courses are chosen in consultation with the student adviser and with the adviser's approval.

- Registration involves payment of the prescribed fees for the semester.
- A fine of Rs.100/- per day will be levied for late registration done after the first day of class.
- Late registration after the first week of the semester can only be done with the permission of the dean, academic or the director of the institute.

Student Adviser

Every student is assigned a Faculty Adviser who will guide the student in all academic and personal matters

Assessment and Grading

CONTINUOUS ASSESSMENT

Continuous assessment will be adopted for all courses.

Theory Course :

Assignments	: 10%
Two Mid Semester Examinations	: 20 % each
End Semester Examination	: 50 %

Practical Course

Class experiments	: 70%
End Semester Examination	: 30 %

GRADING

Relative grading will be adopted.
(a) The letter Grade and Grade Points are as follows:

A	10
B	8
C	6
D	4
F	0
I	Incomplete

(b) Semester Grade Point Average (SGPA) is calculated as:

$$\text{SGPA} = \sum_i \text{C}_i\text{G}_i / \sum_i \text{C}_i$$

Where, C_i = Credit for i^{th} course.; G_i = Grade point secured by the student. Summation is over all the courses credited by the student in the semester.
(c) Cumulative Grade Point Average is calculated as

$$\text{CGPA} = \sum_k \text{C}_k \text{G}_k / \sum_k \text{C}_k$$

Where, C_k = Credit for k^{th} course; G_k =Grade point secured by the student. Summation is over all the courses credited by the student in all the completed semesters.

Maximum Duration

- To qualify for the BS-MS Degree, all CORE courses must be completed successfully.
- The CORE courses of the first 2 years must be completed in a maximum of 3 years and the BS-MS programme in a maximum of 7 years.

Attendance

- Students are required to attend all classes. Students with 80% attendance in each mid-semester session of a theory course will only be permitted for the mid-semester examination. Attendance will be recorded in the prescribed book in every class and attendance grade will appear in the grade transcripts.

Minimum CGPA

- The minimum CGPA required to continue in the programme at any time is 4.0. The minimum CGPA required for award of the BS-MS degree is 5.0.

Make up examinations

- Make up examinations may be given to those who miss the mid semester or end semester examinations due to genuine reasons as determined by the Instructor/Director.

Repeat Exam

- The student with an F grade in a course and not less than 80% attendance may be given a repeat final examination. An F grade may be improved at best to a D grade as a result of the repeat final exam. If he/she does not clear the course, he/she is required to attend the full course when offered next taking all examinations. Failure to clear the core course the second time will lead to the removal of the student from the BS-MS Programme.
- Repeat of a course where the grade obtained is D or above is not permitted.

Take full course

- A student can take at most two make up exams each semester. A student with F or I grade in more than 2 courses in a semester cannot take repeat final examinations, but must repeat the courses when offered next.
- If a student fails in a course and also in the repeat exam, he/she is required to take the full course when offered next.

Removal from BS-MS Programme

- Failure to maintain the minimum CGPA of 4.0 in any two consecutive semesters will lead to automatic removal of the student from the rolls.

In exceptional cases the Director may at his discretion override any of the above provisions.

Sample transcript

Indian Institute of Science Education and Research, Thiruvananthapuram

GRADE TRANSCRIPT

Five Year Integrated Masters Degree in Science

Name of Student: **xxxx**

Batch Name: **Batch xxxx**

Roll Number: **IMS0XXXX**

Grades for Varsha xxx*

COURSE NAME	COURSE CODE	COURSE CREDIT	MAX POINTS	LETTER GRADE OBTAINED	GRADE POINTS OBTAINED	ATTENDANCE MAX 10
Introductory Biology	BIO 111	3	30	B	24	8.5
Principles of Chemistry	CHY 111	3	30	C	18	8.0
Introduction to Algebra	MAT 111	3	30	D	12	8.8
Mechanics	PHY 111	3	30	D	12	8.0
Mathematical Tools	IDC 111	3	30	B	24	8.9
Communication Skills	HUM 111	1	10	A	10	9.0
Biology Laboratory	BIO 112	1	10	A	10	10
Chemistry Laboratory	CHY 112	1	10	B	8	10
Physics Laboratory	PHY 112	1	10	B	8	10
TOTAL		19	190		126	

Semester Grade Point Average: **6.63**

Cumulative Grade Point Average: **6.63**

Date:

Thiruvananthapuram

Professor in Charge, Academics

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* *Varsha Semester: August – December, Vasanth Semester: January – May*
Grade Points: A=10, B=8, C=6, D=4, F=0, I=Incomplete, M=Medical Leave

Conduct Regulations

1. The student must sign and submit to the Institute the following Honour Pledge at the time of registration in the Varsha semester. The pledge must be countersigned by the parent/guardian.

   IISER TVM STUDENT HONOUR PLEDGE

   a. I promise, on my honour, that I will conduct myself in the Institute and outside, with decorum and decency befitting the high moral and ethical standards expected of the members of the National Institute, IISER TVM and follow its rules and regulations
   b. I will not engage in ragging. I understand that ragging is unlawful and liable to prosecution by law enforcement authorities of the State besides any disciplinary action the Institute may take which may include dismissal from the Institute.
   c. I will not engage in overt/covert sexual harassment.
   d. I will not resort to any dishonest practice in examinations/assignments.
   e. I will not engage in plagiarism in my writings and will acknowledge the work of other authors according to international practices.
   f. I will follow the Library and Hostel regulations of the Institute.
   g. I understand that violation of this pledge makes me liable to disciplinary action by the Institute.

   Sd/- Sd/-
   Student Parent/Guardian

2. The student and his/her parent /guardian should sign, at the time of admission, the prescribed anti-ragging forms (See website: www.iisertvm.ac.in) as per the stipulation of the MHRD, Govt. of India.

3. Use of mobile phones in the library, class rooms, laboratories and exam hall is prohibited.

Library Regulations

1. Library hours:

Monday to Saturday	:	9 AM to 6 PM
Exam Week	:	8 AM to 10 PM
Sundays and National Holidays	:	Closed

2. Membership: All BS-MS students are eligible for membership at the institute library
3. Borrowing books: BS-MS students can borrow a maximum of 4 books at a time for 2 weeks.

4. Users must leave their Bags and other belongings outside the Library. Only notebooks, papers and laptops will be allowed inside the library.
5. Users have to show their IISER Identity Card while entering in the Library.
6. Silence has to be maintained by all users in the Library.
7. Use of Mobile Phones, consumption of food and drinks are strictly prohibited in the Library.
8. Return of a book is mandatory before the due date. A fine of Re.1/- per day per book for the first week of delayed return and Rs.10/- per day per book thereafter will be levied. Renewal of a book is possible only if there is no pending reservation against it. A book may be recalled anytime before the due date if it is urgently required by another member. A late fee of Rs. 10/- per day per book will be imposed for the non-compliance with the requirement.
9. Mutilation of books in any form (e.g. underlining, writing on pages, tearing off pages, damaging the binding etc) will lead to a heavy fine or even replacement of the book. Before borrowing a book users should look at the condition of the book and bring to the notice of the library staff if any mutilation found.
10. A lost or damaged book will have to be replaced by the borrower with its latest edition (Hard Bound or Paper Bound as the case may be), or else a fine equal to the purchase price of the book will have to be paid to the library.
11. Library books cannot be photocopied in their entirety. Students may photocopy their class notes and personal study materials with a charge of 50 paise per page per side (A-4 size paper). Students will be permitted to photocopy a maximum up to 20 pages per day. They should make the payment at the library counter and sign on a log book for official records. Please note that the Library Staff have the right to decline photocopy of a certain material if they feel violation of copyright is taking place
12. BS-MS students should return all the books they have borrowed before they go for vacation
13. Users should obey the Library Rules and Regulations. Violation of rules and any act of misbehaviour to the library staff will be brought to the notice of the Library Committee Chair, and will lead to strong disciplinary action.

Hostel Regulations

1. Please do not make noise in the rooms, corridors and premises of the hostel especially during night.
2. Keep your rooms and premises clean and tidy. You are responsible for keeping your rooms clean.
3. Please take utmost care not to damage furniture, TV, washing machines, building structure, electrical fittings etc.
4. Strictly avoid getting into arguments with fellow hostellites, localites and office staff.
5. Cooking inside the rooms is strictly prohibited.
6. Guests are not allowed in hostel rooms.

7. In case of any emergency (illness, accidents etc), contact the concerned warden.
8. Any overt or covert sexual/caste/religion/creed/linguistic/color remark will lead to immediate removal of the offender from the institute rolls.
9. All students must return to the hostel by 10.00 pm.
10. Bringing illegal substances such as explosives, drugs, narcotics and other illegal substances to the hostel /hostel premises is strictly prohibited.
11. Please switch off all electrical equipment after usage, if found otherwise, a fine will be levied, including recovery of cost of electrical equipment/fitting/appliances etc.
12. Please take care of your personal belongings.
13. Anti-ragging regulations of the institute have to be strictly followed in the hostels too.
14. Leaving the hostel for a day or longer need prior permission from the concerned warden.
15. Use of drugs/alcoholic beverages/tobacco products in the hostels is strictly prohibited. Smoking in public is a punishable offence.
16. Students should be either in the hostel or in the IISER. Prior permission from the concerned warden has to be obtained in case the student need to go anywhere else. This has also to be recorded in the register kept for the purpose in the Hostel.
17. Permanent address including the phone numbers of the parent/guardian has to be given to the Warden/IISER office. Also the address has to be updated whenever there is a change due to shifting/ change of phone number of the parent etc.

INSPIRE Fellowship

The Department of Science and Technology Government of India has instituted the INSPIRE Fellowship available to each student of IISER. This provides Rs. 5,000/- per month stipend and Rs. 20,000/- for mentoring institutions and for doing summer projects.

The fellowship is contingent upon good performance in each semester with a minimum SGPA of 6.0. If the SGPA goes below 6.0 in any semester, the stipend will be stopped and can be restarted only when the SGPA goes to 6.0 or above. This rule applies to KVPY students also.

MOODLE and Course Feedback

MOODLE (Modular Object Oriented Dynamic Learning Environment) will be employed extensively in the teaching programmes. This includes course contents, assignments, quizzes, and course grades.

Online course feedback by students will be done for every course.

Course Structure

The first two years of the BS-MS programme consists of CORE or FOUNDATION courses common to all students. Third and fourth year courses will be specialized in one major (Biology, Chemistry, Mathematics or Physics) and one or more minors. The fifth year will be devoted to a thesis by research.

TABLE 1A: FOUNDATION COURSES FOR STUDENTS ADMITTED IN AUG 2010

FIRST FOUR SEMESTERS

(core courses, common to all streams)

SEMESTER	BIOLOGY	CHEMISTRY	MATHEMATICS	PHYSICS	INTER DISCIPLINARY	SHORT COURSES	LABORATORY
SEMESTER 1	BIO 111 INTRODUCTORY BIOLOGY (3103)	CHY 111 PRINCIPLES OF CHEMISTRY (3103)	MAT 111 INTRODUCTION TO ALGEBRA (3103)	PHY 111 MECHANICS (3103)	IDC 111 MATHEMATICAL TOOLS (3103)	HUM 111 READING, LISTENING AND WRITING SKILLS (0101)	BIO 112 (0031) CHY 112 (0031) PHY 112 (0031)
SEMESTER 2	BIO 121 GENETICS AND MOL. BIOLOGY (3103)	CHY 121 PRINCIPLES OF COORDINATION CHEMISTRY, ORGANO-METALLICS AND BIOINORGANIC CHEMISTRY (3103)	MAT 121 INTRODUCTORY ANALYSIS - I (3103)	PHY 121 ELECTRO-MAGNETIC THEORY (3103)	IDC 121 THERMO-DYNAMICS (3103)	HUM 121 (0101)	BIO 122 (0031) CHY 122 (0031) PHY 122 (0031)
SEMESTER 3	BIO 211 ECOLOGY AND EVOLUTIONARY BIOLOGY (3103)	CHY 211 CHEMICAL REACTIONS AND REACTIVE INTERMEDIATES (3103)	MAT 211 INTRODUCTORY ANALYSIS - II (3103)	PHY 211 INTRODUCTION TO QUANTUM MECHANICS (3103)	IDC 211 SCIENTIFIC COMPUTING (3103)	HUM 211 (0101)	BIO 212 (0031) CHY 212 (0031) PHY 212 (0031)
SEMESTER 4	BIO 221 BIOCHEMISTRY (3103)	CHY 221 PRINCIPLES OF PHYSICAL CHEMISTRY (3103)	MAT 221 INTRODUCTION TO STATISTICS (3103)	PHY 221 STATISTICAL MECHANICS(3103)	IDC 221 SYMMETRIC AND SPECTROSCOPY (2102) ———— IDC 222 ELECTRONICS (2102)	HUM 221 (0101)	BIO 222 (0031) CHY 222 (0031) PHY 222 (0031)

LTPC: L=Lecture, T=Tutorial. P=Practicals, C=Credit; IDC=Interdisciplinary Course; HUM= Humanities

TABLE 1B: FOUNDATION COURSES FOR STUDENTS ADMITTED IN AUG 2009

FIRST FOUR SEMESTERS

(core courses, common to all streams)

SEMESTER	BIOLOGY	CHEMISTRY	MATHEMATICS	PHYSICS	INTER DISCIPLINARY	SHORT COURSES	LABORATORY
SEMESTER 1	BIO 111 CELL BIOLOGY (3103)	CHY 111 PRINCIPLES OF CHEMISTRY (3103)	MAT 111 CALCULUS AND LINEAR ALGEBRA (3103)	PHY 111 MECHANICS (3103)	IDC 111 SCIENTIFIC COMPUTING (3103)	HUM 111 READING, LISTENING AND WRITING SKILLS (0101)	BIO 112 (0031) CHY 112 (0031) PHY 112 (0031)
SEMESTER 2	BIO 121 BIOCHEMISTRY (3103)	CHY 121 KINETICS AND MECHANISMS (3103)	MAT 121 MULTIVARIATE CALCULUS (3103)	PHY 121 ELECTROMAGNETISM AND OPTICS (3103)	IDC 121 THERMODYNAMICS (3103)	HUM 121 SPOKEN ENGLISH (0101)	BIO 122 (0031) CHY 122 (0031) PHY 122 (0031)
SEMESTER 3	BIO 211 ECOLOGY AND EVOLUTIONARY BIOLOGY (3103)	CHY 211 CHEMICAL REACTIONS AND REACTIVE INTERMEDIATES (3103)	MAT 211 COMPLEX FUNCTIONS (3103)	PHY 211 INTRODUCTION TO QUANTUM MECHANICS (3103)	IDC 211 ELECTRONICS (3103)	HUM 211 (0101)	BIO 212 (0031) CHY 212 (0031) PHY 212 (0031)
SEMESTER 4	BIO 221 GENETICS AND MOL. BIOLOGY (3103)	CHY 221 PRINCIPLES OF PHYSICAL CHEMISTRY (3103)	MAT 221 ELEMENTS OF PROBABILITY AND STATISTICS (3103)	PHY 221 STATISTICAL MECHANICS(3103)	IDC 222 SYMMETRY AND SPECTROSCOPY (3103)	HUM 221 (0101)	BIO 222 (0031) CHY 222 (0031) PHY 222 (0031)

LTPC: L=Lecture, T=Tutorial. P=Practicals, C=Credit; IDC=Interdisciplinary Course; HUM= Humanities

Semesters 5 to 10

Major and Minor Courses

Every student is allowed to choose a major subject. The available majors are in Biology, Chemistry, Mathematics and Physics.Number of seats in each major subject is normally limited to 30% and the top 30% in the order of merit among the students who have chosen that major subject will be given preference. Each student has to choose one minor as well. Both choices will be reflected in the BS-MS degree that will be awarded by IISER TVM on successful completion of the programme.

