STUDENT INFORMATION HANDBOOK AND SCHEME OF INSTRUCTION

FOUR YEAR BACHELOR OF
SCIENCE [RESEARCH] PROGRAM

2021-22

विद्यार्थी सूचना पुस्तिका और शिक्षण योजना

चार साल के विज्ञान स्नातक कार्यक्रम

२०२१-२२

IISc

INDIAN INSTITUTE OF SCIENCE
भारतीय विज्ञान संस्थान

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भारतीय विज्ञान संस्थान
INDIAN INSTITUTE OF SCIENCE

We are delighted to welcome you to the 2021-22 academic session of the Bachelor of Science (Research) & Master of Science Programs of the Indian Institute of Science (IISc). The Student Information Handbook & Scheme of Instruction presents information relevant to the structure of these programs and the courses offered in the programs. It also provides detailed information about the facilities available to you and the rules and regulations related to the life of an undergraduate student on the IISc campus. Please read the Handbook carefully and feel free to contact us or your subject Coordinator/ Faculty Advisor if you have any additional questions.

Our best wishes for a productive, exciting and pleasant academic year.

Cordially,

Balaji R. Jagirdar, Dean
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Nagasuma Chandra, Associate Dean
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EXPANSIONS FOR THE ABBREVIATIONS USED

TGPA	:	TERM GRADE POINT AVERAGE
CGPA	:	CUMULATIVE GRADE POINT AVERAGE
SCC	:	SENATE CURRICULUM COMMITTEE
SCRC	:	SENATE COMMITTEE ON RESEARCH CONFERMENT
DCC	:	DEPARTMENTAL CURRICULUM COMMITTEE

I
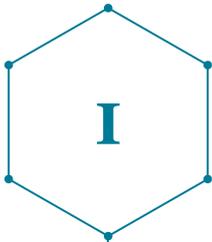
BACHELOR OF SCIENCE (Research) PROGRAM

1.1 BASIC STRUCTURE

The four-year Bachelor of Science (Research) Program is organized into eight semesters. The following major disciplines are available in the Bachelor of Science (Research) Program:

- Biology
- Chemistry
- Earth & Environmental Sciences
- Materials
- Mathematics
- Physics

Each student is required to take a specified number of core courses in the first three semesters. The course work during these three semesters consists of a common program for all students, independent of the future discipline. This will include courses in engineering, humanities and interdisciplinary areas for a well-rounded learning experience. At the end of the third semester, each student will be assigned a major discipline (from the list given above) based on her/his preferences and CGPA. While a student specializes in a major discipline, she/he can also broaden her/his knowledge and skills by taking courses in other disciplines. Students who take a sufficient number of courses in a discipline other than the chosen major will qualify for a minor in that discipline.

1.2   FACULTY ADVISOR

In the first three semesters, the Dean and the Associate Deans will be advising the students. Each student will be assigned a Faculty Advisor at the beginning of the fourth semester. The Faculty Advisor may be consulted about all matters (academic as well as non-academic) that may be of concern to the student. The Faculty Advisors will do their best to promote the development and growth of the students in their scientific career.

1.3   REGISTRATION FOR COURSES AND COURSE LOAD

1.3.1   Registration for courses will be done in consultation with the Faculty Advisor/Subject Coordinator.

1.3.2   All students must complete a total of 131 credits (basic courses in biology, chemistry, mathematics and physics in the first three semesters: 36 credits; engineering courses: 19 credits; humanities courses: 9 credits; major – courses and project: 52 credits; minor or assortment of courses: 15 credits). The course load during the first three common semesters is fixed. From the fourth semester, a student must register for a minimum of 16 credits and a maximum of 19 credits if the student's CGPA is <6 (8-point scale)/<7 (10-point scale) and 23 credits if the student's CGPA ≥ 6 (8-point scale)/≥7 (10-point scale). Students with TGPA (in the preceding semester) or CGPA < 6.0 (8-point scale) / <8.0 (10-point scale) are not allowed to register for more than 19 credits in the subsequent semester. The final semester is devoted to a research project.

1.4   DROPPING OF COURSES

1.4.1   A student may drop a course, after consultation with her/his Faculty Advisor and the course Instructor, provided that the total number of credits carried in the term is not less than the minimum number of credits stipulated in Section 1.3. If the course is dropped on or before 15th October in Term I and 2nd March in Term II, the course will not be listed in the final transcript. Dropping of excessive courses is permitted on or before 15th November in Term I and 1st April in Term II; however, the dropped course will be recorded in the final transcript with a W (Withdrawn) grade marked against it.

1.4.2   A student may register again for a course (in consultation with Faculty Advisor) which she/he has dropped in a previous term.

1.4.3   After a student has passed a course, she/he cannot register again for it, or take an equivalent course in order to improve the grade. Such re- taking for grade improvement arises only when she/he gets a failing F grade; the details of this are discussed in Section 1.8.

1.5   CONTINUOUS ASSESSMENT

1.5.1   Evaluation is based on continuous assessment, in which sessional work and the terminal examination contribute to the final grade.

1.5.2   Sessional work consists of class tests, mid-term examination(s), home- work assignments etc., as determined by the Instructor. Absence from these or late submission of home-work will result in loss of marks. Attendance in the mid-term examination is compulsory. If a student does not attend the examination, she/he shall be considered to have obtained zero marks in it. Absence on medical grounds, certified by the Chief Medical Officer of the Institute, may be condoned, and the student may be permitted to take a substitute examination as decided by the instructor. In such a case, medical certificate issued by the Chief Medical

Officer of the Institute along with a leave letter must be submitted to the UG office within one week after the end date in the certificate in support of her/his absence promptly. Those applications submitted later will not be considered.

1.5.3   The distribution of sessional marks among home-work, class tests, mid-term examinations etc., will be announced by the Instructor at the beginning of the course. After the terminal examination has been graded, the contribution from it is added to the sessional marks, to get the total marks. The marks are then converted to grades, based on cut-offs that are decided by the Instructor. Only the grade is reported; the marks are retained internally by the Instructor. There are 7 grades (10-point scale), designated A+, A, B+, B, C, D, F and 6 grades (8-point scale), designated S, A, B, C, D, F, with corresponding grade points given below. All grades except F are passing grades. To get a passing grade in a course that has both theory and laboratory components, a student must secure at least 20% marks in both theory and laboratory parts. The following new grade and grade point scale (based on 10 point scale) came into effect from the academic year 2016-17. Students of the earlier batches would continue to be graded as per the old grading system on 8 point scale.

10 POINT SCALE	A+	A	B+	B	C	D	F
	10	9	8	7	6	5	0
8 POINT SCALE	S	A	B	C	D	F	
	8	7	6	5	4	0	

1.5.4   The Grade Point Average (GPA) is computed from the grades as a measure of the student's performance. The Term GPA (TGPA) is based on the grades of the current term, while the Cumulative GPA (CGPA) is based on the grades in all courses taken after joining the program. The contribution of each course to the GPA is the product of the number of credits and the grade point corresponding to the grade obtained. For instance, if it is a 3 credit course, and the student gets a B grade (which corresponds to 7 grade points, from the table above), then the contribution of the course to the total grade points is equal to 3 x 7, or 21. To get the TGPA, one adds the grade point contributions of all the courses taken in the term, and divides this total by the number of credits. The CGPA is similarly calculated, the only difference being that one considers the grade point contributions of all the courses taken in all the terms. The TGPA and CGPA are rounded off to the first decimal place.

1.6   TERMINAL EXAMINATIONS

1.6.1   Terminal examinations are held during the last fortnight of each semester and during the last week of the Summer Term. The Time Table will be notified in advance. The graded answer scripts of the terminal examination will be made available to the students on a specified date within one week from the date of the terminal examination. Requests for changes in the grading of the terminal examination papers can be made only when the graded papers are shown to the students.

1.6.2   Attendance of the terminal examination is compulsory. If a student does not attend the examination, she/he shall be considered as having obtained zero marks in it, and will get an F grade. Absence on medical grounds, certified by the Chief Medical Officer of the Institute, may be condoned, and the student may be permitted to take substitute examination(s)

within a prescribed period. In such a case, medical certificate issued by the Chief Medical Officer of the Institute along with a leave letter must be submitted to the UG office within three working days after the end date in the certificate in support of her/his absence promptly. Those applications submitted later will not be considered.

1.7   ACADEMIC CRITERIA FOR CONTINUATION

1.7.1   The student should not have obtained more than four F grades at any given time during the period of studentship. If a fifth F grade is obtained without clearing the four existing F grades, she/he shall leave the Institute.

1.7.2   In the first term, the TGPA should not be below 4.5 (10-point scale)/3.5 (8-point scale), and in subsequent terms the CGPA should not go below 5.0 (10-point scale)/4.0 (8-point scale). If this condition is not satisfied, the student shall have to leave the Institute.

1.8   HANDLING OF 'F' GRADES

1.8.1   Since the F grade is a failing grade, a student cannot graduate until she/ he clears each F grade by taking a make-up examination, by repeating the same course or by taking a substitute course, as decided by the UGCC and SUGCC. Make-up examinations of all courses will be held in the month of July. (Want to mention Summer Term : May - June Session)

1.8.2   If the F grade is obtained in a core course, it must be cleared by taking a make-up examination in the same course or by repeating the same course, as decided by the UGCC and SUGCC. For an elective, the UGCC can specify an appropriate alternative course as the substitute course.

1.8.3   If a student clears an F grade by taking a make-up examination, the highest grade she/ he can get in that course is C (10-point scale)/C (8-point scale). A student who fails the make-up examination must repeat the course. If the student gets an F grade in the repeated course or in the specified substitute course, the student shall have to leave the Institute.