The minimum number of credits required to obtain an BS-MS degree from IISER TVM is 175. Out of this, 76 credits are carried by the common core courses taken by all students over the first two years.

A minimum of 57 credits from courses in the major subject and 9 credits from courses in the minor subject taken during the 3rd, 4th and 5th years are needed for graduation. Individual Schools are free to place additional requirements for obtaining a major or minor in their respective disciplines. Schools will also specify how the credits are split between theory and laboratory courses.

The student may alternatively opt to have no minor, but takes the 9 course credits from more than one School excluding the School of his/her major.

In addition to the courses, each student will undertake a one year research project in their major subject worth 24 credits during the 5th year. The mini project undertaken during the 8th semester should be in the subject other than the major subject and it carries 6 credits.

A course in humanities of the student's choice from among the available courses worth three credits will also have to be successfully completed for awarding the BS-MS degree

A table outlining the course requirements for the 3rd, 4th and 5th years is given below. The total earned credits shown are minimum values. Individual Schools may choose to offer courses that carry more credits than what is shown. The number of courses, however, shall remain fixed for each semester.

CREDITS CARRIED OVER FROM FIRST TWO YEARS: 76

Third Year

SEMESTER 5

SL. NO.	COURSE	CREDITS	MAJOR CREDITS	MINOR CREDITS	TOTAL
1	Major 1	3	This Semester	This Semester	This Semester
2	Major 2	3	15	3	18
3	Major 3	3			
4	Major 4	3			
5	Major 5 (Lab)	3	Cumulative	Cumulative	Cumulative
6	Minor 1	3	15	3	94

SEMESTER 6

SL. NO.	COURSE	CREDITS	MAJOR CREDITS	MINOR CREDITS	TOTAL
1	Major 1	3	This Semester	This Semester	This Semester
2	Major 2	3	15	3	18
3	Major 3	3			
4	Major 4	3			
5	Major 5 (Lab)	3	Cumulative	Cumulative	Cumulative
6	Minor 1	3	30	6	112

Fourth Year

SEMESTER 7

SL. NO.	COURSE	CREDITS	MAJOR CREDITS	MINOR CREDITS	TOTAL
1	Major 1	3	This Semester	This Semester	This Semester
2	Major 2	3	12	3	18
3	Major 3	3			
4	Major 4 (Lab)	3			
5	Minor 1	3	Cumulative	Cumulative	Cumulative
6	Humanities	3	42	9	130

SEMESTER 8

Sl. No.	Course	Credits	Major Credits	Minor Credits	Total
1	Major 1	3	This Semester	This Semester	This Semester
2	Major 2	3	12	6	18
3	Major 3 (Elective)	3			
4	Major 4 (Lab/Theory)	3	Cumulative	Cumulative	Cumulative
5	Project (Minor)	6	54	15	148

Fifth year

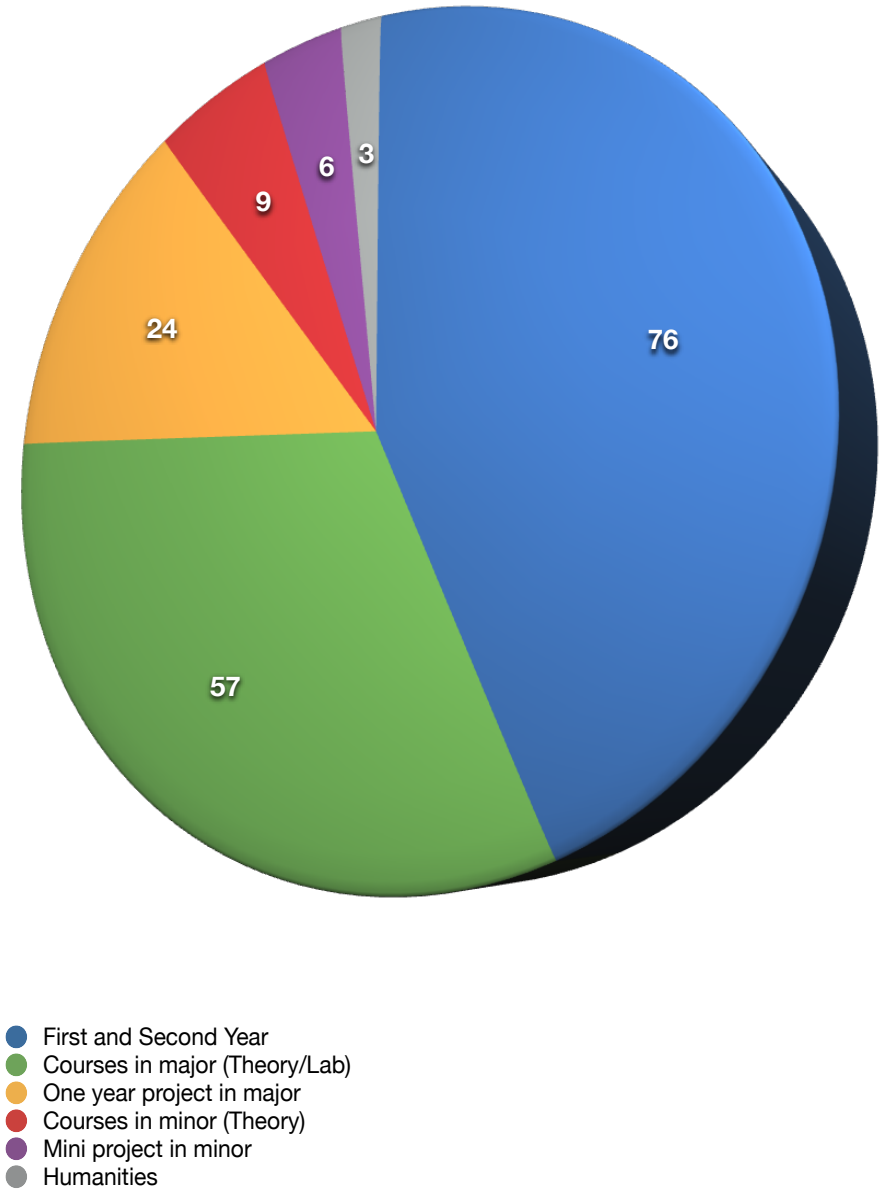
SEMESTER 9

Sl. No.	Course	Credits	Major Credits	Minor Credits	Total
1	Major 1 (Elective)	3	This Semester 12	This Semester 0	This Semester 12
2	Major Project	6			
3	Seminar 1 (Project Proposal)	3	Cumulative 66	Cumulative 15	Cumulative 160

SEMESTER 10

Sl. No.	Course	Credits	Major Credits	Minor Credits	Total
1	Major Project	12	This Semester 12	This Semester 0	This Semester 15
2	Seminar 2 (Final project report)	3	Cumulative 81	Cumulative 15	Cumulative 175

Distribution of credits



Biology Major

Table 2: Biology Courses

Semesters 5 to 10

5th Semester	6th Semester	7th Semester	8th Semester	9th Semester	10th Semester
BIO 311: Neurobiology	BIO 321: Systematics and Physiology	BIO 411: Developmental Biology	BIO 421: Mathematical and Systems Biology	Elective II	BIO 521: Major Project
BIO 312: Immunology	BIO 322: Biophysics and Structural Biology	BIO 412: Plant Biology	BIO 422: Epigenetics	BIO 511: Major Project	
BIO 313: Advanced Cell biology	BIO 323: Advanced Genetics	BIO 413: Biostatistics	BIO 423: Biology and Disease		
BIO 314: Evolutionary Ecology	BIO 324: Microbiology	BIO 414:Advanced Biochemistry	Elective I		
BIO 315: Biology Lab	BIO 325: Biology Lab	BIO415: Biology Lab			

Chemistry Major

Table 3: Chemistry Courses

Semesters 5 to 10

5th Semester	6th Semester	7th Semester	8th Semester	9th Semester	10th Semester
CHY 311: Organometallics and bioinorganic chemistry	CHY 321: Advanced Coordination Chemistry	CHY 411: Concepts of analytical chemistry	CHY 421: Solid State chemistry and Catalysis	CHY 511: Elective	CHY 521: Major Project
CHY 312: Quantum Chemistry and computational chemistry	CHY 322: Advanced molecular spectroscopy	CHY 412: Advanced chemical kinetics and statistical thermodynamics	CHY 422: Chemical biology	CHY 511: Major Project	
CHY 313: Reaction mechanism and stereochemistry	CHY 323: Pericyclic and free radical reactions organic photochemistry	CHY 413: Heterocyclic chemistry, Chiron approach, Medicinal chemistry, Vitamins, Hormones Antibiotics	CHY 423: Chemistry of Natural Products and retro synthesis		
CHY 314: Instrumental methods in chemistry	CHY 324: Spectroscopic methods in structure determination	CHY 414: Nuclear, Radiochemistry & Photochemistry	CHY 424: Surface chemistry and electrochemistry		
CHY 315: Inorganic Chemistry Lab	CHY 325: Laboratory	CHY 415: Macromolecules and bio molecules and supramolecules	CHY 425: Material chemistry including nanomaterials		

Mathematics Major

Table 4: Mathematics Courses
Semesters 5 to 10

5th Semester	6th Semester	7th Semester	8th Semester	9th Semester	10th Semester
MAT 311: Real Analysis	MAT 321: Measure Theory And Integration	MAT 411: Probability Theory	MAT 421: Fourier Analysis	MAT 511: Major Project	MAT 521: Major Project
MAT 312: Abstract Algebra	MAT 322: Linear Algebra	MAT 412: Functional Analysis - I	MAT 422: Functional Analysis - II	MAT ***: Dept Elective II	
MAT 313: Number Theory	MAT 323: General Topology	MAT 413: Algebraic Topology	MAT 423: Differential Geometry	MAT ***: Dept Elective III	
MAT 314: Mathematical Methods	MAT 324: Complex Analysis - I	MAT 414: Complex Analysis - II	MAT 424: Partial Differential Equations -I		
MAT 315: Reading Seminar	MAT 325: Numerical Analysis	MAT 415: Graph Theory And Combinatorics	MAT ***: Dept Elective I		

TABLE 5: PHYSICS COURSES

SEMESTERS 5 TO 10

5th SEMESTER	6th SEMESTER	7th SEMESTER	8th SEMESTER	9th SEMESTER	10th SEMESTER
PHY 311: MATHEMATICAL METHODS IN PHYSICS	PHY 321: INTERMEDIATE QUANTUM MECHANICS	PHY 411: ADVANCED STATISTICAL MECHANICS	PHY 421: CONDENSED MATTER PHYSICS	PHY 511: ELECTIVE	PHY 521: MAJOR PROJECT
PHY 312: CLASSICAL MECHANICS	PHY 322: ELECTRODYNAMICS AND SPECIAL THEORY OF RELATIVITY	PHY 412: GENERAL THEORY OF RELATIVITY AND COSMOLOGY	PHY 422: INTERACTION OF LIGHT AND MATTER	PHY 512: MAJOR PROJECT	
PHY 313: SOLID STATE PHYSICS	PHY 323: ELECTRONICS	PHY 413: ADVANCED QUANTUM MECHANICS: MANY BODY THEORY	PHY423: QUANTUM FIELD THEORY		
PHY 314: OPTICS	PHY 324: EXPERIMENTAL METHODS	PHY 414: NUCLEAR AND PARTICLE PHYSICS	PHY 424: COMPUTATIONAL TECHNIQUES AND PROGRAMMING LANGUAGES		
PHY 315: ADVANCED PHYSICS LAB I	PHY 325: ADVANCED PHYSICS LAB II	PHY 415: ADVANCED PHYSICS LAB III	ELECTIVE		

Choice Form

At the end of the fourth semester, the students make their choice regarding the major and minor subjects. The following choice forms is to be filled up and submitted to the Dean Academics. The choice of major and minor courses will be finalized in a counseling session involving students and concerned members of the faculty.

CHOICE FORM

Name :
Roll Number :
Year of Admission :
CGPA :

In column below each choice, list the grades you have received in that subject in the common core courses of the first and second years. Available choices for major are Biology, Chemistry, Mathematics and Physics. You have the option not to have a minor. The 9 credits for the minor can be filled using courses from Schools other than your major. The short project may then be done in any non-major School.

Please indicate your first and second choices for both major and minor subjects.

I. Major Subject (Choice 1).....

Semester	Theory	Lab
Semester 1		
Semester 2		
Semester 3		
Semester 4		

II. Major Subject (Choice 2) ...

Semester	Theory	Lab
Semester 1		
Semester 2		
Semester 3		
Semester 4		

III. Minor Subject (Choice 1).....

Semester	Theory	Lab
Semester 1		
Semester 2		
Semester 3		
Semester 4		

IV. Minor Subject (Choice 2) .....

Semester	Theory	Lab
Semester 1		
Semester 2		
Semester 3		
Semester 4		

V. No Minor:

If you choose to have no minor, please indicate the subjects (other than your major) in which you will be taking 3 credit courses.

1. .....
2. .....
3. .....

Syllabus

Course codes

The courses are numbered in the format,

XYZ YSC (LTPC)

The numbering may be understood as

XYZ	:	Subject Code
Y	:	Year
S	:	Semester Number
C	:	Number of the course (in a particular subject) in that year
L	:	Lecture hours
T	:	Tutorial hours
P	:	Practical hours
C	:	Credits

Biology

THEORY COURSES

BIO 111 Introductory Biology [3103]

1. Science of Biology. What is life?
2. Viruses, bacteria and protists
3. Plant and animal kingdom
4. Cells and organelles
5. Nucleic acids, amino acids and proteins
6. Plant physiology
7. Animal Physiology
8. Gametogenesis, genes and DNA
9. Populations and communities

BIO 121 Genetics and Molecular Biology [3103]

1. Mendelian laws of inheritance: Mendelian rations, sex determination, sex linked inheritance, gene concept, gene interactions, lethal alleles, epistasis
2. Genetic material and its organization: DNA / RNA as genetic material, Watson and Crick model, chromatin organization and packing, chromosome theory of heredity, chromosome morphology
3. Variation in chromosomes: Euploidy, polyploidy, aneuploidy, chromosomal abnormalities, deletion, inversion, duplication and translocation
4. Bacteriophages and complementation
5. Genes and enzymes: human biochemical genetics
6. Mutation: molecular nature of mutation. Point, spontaneous and induced mutations
7. Gene expression: Information flow and the genetic code, Transcription and translation.
8. Molecular methods: Restriction enzymes, cloning, and libraries
9. Genomics: Basic approaches and applications
10. Genotyping and gene cloning
11. Regulation of gene expression in prokaryotes
12. The Eukaryotic chromosome
13. Mitochondrial genome and Non-Mendelian inheritance

TEXTBOOKS:

1. Hartwell et al. *Genetics: from genes to genomes*, McGraw-Hill
2. Elrod and Stansfield, Genetics, 4th edition, Schaum Outline Series, McGraw-Hill
3. Griffiths et al. *Introduction to genetic analysis*, 8th edition, W. H. Freeman & Co (2005)

BIO 211 Ecology and Evolutionary Biology [3103]

1. Overview: The science of ecology and evolution; why study ecology and evolution?
2. Distribution of living things: The role of abiotic factors, biomes.
3. Species interactions: Antagonistic and mutualistic interactions.
4. Behavioural ecology: Sexual selection, animal behaviour, sociality, game theory
5. Ecosystem functioning: Food webs, biogeochemical cycles, energy flow
6. Biodiversity: Hotspots, key concepts
7. Macroevolution: Reproductive isolation, macroevolutionary concepts.
8. Conservation Biology: Global change, wildlife management and conservation

TEXTBOOKS:

1. Manuel E Molles Jr, *Ecology: Concepts and applications*, (2005).
2. Douglas J Futuyma, *Evolution* (Second Edition)

BIO 221 Biochemistry [3103]

1. Molecules and energetics of life Primary, secondary, tertiary and quaternary structure of proteins, Ramachandran plot, Enzymes: classifications, Kinetics
2. Molecular pathways of protein synthesis, DNA replication, repair, and recombination, molecular pathways of protein synthesis, molecular cloning and gene expression
3. Biochemical pathways DNA, RNA metabolism, protein modification, glycolysis, amino acid and fatty acid biosynthesis
4. Cytoskeleton regulation, Microtubules, actin polymerization and their regulation, regulation of intermediate filaments
5. Cell signaling, Messengers and receptors: structure-function, biochemical pathways of signal transduction cascades.
6. Energy transduction and Bioenergetics, Mitochondria, ATP, electron transport, gap junctions.

BIO 311 Neurobiology

1. Evolution and organization of the nervous system
2. Electrical properties of neurons
3. Ionic basis of membrane potentials and the action potential
4. Development of the nervous system
5. Synaptic transmission
6. Neurobiology of sensory systems
7. Motor functions of the spinal cord
8. The autonomic nervous system
9. Introduction to learning and memory

TEXTBOOKS:

1. Kandel E, et al. *Principles of Neural Science*, 4th Ed. McGraw-Hill Medical (2000)

2. Bear M, et al. *Neuroscience*, 3rd Ed. Lippincott Williams & Wilkins (2006)
3. Sanes D, et al. *Development of the Nervous System*, 2nd Ed. Academic Press (2005)

BIO 312 Immunology

1. Immunology an overview: Innate and adaptive Immunity
2. Antigen and antibody structure and function
3. T and B cell development
4. T-cell receptor and antigen recognition
5. Signaling through immune system receptors.
6. The development and survival of lymphocytes.
7. T cell mediated immunity.
8. Humoral immune response.
9. Response to infections: Innate, antibody response and T cell response.
10. Immune system gone awry: Allergies, hypersensitive reactions, Autoimmunity
11. Vaccines
12. Beyond Immunity: Antigen-antibody interactions as tools for research and therapy
13. Cancer Immunotherapy

TEXTBOOKS:

1. Janeway, *Immunobiology*
2. Kuby, *Immunology*
3. Abdul K. Abbas, *Molecular and Cellular Immunology*

BIO 313 Advanced Cell biology

1. Introduction to Cell Biology, Evolution of the Cell.
2. Methods used in Cell Biology Microscopy, Cell sorting, fractionation of cellular components, radioisotopes and antibodies as a tool to study cellular functions.
3. Cell membrane organization and composition of the cell membrane, membrane transport, endocytosis and exocytosis.
4. DNA and chromosomes packaging and organization.
5. Cellular organelles and function nucleus, lysosomes, peroxisomes, golgi apparatus, endoplasmic reticulum, mitochondria, plastids and chloroplasts.
6. Protein targeting Synthesis, intracellular trafficking and targeting of proteins.
7. Components of the cytoskeleton organization and function of actin, intermediary filaments, microtubules and motor proteins.
8. Integrins, cadherins, selectins, immunoglobulin superfamily, and bacterial adhesins.
9. Cell-Cell signaling overview of extracellular signaling, cell surface receptors, second messengers and regulation of signaling pathways.
10. Cell cycle and its control Mechanisms of growth and division of a prokaryotic and eukaryotic cell, and cell cycle check-points.
11. Frontiers in Cell and molecular biology research.

TEXTBOOKS:

1. B. Alberts, A. Johnson, J. Lewis, M. Raff, K. Roberts, P. Walter, *Molecular Biology of the Cell* 5th Edition
2. H. Lodish, A. Berk, C. A. Kaiser, M. Krieger, M. P. Scott, A. Bretscher, H. Ploegh, P. Matsudaira, *Molecular Cell Biology* 6th edition
3. G. Karp, *Cell and Molecular Biology: Concepts and Experiments* 5th Edition

BIO 314 Evolutionary Ecology

1. Mechanisms of evolution
2. Evolution of the senses and sensory ecology
3. Signaling and communication in plants and animals
4. Asexual reproduction and the evolution of sex
5. Evolutionary perspectives in circadian rhythms and chronobiology
6. Population ecology and population genetics
7. Evolutionary consequences of species interactions
8. Community patterns I: stability, equilibrium hypotheses, non-equilibrium hypotheses
9. Community patterns II: niche theory, metapopulations and biodiversity

TEXTBOOKS:

1. N. B. Gotelli, *A primer of ecology*, 3rd edition, Sinauer Associates (2001)
2. Charles W. Fox, Derek A. Roff, and Daphne J. Fairbairn, *Evolutionary ecology: concepts and case studies*, Oxford University Press, New York (2001)

BIO 321 Systematics and Physiology

BIO 322 Biophysics and Structural Biology

BIO 323 Advanced Genetics

BIO 324 Microbiology

List of Electives in Biology

1. Cancer Biology
2. Advanced Ecology
3. Cognitive science
4. Animal Behaviour
5. Bioinformatics
6. Proteomics and Genomics

LABORATORY COURSES

BIO 112 Introductory Biology lab [0031]

1. Microscopy
2. Cells under a microscope
3. Observations of bacteria and yeast under microscopes
4. Identification of Gram + and Gram - bacteria
5. Mitosis and meiosis
6. Blood grouping
7. Plant physiology experiments

BIO 122 Genetics and Molecular Biology Lab [0031]

1. Estimation of reducing sugars by DNSA method
2. Estimation of iodine number of lipid
3. Preparation of buffers, pH measurement
4. Estimation of DNA
5. Estimation of proteins
6. Enzyme assay and kinetics
7. Agarose gel electrophoresis of DNA
8. Genomic DNA isolation
9. Plasmid isolation
10. Protein expression and SDS-PAGE gel electrophoresis of proteins
11. Restriction digestion of bacteria
12. Transformation of bacteria

BIO 212 Ecology and Evolutionary Biology Lab [0031]

1. Understanding some key concepts in ecology, evolution and behaviour through
2. Short duration field and lab studies.
3. Approaches to formulating questions for ecological studies
4. Population estimation through sampling. What is sampling? Why sample? How Much to sample?
5. Choosing the most appropriate method and the pitfalls of adopting an Inappropriate sampling design. Implications of sample sizes and sampling error.
6. Experimental design in ecology
7. The study and applying bio-statistics in the analysis of ecological data
8. Scientific report writing

BIO 222 Biochemistry Lab[0031]

1. Estimation of Carbohydrates
2. Estimation of Nucleic acids
3. Estimation of Proteins

4. Estimation of Amino acids
5. Estimation of Lipids
6. SDS-PAGE Electrophoresis of proteins
7. Enzyme Assay and Kinetics

BIO 315 Biology Lab

BIO 325 Biology Lab

Chemistry

THEORY COURSES

CHY 111 Principles of Chemistry [3103]

1. Atomic Structure and Periodicity: The importance of chemical principles, introduction to atomic structure and need for quantum mechanics, periodic classification of elements, outer electronic configuration, periodicity in properties, classification into metals, non-metals and insulators
2. Chemical Bonding and Shapes of Compounds: Structure and bonding, VSEPR theory, molecular orbital theory, shapes of molecules, hybridization, dipole moment, ionic solids and lattice energy
3. Classification of elements: Main Group Elements (s and p blocks): Chemistry with emphasis on group relationship and gradation in properties; structure of electron deficient compounds of main group elements and application of main group elements.
4. Transition Metals (d block): Characteristics of 3d elements and coordination complexes, colour and magnetic properties of metal complexes.
5. Rare gas: Structure and bonding in rare gas compounds
6. Acid-base equilibrium: Hard-Soft Acid Bases (HSAB theory), Chemical and biological buffers
7. Basic Concepts in Organic Chemistry and Stereochemistry: Electronic (resonance and inductive) effects. Optical isomerism in compounds containing one and two asymmetric centers, designation of absolute configuration, conformations of cyclohexanes. aromaticity and Huckel's rule.
8. Equilibria, rates and mechanism of chemical reactions: Control of equilibria and rate of reactions, enthalpy and entropy, intermediates and transition states, role of solvent and catalyst, how mechanism of reactions are discovered.

TEXTBOOKS

1. J. D. Lee, *Concise Inorganic Chemistry*, 5th Edition, Wiley-Blackwell
2. J. E. Huheey, R. L. Keiter and E. A. Keiter and O. K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education (2008)
3. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, Oxford University Press
4. T. E. Brown, H. E. LeMay, B. E. Bursten, C. Murphy, *Chemistry: The Central Science*, 11th Edition, Prentice Hall

CHY 121 Principles of coordination chemistry, organometallics and bioinorganic chemistry [3103]

1. Coordination chemistry: Nomenclature. Isomerism in coordination compounds. Lability, trans-effect, chelate effect. Splitting of orbitals in various ligand fields. Crystal field and ligand field theories. MO theory of coordination compounds. Spectrochemical series, Orgel diagrams. Electronic spectra and magnetic properties of coordination compounds. Structural characterization of various metal complexes based on spectral and magnetic properties. Jahn-Teller theorem and its effect on structural features of coordination compounds.
2. Organometallic chemistry: Overview on organometallic compounds. 18-electron rule. Heptacity of ligands. Structural prediction based on 18-electron rule. Metal carbonyls. Donor and acceptor properties of CO in metal carbonyls. Metal nitrosyls. Electron donor properties of NO. Zeise salt, metal olefins, metallocenes, metal polyenes, carbene and cyclobutadiene derivatives of metal ions. Oxidative addition reactions, reductive eliminations, migratory insertion reactions. Organometallic compounds as catalysts.
3. Bio-inorganic chemistry: Metal ions of biological relevance. Transport of Na^{+}, K^{+}, Ca^{2+} and Mg^{2+}. The role of coordination compounds in biological systems. Hemoglobin, chlorophyll, cobalamines. Metalloenzymes. Metalloporphyrins. Cisplatin.

TEXTBOOKS

1. F. A. Cotton, G. Wilkinson and P. L. Gaus *Basic Inorganic Chemistry*, 3rd edition, (1995)
2. J. E. Huheey, R. L. Keiter and E. A. Keiter and O. K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education (2008)
3. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong *Shriver & Atkins Inorganic Chemistry*, 4th editon, Oxford University Press (2008)
4. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models if Inorganic Chemistry*, 3rd edition, Wiley (1994)
5. W. Kaim and B. Schwederski, *Bioinorganic chemistry: Inorganic Elements in the Chemistry of Life*, Wiley (2006)
6. W. K. Li, G. D. Zou and T. C. W. Mak, *Advanced Structural Inorganic Chemistry*, Oxford Science Publication (2008)
7. W. W. Porterfield, *Inorganic Chemistry- A Unified Approach*, 2nd edition, Academic Press (2008)
8. N. N. Greenwood and A. Earnshaw, *Chemistry of Elements*, 2nd edition

CHY 211 Chemical Reactions and reactive intermediates [3103]

1. Reactive intermediates: Formation, structure, stability and fate of various reactive intermediates (Carbanion, carbocation, carbenes, nitrenes, benzynes, free radicals)
2. Nucleophilic Substitution at saturated carbons (S_N1, S_N2 and S_Ni): Types, stereochemical consideration, Role of solvent, NGP.
3. Electrophilic Aromatic Substitution: Benzene and its reaction with electrophiles-Effect of functional groups

4. Nucleophilic Aromatic substitution: Diazonium compounds-benzyne mechanism, Electrophilic addition to alkenes
5. Elimination reactions: Types (E1, E2 and E1cB), stereochemical consideration, Role of solvent-Hofmann rules- Zaytsev Rules, Nucleophilic addition to the Carbonyl group, Nucleophilic substitution at the carbonyl group, Radical Reactions. Reactive intermediates in biology and environment.

TEXTBOOKS

1. R. T. Morrison and R. N. Boyd, *Organic Chemistry*, 6th Edition, Prentice Hall, (1992)
2. J. Clayden, N. Greeves, S. Warren, P. Wothers, *Organic Chemistry*, Oxford University Press, (2000)
3. P. Sykes, *A Guidebook to Mechanism in Organic Chemistry*, Addison-Wesley, (1996)
4. M. B. Smith, J. March, *Advanced Organic Chemistry: Reactions, Mechanisms and Structures*, 6th Edition, Wiley Interscience, (2007)
5. F. A. Carey, R. J. Sundberg *Advnaced Organic Chemistry*, 5th editon, Springer (2007)

CHY 221 Principles of Physical Chemistry [3103]

1. Real Gases: Molecular interactions, van der Waals equations, principle of corresponding states, fugacity and pressure.
2. Molecular Interaction: Electric dipole moment and molecular polarizability, interactions between molecules
3. Chemical Thermodynamics: Overview on the laws of thermodynamics, concepts and applications.
4. Thermodynamics of Physical Transformations: Phase boundaries, supercritical fluids, phase diagram of water and carbon dioxide, phase stability and transitions, Clausius-Clayperon equation, liquid-vapour interface (surface tension, curved surface and capillary action).
5. Thermodynamic of Mixtures: Partial molar quantities and chemical potential, Gibbs-Duhem equation, thermodynamics of mixing, ideal solutions (Henry's and Raoult's law)
6. Properties of Solutions: Colligative properties (elevation of boiling point, depression of freezing point and osmotic pressure), binary solutions
7. Phase Diagrams: Phase rule and two component systems, vapour pressure diagram, temperature composition diagram, fractional, azeotropic and steam distillations and their importance in organic chemistry
8. Chemical Equilibrium: Chemical reactions and Gibbs energy, response of equilibria to various conditions, application to selected systems (extraction of metals from oxide and Ellingham diagram, acid-base systems and Henderson-Hasselbalch equation).
9. Electrochemistry: Themodynamic properties of ions in solution, Debye-Huckel law, conductance and its applications, transport number, electrochemical cells, Nernst equation, standard electrode potential, electrochemical series, redox reactions in biology, EMF and free energy, determination of solubility constants, pH and pKa from EMF measurements, concentration cells with and without transference, ion pumps in biology, polarography, batteries and fuel cells.

10. Chemical Kinetics: Reactions of various order, Arrhenius equation, collision theory, theory of absolute reaction rate, chain reactions, enzyme kinetics, fast reactions, photophysical and photochemical processes; catalysis and surface reactions.

TEXTBOOKS

1. P. Atkins, Physical Chemistry, 8th editon, Oxford University Press
2. Physical Chemistry, Thomas Engel and Philip Reid, Prentice Hall (2009).