1.8.4   Such repetition of courses is permitted only to clear F grades. Students are not permitted to retake courses in which they have obtained any higher grade.

1.8.5   Both the F grade that was initially obtained and the higher grade that was obtained in the subsequent taking of the course will be reflected in the transcript.

1.8.6   When an F grade is obtained, it is used for the computation of the TGPA and the CGPA. When the F grade is subsequently cleared, it will no longer be included in computing the TGPA of the term in question, and the grade from the repeated or substitute course will replace it in the subsequent CGPA computations.

1.8.7   Make up exams will be held only once, in the month of July for courses offered in that particular academic year. Registration for the summer term is mandatory for students opting to appear for make-up exams. To be eligible to appear for make-up examinations, 80% attendance must have been satisfied during the regular term.

1.9   PROJECT

1.9.1   Each student registers for a project at the end of the sixth semester. Each student will carry out the project under a Project Advisor who is chosen based on the student's interests. The Project Advisor also becomes the Faculty Advisor from this stage.

1.9.2   Minimum Project Pass Grade: The minimum pass grade is D (10-point scale)/D (8-point scale). This policy change came in to effect from the academic year 2018-19. Should there be a need for extension of the project, prior approval from the Dean need to be obtained on or before April 15, 2020. In such cases, an application forwarded by the project advisor and the subject coordinator is to be submitted. Then the student must register for the summer term and the maximum grade that can be obtained for project will be B grade.

1.9.3   Internship to be undertaken in a laboratory/institute outside the institute in connection with the project, has to be proposed by the primary project advisor at IISc in the form of an application to the Dean with details of the work to be carried out by the student. A period not exceeding one semester may be permitted based on the application. A specific recommendation by the primary project advisor at IISc has to be made. No exemptions will be given for compulsory courses during the period of absence. Project credits will have to be registered for that semester before leaving for internship.

1.10   FINANCIAL SUPPORT FOR INTERNATIONAL CONFERENCES

Requests for partial financial support to attend and present papers at international conferences could be made by students in the fourth year (Bachelor's program) or in the fifth year (Master's program).

Following conditions should be met in order to apply:

1.10.1   CGPA should be 7.0 or more (10-point scale)/6.0 or more (8-point scale) in Bachelor's or Master's program.

1.10.2   Student seeking financial support should be the first author of the paper to be presented in the conference.

1.10.3   A specific recommendation by the research advisor should be submitted.

1.10.4   Conference should have been scheduled before 30th April of that particular year.

1.11   DEGREE REQUIREMENTS

1.11.1   Normally, students have to complete the Bachelor of Science (Research) program in 8 terms. However, in special circumstances, a student may be permitted an extension, so as to complete all requirements for the degree within a maximum of 12 terms. Further, the core courses need to be cleared within a maximum of 6 terms. Summer terms are not counted for this purpose.

1.11.2   The computation of the final CGPA is done only if the student clears all courses successfully within the period specified.

1.11.3   A student must complete the specified course requirements of 131 credits of the relevant degree programme with a minimum CGPA of 5.0 (10-point scale) / 4.0 (8-point scale) in the course work and at least a D (10-point scale) / D (8-point scale) grade in the project work.

1.12   CLASSIFICATION OF AWARDS

1.12.1   Successful completion of the course can carry any one of the following awards: First Class with Distinction and First Class. The CGPA requirements for each award are given below:

CGPA	Award
8.5 and above (10-point scale) (7.0 and above-8-point scale)	First Class with Distinction
6.0 and above (10-point scale) (4.8 and above-8-point scale)	First Class

1.13 ATTENDANCE

1.13.1   Attendance in all classes (lectures, tutorials, laboratories, etc) must be at least 80% of the total number of classes. Students with less than 80% attendance in a course at the time of the mid-term examination will not be allowed to take the examination. A student will be debarred from appearing in the terminal examination of a course if her/his attendance in the course for the semester falls below 80%. A shortage of attendance may be condoned by the Dean only in exceptional circumstances.

1.14 BREAK IN STUDIES

1.14.1   Students may be permitted a break in studies on medical grounds with the prior written permission of the UGCC. The break may be for a maximum period of one year.

1.14.2   Request for a break in studies should be submitted at least a month in advance, and must be accompanied by a certificate from the Chief Medical Officer (CMO) of the Institute. It should be forwarded through the Faculty Advisor.

1.14.3   Resumption of studies requires a fitness certificate from the CMO of the Institute.

1.14.4   To maintain the studentship status, the student should pay tuition and all other fees even during the break period.

1.15 PRIVILEGES AND RESPONSIBILITIES

1.15.1   All students are bound by the rules and regulations framed by the Institute.

1.15.2   Full Time Students: During the tenure of their studentship, full-time students are eligible for the following:

‣   Residence in the Hostel as per hostel rules, subject to availability
‣   Membership of the Gymkhana
‣   Participation in the activities of the Students' Council
‣   Assistance from the Students' Aid Fund (SAF)
‣   Leave privileges as may be applicable from time to time
‣   Limited assistance through the Special Medical Care Scheme

1.16 GENERAL

On all matters connected with their course work and the prescribed requirements for the degree, students are advised to seek the guidance of the Faculty Advisor or the Dean of Undergraduate Studies.
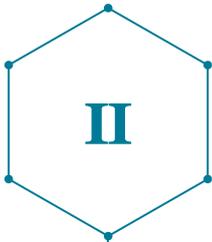
MASTER OF SCIENCE PROGRAM

2.1 BASIC STRUCTURE

Undergraduate students who fulfil the requirements towards the Bachelor of Science (Research) degree at the end of the fourth year with no pending backlog course(s) to be cleared in the final semester have an option to continue for a fifth year to register for a Master of Science degree. The fifth year is organized in two semesters. Students are required to take a specified number of courses (as outlined in Table below) and complete a research project in their major discipline. A project report has to be submitted which will be evaluated and graded. All other guidelines as laid out for the Bachelor of Science (Research) program will be applicable for the Master of Science program as well.

2.2   MAJOR DISCIPLINE REQUIREMENTS

DISCIPLINE	CREDIT REMARKS	CLASSROOM COURSES	PROJECT CREDITS	OTHERS
BIOLOGY	12	Mandatory courses to be fulfilled	20	
CHEMISTRY	12	Min. of 6 credits (200 or 300 level) from within chemical sciences division + 6 credits (200 or 300 level) from any division OR all 12 credits from the chemical sciences division	20	
EARTH & ENVIRON SCIENCES	12	Mandatory courses to be fulfilled	20	
MATERIALS	12	Any 4 courses from Materials Engineering or Materials Research Centre or some other equivalent courses as per Student's Handbook	20	
MATH	30	Mandatory courses to be fulfilled	0	2 (seminar course)
PHYSICS	12	Mandatory courses to be fulfilled	20	

2.3   CREDIT CARRYOVER

Credits fulfilled over and above 131 in the Bachelor's degree could be considered towards Master's degree provided the following conditions are met:

a.   A maximum of 12 credits completed over and above 131 in the Bachelor's degree and belonging to the subject area of the student's major discipline could be considered towards the Master's degree.

b.   If the 12 credits taken in excess of the required 131 in the Bachelor of Science (Research) program are those of mandatory course credits required to be fulfilled in the Master's program, then the student will only have to fulfill project credits in the fifth year.

c.   If the excess 12 credits (fulfilled in the Bachelor's program) do not include any compulsory courses (as prescribed by the respective discipline for the Master' degree program) then the student is required to fulfill the compulsory course credits in the fifth year.

d.   No exemptions will be given for compulsory courses.

e.   Students wishing to exercise credit carry over must submit a form with course details duly forwarded by the subject coordinator for approval before 3rd August 19.

2.4   CLASSIFICATION OF AWARD

CGPA	8.5 and above (10-point scale); 7.0 and above (8-point scale)
Award	**First Class with Distinction**

2.5   MANDATORY COURSE REQUIREMENTS

BIOLOGY

Students are required to fulfill the 'mandatory 12 credits' by choosing courses from the following 'basket of courses'.

If they took some/ all of these courses in their Bachelor of Science itself, then they can fulfill the 'mandatory 12 credits' by taking the remaining courses from this basket AND/ OR other departmental courses.

   i)   UB 304L Experiments in Neurobiology (0:1)
   ii)   RD 201 Genetics (2:0)
   iii)   MC 207 Molecular Biology (3:0) OR UB 208 Basic Molecular Biology (2:0)
   iv)   BC 201 Cell Biology (2:0) OR MC 212 Advances in Cell Biology (2:0)
   v)   MB 207 DNA-protein interactions, regulation of gene expression, nanobiology (2:0) OR MB 303 Elements of Structural Biology (3:0) OR BC 202 Proteins: Structure andFunction (2:0)
   vi)   NS 201 Systems Neuroscience: Neuronal biophysics, sensation & perception, motor system (2:0) OR NS 202 Molecular and Cellular basis of behavior (2:0)
   vii)   EC 204 Evolutionary Biology (2:1) OR EC 203 Ecology: Principles and Applications (2:0)
   viii)   MC 203 Essentials in Microbiology (3:0) OR BC 306 Essentials in Immunology (3:0)

‣ UB 500: Master's Project (0:20)

In case any of the Departmental courses in the above list is dropped for some reason, please consult the Biology Coordinators to choose an equivalent course as an alternative.

CHEMISTRY

Minimum of 6 credits (200 or 300 level) from within the Chemical Sciences Division and 6 credits (200 or 300 level) from any division OR all 12 credits (200 or 300 level) from within the Chemical Sciences Division.

‣ UC 500: Master's Project (0:20)

EARTH & ENVIRONMENTAL SCIENCES

Any 4 courses (12 credits) from Departments/Centres participating in the E & ES program or some other equivalent courses as per Student's handbook.

‣ UES 500: Master's Project (0:20)

MATERIALS

The choice of 4 courses (12 credits) should be as follows: Core courses*:
‣ MT 202: Thermodynamics and Kinetics
‣ MT 241: Structure and Characterization of Materials

Any one out of the following soft core courses:
‣ MT 203 3:0 Materials Design and Selection
‣ MT 209 3:0 Defects in Materials
‣ MT 220 3:0 Microstructural Engineering
‣ MT 231 3:0 Interfacial Phenomena in Materials Processing
‣ MT 245 3:0 Transport Processes in Process Metallurgy
‣ MT 253 3:0 Mechanical Behavior of Materials
‣ MT 260 3:0 Polymer Science and Engineering – I

Any one course offered in Materials Engineering or Materials Research Centre
*Those who have already taken MT 202 and/ or MT 241 in their Bachelor's program, must substitute the same from the above list of soft core courses

‣ UMT 500: Master's Project (0:20)

MATHEMATICS

Following mandatory courses to be fulfilled:
‣ MA 399: Seminar
‣ MA 223: Functional Analysis
‣ MA 232: Introduction to Algebraic Topology
‣ MA 242: Partial Differential Equations

PHYSICS

Following mandatory courses to be fulfilled: Condensed Matter Physics
‣ PH 208: Condensed Matter Physics -1
‣ PH 206: Electromagnetic Theory
‣ PH 217: Fundamentals of Astrophysics
‣ P/HE 215: Nuclear and Particle Physics

Among the 12 credits in the fifth year there should be at least 6 credits at 300 level. The 5th year course(s) can be from any department with the permission of the respective instructors and Physics coordinator

‣ UP 500: Master's Project (0:20)
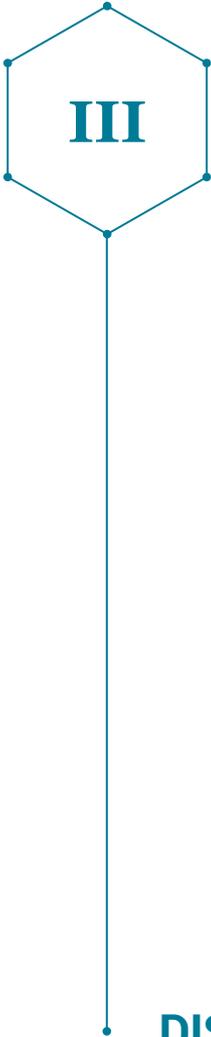
DISCIPLINE, ATTENDANCE AND LEAVE RULES

3.1 DISCIPLINE

3.1.1   Students are expected to dress and conduct themselves in a proper manner.

3.1.2   All forms of ragging are prohibited. If any incident of ragging comes to the notice of the authorities, the student concerned will have to provide an explanation for her/his conduct. If the explanation is not found to be satisfactory, the authorities can expel her/him from the Institute.

3.1.3   If a student is found under the influence of any form(s) of intoxication (other than the prescription medication), she/he would be expelled from the Institute.

3.1.4   The students are expected to conduct themselves in a manner that provides a safe working environment for women. Sexual harassment of any kind is unacceptable and will attract appropriate disciplinary action. Further details can be obtained from the website: http://www.iisc.ac.in/ icash/.

3.2 LEAVE

3.2.1   A student is governed by the following leave rules:

3.2.1.1   To obtain leave, prior application will have to be submitted to the Dean of Undergraduate Studies through the Faculty Advisor stating fully the reasons for the leave requested for along with supporting document(s). Such leaves will be granted by the Dean.

3.2.1.2   Absence for a period not exceeding two weeks in a semester due to unavoidable reasons for which prior application could not be made may be condoned by the Dean of Undergraduate Studies provided she/he is satisfied with the explanation.

3.2.1.3   The Dean of Undergraduate Studies may, on receipt of an application, also decide whether the student be asked to withdraw from the courses for that particular semester because of long absence.

3.2.1.4   The leave of absence as per 3.2.1.1 and 3.2.1.2 will not be condoned for attendance.

3.2.1.5   All students are entitled to take leave for the full summer term at the end of the second semester.

3.2.2   Leave of absence on medical grounds: Up to 21 days in a semester for extended sickness normally requiring hospitalization. If the medical leave exceeds 21 days, the Dean of Undergraduate Studies may, on receipt of an application, also decide whether the student beasked to withdraw from the courses and drop the semester because of long absence.

3.2.2.1   Women research scholars can avail of maternity leave for 135 days once during the tenure of studentship. Discipline, Attendance and Leave Rules

3.2.2.2   For leave under 3.2.2 above, a Medical Certificate and a subsequent Fitness Certificate (for resumption of studies) are required. These are to be issued by the CMO of the Institute.

3.2.2.3   A combination of different types of leave is not normally permitted.

3.2.3   With regard to leave, the year is reckoned as follows: from the date of commencement of the session, irrespective of the date of joining.

3.2.4   Students permitted to attend approved conferences may be considered to be on duty.
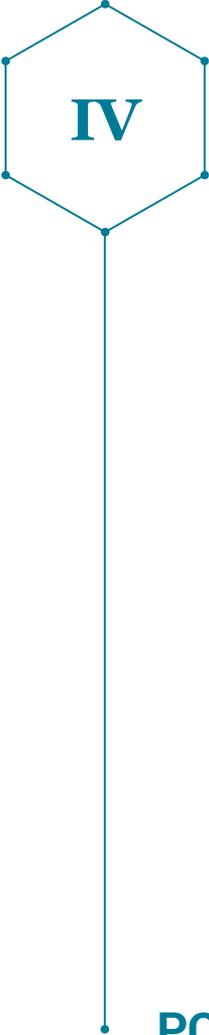
IV

POLICY ON CONDUCT AND
ACADEMIC INTEGRITY FOR STUDENTS

4.1   PREAMBLE

This Handbook highlights the standard procedures and practices of the Indian Institute of Science (hereinafter referred to as the 'Institute') for all students enrolling with the Institute for pursuing various courses. All students must know that it is their responsibility to abide by the Code of Ethics and Conduct (hereinafter referred to as the 'Code').

The Institute's endeavor, by means of enforcing this Code is to put in place a Document for all students that is egalitarian, conscientious, effectual and expeditious; and to provide a system which promotes student growth through individual and collective responsibility.

All students are requested to be familiar with this Code, which can be also be found on the official website of the Institute.

The Code holds students (both individuals and groups) responsible for their actions and its consequences. Those who fail to fulfill their responsibilities stand to lose their privileges or have penalties imposed on them.

4.2   JURISDICTION

4.2.1   The Institute shall have jurisdiction over the conduct of the students enrolled in or associated with the Institute.

4.2.2   This Code shall apply to any student enrolled in a degree programme, or a course at the Institute or visiting scholars, post-docs, etc. The Code will apply to conduct that occurs on the premises of the Institute, including activities sponsored by the Institute and functions hosted by other recognized student organizations. It also applies to conduct that occurs elsewhere, which could impact the Institute's interests or reputation such as those occurring in sponsored programmes, activities by the Institute (students travelling for educational purposes or to attend seminars etc.), or in the context of a relationship between the student and a third party that involves the student's standing, status or academic record at the Institute.

4.2.3   At the time of admission, each student must sign a statement accepting this Code and give an undertaking that

(a)   He/she shall be regular and will complete his/her studies in the Institute.

(b)   In the event that a student is forced to discontinue studies for any legitimate reason, then the student will be relieved from the Institute, but only after submitting a written consent from the Deans. Before leaving, the student must clear all pending dues including hostel/mess dues. And if a student has a scholarship, the said grant shall be revoked.

4.3   WHAT CONSTITUTES MISCONDUCT?

The Institute believes in promoting an environment that ensures safety to all and promotes academic efficiency by enforcing behavioural standards. These standards include upholding of academic integrity and respecting all persons, their rights and property, etc. Prohibited conduct includes, but is not limited to, the following:

4.3.1   **Alcohol and Substance Abuse**

(a)   Consumption, manufacture, sale, possession and distribution of alcohol is prohibited on campus. Any student found guilty of behaving irresponsibly under the influence of alcohol will be penalised. A first-time offender will be charged a fine of Rs 10,000/- and asked to submit a written commitment that he/she will not repeat the offence. A second-time offender will be fined Rs 25,000/- and the offence will also be reflected in the student records. A third-time offence will attract a more severe penalty, including rustication from the Institute.

(b)   Students found guilty of engaging in any unlawful possession, use, distribution or manufacture of controlled substances or illegal drugs, or their raw materials will be referred to the state police. Once found guilty the student will be suspended and could also be dismissed.

4.3.2   **Ragging**

The Institute has a coherent and an effective anti-ragging policy in place which is based on the UGC Regulation on Curbing the Menace of Ragging in Higher Educational Institutions, 2009 [hereinafter referred to as the 'UGC Regulations']. The UGC Regulations have been framed as per the directions issued by the Honorable Supreme Court of India to prevent and prohibit ragging in all Indian educational institutions and colleges.