CHY 311 Organometallics and bioinorganic chemistry

Prerequisite: CHY 121

1. Organometallics: Structural aspects of various organometallic compounds. Metal carbonyls having both terminally bound and bridging type COs. Structural information of metal carbonyls from IR spectra. Metal nitrosyls. Various modes of coordination of NO and their structural consequences. Comparison of sigma-donor and pi-acceptor properties of CO, NO and CN- moieties. Metal carbenes, metal olefins, metal alkynes, metal alkyls, metallocenes and half-sandwich compounds, metal-polyenes, metal-allyls. Fragment molecular orbitals of various ligands and MLn moieties. Detailed study on the structure and bonding in above compounds based on FMO approach. Orbital interaction diagrams involving fragments in metal carbonyls, metallocenes, metal-olefins. Stabilization of unstable moieties like carbene and cyclobutadiene through MLn fragments; discussions based on orbital interaction diagrams in them. Isolobal concept and comparison of various organic and inorganic moieties. Fluxional organometallic compounds, Nature of non-rigidity and their charactrisation by NMR spectroscopy. Activation of small molecules by metal ions. Synthetic and catalytic aspects of organometallic chemistry. Oxidatve addition reactions, reductive elimination reactions and migratory insertion reactions. Wilkinsons catalyst, hydrogenation and hydroformylation reactions. Fischer-Tropsch process, olefin metathesis, oligomerisation of alkynes, metallacycles, ortho-metallation. Reactions of coordinated ligands.
2. Bioinorganic chemistry: Occurrence and availability of inorganic elements in organisms. Biological functions of various elements. Photosynthetic process. Uptake, transport and storage of dioxygen, haemoglobin and myoglobin, cooperative effect in haemoglobin. Haemoerythrin and haemocyanin, catalase and peroxidase, cytochrome. Uptake, transport and storage of iron, Fe-S and other nonheme iron proteins, transferrin, ferritin, copper containing proteins. Zinc in biological systems, metalloenzymes. Function and transport of K^+, Na^+, Ca^{2+} and Mg^{2+} ions. Biomimetic chemistry, metalloporphyrins, picket-fence porphyrins. Cis-platin. Photodynamic therapy.

TEXTBOOKS

1. J. E. Huheey, R. L. Keiter and E. A. Keiter and O. K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education (2008)
2. F. A. Cotton, G. Wilkinson, C. A. Marillo and M. Bochmann *Advanced Inorganic Chemistry*, John Wiley, (2003)

3. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong, *Shriver & Atkins Inorganic Chemistry*, 4th editon, Oxford University Press (2008)
4. J. P. Collman, Hegedus, Nortaon and Finke, *Principles and Application of Organotransition Metal Chemistry*, 2nd edition (1987)
5. J. D. Atwood, *Inorganic and Organometallic Reaction Mechanism*, 2nd editon, Wiley-VCH (1997)
6. R. H. Crabtree, *The Organometallic Chemistry of Transition metals*, Wiley, New York (1988)
7. M. Bochmann, *Orgaonometallics and Complexes with Transition Metal-Carbon Sigma Bonds* Oxford Science publications (2005)
8. R. C. Mehrotra and A. Singh, *Organometallic Chemistry-A Unified Approach*, 2nd edition, New Age International Publication (2000)
9. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models if Inorganic Chemistry*, 3rd edition, Wiley (1994)
10. W. Kaim and B. Schwederski, *Bioinorganic chemistry: Inorganic Elements in the Chemistry of Life*, Wiley (2006)

CHY 312 Quantum Chemistry and computational chemistry

1. Fundamental Background: Postulates of Quantum Mechanics, Measurements, Operators, Symmetry and the Separability of the Wave Function.
2. Exactly Solvable Problems: Free Particle, Quasi-Free Particle (1-D, 2-D and 3-D box problems), Applications in organic metals, The simple Harmonic Oscillator, Orbital Angular Momentum, The Hydrogen Atom problem, Atomic Orbitals, Quantum Tunneling and scattering.
3. Many Electron Atoms: The independent electron approximation, Simple Products and Electron exchange Symmetry, Slater Determinants and Pauli Principle, The self-consistent field, Slater Type orbitals, Aufbau Principle, Spin-Orbital Angular Momentum for Many-electron Atoms.
4. The Variation Method: Rayleigh-Ritz Method, Simple Examples: Hydrogen, Helium, Screening Constants, polarizabilities, The Non-Crossing Rule, Hartree and Hartree-Fock Models, Koopmans Theorem.
5. Applications of the Variation Principle: Born-Oppenheimer Approximation, The H_2^+ Molecule-Ion, LCAO-MO, Molecular Orbitals for Diatomic Molecules, Block Diagonalization, Basis-set choice and Variation Wavefunction, Huckel Theory and applications across organic chemistry, Connection between solid-state physics and chemistry, Tight-binding approximation, WKB, Kronig-Penney Model, The extended Huckel Model, Hybridization, Walsh M. O. diagrams, Why these approximations work: Hellmann-Feynman Theorem, Matrix Formalism of the Variational Method.
6. Time Independent Perturbation Theory: Formal Development for Non-degenerate states, Electron in a Wire, Zeeman and Stark Effects, Crystal Field Theory, The Anharmonic Oscillator, Perturbation Theory for a degenerate state, Polarizability of H-atom in the excited state, Interaction between orbitals, Spectroscopic selection rules.
7. Time Dependant Perturbation Theory: Formalism, constant perturbation, Augur Effect, Fermi Golden Rule, Electron and Proton Transfer rates.

8. Molecular Orbital Theory of Periodic Systems/Band Theory/Electronic Properties of Materials: Free Particle, Particle in a ring, Blochs Theorem, Polyacetylene and Peierls Theorem, Effects of doping, quasi-particles: solitons, excitons, polarons and bipolarons, Periodicity in 2 and 3 dimensions: Cases for band structure of graphene, nanotubes with different chirality, graphite, Parametric correction for correlation effects in band gap for molecular materials.

TEXTBOOKS

1. J. P. Lowe, K. A. Peterson, *Quantum Chemistry*, 3rd Edition, Elsevier
2. S. N. Datta, *Lecture Notes on Chemical Bonding and Quantum Chemistry*, Prism Books
3. J. B. Foresman, A. Frisch, *Exploring Chemistry with Electronic Structure Methods*, Gaussian Inc.
4. Richard M. Martin, *Electronic Structure: Basic Theory and Practical Methods*, Cambridge University Press.
5. R. Hoffmann, *Solids and Surfaces: A Chemist's View of Bonding in Extended Structures*, Wiley-VCH.

CHY 313 Reaction mechanism and stereochemistry

1. Reaction mechanisms of important reactions
2. Molecular symmetry and chirality, Stereoisomerism, Classification of stereoisomerism, configuration, chiral centre, Axial chirality, planar chirality, helicity, Racemization and methods of optical resolution, Determination of configuration, Conformation of acyclic and monocyclic molecules-conformation and reactivity, Prochirality and prostereoisomerism, Stereochemistry of alkene, Chirality in molecules devoid of chiral centers, Chiro-optical properties.

TEXTBOOKS

1. E. L. Elilel, S. H. Wilen, L. N. Mander, *Stereochemistry of Organic compounds* (Wiley)
2. J. March, *Advanced organic chemistry*, 4th Edition, Wiley (2008)

CHY 314 Instrumental methods in chemistry

1. Basics of measurement
2. Separation Techniques: Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), gas and liquid chromatography, electrophoresis (plates and capillary).
3. Analytical Techniques: Elemental analysis, index of refraction, Flame photometry, Mass spectrometry, Infra-red absorption, static and dynamic light scattering techniques, electrochemical techniques, thermoanalytical techniques; techniques in nuclear and radiochemistry (GM counter, ionizing chamber etc.)
4. Spectroscopic Techniques: Ultraviolet, visible and near infrared absorption, linear and circular dichroism, Emission spectroscopy, nuclear magnetic resonance spectroscopy, electron spin resonance spectroscopy
5. Microscopic Techniques: Diffraction limit, optical microscopy (bright field, dark field and confocal), electron microscopy (SEM and TEM), scanning probe microscopy (STM and AFM).

TEXTBOOKS

1. D. A. Skoog, F. J. Holler, T. A. Nieman, *Principles of Instrumental Analysis*, 5th edition, Brooks Cole
2. H. Willard, L. Merritt, J. Dean, *Instrumental Methods of Analysis*, 7th Sub-Edition, Wadsworth Publishing Company

CHY 321 Advanced Coordination Chemistry

Prerequisites: CHY 121, CHY 311

1. Crystal field theory and ligand field theory of coordination compounds. MO theory and MO diagrams of metal complexes. Metal-ligand sigma- and pi-bonds involving s, p, d and their hybridized orbitals. d-p and d-d pi bonds. Metal-metal multiple bonds in dinuclear and polynuclear coordination compounds. d-d delta bonds. Orgel diagrams. Tanabe-Sugano diagrams. Electronic spectra and magnetic properties of coordination compounds, structure determination using electronic spectra, IR and magnetic susceptibility measurements. Ligand field parameters, Dq, Racah parameter B and nephelauxetic constant b. Jahn-Teller theorem and its effect on the structural features of metal complexes. Charge transfer MLCT and LMCT transitions.
2. Reactions involving coordination compounds. Stability and labile nature of coordination compounds. Trans-effect, chelate effect. Electron transfer reactions, Inner sphere and outer sphere mechanisms. Circular dichroism of coordination compounds.
3. Photochemical reactions of coordination compounds. Photoisomerisation, photosubstitution and photo redox reactions. Photo reaction and solar energy conversion.
4. Lanthanide compounds. Lanthanide contraction, coordination behavior of lanthanide ions. Magnetic and spectroscopic properties of lanthanide complexes. Fluorescent properties of lanthanide compounds. Lanthanide shift reagents.
5. Actinide compounds. Coordination behavior of actinide elements and their coordination compounds. Magnetic and spectroscopic properties.

TEXTBOOKS

1. W. K. Li, G. D. Zou and T. C. W. Mak, *Advanced Structural Inorganic Chemistry*, Oxford Science Publication (2008)
2. W. W. Porterfield, *Inorganic Chemistry - A Unified Approach*, 2nd edition, Academic Press (2008)
3. D. Banerjea, *Coordination Chemistry*, Asian Books Pvt. Ltd. (2007)
4. N. N. Greenwood and A. Earnshaw, *Chemistry of Elements*, 2nd edition
5. N. Kaltsoyannis and P. Scott, *The f-elements*, Oxford Science Publications (2008)
6. J. E. Huheey, R. L. Keiter and E. A. Keiter and O. K. Medhi, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edition, Pearson Education (2008)
7. F. A. Cotton, G. Wilkinson, C. A. Marillo and M. Bochmann *Advanced Inorganic Chemistry*, John Wiley, (2003)
8. P. Atkins, T. Overton, J. Rourke, M. Weller, F. Armstrong *Shriver & Atkins Inorganic Chemistry*, 4th editon, Oxford University Press (2008)

9. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models in Inorganic Chemistry*, 3rd edition, Wiley (1994)

LABORATORY COURSES

CHY 112 Introduction to qualitative and quantitative analysis [0031]

1. Qualitative Semimicro Analysis of Mixture containing two anions (non-interfering) and two cations
2. Introduction to titrimetric analysis Acidimetry and alkalimetry

CHY 122 Inorganic titrations and preparations [0031]

1. Redox Titration
   a. Using $KmnO_4$
      i. Estimation of Hydrogen peroxide, nitrite and checking the purity of Potassium Nitrate
      ii. Estimation of Calcium.
   b. Using Potassium dichromate
      i. Estimation of ferrous and ferric iron using N-phenyl anthranilic acid indicator.
      ii. Estimation of zinc using potassium ferrocyanide
   c. Iodometry
      i. Estimation of Barium in the given solution
      ii. Estimation of copper in the given solution
      iii. Estimation of dissolved oxygen in the given sample of water
   d. Iodimetry
      i. Estimation of Ascorbic acid in grape,orange and apple juices
   e. Argentometry
      i. Estimation of Chloride ion using Mohrs and Volhards methods
   f. Complexometry
      i. Estimation calcium and magnesium in the given mixture using different metal ion indicators
      ii. Esimation of copper using Fast Sulphon black indicator
      iii. Estimation of zinc and magnesium using eriocrome black T indicator
      iv. determination of total, permament and temporary hardness of water
   g. Gravimetric Analysis
      i. Estimation of barium/sulphate as barium sulphate
      ii. Estimation of iron as ferric oxide
2. Inorganic preparation.
   a. Preparation of alum from scrap aluminium

b. Preparation of hexaminenickel(II)chloride
c. Preparation of tetramine copper(II)sulphate.

CHY 212 Qualitative and Quantitative Organic analysis [0031]

1. Determination of melting point and boiling point.
2. Purification of organic compounds by crystallization
3. Identification of Organic functional groups: carboxylic acid, ester, amide,alcohol, phenol, aldehyde, ketone, 10,20,30 amine, hydrocarbon, polynuclear hydrocarbon halogenated hydrocarbon and nitrocompound,
4. Single stage preparations including nitration, acetylation, benzoylation, bromination, oxidation etc.
5. Two stage preparation
   a. Conversion of acetanilide to p- bromoaniline
   b. Conversion of acetanilide to p-nitroaniline
   c. Conversion of aniline to sym-tribromobenzene
   d. Conversion of nitrobenzene to m-nitroaniline
6. Organic estimations
   a. Estimation of phenol/aniline
   b. Estimation of glucose
   c. Estimation of ester
   d. Saphonification value of oil
   e. Iodine value of oil

CHY 222 Experiments in Physical Chemistry [0031]

1. Determination of partial molar volume of a mixture
   a. NaCl-water
   b. CCl_4-water
   c. methanol- water
2. Kinetics Experiments
   a. Bromination/iodination of acetone
   b. Ester hydrolysis using HCl
   c. Ester hydrolysis using NaOH
   d. Reaction between persulphate and potassium iodide
   e. Determination of order of a reaction
   f. Determination energy of activation
3. Phase Rule
   a. Construction of phase diagram of phenol water system and determination of critical solution temperature

   b. Effect of impurity on critical solution temperature: (KCl, Naphthalein, succinic acid)
   c. Determination of percentage composition of given KCl solution using miscibility temperature graph
   d. Triangular phase diagram: construction of phase diagram, drawing the tie line and determination of percentage composition of given mixture of two components

4. Distribution coefficient/Equilibrium constant

   a. Determination of partition coefficient of Iodine between CCl_4 and water
   b. Determination of equilibrium constant of the reaction $KI + I_2 \rightarrow KI_3$
   c. Determination of partition coefficient of benzoic acid between toluene and water.
   d. Determination of partition coefficient of ammonia between toluene and water and hence find the value of n in $[Cu(NH_3)_n]^{2+}$

5. Conductometric Experiments

   a. Determination of equivalent conductance of a weak electrolyte
   b. Determination of equivalent conductance of a strong electrolyte
   c. Conductometric titrations
   (i) HCl vs NaOH (ii) HCl vs NH_4OH (iii) CH_3COOH vs NaOH (iv) Mixtures of acids vs NaOH

6. Potentiometric titration

   a. Titration of HCl vs NaOH using quinhydrone electrode
   b. Redox titration using $KMnO_4$, $K_2Cr_2O_7$
   c. Estimation of KCl, KBr and KI in a mixture

CHY 315 Lab

ORGANIC CHEMISTRY [MONDAY]

1. Separation and quantification of ternary mixtures. Determination of purity by melting points and TLC.

   a. Mixture No.1
   b. Mixture No.2
   c. Mixture No.3
   d. Mixture No.4

2. Determination of moisture content in the organic solvents using Karl- Fischer titration
3. Estimation of Nitrogen, in the given organic compound by Kjeldahls method
4. Extraction of eugenol from cloves by steam distillation and comparison with synthesized eugenol
5. Multistage preparations and spectroscopic characterization

a. Conversion of bromobenzene to triphenyl carbinol and then to tritylchloride
b. Preparation of vanilline and its derivatives fron p-hydroxybezaldehyde.
c. Benzaldehyde to methylstyrene and to 1-phenyl1,2-dihydroxypropane
d. Preparation of benzotriazole from o-nitroaniline
e. Preparation of caprolactum from cyclohexanone

INORGANIC CHEMISTRY [WEDNESDAY]

1. Reactions of transition metal ions [Ti, V, Cr and Mn]
2. Reactions of transition metal ions contd. [Fe, Co, Ni and Cu]
3. Preparation of chromium complexes
   a. Preparation of tris(1,-diaminoethane)chromium(III)chloride $[Cr(en)_3]Cl_3$
   b. Preparation of Potassiumaquaethylenediaminetetracetic acidchromate(III), $K[Cr(EDTA)(H_2O)]$
   c. Preparation of hexakis-(urea) Chromium (III) chloride $[Cr\ (CO(NH_2)_2)_6]Cl_3$
4. Preparation of chromium complexes (Continued)
   a. Preparation of Potassiumhexathiocyanatochromate(III), $K_3[Cr(NCS)_6]$
   b. Preparation of cis dichlorobis-(1,2-diaminoethane)chromium(III)chloride
   c. Preparation of cis- potassium diaqua dioxalato chromate(III) dehydrate, $K[Cr(ox)_2(H_2O)_2].2H_2O$
5. Characterization of the complexes
   a. Determination of molecular weights by Rasts method
   b. Estimation of chromium
   c. Estimation of chloride ion
6. Characterization of the complexes (continued)
   a. Conductance measurements
   b. Measurement of magnetic susceptibility
   c. UV-Visible spectrum and comparison CFSE
   d. IR Spectrum and identifying the characteristic bands
7. a. The preparation of Potassium tris(oxalato)ferrate(III) trihydrate, $K_3[Fe(C_2O_4)_3]$
   b. Determination of the oxalate content of Potassium trisoxalatoferrate(III) trihydrate.
   c. Photochemical reactions of Potassium trisoxalatoferrate(III) trihydrate
8. The Mechanism of Aquation of trans-dichlorobis(1,2-diaminoethane)cobalt(III) chloride
9. Determination of stability constant of $[Ni(en)_3]$ complex (spectrophotometric method)
10. Determination of stability constant of $[Ag(RNH_2)_2]$ complexes (Titration method)

PHYSICAL CHEMISTRY[FRIDAY]

1. a. Heat of neutralization of HCl $><$NaOH
   b. Heat of neutralization of weak acid and hence its heat of ionization
   c. Heat of neutralization of phenol and NaOH
2. Determination of heat of combustion by bomb calorimeter

3. a. Calculation of refraction of CH_2- group
   b. Determination of electron polarization and electron polarizability of a liquid.
   c. Determination of composition of unknown liquid mixture by refractive index method
4. Determine the molar refraction of a solid and determine the concentration of the unknown solution.
5. a. Determination of extinction coefficient of an organic dye
   b. Dissociation constant of weak acids
6. Analysis of binary mixture
7. a. Iodination of acetone (i) Spectrophotometry (ii) Titration (iii) Visual methods
   b. Calculation of activation of energy, enthalpy , entropy and free energy of the reaction
8. Study of clock reaction and determination of energy of activation
9. Iodination of aniline pH and base catalytic effect
10. a. Determination of radius of glycerol molecule
11. Determination of dipole moment using dipole meter

Mathematics

All the theory courses for MAT are of 3 credits each. Reading and Seminar courses are of 2 credits each.

MAT 111 Introduction to Algebra [3103]

1. Linear Algebra: Fields, System of linear equations, Matrices and elementary row operations, Row reduced echelon matrices, Matrix multiplication, Invertible matrices, Rank of a matrix.Definition of a linear vector space and examples; linear independence of vectors, basis and dimension, Subspaces; Linear transformations, Isomorphism, Linear functionals, The double dual; Inner product, Orthogonal basis, Gram-Schmidt orthogonalization process; Linear operators; Orthogonal and Hermitian matrices, Eigen vectors of a matrix and matrix diagonalization, Applications.
2. Group Theory: Definition and examples of groups, Finite groups, Abelian and cyclic groups, Subgroups, Functions and permutations, Groups of permutations, Cycles and Cyclic notations, Even and Odd permutations, The alternating group. Isomorphism, Cayleys theorem, Cosets, Inner automorphism, Normal subgroups and Quotient groups, Applications.

TEXTBOOKS

1. K. Hoffman and Kuntz, *Linear Algebra*, 2nd edition, Pearson Education, New Delhi, (2006)
2. I. N. Herstein, *Topics in Algebra*, 2nd Edition, Wiley and Sons, (1996)
3. Lang, *Undergraduate Algebra*
4. P. Halmos, *Finite-Dimensional Vector Spaces*, VanNostrand, Priceton,N.J, (1958)
5. V.S. Varadarajan, *Algebra in ancient and modern times*, Hindustan Book agency, Copyrighted Material (American Mathematical Society)

MAT 121 Introductory Analysis - I [3103]

1. The Natural Numbers: The Peano axioms, Addition, Multiplication. Set Theory: Fundamentals, Functions, Images and inverse images, Cartesian product, Cardinality of sets. Integers and Rationals: The integers, Therationals, Absolute value and exponentiation, Gaps in the rational numbers. The real numbers: Cauchy sequence, Construction of the real numbers, Ordering of reals, The least upper bound property.
2. Limits of Sequences: Convergence and limit laws, Suprema and infima of sequences, limsup, liminf, and limit points, Some standard limits, Subsequences.
3. Series: Finite and infinite series, Sums of non-negative numbers, Absolute and conditional convergence of an infinite series, tests of convergence, examples.

4. Continuous function on R: Formal definition, continuity and discontinuity of a function at a point; left and right continuity, examples of continuous and discontinuous functions, The Maximum principle, Intermediate value theorem, Monotonic functions, Uniform continuity, Limits at infinity.
5. Differentiation of functions: Definition and basic properties, Local maxima, local minima, and derivatives, Monotone functions and derivatives, Inverse functions and derivatives, Rolles theorem, Mean value theorem, Taylors theorem.
6. The Riemann Integration: Partitions, Piecewise constant functions, Upper and lower Riemann integrals, Basic properties of Riemann integral, Riemann integrability of continuous functions, monotone functions, and discontinuous functions, The non-Riemann integrable functions, The fundamental theorems of calculus, The consequences of the fundamental theorems.

TEXTBOOKS

1. Terrence Tao, *Analysis I*, Hindustan Book Agency.
2. W. Rudin, *Principles of Mathematical Analysis*, 3rd edition, McGraw-Hill India, (1953)
3. S. Lang, *First Course in Calculus*, 5th edition, Springer (India), New Delhi, (2006)
4. Tom M Apostol, *Calculus*, Vol. 1, 2nd edition, John Wiley, New York, (2006)
5. G. B. Thomas and R. L. Finney, *Calculus and Analytic Geometry*, 9th edition, Pearson Education, New Delhi, (2005)
6. E. Kreyszig, *Advanced Engineering Mathematics*, 8th edition, Wiley & Sons, (2006)
7. James Stewart, *Calculus: Concepts and Contexts*, 3rd edition, Thompson Brooks/Cole (2005)
8. A. E. Taylor and W. R. Mann, *Advanced Calculus*, 3rd Edition, Wiley & Sons, (1983)

MAT 211: Introductory Analysis II [3103]

1. Limits and continuity of functions of several variables: Definition, properties and examples. Differentiability: Partial derivatives, Total differential, Composite functions, Chain rule, Partial derivatives of higher order, Change of variables, Calculation of second order partial derivatives, Jacobians, Implicit functions, Directional derivatives, Gradient and Curl. Unconstrained Maxima and Minima, Constrained optimization, Lagrange multipliers.
2. Improper Integrals: Improper integral of first and second kind, Tests for convergence of improper integrals of various kinds, Tests for convergence of integral of the product, Some important results, Beta and Gamma functions.
3. Integral as a function of parameter: Definite integral as a function of paramter, Uniform convergence of improper integral, Consequences of uniform convergence of improper integral.
4. Power Series: Convergence of power series, Radius of convergence, Properties of power series.
5. Rectification of plane curves: Rectifiable curves, Evaluation of length of plane curves.
6. Multiple Integrals: Double integrals on rectangular regions, Conditions of integrability, Properties of integrable functions, Repeated or iterated integrals, Double integrals over any finite region, Change in the order of integration, Triple integrals over any bounded domain, Evaluation of multiple integral by change

of variables. Surface area, Volume of a region.Theorems of Green, Gauss, and Stokes.

TEXTBOOKS

1. Terrence Tao, *Analysis II*, Hindustan Book Agency.
2. W. Rudin, *Principles of Mathematical Analysis*, 3rd edition, McGraw-Hill India, (1953)
3. G. B. Thomas and R. L. Finney, *Calculus and Analytic Geometry*, 9th edition, Pearson Education, New Delhi, (2005)
4. S. Lang, *Calculus of Several Variables*
5. E. Kreyszig, *Advanced Engineering Mathematics*, 8th edition, Wiley & Sons, (2006)
6. James Stewart, *Calculus: Concepts and Contexts*, 3rd edition, Thompson Brooks/Cole (2005)
7. A. E. Taylor and W. R. Mann, *Advanced Calculus*, 3rd Edition, Wiley & Sons, (1983)
8. U. Chatterjee, *Advanced Mathematical Analysis*.
9. University of California Berkley Video Lectures: http://academicearth.org/courses/multivariable-calculus

MAT 221 Introduction to Statistics[3103]

1. Basic Probability: Set operations, Counting, Combinatorics, Finite sample spaces, Conditional probability, Independence of events, Bayes' Rule, Geometric probability.
2. Random variables and distributions: Univariate, Bivariate and multivariate random variables, Cumulative and marginal distribution function, Conditional and multivariate distributions, Functions of random variables: Sum, product, ratio, change of variables.
   Computer simulations: De Mere's problem, Buffon's needle and estimation of , Birthday problem, Bertrand's paradox
3. Measure of central tendency and dispersion : Mean, Median, Variance, Standard deviation, Raw and central moments, Covariance, Correlation, Moment generating function, Cauchy-Schwartz inequality, Karl Pearson's measure of skewness and kurtosis.
4. Discrete/continuous distributions and limit theorems: Binomial distribution, Geometric distribution, Poisson distribution, Normal distribution, Exponential distribution, Gamma distribution, Beta distribution, Central limit theorem, Tchebeyche's inequality, Law of large numbers
5. Estimation Theory: Bias of estimates, Confidence intervals, Minimum variance unbiased estimation, Bayes' estimators, Moment estimators, Maximum likelihood estimators, Chi-square distribution, Confidence intervals for parameters of normal distribution
6. Hypothesis testing: Tests for means and variances, hypothesis testing and confidence intervals, Bayes' decision rules, Power of tests, Goodness-of-fit tests, Kolmogorov-Smirnov Goodness-of-fit test

TEXTBOOKS

1. Feller, *Introduction to Probability*, Vol. 1
2. Murray R. Spiegel, John J. Schiller, R. Alu Srinivasan, *Schaum's Outline of Probability and Statistics*

3. Montgomenry and Runger Applied Statistics and Probability for Engineers; 4. Introduction to Probability and Statistics for Science, Engineering and Finance, Walter Rosenkrantz 5. Groundwork Of Mathematical Probability and Statistics; Amritava Gupta 6. A first course in Probability; Sheldon Ross 7. Introduction to Probability; Grinstead and Snell 8. Intuitive Probability and Random Processes using Matlab; Steven Kay

MAT 311: Real Analysis [3003]

1. Metric spaces: Open sets, Closed sets, Continuous functions, Completeness, Cantor intersection theorem, Baire category theorem, Compactness, Totally boundedness, Finite intersection property. Functions of several variables: Differentiation, The contraction principle, Inverse and implicit function theorems, The rank theorem, Determinants, Differentiation of integrals.
2. Riemann-Stieitjes integral: Definition and existence of the integral, Properties of the integral, Differentiation and integration.
3. Sequence and Series of functions: Uniform convergence, Uniform convergence and continuity, Uniform convergence and integration, Uniform convergence and differentiation. Equicontinuity, Ascolis Theorem, Stone-Weierstrass Theorem.

TEXTBOOKS

1. Walter Rudin, *Principles of Mathematical Analysis*
2. Terence Tao, *Analysis II*
3. Apostol, *Mathematical Analysis*
4. Richard R. Goldberg, *Methods of Real Analysis*
5. Serg Lang *Undergraduate Analysis*
6. Bertle and Sherbert *Introduction to Real Analysis*

MAT 312: Abstract Algebra [3003]

1. Groups, Subgroups, A counting principle, Normal subgroups, Quotient groups, Homomorphisms, Automorphisms, Cayley's theorem, Permutation groups, Direct product of groups, Group action on a set, Semi-direct product, Sylow's theorem. Structure of finite abelian groups.
2. Rings, Examples and Basic properties. Zero divisors, Integral domains, Fields, Characteristic of a ring, Quotient field of an integraldomain. Subrings, Ideals, Quotient rings, Isomorphism theorems. Ring of polynomlals. Unique factorization domain, Principal ideal domain and Euclidean domains. Prime and Maximal ideals.

TEXTBOOKS

1. Herstein, *Topics in Algebra*
2. Fraleigh, *A First Course in Abstract Algebra*
3. Artin, *Algebra*
4. Serg Lang, *Algebra, Graduate Texts in Mathematics*
5. Gopalakrishnan, *University Algebra*
6. N. Jacobson, *Basic Algebra*
7. Luthar and Passi, *Algebra (Vol-1)*

MAT 313: Number Theory [3003]

1. Divisibility in integers, Division algorithm, GCD, LCM, Fundamental Theorem of Arithmetic, Primes, Binomial Theorem.
2. Congruences, Solution of congruences, Fermat's and Euler's Theorems, Wilson's Theorem, Linear Congruence, Chinese Remainder Theorem.
3. Quadratic Residues, Quadratic Reciprocity, Jacobi symbol, Sum of two squares.
4. Arithmetic function, greatest integer function, Mobius inversion formula. Diophantine equations, the equation $ax + by = c$, Simultaneous linear equations.
5. Algebraic numbers, Algebraic number fields, Algebraic integers, Quadratic fields, Units in quadratic fields, Primes in quadratic fields.

TEXTBOOKS

1. Nivam and Zuckerman, *An Introduction to Number Theory*
2. Hardy and Wright, *Introduction to Number Theory*
3. Apostol, *An Introduction to Analytical Number Theory*
4. Serre, *A Course in Arithmetic*

MAT 314: Mathematical Methods [3003]

1. Calculus of Variations: Equations of mathematical physics as variational problems, Lagrange multipliers, origin of eigenproblems.
2. Ordinary differential equations: Linear equations: Solution space, linear independence, Wronskians. Eigenvalue problems: Boundary conditions, self-adjointness, completeness of eigen functions, Fourier series, continuous spectra and Fourier integrals. Green Functions.
3. Partial Differential equations: Classification of PDE's. Hyperbolic equations: wave equation, method of characteristics, shocks and weak solutions. Heat equation: solution by integral transforms. Elliptic equations: Dirichlet and Neumann problems, Poisson's equation, Legendre functions, spherical harmonics, Bessel and spherical Bessel functions, examples from electrostatics.
4. Complex Analysis: Complex differentiability. Conformal mapping and its physical applications. Cauchy, Taylor, and Laurent theorems, analytic functions. Applications to contour integration, solution of differential equations and asymptotics.
5. Integral Equations: Solution via Fourier and Laplace transforms, Abel's equation.
6. Approximate methods.