4.3.2.1   Ragging constitutes one or **more** of the following acts:

a)   any conduct by a student or students hurting, teasing, or being rude to other students;

b)   rowdy or undisciplined activities which cause or are likely to cause annoyance, hardship, physical or psychological harm or raise fear or apprehension thereof in any other student;

c)   asking a student to do an act which makes him/her uncomfortable and which has the effect of causing or generating a sense of shame, torment or embarrassment, affecting the physique or psyche of such a student;

d)   any act that prevents, disrupts or disturbs the regular academic activity of any student;

e)   exploiting other students to complete academic tasks assigned to them;

f)   any act of financial extortion or forceful expenditure burden put on a student by other students;

g)   any act of physical abuse including sexual abuse, stripping, indulging in obscene, lewd acts including but not limited to gestures, causing bodily harm or any other danger to the health of a student;

h)   any act or abuse either orally or in writing including by spoken words, emails, post, public insults which would also include deriving perverted pleasure, the vicarious or sadistic thrill from actively or passively participating in the discomfiture to any other student;

i)   any act that affects the mental health and self-confidence of any other student with or without intent to derive sadistic pleasure.

4.3.2.2   **Anti-Ragging Committee**
The Anti-Ragging Committee, as constituted by the Director and headed by students' affairs advisors, shall examine all complaints of anti-ragging and come up with recommendations based on the nature of the incident. The committee can have the Deans, Student Counselors, Faculty Advisors, and the Chairperson of the concerned Department as its members as decided by the Competent Authority from time to time. The Committee, however, should have a diverse mix of membership in terms of levels and gender.

4.3.2.3   **Anti-Ragging Squad**
To assist students, the Institute has also constituted a body called the Anti-Ragging Squad, which consists of various members of the campus community. The Squad shall keep a tab on ragging incidents taking place in the community and undertake patrolling functions. Students may note that the Squad is active and alert at all times and is empowered to inspect places of potential ragging and make surprise raids in hostels and other hotspots in the Institute. The Squad can also investigate incidents of ragging and make recommendations to the Anti-Ragging Committee.

4.3.2.4   **Penalties**
On receipt of any recommendation from the Anti-Ragging Squad or on receipt of any information concerning any reported incident of ragging, the Head of the Institution shall also immediately determine if a case under criminal law has been made out and if so, then either

on his own or through a member of the Anti-Ragging Committee authorized by him on his behalf proceed to file a First Information Report (FIR) within twenty four hours of receipt of such recommendation with the police or local authorities. Offences include those of abetment to ragging, criminal conspiracy to rag, unlawful assembly and other offences as enumerated in Regulation 7 of the UGC Regulation.

The Institute shall also continue with its own inquiry initiated under clause 9 of these Regulations and other measures and any remedial action shall be initiated and completed immediately and no later than 7 days of reported occurrence of the incident of ragging. A student found guilty by the committee will attract one or more of the following penalties, as imposed by the Anti-Ragging Committee:

i.   Suspension from attending classes and academic privileges;
ii.   Withholding/withdrawing scholarship/fellowship and other benefits;
iii.   Debarring from appearing in any test/examination or other evaluation processes;
iv.   Withholding results;
v.   Debarring from undertaking any collaborative work or attending national or international conferences/symposia/meetings to present his/her research work;
vi.   Suspension/expulsion from the hostels and mess;
vii.   Cancellation of admission;
viii.   Expulsion from the institution and consequent debarring from admission to any other institution for a specified period;
ix.   When the persons committing or abetting the act of ragging are not identified, the institute shall resort to collective punishment;
x.   If need be, in view of the intensity of the act of ragging committed, a First Information Report (FIR) shall be filed by the Institute with the local police authorities.

The Anti-Ragging Committee of the Institute shall take an appropriate decision, including the imposition of punishment, depending on the facts and the nature and gravity of the incident.

An Appeal against any of the orders of punishment enumerated above can be submitted to the Director of the Institute.

4.3.3   Sexual harassment

Students should note that sexual misconduct or harassment encompasses a range of behaviour, including but not limited to sexual assault, unwanted physical contact, persistent unwelcome comments, sending e-mails, messages on social media or pictures that are insulting or degrading.

Sexual harassment amounts to serious misconduct and will be dealt with as per the Indian Institute of Science Policy on Prevention and Prohibition of Sexual Harassment at Workplace, 2017 and the Indian Institute of Science Rules for Internal Committee, 2017. All cases will be referred to the 'Internal Committee Against Sexual Harassment' (ICASH) of IISc. ICASH will determine, based on the circumstances of each case, whether the actions brought to its notice constitute a violation of the sexual autonomy and dignity of the recipient of the action.

4.3.4   Other misconduct

a)   Storing, possessing or using real or replica firearms or other weapons, explosives (including fireworks), ammunition, drugs, or toxic or otherwise dangerous materials on Institute premises.

b)   Stealing, misusing, destroying, defacing or damaging Institute property or property belonging to someone else.

c)   Unauthorised use of any Institute facilities, equipment, services or computers. This includes theft or abuse of Institute computers and other electronic resources such as computer and electronic communications facilities, systems, and services which includes unauthorized entry, use, tampering of Institute property or facilities, the private residence of staff/professors, offices, classrooms, computers networks, and other restricted facilities.

d)   Making false accusations against any member of the Institute.

e)   Any act of discrimination (physical or verbal conduct) based on an individual's gender, caste, race, religion or religious beliefs, skin colour, region, language, sexual orientation, marital or family status, physical or mental disability, etc.

f)   Not producing the identity card issued by the Institute or refusing to produce it on demand by campus security.

g)   Physical assault, threats of violence, which includes any disruptive activity in a classroom or in an event sponsored by the Institute. Any conduct which has a negative impact or constitutes a nuisance on and off campus.

h)   Organising meetings and processions without permission from the Institute.

i)   Accepting membership of religious or terrorist groups banned by the Institute/ Government of India.

j)   Smoking on the campus of the Institute.

k)   Parking a vehicle in a no parking zone or an area earmarked for parking other types of vehicles.

l)   Rash driving on the campus that may cause any inconvenience to others.

m)   Not disclosing a pre-existing health condition, either physical or psychological, to the Chief Medical Officer which may cause hindrance to the academic progress.

n)   Mis-behaviour at the time of student body elections or during any activity of the Institute.

o)   Engaging in disorderly, lewd, or indecent conduct, including, but not limited to, creating unreasonable noise; pushing and shoving; inciting or participating in a riot or group disruption at the Institute.

p)   Altercations of any kind between students or student groups will be taken seriously as a violation of the code and will be dealt with accordingly.

q)   Students encouraging, aiding, or conspiring in any prohibited conduct. And failing to comply with a disciplinary measure or disciplinary measures imposed under the procedures of this Code. If these acts are committed off-campus, the Institute will determine whether the Code will apply after considering the seriousness of the alleged offence, the risk of harm involved whether the victim(s) are members of the campus community and/or whether the off-campus conduct is part of a series of actions, which occurred both on, and off-campus.

4.4   IISc POLICY FOR ACADEMIC INTEGRITY

As a premier institution for advanced scientific and technological research and education, the Institute values academic integrity and is committed to fostering an intellectual and ethical environment. Academic integrity encompasses honesty, responsibility and awareness of the ethical standards for the conduct of research and scholarship. The Institute believes that in all academic work, the ideas and contributions of others must be appropriately acknowledged. Academic integrity is essential for the success of the Institute and its research missions, and hence, violations of academic integrity constitute a serious offence.

4.4.1   Scope and Purpose

Academic integrity, which forms an integral part of the Code, applies to all students at the Institute. Students are required to adhere to the said policy. The purpose of the policy is twofold:
i.   To clarify the principles of academic integrity;
ii.   To provide examples of dishonest conduct and violations of academic integrity.

Failure to uphold these principles of academic integrity threatens both the reputation of the Institute and the value of the degrees awarded to its students. Every member of the Institute community, therefore, bears a responsibility for ensuring that the highest standards of academic integrity are upheld.

The principles of academic integrity require that a student:
i.   properly acknowledges and cites the use of the ideas, results, material or words of others;
ii.   properly acknowledges all contributors to a given piece of work;
iii.   makes sure that all work submitted is his or her own in a course;
iv.   produces academic work without the aid of impermissible materials or impermissible collaboration;
v.   obtains all data or results by ethical means and reports them accurately without suppressing any results inconsistent with his or her interpretation or conclusions;
vi.   respects the integrity of other students and their right to pursue educational goals without interference. This requires that a student neither facilitates academic dishonesty by others nor obstructs their academic progress.

Violations of this policy include, but are not limited to:

Plagiarism: It includes the use of material, ideas, figures, code or data as one's own, without appropriately acknowledging the original source. This may involve the submission of material, verbatim or paraphrased, that is authored by another person or published earlier by oneself. Examples of plagiarism include:
a.   Reproducing, in whole or part, text/sentences from are port, book, thesis, publication or the internet.

b.   Self-plagiarism which constitutes copying verbatim from one's own earlier published work (data, illustrations, figures, images) in a journal or conference proceedings without appropriate citations.

c.   Taking material from class notes or incorporating material from the internet graphs, drawings, photographs, diagrams, tables, spreadsheets, computer programs, or other non-textual material from other sources into one's class reports, presentations, manuscripts, research papers or thesis without proper attribution.

d.   Submitting a purchased or downloaded term paper or other materials to satisfy a course requirement.

Cheating: It includes, but is not limited to:

a) Copying during examinations, and copying homework, assignments, term papers, theses or manuscripts.

b) Allowing or facilitating copying, or writing are port or taking an examination for someone else.

c) Using unauthorized material, copying, collaborating when not authorised and purchasing or borrowing papers or material from various sources.

d) Fabricating or falsifying (manipulating) data and reporting them in theses and publications.

e) Creating sources or citations that do not exist

f) Altering previously evaluated data and resubmitting the work for re-evaluation.

g) Signing another student's name on an assignment, report, research paper, thesis or attendance sheet.