TEXTBOOKS

1. G. B. Arfken and H. J. Weber, *Mathematical methods for physicists*, Academic press
2. R. Courant and Hilbert, *Methods of mathematical physics*, Wiley
3. Bender and Orzag, *Advanced mathematical methods for scientists and engineers*, Springer
4. Dennery and Andre Krzywicki, *Mathematics for Physicists*, Dover
5. J. David Logan, *Applied mathematics*, 3rd edition, Wiley

MAT 321: Measure Theory and Integration [3003]

1. Lebesgue measure: σ-algebras of Sets, Borel sets, Lebesgue outer measure and its properties, σ-algebra of measurable sets, Non-measurable set, Lebesgue Measure and its properties, measurable functions, Egoroffs theorem, Lusins theorem.
2. Lebesgue integration: Simple functions, Lebesgue integral of a bounded function over a set of finite measure, bounded convergence theorem, integral of non-negative functions, Fatou's Lemma, monotone convergence theorem, the general Lebesgue integral, Lebesgue convergence theorem.
3. Differentiation and integration: Functions of bounded variation, differentiation of an integral, absolute continuity, Radon-Nikodym theorem, product measures, Fubinis theorem.
4. Lp-spaces: Definition and properties, The Minkowskis inequality and Hlders inequality, completeness of L_p, denseness results in L_p.

TEXTBOOKS

1. Royden, *Real Analysis*
2. Rudin, *Real and Complex Analysis*
3. Michael Taylor, *Measure Theory and Integration*
4. E. M. Stein and R. Shakarchi, *Real Analysis: Measure Theory, Integration, and Hilbert Spaces*
5. G. Debarra, *Measure Theory and Integration*
6. I. K. Rana, *An Introduction to Measure and Integration*
7. K. R. Parthasarathy, *Introduction to Probability and Measure*

MAT 322: Linear Algebra [3003]

1. Matrix Theory: Matrices and Determinants, Row Operations, Row reduced echelon matrices, Invertible matrices, Rank of matrices, System of linear equations.
2. Vector Space: Fields, Vector Spaces, Subspaces, Quotient spaces, Linear independence, Bases, Dimensions, Linear Transformations, Kernel, Range, Isomorphism, Matrix representation of a linear transformation, Change of bases, Linear functional, Dual space, Projection, Eigen values and Eigen vectors, Cayley-Hamilton theorem, Elementary canonical forms, Annihilating polynomials, Invariant subspaces, simultaneous triangulation, Simultaneous digitalization, Direct sum decomposition, Invariant direct sum, The primary decomposition theorem, Jordan form, Inner product spaces.

TEXTBOOKS

1. Hoffman and Kunze, *Linear Algebra*
2. Herstein, *Topics in Algebra*
3. Halmos, *Finite Dimensional Vector Spaces*

MAT 323: General Topology [3003]

1. Topological Spaces and Continuous Functions: Topological spaces, Basis for a topology, The order topology, The product topology, The subspace topology,

Closed sets and limit points, Continuous functions, The metric topology, The quotient topology.
2. Connectedness and Compactness: Connected spaces, connected sets in the real line, Components and path components, Local Connectedness, Compact spaces, Compact sets in the real line, Limit point compactness, Local compactness.
3. Countability and Separation Axioms: The countability axioms, The separation axioms, The Urysohn lemma, The Urysohn metrization theorem.
4. The Tychonoff Theorem: The Tychonoff theorem, Completely regular spaces, The Stone-Cech compactification, Para compactness.

TEXTBOOKS

1. Munkres, *Topology*
2. G. F. Simmons, *Introduction to Topology and Modern Analysis*
3. J. Dugundji, *Topology*
4. Singer and Thorpe, *Lecture Notes on Elementary Topology and Geometry*

MAT 324: Complex Analysis I [3003]

1. Analytic functions: Functions of a complex variable, Mapping, Limits, Theorems on continuity, Derivatives, Differentiation formulas, The Cauchy-Riemann (C-R) Equations, Sufficient conditions, The C-R equations in polar form, Analytic functions, Harmonic functions.
2. Mapping by elementary functions: Linear functions, The function 1/z, Linear fractional transformations, The function zn, The function z1/2, Other irrational functions, The transformations w = exp z, w = sin z, Successive transformations.
3. Integrals: Definite integrals, Contours, Line integrals, The Cauchy-Goursat theorem, Simply and multiply connected domains, Indefinite integrals, The Cauchy integral formula, Derivatives of analytic functions, Moreras theorem, The maximum moduli of functions, The fundamental theorem of algebra.
4. Series: Convergence of sequences and series, Taylor series, Laurent series, Uniform convergence, Integration and differentiation of power series, Uniqueness of representations, Zeros of analytic functions.
5. Residues and Poles: Residues, The residue theorem, The principal part of a function, Poles, Quotient of analytic functions, Evaluation of improper real integrals, Improper and definite integrals involving trigonometric functions, Integration around a branch point.

TEXTBOOKS

1. Churchill and Brown, *Complex Analysis*
2. Ahlfors, *Complex Analysis*
3. Rudin, *Real and Complex Analysis*
4. Mathews and Howell, *Complex Analysis for Mathematics and Engineering*

MAT 325: Numerical Analysis [3003]

1. Solutions of equations in one variable: The bisection method, Fixed-point iteration, Newtons method, Error analysis for iterative methods, Accelerating convergence, Zeros of polynomials and Muellers method.
2. Interpolation and polynomial approximation: Interpolation and Lagrange polynomial, Divided difference, Hermite interpolation, Cubic spine interpolation, Parametric curves.
3. Numerical Differentiation and Integration: Numerical differentiation, Richardsons extrapolation, Elements of numerical integration, Composite numerical integration, Romberg integration, Adaptive quadrature methods, Gaussian quadrature.
4. Initial value problems (IVP) for ordinary differential equations: Eulers method, Higher order Taylor methods, Runge-Kutta methods, Error analysis, Stability; Direct and iterative techniques for solving linear systems with error analysis, Eigen values and eigen vectors for linear algebraic systems.

TEXTBOOKS

1. Burden and Faires, *Numerical Analysis*
2. Atkinson, *An Introduction to Numerical Analysis*
3. Hildebrand, *Introduction to Numerical Analysis*

List of electives for Mathematics

1. Harmonic Analysis
2. Sobolev Spaces
3. Commutative Algebra
4. Algebraic Geometry
5. Algebraic Number Theory
6. Stochastic Analysis
7. Control Theory
8. Rings And Modules
9. Lie Groups And Lie Algebra
10. Galois Theory
11. Discrete Mathematics
12. Cryptography
13. Partial Differential Equations II
14. Mathematical Fluid Dynamics
15. Calculus Of Variations
16. Operation Research
17. Finite Element Methods

Physics

THEORY COURSES

PHY 111 Mechanics [3103]

1. Introduction to essential mathematical tools.
2. Newtons laws-a recapitulation: Structure and validity of the laws. The concept of inertial reference frames and Galilean relativity. Non-inertial frames and pseudoforces.
3. Systems in one dimension: Conceptual issues. Illustrations of various methods of solving the EOMs. Work energy theorem and energy conservation in ID motion. The use of potential energy graphs to understand motion. The small amplitude approximation and oscillations: The simple harmonic oscillator; the damped oscillator; the forced harmonic oscillator; nonlinear oscillators.
4. Motion in three dimensions: Equations of motion in Cartesian and Polar Coordinates. The work energy theorem in 3D; conservative and non-conservative forces; force as the gradient of potential energy. Conservation of angular momentum for a point particle. Applications: The projectile; charged particle in a uniform electromagnetic field. Central force field motion; equations for the orbit. The Kepler problem. The effective potential and the stability of circular orbits.
5. Systems of particles: Conservation laws for linear momentum, angular momentum and energy. Center of mass. The concept of equivalent forces. Collisions. Two-body systems and the concept of reduced mass. Coupled oscillations.
6. Rigid bodies: The angular velocity vector. Rotating reference frames and pseudoforces. The moment of inertia tensor: Connection between angular momentum and angular velocity; brief discussion on scalars and vectors; calculation of moment of inertia for simple bodies; principal axes.
7. Special Theory of Relativity: The principle of relativity. Lorentz transformations. Kinematic effects of STR. The concept of 4-vectors. The energy-momentum 4-vector. Applications.

TEXTBOOKS

1. C. Knight, W. D. Ruderman, M. A. Helmholz, C. A. Moyer and B. J. Kittel, *Berkeley Physics Course: Vol. I – Mechanics*, McGraw-Hill (1965)
2. D. Kleppner and R. Kolenkow, *An introduction to Mechanics*, McGraw-Hill Science/Engineering/Math (1973)
3. R. Feynman, R. B. Leighton and M. Sands, *Feynman Lectures in Physics - Vol. I*, Addison Wesley (2005)
4. J. R. Taylor, *Classical Mechanics*, University Science Books (2005).
5. Louis N. Hand and Janet D Finch, *Analytical Mechanics*, Cambridge University Press (1998)
6. A Douglas Davis, *Classical Mechanics*, Harcourt College Publications (1986)

PHY 121 Electromagnetic Theory [3103]

1. Electrostatics: Coulomb's law and Gauss's law Simple applications. Differential form of the Gauss's law. Electrostatic potential, electrostatic energy Calculation for some simple cases.Conductors. Surface charges induced on a conductor. Solutions of Poisson's and Laplace's equations. Method of images. Solution by the method of separation of variables in cartesian and spherical polar coordinates. Potential due to an arbitrary charge distribution. Monopole and dipole terms. Electrical field and potential due to a point dipole. Dipole in an electric field.
2. Magnetostatics: Biot - Savart and Ampere's laws. Ampere's law in differential form. Magnetic vector potential. Determination of magnetic fields for simple cases. Energy in a magnetic field.
3. Current electricity: Electromotive force.Ohm's law. Motional emf. Electromagnetic induction.Faraday's law. Self inductance and mutual inductance. Impedance. LCR circuit.
4. Electrodynamics: Maxwell's equations. Equation of continuity. Poynting's theorem. Electric and magnetic fields in matter. Fields D and H. Constitutive relations. Linear and nonlinear media.
5. Electromagnetic Waves: EM waves in vacuum and in a dielectric medium. Boundary conditions on an interface. Reflection and transmission at an interface. Conducting surface.

TEXTBOOKS

1. D. J. Griffths, *Introduction to Electrodynamics*, Prentice-Hall India (2007)
2. E. M. Purcell, *Berkeley Physics course: Vol 2. Electricity and Magnetism*, McGraw Hill
3. R. P. Feynman, R. B. Leighton and M. Sands, *Feynman Lectures in Physics Vol 2* Addison-Wesley

PHY 211 Introduction to Quantum Mechanics [3103]

1. Quantum kinematics: The state vector, Dirac Bra and Ket notation, the principle of superposition, the Stern-Gerlach experiment. Hilbert space and some general properties of linear vector spaces, Rays and vectors in Hilbert space, Normalization, Basis vectors. Non commutating operators and observables, the uncertainty principle, Operators, eigenvalues, eigenvectors, observables and expectation values (a bit of linear algebra) ,Quantum amplitudes, probabilities and the Born rule. A basis labeled by a continuous parameter and the wave function, The position and momentum bases, Fourier transforms, Delta function normalization, Function spaces, The uncertainty principle revisited, The probability current and the continuity equation.
2. Quantum Dynamics: The Schrödinger equation: The Hamiltonian and the idea of generators, finite time evolution and unitary transformations, properties of unitary transformations, time evolution of expectation values. The Heisenberg picture, Commutation relations.

3. The time independent Schrödinger equation, Stationary states, Examples: particle in an infinite square well and particle in a finite square well, scattering off a potential barrier. quantum tunneling, the quantum harmonic oscillator.
4. The Schrödinger equation in three dimensions: The Schrödinger equation in spherical coordinates, Separation of variables, The radial equation and energy quantization, the angular equation, spherical harmonics and introduction to quantized angular momentum. Spin, Addition of angular momenta, The Hydrogen atom.
5. Identical particles: Two particle wave functions, Bosons and Fermions, symmetrization and anti-symmetrization of the wave function, exchange forces and chemical bonds, Fermions and the Pauli exclusion principle, the Helium atom, the periodic table of elements, Hund's rules. Quantum statistical mechanics: Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein distributions, The black body spectrum and coming back to the beginning: Planck's hypothesis.
6. Path Integrals: Revisiting the double slit experiment and making it a multi-slit experiment, Interference between the paths, The transition amplitude and the propagator, Evaluation of the path integral for the case of a free particle.

TEXTBOOKS

1. D. J. Griffiths, *Introduction to quantum mechanics*, Benjamin-Cummins (2004)
2. J. S. Townsend, *A modern approach to quantum mechanics*, University Science Books (2000)
3. J. J. Sakurai, *Modern quantum mechanics*, Addison-Wesley (1994)
4. R. P. Feynman, *The Feynman lectures on physics Vol 3*, Narosa (2007)
5. S. Gasirorowicz, *Quantum Physics*, 3rd Edition, John Wiley (2003)
6. Marvin Chester, *Primer of Quantum Mechanics*, Dover Publications (2003)

PHY 221 Statistical Mechanics [3103]

1. Review of thermodynamics
2. Basics of statistical Mechanics: Definition of state of system: Macroscopic and Microscopic, connection between Micro-state and Macrostate, concept of ensemble
3. Systems with constant energy: Microcanonical ensemble: Maximum probability postulate and Boltzmann entropy (Microcanonical ensemble), application of Boltzmann entropy formula to simple systems
4. Systems with varying energy: Canonical emsemble, Boltzmann probability distribution law, Canonical Ensemble, difference between microcanonical and canonical ensemble, partition function, Gibbs entropy and relation to Boltzmann entropy, validity of canonical ensemble
5. Systems with varying energy and number: Grand-canonical ensemble, need for definition of chemical potential, mathematical definition of chemical potential, Grand-canonical Ensemble, Grand-partition function
6. Application of canonical ensemble to discrete systems: Einstein model of solids, paramagnetic systems in external magnetic field, Interacting spin systems – 1-D Ising model

7. Application of canonical ensemble to continuous systems: Ideal monoatomic and polyatomic gases, Black-body radiation, Debye model of solids
8. Semi-classical partition function: Cluster expansion, non-ideal gases
9. Quantum ideal gases: Bose-Einstein, Fermi-Dirac, Applications

TEXTBOOKS

1. F. Reif, *Statistical Mechanics*, Berkeley physics course Vol: 5,
2. F. Mandl, *Statistical Physics*, Wiley (II edition)
3. H. B. Callen, *Thermodynamics and introduction to thermostatistics*, Wiley
4. R. K. Pathria, *Statistical Mechanics*

PHY 311 Mathematical Methods in Physics

1. Calculus of Variations: Equations of mathematical physics as variational problems, Lagrange multipliers, origin of eigenproblems.
2. Ordinary differential equations: Linear equations: Solution space, linear independence, Wronskians. Eigenvalue problems: Boundary conditions, self-adjointness, completeness of eigen functions, Fourier series, continuous spectra and Fourier integrals. Green Functions.
3. Partial Differential equations: Classification of PDE's. Hyperbolic equations: wave equation, method of characteristics, shocks and weak solutions. Heat equation: solution by integral transforms. Elliptic equations: Dirichlet and Neumann problems, Poisson's equation, Legendre functions, spherical harmonics, Bessel and spherical Bessel functions, examples from electrostatics.
4. Complex Analysis: Complex differentiability. Conformal mapping and its physical applications. Cauchy, Taylor, and Laurent theorems, analytic functions. Applications to contour integration, solution of differential equations and asymptotics.
5. Integral Equations: Solution via Fourier and Laplace transforms, Abel's equation.
6. Approximate methods.

TEXTBOOKS

1. G. B. Arfken and H. J. Weber, *Mathematical methods for physicists*, Academic press
2. R. Courant and Hilbert, *Methods of mathematical physics*, Wiley
3. Bender and Orzag, *Advanced mathematical methods for scientists and engineers*, Springer
4. Dennery and Andre Krzywicki, *Mathematics for Physicists*, Dover
5. J. David Logan, *Applied mathematics*, 3rd edition, Wiley

PHY 312 Classical Mechanics

1. Review of Newtonian mechanics. Generalized coordinates. The principle of least action. Lagrange's equation. The Lagrangian for a free particle and for a system of particles.
2. Symmetries, Conservation laws and Noethers theorem. Conservation of energy, momentum and angular momentum.