Guidelines for academic conduct are provided below to guard against negligence as well as deliberate dishonesty:

Use proper methodology for experiments and computational work. Accurately describe and compile data.

i. Carefully record and save primary and secondary data such as original pictures, instrument data readouts, laboratory notebooks, and computer folders. There should be minimal digital manipulation of images/photos; the original version should be saved for later scrutiny if required, and the changes made should be clearly described.

ii. Ensure robust reproducibility and statistical analysis of experiments and simulations. It is important to be truthful about the data and not to cherry pick data: omitting some data points to make an impressive figure.

iii. Laboratory notes must be well maintained in bound notebooks with printed page numbers, which can be checked during publications or patents. The date should be indicated on each page.

iv. Write clearly in your own words. It is necessary to resist the temptation to "copy and paste" from the Internet or other sources for class assignments, manuscripts and thesis.

v. Give due credit to previous reports, methods, computer programmes, etc., with appropriate citations. Material taken from your own published work should also be cited.

4.4.2 Conflict of Interest

A clash of personal or private interests with professional activities can lead to a potential conflict of interest, in diverse activities such as teaching, research and publication, and working in committees, funding and consultancy. It is necessary to protect actual professional independence, objectivity and commitment, and also to avoid any impropriety arising from conflicts of interest.

Conflict of interest is not restricted to personal financial gain; it extends to a large gamut of professional academic activities, including peer reviewing, serving on various committees, which may, for example, oversee funding or give recognition, as well as influence public policy.

To promote transparency and enhance credibility, potential conflicts of interests must be disclosed in writing to appropriate authorities, so that a considered decision can be made on a case-by-case basis.

4.4.3   Individual and Collective Responsibility

The responsibility varies with the role one plays.

Student roles: Before submitting a thesis (M Tech, M Tech(Res), or PhD) to the department, the student is responsible for checking the thesis for plagiarism using software that is available on the web. In addition, the student should undertake that he/she is aware of the academic guidelines of the Institute, has checked the document for plagiarism, and that the thesis is an original work. A web-check does not necessarily rule out plagiarism. If a student observes or becomes aware of any violations of the academic integrity policy he/she is strongly encouraged to report the misconduct in a timely manner.

Faculty roles: Faculty members should ensure that the students follow proper methods for experiments, computations and theoretical developments, record proper data and save them for future reference. In addition, they should review manuscripts and theses carefully. Faculty members are also responsible for ensuring personal compliance with the above broad issues related to academic integrity. Faculty members are expected to inform students of the Institute's academic integrity policy within their specific courses to ensure minimal academic dishonesty, and to respond appropriately to violations of academic integrity.

4.4.4   Reporting Authority and Penalties

i.   It is recommended that the faculty bring any academic violations to the notice of the Department Chairperson. All complaints lodged against students regarding breach of academic integrity and research misconduct against students shall be governed by the Indian Institute of Science (IISc) policy for handling Misconduct in Research.

ii.   All cases of student-faculty conflict will be handled by the concerned Dean with assistance from the committee. Students may approach the committee or the Dean if they have a genuine problem.

iii.   Upon receipt of reports of scientific misconduct, the Director may appoint a committee to investigate the matter and suggest appropriate measures on a case-by-case basis.

iv.   A breach of academic integrity is a serious offence with long-lasting consequences for both the individual and the institute, and this can lead to various penalties. In the case of a student, the first violation of academic breach will lead to a warning and/or an "F" course grade. A repeat offence, if deemed sufficiently serious, could lead to expulsion.

4.4.5   Print and Visual Media, and Social Media Clauses

i.   Students are expected not to interact, on behalf of the Institute, with media representatives or invite media persons to the campus without the permission of the Institute authorities.

ii.   Students are not permitted to record either audio or video lectures in classrooms, actions of other students, faculty, or staff without prior permission.

iii. Students are not permitted to provide audio and video clippings of any activity on campus to the media without prior permission.

iv.   Students are expected to use social media carefully and responsibly. They cannot post derogatory comments about other individuals from the Institute on social media or indulge in any such related activities that could have negative ramifications on the reputation of the Institute.

4.5 THE DISCIPLINARY PROCESS

A complaint of misconduct can be made by any student, staff or faculty member of the Institute at the concerned Department, Security Office, the Hostel Office or the Dean's Office. An enquiry will be made by the concerned authority. All efforts will be made to address the issue. If the problem persists, the case may be referred to the Committee for Students Affairs.

The subsequent process will be as follows: A case sheet will be opened. The student(s) will be called for a hearing and the alleged charges and circumstances will be documented. If the committee feels there is indeed an offence, the committee will make recommendations to the Dean of Science or the Dean of Engineering, who are the disciplinary authorities. The recommendation will be reviewed by the Dean, who will recommend subsequent action. The officer in charge of the academic section will issue the penalty.

4.5.1   Penalties:

The recommendation can be, but will not be restricted to, one or more of the following actions, depending on the nature of the offence:

i.   **Warning**- Indicating that the action of the said student was in violation of the Code and any further acts of misconduct shall result in severe disciplinary action. The student may be required to tender a written apology.

ii.   **Community Service** - For a specified period of time, to be extended if need be. However, any future misconduct along with failure to comply with any conditions imposed may lead to severe disciplinary action, including suspension or expulsion.

iii. **Restrictions** - Reprimanding and restricting access to various facilities on the campus for a specified period of time.

iv.   **Monetary Penalty** - May also include suspension or forfeiting scholarship/fellowship for a specific time period.

v.   **Withholding Grades** - Withholding the grade card or certificate for the courses studied or work carried out.

vi.   **Suspension** - A student may be suspended for a specified period of time, which will entail prohibition from participating in student-related activities, classes, programs etc. Additionally, the student will be forbidden to use various Institute facilities unless permission is obtained from the Competent Authority. Students may be suspended and dismissed, along with the following additional penalties.

vii. **Expulsion** - Student may be expelled from the Institute permanently. The student is prohibited from entering the Institute premises or participating in any student-related activities and staying in campus residences etc.

viii. **Ineligibility** - To reapply for admission to the Institute for a period of three years.
Note: Repeat offenders will be given a higher penalty.

4.5.2 **Disciplinary Authorities:**
For imposing the penalties 5.1.1 and 5.1.2, the Students' Affairs Committee will be the Disciplinary Authority.

For all other penalties, the Dean of Science, Dean of Engineering, or Dean of Undergraduate Programme will be the Disciplinary Authority for students from Science, Engineering and the Undergraduate Programme, respectively.

4.6 APPEAL

If the delinquent student is aggrieved by the imposition of any of the aforementioned penalties, he/she may appeal to the Director. The Director may decide on one of the following:

(a) Accept the recommendation of the committee and impose the punishment as suggested by the Committee or modify and impose any of the punishments as stipulated in the Code corresponding to the gravity of the proved misconduct, or

(b) Refer the case back to the committee for reconsideration.

In any case, the Director's decision is final and binding in all the cases where there is possible misconduct by a student.

4.7 STUDENT PARTICIPATION IN GOVERNANCE

Students are members of the Institute campus and they have a substantial interest in the governance of the Institute. The Code, policies and the varied procedures laid down herein seek to encourage students to be involved in governance in both administrative and academic areas. Students must, at all junctures, be encouraged to put forth their views and advice, for informed decision making. Therefore, all students who are a part of the Institute and who are going to be enrolled in the Institute, are advised to uphold the policy, inform the Institute of any violations, and assist individually and collectively to improve the quality and effectiveness of this Code and policies.

References

1. National Academy of Sciences article "On being a scientist,"
http://www. nap.edu/openbook.php?record_id=4917&page=R1

2. http://www.admin.cam.ac.uk/univ/plagiarism/

3. http://www.aresearchguide.com/6plagiar.html

4. https://www.indiana.edu/~tedfrick/plagiarism

5. http://www.files.chem.vt.edu/chem-ed/ethics/index.html

6. http://www.ncusd203.org/central/html/where/plagiarism_stoppers.html

7. http://sja.ucdavis.edu/files/plagiarism.pdf

8. http://web.mit.edu/academicintegrity/

9. http://www.northwestern.edu/provost/students/integrity/

10. http://www.ais.up.ac.za/plagiarism/websources.htm#info

11. http://ori.dhhs.gov/

12. http://www.scientificvalues.org/cases.html
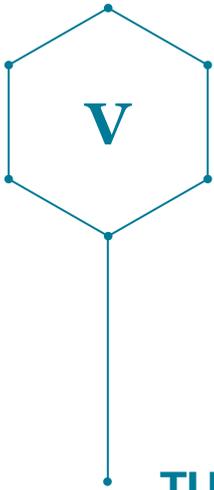
TUITION AND OTHER FEES

Students are required to pay the fees prescribed by the Institute during the period of studentship. These are liable to changes from time to time. The details of the fees in force are given below:

5.1   FEES PER ANNUM:

BACHELOR OF SCIENCE (RESEARCH) STUDENTS (GENERAL/OBC)

FEE DETAILS	INR
Tuition Fee	10,000
Gymkhana Fee	1200
Other Academic Fee	3700
Statutory Deposit	7500
Library Deposit	7500
Students' Emergency Fund	300
Group Mediclaim Policy Premium	1060
TOTAL (INR)	31,260
HOSTEL DEPOSIT	20,000

5.2   FEE PAYMENT SCHEDULE FOR THE SESSION 2021-22

BACHELOR OF SCIENCE (RESEARCH) STUDENTS (GENERAL/OBC)

	INSTALLMENT (I)	INSTALLMENT (II)	INSTALLMENT (III)
Tuition Fees (INR)	2000	4000	4000
Other Fees (INR)	6200	--	--
TOTAL (INR)	8260	4000	4000

DUE DATES

PERIOD	DUE DATE
I Installment (1 August - 31 October)	15/08/2019
II Installment (1 November - 31 December)	14/11/2019
III Installment (1 January - 31 July)	16/01/2020

Bachelor of Science (Research) Students (SC/ST)

FEE DETAILS	AMOUNT (INR)
Tuition Fee	Fully waived
Gymkhana Fee	1,200
Other Academic Fee	3700
Students' Emergency Fund	300
Group Mediclaim Policy Premium	1,060
TOTAL (INR)	6,260

Due Date: August 16, 2019

5.2.1   PENALTIES

5.2.1.1   Fees are payable on or before the dates noted above. If the due date falls on a holiday, it can be paid on the next working day without a fine. A fine of Rs. 20/- per week shall be levied for all students who default and do not pay the fees before the prescribed date.

5.2.1.2   If a student fails to pay tuition and other fees by the due date, any one or more of the following penalties will be levied:

a.   Overdue charges of Rs. 20/- per week or part thereof;
b.   Stoppage of scholarship and/or loss of attendance for the period of non-payment or delay in payment;
c.   Withdrawal of permission to take the examinations or to continue research; and
d.   Cancellation of registration to continue as a student at the Institute.

5.3.   DEPOSITS (REFUNDABLE)

STATUTORY DEPOSIT: RS. 7,500/- | LIBRARY DEPOSIT: RS. 7,500/-

5.3.1   The deposits are to cover liabilities such as:
a.   Damage of apparatus or other property
b.   Wastage of materials
c.   Fines
d.   Hostel and dining hall dues
e.   Loss of books and
f.   Other dues.

5.3.2   A request for refund of Statutory and Library deposits is to be submitted in the prescribed forms at the time of leaving the Institute. The form may be obtained either from the Undergraduate Office or from the Finance Section (Unit V-C). A student should submit the request through the Dean of the Undergraduate Program before leaving the Institute, to obtain a refund of the deposits.

5.4.   CONCESSIONS

5.4.1   Students belonging to SC and ST communities are exempted only from tuition fees.

VI
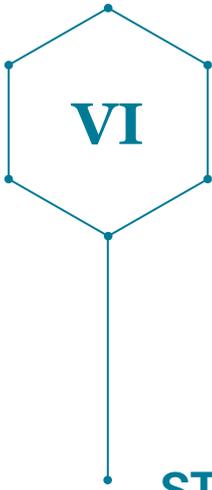
STUDENTS' ASSISTANCE

6.1 STUDENTS' AID FUND

6.1.1   Each student shall contribute to the Fund a sum of at least Rs. 50 per annum. Donations are also received from other sources.

6.1.2   The Fund is administered by a Committee constituted by the Director. This Committee may also prescribe operational rules for sanction of assistance from the Fund from time to time. A guarantee from one or both the parents or guardian is required before the assistance can be sanctioned.

6.1.3   Assistance in the form of loans from the Fund is available to poor students to:
a)   Meet tuition fees;
b)   Purchase books, instruments and stationery necessary for the pursuit of their courses or research project;
c)   Meet other expenses connected with their work and for their maintenance at the Institute as may be approved by the Committee; and
d)   Meet hostel, dining hall, medical expenses, etc.

6.1.4.   No payment shall be made by way of scholarships or prizes to students.

6.1.5.   This assistance in the form of loans will be as reimbursement of expenditure incurred on different items. The amount will be recovered in equal installments. The number of installments will be decided at the time of sanctioning the loan.

6.1.6   Requests for assistance should be made to the Academic Section in the prescribed form.

6.2 FINANCIAL ASSISTANCE FOR MEDICAL CARE

6.2.1   Students can get limited assistance to meet the cost of expenditure incurred in case of hospitalization, from the Students' Medical Care Fund, formed out of contributions made by the students and a matching grant made by the Institute.

6.3   Medical Insurance: Students are required to sign up for the mandatory Group Medical Insurance
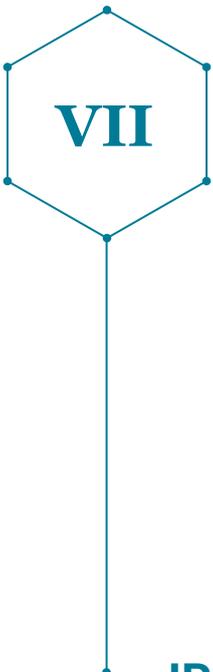
VII

JRD TATA MEMORIAL LIBRARY

The Library was established in 1911, and was renamed the JRD Tata Memorial Library in May 1994. It is one of the best scientific and technical libraries in India. The library aims to develop a comprehensive collection of documents that are useful to the faculty, students and research scholars in their educational and research activities.

The library has a total collection of about 5 lakh documents, which includes books and monographs, bound volumes and periodicals, theses, standards, technical reports, Indian patents and non - book materials like CD ROMs, floppy disks etc.
It receives over 1700 current periodicals.

Books, journals, technical reports, standards and theses are available at the library building.

The Digital Information Service Centre (DISC) is located on the left wing of the first floor of the annexe building. CD-ROM database access facilities are provided here. Digital library services have been started. As part of the digital library, the digitization of institute theses and the rare books collection initiative has been started.

Computer systems are provided at various locations to help access the Online Public Access Catalogue (OPAC) of the library. Users can also access the Online Catalogue from their respective departments, through the library homepage (URL http://www.library.iisc.ac.in).

The following information can be accessed
i.   Information about the library
ii.   Weekly list of books and journals received in the library
iii. List of current journals received
iv.   Complete journal holdings
v.   List of journals received by the five IITs
vi.   Web access to the Online Catalogue (OPAC)

The creation of barcode labels for new books is in progress.

ACCESS TO ELECTRONIC RESOURCES

The library provides access to the following e-resources through the INDEST consortium and also on its own subscription. Some of the full-text resources include Elsevier Science (Science Direct), Springer Verlag (LINK), and ACM, ASCE, ASME, IEEE (IEL). It also gives access to back-files of Elsevier Science, Wiley Inter- science, IOP, APS. Bibliographic and citation databases like Compendex, INSPEC, Web of Science can also be accessed.

WORKING HOURS

MONDAY - SATURDAY : 0800 TO 2300 HRS.
SUNDAY : 0900 TO 1700 HRS.
GENERAL HOLIDAYS : 1000 TO 1600 HRS.

CIRCULATION RULES AND PROCEDURES

WHAT MAY BE LOANED

a) Books
b) Series Publications
c) Reference Books (except Handbooks, Dictionaries, Encyclopedias, etc.)

WHAT MAY NOT BE LOANED

a) Annual Reports
b) Handbooks
c) Dictionaries
d) Encyclopedias

LOAN PERIOD

a) Books (general) 14 days
b) Periodicals (bound/series/ references) 48 hours

VIII

HEALTH CENTRE

Medical services are provided at the Health Centre. It has out-patient and in-patient facilities served by Medical Officers and nursing staff. Specialists in the areas of eye, dental and psychiatric care including an Ayurvedic consultant visit the Health Centre regularly. In addition, there is a doctor on duty to look after emergency cases at night.

Diagnostic facilities like a clinical laboratory, an X-ray facility, ECG and ultrasonography are available. Cases requiring other specialist services are referred to appropriate centres/ hospitals.

All the regular students of the Institute are covered by the "Students Health Care Scheme" which permits reimbursement of medical expenses incurred as per norms. Students are to undergo a medical examination at the time of joining.

HOSTEL AND DINING HALLS

Adequate accommodation is available for all registered students of the Institute in the hostels.
There are four dining halls: Vegetarian 'A', Composite 'B', 'C' and 'D' (both vegetarian and non-vegetarian).

Charges towards Hostel facilities (for each month) are given below:

	Gen/OBC	SC/ST
	INR	INR
Room Rent (Single)	400.00	200.00
Room Rent (Double)	200.00	100.00
Establishment	200.00	200.00
Amenities	200.00	200.00
Elec. & Water	200.00	200.00
TOTAL	1200.00	900

Additional Mess Amenities – Rs.1000 for all

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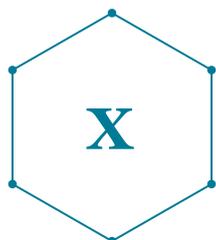
STUDENTS' COUNCIL

The Students' Council (SC) is the representative body of the entire student community of the Institute. It is the interface between the students and the administration and works with both entities to identify and address concerns that affect the students directly and indirectly. The SC represents the interests of the students and participates in discussions and decisions that affect the student community.

The SC aims at the all-round development of students and organizes several extra-curricular events throughout the year in association with the Gymkhana and the various activity clubs on campus.

It also coordinates the student volunteer effort for Institute events that are organized periodically.

It also provides students an opportunity to be a part of the activity, motivated by a sense of social responsibility and aiming to give something back to society.

Three Office bearers are elected for a period of one year. Nominated members constitute the steering and executive committees of the SC. Two representatives from each of the departments are members of the SC. Additionally, the following committees are also constituted by the SC.

- Academic - All issues relating to courses, academic resources
- Amenities - Deciding on new on-campus amenities and monitoring the quality of existing ones
- Communications - Media interface and dissemination of information to students
- Cultural - Organizing and promoting intra and inter-institute cultural events
- Social Initiatives - Organizing volunteer activities and drives and coordinating the efforts of the students and student groups in execution
- Support Network, Health - Counseling Center, Women's Cell and the Health Center

RECREATIONAL FACILITIES

11.1 GYMKHANA

The Gymkhana is the center of cultural activity at the Institute. It has a cricket ground, tennis, volley-ball, basket ball courts and a cinder track. An indoor badminton court, table tennis, billiards, karate, shaolin-chu-kung-fu, taek-wondo, chess and carom, are among the many facilities in the Gymkhana. Athletic and recreational facilities at the Gymkhana come as a break from regular work schedules at the Institute. It also provides an atmosphere conducive to interaction between students and staff.