3. Integrating the equations of motion: motion in one dimension. Central force motion and Kepler's problem. Collisions: elastic collisions, scattering and Rutherfords formula.
4. Motion of a rigid body. Angular velocity. Moment of inertia. Angular momentum, Euler angles, Euler's equations. Motion in a non-inertial frame.
5. Small oscillations: simple harmonic, forced, damped and anharmonic oscillations.
6. The Hamilton equations of motion, Legendre transformations, Cyclic coordinates. Routhian
7. Invariance properties of the Lagrangian and Hamiltonian descriptions, Poisson and Lagrange brackets. Canonical transformations. Group properties and methods of constructing canonical transformations.
8. Hamilton-Jacobi theory and action-angle variables. The harmonic oscillator as an example. The Kepler problem in action angle variables

TEXTBOOKS

1. H. Goldstein, C. Poole and J. Safko, *Classical Mechanics*, 3rd Ed. Addison-Wesley, (2005)
2. L. D. Landau and E. M. Lifshitz, *Mechanics*, Vol. 1 of course of Theoretical Physics, Pergamon Press, (2000)

PHY 313 Solid State Physics

1. Crystal structure: Bravais lattice, two and three dimensional lattices, primitive cells, symmetry, space group and point groups, classification of lattices by symmetry.
2. Experimental determination of crystal structure: Scattering from crystals, Laue method, rotating crystal method, powder method, interaction of X-rays with matter, deciphering the structure
3. Electronic structure: The single electron model, free electron model, specific heat of noninteracting electrons
4. The Schrödinger equation and symmetry: Bloch's theorem, Fermi surface, density of levels, van Hove singularities, Kronig-Penny model, band structure, rotational symmetry and group representations
5. Models: Nearly free electrons, Brillouin zones, tightly bound electrons, Wannier functions, tight binding model, electron-electron interactions, Hartree-Fock equations, density functional theory
6. Mechanical properties: elasticity, liquid crystals, phonons, Einstein and Debye models, inelastic scattering from phonons
7. Electron transport: Drude theory, semiclassical electron dynamics, noninteracting electrons in an electric field, Zener tunneling
8. Electronics: metal interfaces, work functions, Schottky barrier, semiconductors, diodes and transistors
9. Magnetism: Classical theories, magnetic dipole moments, mean field theory and Ising model, critical phenomena, Atomic magnetism, Hund's rules, Curie's law, magnetism of the free electron gas, quantum hall effect

TEXTBOOKS

1. Michael P. Marder, *Condensed matter physics*, John Wiley (2000)
2. N. W. Ashcroft, N. David Mermin, *Solid state physics*, Harcourt (1976)
3. C. Kittel, *Introduction to solid state physics*, 7th edition, John Wiley (2004)
4. A. J. Dekker, *Solid state physics*, Macmillan India (2005)

PHY 314 Optics

1. What is light? The corpuscular model and wave model, Particle nature of light and wave nature of matter, Uncertainty principle, Single slit diffraction experiment, Double Slit interference experiment
2. Geometrical Optics: Fermat's Principle, Laws of reflection and refraction from Fermat's principle, The ray equation and its solutions. Refraction at a Single Spherical Surface, Reflection by a single Spherical Surface, The thin lens, Thin lens equation, Matrix method in paraxial optics, Analytical Ray tracing, Thick and Thin lens combinations, Aberrations, Prisms, Optical Systems
3. Wave Optics: Wave Motion, One dimentional waves, Harmonic Waves, Phase Velocity, Group Velocity of a wave packet, The superposition principle, Phasors and the addition of waves, The three-dimensional wave equation, Spherical waves, Cylindrical waves, Anharmonic periodic waves
4. Brief review of Maxwell's equations, Electromagnetic waves and propagation, Dipole Radiation
5. Polarisation: The nature of polarized light, Polarizers, Malus law, Dichroism, Birefrigence, Scattering and Polarization, Polarization by reflection, Retarders; full-wave plate, half-wave plate, quarter-wave plate, Circular Polarizers, Polarization of Polychromatic light, Mathematical description of polarisation; Stokes parameters.
6. Interference: Superposition of waves, Condition for interference, Coherence, Two beam interference by division of wavefront; Fresnel' Biprism, Interference by division of amplitude; interference by a plane parallel film, Newton's rings, Michelson interferometer, Multiple beam interferometry; Fabry-perot interferometer.
7. Diffraction: Fraunhofer diffraction; Single slit diffraction, Diffraction by a circular aperture, Two-slit fraunhofer diffraction, N-slit Fraunhofer diffraction, The diffraction grating, Oblique incidence, X-ray diffraction.
8. Fraunhofer diffraction and Fourier optics: The Fresnel diffraction integral, The Franhofer approximation, Fraunhofer diffraction by a Rectangular and circular aperture, Array of identical apertures.
9. Fresnel diffraction: Fresnel Half-period zones, The zone-plate, Diffraction by a straight edge

TEXTBOOKS

1. Ajoy Ghatak, *Optics*
2. Eugune Hecht and A. R. Ganesan, *Optics*
3. Frank S. Crawford, *Waves: Berkeley Physics Course, Vol. 3*

4. R. P. Feynman, R. B. Leighton and M. Sands, *Feynman Lectures in Physics - Vol. I*, Addison Wesley (2005)

PHY321 Intermediate Quantum Mechanics

1. Charged Particle in a Magnetic Field: Oscillator algebra; Energy spectrum and Eigenstates; Landau-level Wave-functions.
2. Angular Momentum: Angular Momentum algebra; Eigenvalues and Eigenstates of Angular Momentum; SU(2) Representations; Addition of Angular Momentum; Schwinger's Oscillator Model of angular momentum.
3. Approximation methods:
   a. Time-independent Perturbation Theory (non-degenerate case, degenerate case); and Applications (Fine structure of hydrogen, relativistic and spin-orbital effects; Zeeman effect; Stark effect; Van der Waals interaction; etc);
   b. Variational Methods; and Applications (Ground and Excited states of Helium, etc)
   c. Semi-classical (WKB) Approximation; and Applications (Bohr-Sommerfeld quantization rule; Tunelling; Transition Probabilities; Bound-state energies; etc)
   d. Time-dependent Potentials, and the Interaction Picture; Time-dependent Perturbation Theory; Applications to Interactions with the Classical Radiation Field; Fermi's Golden rule; Transition rates; Spontaneous emission; Energy Shift and Decay Width;
   e. The Adiabatic Approximation and Geometrical Phase: Adiabatic theorem; Berry's phase; Application to spin in a time-varying Magnetic Field; Born-Oppenheimer approximation.
4. Scattering theory: Scattering cross-section; Lippmann-Schwinger Equation; Born Approximation; and application to scattering from various spherically symmetric potentials, including Yukawa and Coulomb; Optical theorem; Eikonal approximation; Free-Particle states (plane waves, spherical waves); Method of Partial Waves; Low-Energy Scattering and Bound States; Resonance Scattering; Identical Particles and Scattering; Symmetry considerations in Scattering; Time-dependent formulation of Scattering; Inelastic Electron-Atom Scattering.

PREREQUISITES

1. PHY 211: Introduction to Quantum Mechanics
2. PHY 312: Classical Mechanics

TEXTBOOKS

1. J. J. Sakurai, *Modern Quantum Mechanics*, Addison-Wesley
2. Cohen-Tannoudji and Diu-Laloë, *Quantum Mechanics* (2 volumes), Wiley
3. R. Shankar, *Principles of Quantum Mechanics* 2nd Ed. Springer
4. L. D. Landau and E. M. Liftshitz, *Quantum Mechanics* Vol-3 of course of theoretical physics, Butterworth-Heinmann (2000)

PHY 322 Electrodynamics and special theory of relativity

1. Postulates of the special theory of relativity. Experimental evidence. An inertial observer. Space-time diagrams. Coordinates used by another observer. Invariance of the interval. Invariant hyperbolae. The Lorentz transformation. The velocity composition law. Four vectors: four velocity and four momentum.
2. Principle of least action, Energy and momentum, Transformation of distribution functions, Elastic collisions, Angular momentum.
3. Charges in electromagnetic fields: Elementary particles in special theory of relativity, four potential of a field, Gauge invariance, Electromagnetic field tensor, Lorentz transformation of the field, Invariants of the field.
4. Electromagnetic field equations: The first pair of Maxwells equations, The action function of the electromagnetic field, Four dimensional current vector, Continuity equation, The second pair of Maxwells equations, Energy density and energy flux, the energy-momentum tensor of the electromagnetic field.
5. Constant electromagnetic fields: Coulombs law, Electrostatic energy of charges, The field of a uniformly moving charge, Motion in the coulomb field, The dipole and multipole moments, System of charges in an electric field, Magnetic field and moments . Larmors theorem.
6. Electromagnetic waves: The wave equation, Plane waves, Spectral resolution, Partially polarized light, Fourier resolution of the electrostatic field.
7. Field of moving charges: The retarded potentials, Lienard-Wiechert potentials, Spectral resolution of retarted potentials, The Lagrangian to terms of second order.
8. Radiation of electromagnetic waves: The field of a system at large distances, Dipole radiation, Quadrupole and magnetic dipole radiation. Synchrotron radiation, Radiation damping in the relativistic case.

TEXTBOOKS

1. L. D. Landau and E. M. Lifshitz, *Classical Theory of Fields*, Vol-2 of course of theoretical physics, Pergamon (2000)
2. David J. Griffiths, *Introduction to Electrodynamics*, Prentice Hall (1999)
3. Bernard F. Schutz, *A first course in General Relativity*, Cambridge (2009)
4. John David Jackson, *Classical Electrodynamics*, John Wiley (1998)

PHY 323 Electronics

1. Module 1: Transistor hybrid model-analysis of a transistor amplifier using h-parameters-Thevenins and Norton's theorems-CE, CB, CC configurations-multistage amplifiers, DC, RC, ttansformer coupled amplifiers, frequency response of RC coupled amplifiers. Class A, Class B, Class C amplifiers, Push pull amplifiers. Feedback amplifiers: positive and negative feedback-advantages of negative feedback-input and output resistances-voltage series and current series feedback-frequency response of amplifiers with and without feedback.

2. Module 2: FETS, characteristics, small signal model, common source and common drain amplifiers, biasing, MOSFET. Silicon controlled rectifiers, SCS, Diac, Triac, Tunnel diodes, characteristics and applications
   Oscillators, Barkhausen criterion, phase shift oscillator, resonant circuit oscillators, Wien bridge oscillator, crystal oscillators, Multivibrators, comparators, square wave and triangle wave generators, Schmitt trigger, 555.
   Operational amplifiers-revision, actual circuits of operational amplifiers, uses as amplifiers, analog circuits-adding, integration and differential circuits, comparators, waveform generators, logarithmic generators.
3. Module 3: Binary number systems, binary-decimal conversions, hexadecimal numbers, ASCII code. Logic gates, combinational logic circuits, multiplexers, demultiplexers and decoders, encoders, half adder, full adder, RS, D, JK flip-flops, registers, different types, synchronous and asynchronous counters, D/A and A/D conversions.
   Microprocessors architecture, addressing modes, 8085, 8086 microprocessors, peripheral devices, micro-controllers, RAM, ROM, programming.

TEXTBOOKS:

1. J. Millman and A. Grabel, *Microelectronics* 2nd Edition, Tata McGraw Hill (1999)
2. J. Milman and C. C. Halkias, *Integrated Electronics*, Tata McGraw Hill (2008)
3. D. P. Leach, A. P. Leach and G. Saha, *Digital Principles and Applications*, Tata McGraw Hill (2006)
4. R. L. Boylestad and L. Nashelsky, *Electronic Devices and Circuit Theory* 9th Ed., PHI (2006)
5. Anil K. Maini, *Digital Electronics*, Wiley India (2008).

List of Electives in Physics

1. Fluid dynamics
2. Nonlinear Dynamics
3. Statistical Field Theory
4. Non-equilibrium Statistical Mechanics
5. Advanced Mathematical Methods
6. Early Universe
7. Astrophysics
8. Quantum Information Theory
9. Physics at the Nano scale
10. Quantum Theory of Fields-2
11. String Theory

LABORATORY COURSES

PHY 112 Experiments in Mechanics [0031]

1. Simple Pendulum
2. Variable g Pendulum
3. Moment of a Force
4. Meldes String
5. Projectile Motion
6. Conservation of momentum
7. Centripetal Force
8. Ballistic Pendulum
9. Basic Measurements Common Balance, Verniar Calliper and Screw Gauge
10. Sonometer

PHY 122 Experiments in Optics [0031]

1. Convex Lens Focal Length
2. Concave Mirror Focal Length
3. Spectrometer - Prism
4. Spectrometer - Grating
5. Conservation of Energy
6. Newtons Laws of Motion
7. Deflection Magnetometer
8. Magnetic Field along the Axis of a Circular Coil
9. Potentiometer Internal Resistance of a Cell
10. Compound pendulum

PHY 212 Experiments in Physics I [0031]

1. Newtons Rings
2. Diffraction at Slit
3. Michelsons Interferometer
4. Spectrometer Liquid Prism
5. Conversion of a Galvanometer to Voltmeter and its Calibration.
6. Ballistic Galvanometer - Capacitance Measurement
7. Specific Heat of a Solid
8. Thermal Conductivity of Rubber
9. Liquid Lens
10. Viscosity of a Liquid - Constant Pressure Head Method

PHY 222 Experiments in Physics II [0031]

1. Spectrometer: i-d curce
2. Electronics using Labview

3. Hall Effect
4. Conversion of a Galvanometer to Ammeter and its Calibration.
5. Thermo emf
6. Reflection Grating
7. Specific Latent Heat of Steam
8. Newtons Law of Cooling
9. Malus Law
10. Ballistic Galvanometer - High Resistance Measurement

PHY 315 Advanced Physics Experiments I [0093]

1. Viscosity of a Liquid Oscillating Disc
2. Andersons Bridge
3. Hyperbolic Fringes Cornus Method
4. Spectrometer: i-i' curve
5. LCR circuit
6. Owen's Bridge
7. Spectrometer Hartmanns formula
8. Youngs modulus optic lever
9. Quincke's Method Surface Tension
10. Spot Galvanometer- High resistance by leakage
11. ESR spectrometer
12. X-ray spectrum analysis
13. Thermal conductivity Lees disc
14. Diffraction by ultrasonic waves
15. Band gap of a semiconductor
16. Magnetic susceptibility
17. Fabrey-Perot Interferometer
18. Determination of heat capacity
19. Determination of resistance-Potentiometer
20. Elliptical fringes-Youngs modulus
21. Divergence of a laser beam
22. Temperature coefficient of resistance of copper
23. Velocity of sound in air
24. Frequency dependence of impedance and phase of a coil

Interdisciplinary courses

IDC 111: Mathematical Tools [3103]

1. Ordinary differential equations: First order differential equations-Basic concepts and ideas; separable differential equations, Integrating factors, linear differential equations;Second order linear differential equations homogenous equations with constant coefficient, Linear Independence of solutions-Wronskian, Non-homogenous equations general solution.
2. Partial differential equations: Wave, Heat and Laplace equations; Fourier series; Separation of variables, use of Fourier series.
3. Complex numbers and functions: Arithmetic operation, conjugates, modulus, polar form, powers and roots; Derivative; analytic function; Cauchy-Riemann equation, Laplace equation- Harmonic functions; Complex integration- Cauchys integral theorem (without proof), Cauchys integral formula; Power series, Taylor series, Laurent series; Laurent theorem (without proof), Residue integration method; Evaluation of real integrals, Application to Physics, Chemistry and Biology related problems.
4. Integral transforms: Laplace & Fourier transforms; Applications to Physics and Spectroscopy.