The Gymkhana also has a good gymnasium with facilities like Home Gym, a Hercules multi trainer and wall bar equipment.

Attached to the Gymkhana is a small well-kept swimming pool where coaching classes are also conducted during the summer.

The Gymkhana subscribes to about 14 magazines in English at its Ranade Library, apart from making available about 10,000 books to readers. The music room in the Gymkhana houses a stereo system and record player, with a good collection of records. There is a separate TV lounge. An indoor Students' Auditorium where cultural activities can be organized is available as a facility.

There is also an open-air auditorium. The Film Club regularly screens popular and classic films in its main hall for the benefit of the members. The Gymkhana organizes inter-departmental, inter-collegiate and inter-university tournaments in sports, games and cultural events. A dark room facility for the Photography Club situated at the Gymkhana caters to the needs of camera-loving members.

A snack parlor, which serves coffee, snacks and soft drinks to the members, is also situated on the Gymkhana premises.

11.2 GENERAL FACILITIES

Other general facilities at the Institute include banks, xerox centers, travel agencies, bookstores and a cafe and tea kiosk.
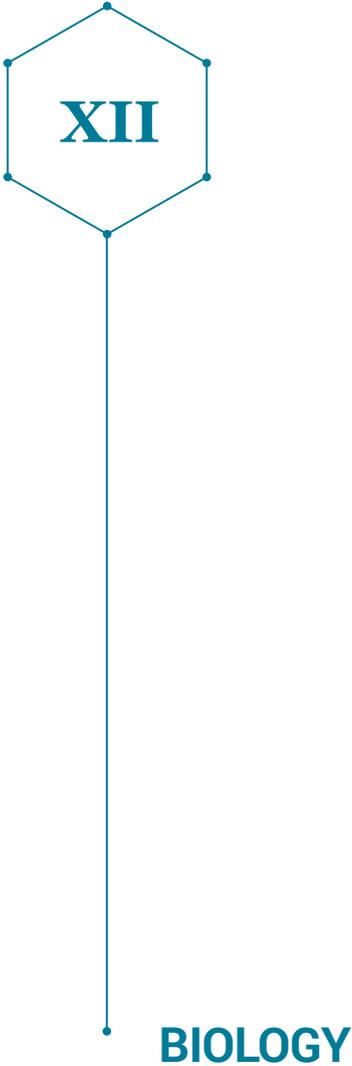
XII

BIOLOGY

INSTRUCTORS
Abhijeet Bayani, Padma Priya, Jean Cletus, Kavitha Sarvepalli, Deepu Oommen

SEMESTER 1 (AUGUST)

UB 101T and UB 101L (2:1)

UB 101: Introductory Biology I
(Organismal Biology and the Molecular Basis of Life)

Introduction to the World of Living Organisms; Levels of Biological Organisation; the Scientific Method and Causation in Biology; Diversity of life on Earth; Evolution: History and Evolution of Life on Earth; Mechanisms of Evolution; the Evidence for Evolution and Natural Selection; Adaptation, Speciation and Diversification; Phylogenetics; Sex and Sexual selection; Animal Behavior : Classical Experiments in Ethology; Communities and Ecosystem: Species Interactions, Trophic Cascades, Ecology and Global Change; Why Biodiversity Matters.

Introduction to Chemical Evolution; Thermodynamic Principles and Biological Macromolecules (water, lipids, carbohydrates, nucleic acids, proteins, enzymes); Placing Biomolecules in the Cellular Context: Cell as a Unit of Life and the Site for Life Processes. Central themes of Metabolism; General Principles underlying the Design of Metabolic Pathways; Elementary Enzymology; Pathway Integration and Regulation.

UB 101L

Understanding methods and concepts in evolution, ecology, and behaviour by observing, describing and quantifying; experimental manipulations; representing and interpreting data; titration of amino acids, estimation of reducing and nonreducing sugars, estimation of proteins, DNA, RNA, lipids. Techniques like thin layer chromatography for lipids, melting curves for DNA and SDS-PAGE for proteins.

INSTRUCTORS: Rohini Balakrishnan and Jayanta Chatterjee

Suggested Books:
1. Campbell Biology (10th/11th editions) By JB Reese, LA Urrey, ML Cain, SA Wasserman. Pearson Global Editions. ISBN 10: 0321739752; ISBN 13: 9780321739759, 2010/ 2013
2. Ernst Mayr, This is Biology: The Science of the Living World, Harvard University Press, 1997
3. Jerry A. Coyne, Why Evolution is True, Viking Penguin, New York, USA, 2009
4. Jonathan Weiner, The Beak of the Finch, Vintage Books, New York, USA, 1995
6. Sean B. Carroll, The Serengeti Rules: The Quest to Discover How Life Works and Why it Matters, Princeton University Press, New Jersey, 2016
7. Wilson, E. O., Life on Earth.Freely available at: http://eowilsonfoundation. org/e-o-wilson-s-life-on-earth
8. Wilson, E. O. The Future of Life, Alfred A.Knopr, 2002
9. Lodish, H., Berk, A., Kreiger, C. A., Scott, M. P., Bretscher, A., Ploegh, H. and Matsudaira, P., Molecular Cell Biology, W. H. Freeman Publishers, 6th Edition, 2008
10. Krebs, J. E., Goldstein E. S., and Kilpatrick, S. T., Lewin's Genes X, Jones and Bartlett Publishers, 10th Edition, 2011
11. Nelson, D. L. and Cox, M. M., Lehninger Principles of Biochemistry, W. H. Freeman Publishers, 5th Edition, 2009
12. Berg, J. M., Tymoczko, J. L. and Styrer, L., Biochemistry, W. H. Freeman & Co., 6th Edition, 2006
13. Voet, D. and Voet, J. G., Biochemistry, Wiley, 4th Edition, 2010

SEMESTER 2 (JANUARY)

UB 102T and UB 102L (2:1)

UB 102: INTRODUCTORY BIOLOGY II
(Microbiology, Cell Biology and Genetics)

Introduction to the microbial world and its diversity; importance of microbes in exploration of basic principles of biology; bacterial growth and its modulation by nutrient availability in the medium; structure and function of a bacterial cell; structure of cell wall; isolation of auxotrophs; introduction to viruses – life cycles of temperate and lytic bacteriophages, structure and function of extra-chromosomal elements and their applications in molecular microbiology.

Introduction to cell biology, eukaryotic cells and their intracellular organization; introduction to the light microscopes and other methods of studying intracellular organelles; further studies on endoplasmic reticulum, Golgi apparatus, lysosomes, mitochondria, nucleus (organization and function), plasma membrane structure and its function, the cytoskeleton, the cell cycle.

Mendelian genetics (segregation and independent assortment); sex determination and sex linkage in diploids; cytoplasmic inheritance; pedigrees, markers, mapping and genetic disorders; gene frequencies and Hardy- Weinberg principle.

UB 102L

Light microscopy, identification of microorganisms, staining techniques (Gram's, acid fast), bacterial plating, tests for antibiotic resistance, cell media and tissue culture; cell counting, immunostanining for actin, microtubules, DNA and identifying interphase and various mitotic phases; Drosophilcrosses using red eye and white eye mutants,observation of Barr body in buccal mucosa cells, preparation of mitotic/ polytene chromosomes from Drosophila larvae; and karyotyping using human metaphase plate photos.

INSTRUCTORS: Dipshikha Chakravortty, Sachin Kotak and Arun Kumar

SUGGESTED BOOKS:
1. Berg, J. M., Tymoczko, J. L. and Styrer, L., Biochemistry, W. H. Freeman & Co., 6th Edition, 2006
2. Stanier, R. Y., Adelberg, E. A. and Ingraham, J. L., General Microbiology, MacMillan Press, 5th Edition, 2007
3. Alberts, B., Molecular Biology of the Cell, Garland Science, 5th Edition, 2008
4. Strickberger, M. W., Genetics, Prentice-Hall, India, 3rd Edition, 2008
5. Daniel, H., Essential Genetics: A genomics perspective, Jones & Bartlett, 3rd Edition, 2002
6. Strachan, T. and Read, A. P., Human Molecular Genetics, Garland Science, 3rd Edition, 2004

SEMESTER 3 (AUGUST)

UB 201T AND UB 201L (2:1)

UB 201: INTRODUCTORY BIOLOGY III
(MOLECULAR BIOLOGY, IMMUNOLOGY AND NEUROBIOLOGY)

Molecular biology (central dogma, DNA repair, replication, transcription, genetic code and translation); examples of post-transcriptional and post-translational modifications; genetic methods of gene transfer in bacteria.

Introduction to the immune system – the players and mechanisms, innate immunity, adaptive responses, B cell receptor and immunoglobulins, T cell activation and differentiation and Major Histocompatibility Complex encoded molecules.

Overview of the nervous system, ionic basis of resting membrane potential and action potentials, neurodevelopment, neurotransmitters, sensory systems, motor systems, learning and memory, attention and decision making.

UB 201L

M13 infection, plaque assay, preparation of bacterial competent cells, transformation, transduction, conjugation, β -galactosidase assay. Immune organs and isolation of cells from lymph node, spleen and thymus; lymphocyte and macrophage activation studies, nitrite detection, ELISA and cell cycle analysis; gross anatomy of the human brain; staining of mouse brain sections; generation of action- potential; psychophysical and cognitive neurobiology experiments.