TEXTBOOKS

1. Bender and Orzag, *Advanced mathematical methods for scientists and engineers* (Springer)
2. G. B. Arfken and H. J. Weber, *Mathematical methods for physicists*, Academic press
3. Ahlfors, *Complex Analysis*
4. Churchill and Brown, *Complex Analysis*
5. Mathews and Howell, *Complex Analysis for Mathematics and Engineering*
6. D. Kreyszig, *Advanced Engineering Mathematics*, 8th edition, Wiley & Sons, (2006)
7. W. E. Boyce and R. C. Diprima, *Elementary Differential Equations and Boundary Value Problems*, 8th Edition, Wiley & Sons, (2004)
8. C. Edwards, and D. Penney, *Elementary Differential Equations withBoundary Value Problems*, 5th Edition, Prentice Hall, (2003)

IDC 121 Thermodynamics [3103]

1. The scope and methods of thermodynamics: Macroscopic description of the state of a system, Extensive and intensive properties, Thermal equilibrium between systems, Zeroth Law of Thermodynamics, Concept of thermal equilibrium and temperature in classical physics, Adiabatic and diathermal walls, Temperature Scales.
2. The First Law of Thermodynamics: The concept and definition of work, General compression and expansion, General form of expressions for reversible, irreversible and quasi-static work, Joules Experiment, Formulation of the 1st law

of thermodynamics for a closed system, Concept of internal energy, Conservation of energy in a cycle, Perpetual motion of the 1st kind, Reversible transfer of heat, Definition of specific heat capacity and enthalpy, Adiabatic and isothermal processes. Calculation of pressure, kinetic interpretation of temperature; mean free path; distribution of molecular speeds; equipartition of energy. Microscopic versus macroscopic points of view; temperature; thermodynamic systems and thermodynamic equilibrium; Isothermal and adiabatic changes of ideal and real gases.

3. Reversible and irreversible processes: The Second Law of thermodynamics. Carnot cycle and the Kelvin temperature scale; Clausius' theorem; entropy and its physical interpretation; entropy change for simple processes; thermodynamic functions: Helmholtz free energy, Gibbs free energy and enthalpy; conditions of equilibrium; Maxwell's relations and their applications. Equilibrium between two phases; general equilibrium conditions; the Clausius- Clapeyron equation; phase transformation of pure substances and mixtures; dilute solutions; chemical equilibrium; the chemical potential.
4. The Third Law of thermodynamics : Perfect crystal, The unattainability of absolute zero, Application in magnetic and charge ordering of materials, Adiabatic demagnetization, localization and defects.
5. Thermodynamics of Chemical and Biological Systems: Non-equilibrium Thermodynamics: Flow of energy in biological systems, molecules of energy in life, storage of energy, the hydrogen economy, Onsager reciprocal relations, Bose-Einstein Condensation, Negative temperature, Thermodynamics of small systems and molecular machines.

TEXTBOOKS

1. M. W. Zemanski, *Heat and Thermodynamics*, MacGraw-Hill, New York, (1968)
2. E. Fermi, *Thermodynamics*, Dover
3. R. P. Rastogi, R. R. Mishra, *Chemical Thermodynamics*, Vikas Publishing
4. S. R. De Groot, P. Mazur, *Non-Equilibrium Thermodynamics*, Dover
5. Yasar Demirel, *Nonequilibrium Thermodynamics, 2nd Edition: Transport and Rate Processes in Physical, Chemical and Biological Systems*, Elsevier.
6. K. A. Dill and S. Broomberg, *Molecular driving forces: Statistical Thermodynamics in Chemistry and Biology*, Routledge, 2002

IDC 211 Scientific Computing [3103]

1. Introduction to computers and computations.
2. Principles of programming and scientific computing.
3. Introduction to Mathematica/Matlab/Scilab.
4. Applications from Chemistry, Physics and Mathematics involving:

   a. Regression analysis: polynomial and spline fitting of data.
   b. Systems of simultaneous equations
   c. Differential equations: Classical dynamics (planetary motion, pendulum) Schrodinger equation (harmonic oscillator, hydrogen atom)
   d. Matrix algebra: Secular equations, Huckel theory for cyclic polyenes.

e. Difference equations: population biology; logistic equation, chaos, attractors
f. Random Phenomena: random walk, polymer growth, modeling epidemic.
g. Spectral analysis: Fourier transform

5. Graphics: 2D and 3D plots, animations

TEXTBOOKS

1. Rubin H. Landau, *A first course in scientific computing*, Princeton University Press, (2005)
2. Angela B. Shiflet, *Introduction to Computational Science: Modeling and Simulation for the Sciences*, Princeton University Press.
3. Michael T. Heath, *Scientific Computing: An introductory Survey*, McGraw-Hill, NY
4. Alfio Quarteroni and Fausto Saleri, *Scientific Computing with MATLAB*, Springer (2003)
5. Peter R Turner *Guide to Scientific Computing*, Macmillan Press (2000)
6. Peter Linz, *Exploring Numerical Methods: An introduction to Scientific Computing using MATLAB*
7. Frank R. Giordano, Mauarice D. Wei, William P. Fox, *First Course in Mathematical Modeling*, Vikas Publishing House
8. D. Kiryanov and E. Kiryanova, *Computational Science*, Firewall Media, Bangalore, (2007)

IDC 221 Symmetry and Spectroscopy [2102]

1. Group Theory: Definition of group, symmetry operations and elements of point groups, classification of point groups of molecule, matrix representation of symmetry operations, theorems on characters of irreducible representations, character talks, applications of group theory in chemical bonding, vibrational and electronic spectroscopy and ligand field theory.
2. Spectroscopy: Rotational and Vibrational Spectroscopy: Rotation of Molecules, Microwave spectra, Diatomic and Polyatomic Molecules, Rigid and Non-Rigid Rotator, Harmonic Oscillator, Vibration rotation spectra, Interaction of rotations and vibrations, Normal Mode Analyses, Anharmonic Oscillator, Visualization of normal modes of vibrations in computational chemistry and comparison with KBr-pellet IR of simple organic compounds.
3. NMR Spectroscopy: Energy levels of spin systems in a magnetic field, NMR spectrometer, NMR spectra of AX,AB,AX2 etc systems, chemical shift and spin-spin coupling, applications to chemical structure and dynamics, biological applications, NMR imaging, 2-dimensional NMR spectra.

TEXTBOOKS

1. V. Ramakrishnan and M. S. Gopinathan *Group Theory in Chemistry* ,Vishal Publishers, (2005)
2. F. A. Cotton, Chemical Application of Group Theory, Wiley-Interscience, 3rd edition (1990)
3. P. Atkins and J. De Paul, *Physical Chemistry*, Chapter 15, 8th Edition, Oxford University Press (2006)
4. Colin N. Banwell, E. N. McCash, *Fundamentals of Molecular Spectroscopy* 4th Edition, Tata McGraw-Hill (1995)

IDC 222 Electronics [1032]

1. Study of forward and reverse biased characteristics of the p-n diode and the Zener diode. Design of different simple logic gates such as OR and AND using diodes.
2. Study of DC regulated power supply with and without different types of filters.
3. Measurement of the input and output characteristics of a NPN transistor.
4. Determination of the value of hfe.
5. Study the uses of transistors as amplifiers (single stage and two stage) and switches (ON/OFF).
6. Use of transistors as Oscillators, phase shift, Colpitts and Harley
7. Study of OPAMP IC741 as comparators and amplifiers (both inverting and non-inverting).
8. Study of OPAMP IC741 as feedback amplifier and determine the frequency response of the OPAMP and the gain bandwidth product.
9. Study of OPAMP IC741 as a mathematical tool : adder, multiplier, differentiator, integrator.
10. Verification of De Morgans theorem and other Boolean identities.
11. Study of D, RS and JK flip flops and the use of these flip-flops in time division multiplexing operations.
12. Study of ripple and ring counters.

TEXTBOOKS

1. A. Malvino, D. J. Bates, *Electronics Principles* 7th(Indian Edition), Tata McGraw Hills, New Delhi (2006)
2. A. Malvino and J. Brown, Digital Computer Electronics, Career Education (1992)
3. P. B. Zbar, A. P. Malvino, M. A. Miller, *Basic Electronics: A Text-Lab Manual*, Glencoe Division Macmillian/McGraw-Hill (1994)
4. D. C. Sarkar, *Transistor Circuits*

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    Joining August, 2010

22. Dr. Vinesh Vijayan, Ph.D. (University of Gottingen)
    Joining August, 2010

23. Dr. Suresh Koduru, Ph.D. (University of Hyderabad)
    Joining August, 2010

24. Dr. Kalika Prasad, Ph.D. (IISc Bangalore)
    Joining August, 2010

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Academic Calendar: Varsha 2010

AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1 Sun *Arrival*	1 Wed *Sree krishna Jayanthi*	1 Fri	1 Mon	1 Wed *Final Exam*
2 Mon *Ph.D./MS* 3rd *and* 5th *Registration*	2 Thu	2 Sat *Gandhi Jayanthi*	2 Tue	2 Thu *Final Exam*
3 Tue *Classes begin*	3 Fri	3 Sun	3 Wed	3 Fri *Varsha Semester ends*
4 Wed	4 sat	4 Mon	4 Thu	4 Sat
5 Thu	5 Sun	5 Tue	5 Fri *Deepavali*	5 Sun
6 Fri *Arrival first sem*	6 Mon	6 Wed	6 Sat	6 Mon
7 Sat	7 Tue	7 Thu	7 Sun	7 Tue
8 Sun	8 Wed	8 Fri	8 Mon	8 Wed
9 Mon *Instruction begins for* 1st *sem*	9 Thu	9 Sat	9 Tue	9 Thu
10 Tue	10 Fri *Ramadan (Eid-ul-Fiter)*	10 Sun	10 Wed	10 Fri
11 wed	11 Sat	11 Mon	11 Thu	11 Sat
12 Thu	12 Sun	12 Tue	12 Fri	12 Sun
13 Fri	13 Mon 1st *mid sem*	13 Wed	13 Sat	13 Mon
14 Sat	14 Tue 1st *mid sem*	14 Thu	14 Sun	14 Tue
15 Sun *Independence day*	15 Wed 1st *mid sem*	15 Fri *Durgashtami*	15 Mon	15 Wed
16 Mon	16 Thu 1st *mid sem*	16 Sat *Mahanavmi*	16 Tue	16 Thu *Muharam*
17 Tue	17 Fri 1st *mid sem*	17 Sun *Vijayadasmi*	17 Wed *Bakrid*	17 Fri
18 Wed	18 Sat	18 Mon	18 Thu	18 Sat
19 Thu	19 Sun	19 Tue	19 Fri *Course evaluation*	19 Sun
20 Fri	20 Mon	20 Wed	20 Sat	20 Mon
21 Sat	21 Tue	21 Thu	21 Sun *Guru Nanak Jayanthi*	21 Tue
22 Sun	22 Wed	22 Fri	22 Mon *Final Exam*	22 Wed
23 Mon *Thiruvonam*	23 Thu	23 Sat	23 Tue *Final Exam*	23 Thu
24 Tue *Sports day*	24 Fri	24 Sun	24 Wed *Final Exam*	24 Fri
25 Wed *Sports day*	25 Sat	25 Mon 2nd *mid sem*	25 Thu *Final Exam*	25 Sat *Christmas*
26 Thu	26 Sun	26 Tue 2nd *mid sem*	26 Fri *Final Exam*	26 Sun
27 Fri	27 Mon	27 Wed 2nd *mid sem*	27 Sat	27 Mon
28 Sat	28 Tue	28 Thu 2nd *mid sem*	28 Sun	28 Tue
29 Sun	29 Wed	29 Fri 2nd *mid sem*	29 Mon *Final Exam*	29 Wed
30 Mon	30 Thu	30 Sat	30 Tue *Final Exam*	30 Thu
31 Tue		31Sun		31 Fri
Working days: 20	Working days: 21	Working days: 21	Working days: 20	Working days: 2
Total: 20	Total: 41	Total: 62	Total: 81	Total: 83

Time table for Mid Semester Examinations (Varsha 2010)

	1st Semester 8:15 AM - 9:15 AM	3rd Semester 8:15 AM - 9:15 AM	5th Semester Forenoon	5th Semester Afternoon
MONDAY	BIO 111	IDC 211	CHY 314, PHY 311/MAT 314	BIO 313
TUESDAY	CHY 111	PHY 211	BIO 311, MAT 313	PHY 313
WEDNESDAY	MAT 111	MAT 211	CHY 313	BIO 314, CHY 311
THURSDAY	PHY 111	CHY 211	PHY 314, MAT 312	MAT 311
FRIDAY	IDC 111	BIO 211	CHY 312, BIO 312	PHY 312

The examinations for the 5th semester courses will be during the regular class hour of the respective courses on the scheduled date.

Time table for Final Examinations for Theory Courses (Varsha 2010)

	FORENOON (9.30 AM-12.30 PM)
Monday, 22 Nov 2010	BIO 111, IDC 211, CHY 314, PHY 311/MAT 314
Tuesday, 23 Nov 2010	CHY 111, PHY 211, BIO 311, MAT 313, PHY 312
Wednesday, 24 Nov 2010	MAT 111, CHY 211, MAT 312
Thursday, 25 Nov 2010	PHY 111, MAT 211, BIO 314, CHY 311
Friday, 26 Nov 2010	IDC 111, BIO 211, BIO 312, CHY 313, PHY 314
Monday, 29 Nov 2010	BIO 313, PHY 313
Tuesday, 30 Nov 2010	CHY 312, MAT 311

Time table for Final Examinations for Laboratory Courses (Varsha 2010)

	AFTERNOON(2:30 PM- 5:30 PM)
Monday, 15 Nov 2010	BIO212(GRP I) PHY212(GRP II,SUBGRP I) CHY212(GRP II,SUBGRP II)
Tuesday, 16 Nov 2010	PHY 212(GRP II, SUBGRP II) CHY212(GRP II, SUBGRP I)
Thursday, 18 Nov 2010	PHY 212(GRP I,SUBGRP I) CHY212(GRP I,SUBGRP II) BIO212(GRP II)
Friday, 19 Nov 2010	PHY 212(GRP I,SUBGRP II) CHY212(GRP I,SUBGRP I
	FORENOON(9.30 AM- 12.30 PM)
Saturday, 20 Nov 2010	BIO 315(LAB EX PART-I) CHY315(LAB EX PART-I) PHY315(LAB EX PART-I)
	AFTERNOON(2:30 PM- 5:30 PM)
Monday, 22 Nov 2010	BIO 315(LAB EX PART-II)
Tuesday, 23 Nov 2010	CHY 315(LAB EX PART-II)
Wednesday, 24 Nov 2010	CHY 315(LAB EX PART-III) BIO 315(LAB EX PART-III) PHY 315(LAB EX PART-II)
Thursday, 25 Nov 2010	PHY 315(LAB EX PART-III)
Monday, 29 Nov 2010	BIO 112(GRP-I) PHY 112(GRP-II,SUBGRP-I) CHY 112(GRP-II,SUBGRP-II)
Tuesday, 30 Nov 2010	PHY 112(GRP-II,SUBGRP-II) CHY 112(GRP-II,SUBGRP-I)
Wednesday, 1 Dec 2010	PHY 112(GRP-I, SUBGRP-I) CHY112(GRP-I,SUBGRP-II) BIO 112(GRP-II)
Thursday, 2 Dec 2010	PHY 112(GRP-I, SUBGRP-II) CHY 112(GRP- I,SUBGRP-I)