INSTRUCTORS: Umesh Varshney, Dipankar Nandi, Arnab Barik and Ashesh Dhawale

SUGGESTED BOOKS:
1. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Scott, M. P., Bretscher, A., Ploegh, H. and Matsudaira, P., Molecular Cell Biology, W. H. Freeman Publishers, 6th Edition, 2007
2. Kindt, T., Goldsby, R. and Osborne, B. A., Kuby Immunology, W. H. Freeman Publishers, 6th Edition, 2006

3. Bear, M., Connors, B. and Paradiso, M., Neuroscience: Exploring the Brain, Lippincott Williams & Wilkins, 3rd Edition, 2006

SEMESTER 4 (JANUARY)

UB 207 and UB205

UB 207: GENERAL BIOCHEMISTRY (2:0)
(CORE COURSE FOR BIO MAJOR AND MINOR)

Biochemical properties of proteins and nucleic acids, basics of protein structures, protein sequencing, introduction to proteomics, protein purification and characterization strategies, methods of DNA sequencing, biological membranes and membrane proteins, structure of nucleic acids with emphasis on RNA tertiary structures and folding, protein−nucleic acid (DNA/RNA) interaction.

Basic concepts of enzymes and enzyme kinetics, mechanisms of enzyme actions, basic concepts of metabolism and its design, catabolism and anabolism, energy generation and storage, glycolysis, citric acid cycle, oxidative phosphorylation, gluconeogenesis, fatty acid metabolism, integration of metabolism etc.

INSTRUCTORS: Mahavir Singh and D. N. Rao

SUGGESTED BOOKS:
1. Voet, D. and Voet, J. G., Biochemistry, Wiley, 4th Edition, 2010
2. Berg, J. M., Tymoczko, J. L. and Styrer, L., Biochemistry, W. H. Freeman & Co., 7th Edition, 2011

UB 205: INTRODUCTORY PHYSIOLOGY (2:0)
(CORE COURSE FOR BIO MAJOR)

Mammalian Physiology: Introduction to physiology, internal environment, control of internal environment by feedback systems, renal physiology, body fluids and kidneys, urine formation by the kidneys, principles of membrane transport, transporters, pumps and ion channels, cell signalling and endocrine regulation, hormonal regulation of energy metabolism, hormonal regulation of calcium metabolism, hormonal control of reproduction in males and females, pregnancy and lactation; structure of heart, cardiac muscle contraction, cardiac cycle, electric conductivity of heart, regulation of cardiac homeostasis, structure and function of arteries and vein, blood pressure, blood flow, capillary exchange, physiology of lymphatic system.

Plant Physiology: Plant cell structure and cell wall, water uptake, photosynthesis and photorespiration, secondary metabolites, phytochrome and light signalling, hormone signalling in plants, control of flowering, stress physiology.

INSTRUCTORS: N. Ravi Sundaresan and C. Jayabhaskaran

SUGGESTED BOOKS:
1. Hall, J. E., Guyton and Hall Textbook of Medical Physiology, Elsevier, 12th Edition, 2011
2. Jameson, J. L. and De Groot, L. J., Endocrinology, Elsevier, 6th Edition, 2010
3. Taiz, L. and Zeiger, E., Plant Physiology, Sinauer Associates, 5th Edition, 2010

UB 208: BASIC MOLECULAR BIOLOGY (2:0)

Introduction, early days of Molecular Biology, Proteins, Nucleic Acids, DNA and heredity, biochemistry

of DNA, Chargaff's rule, early models of DNA structure, the double helix and the origin of molecular biology, alternative structures of DNA, unidirectional flow of genetic information –The Central Dogma, the coding problem-elucidation of the genetic code, confirmation of DNA as a genetic material, models for replication of DNA. Gene organization in bacteria: operons and regulons, structure of bacterialpromoters, RNA polymerase and initiation of transcription, repressors and activators. Chromosome organization in eukaryotes: histones and nucleosomes, gene regulation in eukaryotes: transcription factors and enhancers, histone modification and epigenetics, gene expression during development, regulation mediated by RNA. Translation and its regulation. Restriction-modification systems in bacteria, DNA topology and its homeostasis. DNA repair mechanisms. Omics: genomics, proteomics, transcriptomics.

INSTRUCTORS: Tanweer Hussain and Sona Rajakumari

SUGGESTED BOOKS:
1. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A. and Levine, M., Molecular Biology of the Gene, Benjamin-Cummings Publishing Company, 7th Edition, 2013
2. Bruce Alberts, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter, Mo- lecular Biology of the Cell, Garland Science, 6thEdition

UB 206: EXPERIMENTS IN BIOCHEMISTRY AND PHYSIOLOGY (0:2)
(CORE COURSE FOR BIO MAJOR)

Expression of recombinant proteins, purification and characterization. Quantitation of proteins using biochemical assays and physico-chemical characterization of proteins by immunoasays (solid phase and Western blotting). Enzyme assays and determining specific activity of enzymes. Assessing metabolic activity of cells and their susceptibility to drugs.

INSTRUCTORS: Shantanu Shukla, Mahipal Ganji and Deepak Saini

SEMESTER 5 (AUGUST)

UB 301L: EXPERIMENTS IN MICROBIOLOGY (0:1)
(CORE COURSE FOR BIO MAJOR)

Students will get a hands-on experience in understanding the basic concepts of microbiology. The topics include the microbial growth curve, microbial nutritional requirements, genetic engineering techniques, plasmid isolation, creation of genetic knock out in bacteria, bacterial infection in cell culture system, estimation of infection by colony forming unit (CFU) analysis and fluorescence technique.

INSTRUCTOR: Dipshikha Chakravortty

SEMESTER 6 (JANUARY)

UB 302: DEVELOPMENTAL BIOLOGY (2:0)
(CORE COURSE FOR BIO MAJOR)

Introduction, history, and concepts of developmental biology; the current understanding on the mechanisms of development using model organisms including invertebrates, vertebrates and plants; general principles for the making of a complex, multicellular organism from a single cell; the creation of multi-cellularity (cellularization, cleavage), reorganization into germ layers (gastrulation), cell type determination; creation of specific organs, (organogenesis); molecular mechanisms underlying morphogenetic movements, differentiation, and interactions during development; fundamental differenc-

es between animal and plant development; embryogenesis in plant – classical and modern views; axis specification and pattern formation in angiosperm embryos; organization and homeostasis in the shoot and root meristems; patterning in vegetative and flower meristems; growth and tissue differentiation in plants; stem cells and regeneration; evolution of developmental mechanisms

INSTRUCTORS: Usha Vijayraghavan, Ramray Bhat and Utpal Nath

SUGGESTED BOOKS:

1. Wolpert, L. and Tickle, C., Principles of Development, Oxford University Press, 4th Edition, 2010
2. Gilbert, S. F., Developmental Biology, 9th edition, Sinauer Associates, 2010
3. Slack, J. M. W., Essential Developmental Biology, John Wiley & Sons, 3rd Edition, 2012
4. Leyser, O. and Day, S., Mechanisms in Plant Development, Willey-Blackwell, 2003
5. Taiz, L. and Zeiger, E., Plant Physiology, 5th edition, Sinauer Associates, 2010
6. Alberts, B., Molecular Biology of the Cell, Garland Science, 5th Edition, 2008

UB 303L: EXPERIMENTS IN MOLECULAR BIOPHYSICS (0:1)
(CORE COURSE FOR BIO MAJOR)

UV spectroscopy of proteins (quantitation and determination of extinction coefficient), Estimation of free sulfhydryl groups in proteins by Ellman's assay, Fluorescence spectroscopy of proteins, determination of tryptophan accessibility by acrylamide quenching, CD spectroscopy of proteins and calculation of helical contents, CD spectroscopy of DNA (monitoring the role of salt and oligonucleotide sequence in the formation of G-quadruplexes), UV spectroscopy of DNA (determination of melting temperature and influence of buffer composition), computational biophysics: molecular visualization and graphics.

INSTRUCTOR: Jayanta Chatterjee

UB 304L: EXPERIMENTS IN NEUROBIOLOGY (0:1)

The vertebrate nervous system and its organization; demonstration of tissue sectioning techniques; preparation of primary neuronal cultures and imaging neurons; recording and manipulating activity live neurons; rate coding; macrostimulation; effect of temperature and stretch on conduction velocity; neuropharmacology – effects of nicotine MSG;measuring the somatosensory homunculus; measuring alpha rhythm and surprise potentials with EEG; building a blink interface by recording eye potentials.

PREREQUISITE: NS 201 or NS 202 (AUG) (2:0)

INSTRUCTORS: Arnab Barik and Ashesh Dhawale

UB 305L EXPERIMENTS IN ECOLOGY (0:1)

Students will explore key concepts in Ecology, Evolution and Behavior using field methods, laboratory manipulations and computer simulations. Students will design many of their own experiments and will utilize different modes of scientific communication, including oral presentations and documentaries. Topics include niche and population dynamics, competition and predation,trophic interactions, evolution and adaptation, natural and sexual selection, and conservation. This module also includes a mandatory field trip where students develop an independent research project.

INSTRUCTOR: Kartik Shanker

SEMESTER 8 (JANUARY)

UB 400: RESEARCH PROJECT (0:16)

An independent research project will be carried out by all the UG-Biology major students under the supervision of the faculty members. It is recommended that students initiate laboratory work during the summer break after completing their sixth semester. The progress of the project will initially be monitored at the end of the seventh semester. Finally, the submitted project report will be graded before the end of the eighth semester as follows: faculty assessment (30% marks), independent referee (30% marks) and presentation by the students (40%). Based on the student's performance, the final grade will be determined.

i.   Faculty members in the Division of Biological Sciences, IISc.
ii. Faculty members outside the Division of Biological Sciences can also act as Project guides. In that case, the student and the Project Guide are required to briefly describe the project in a one-page write-up and get it approved by the Biology Coordinators before starting the project. The proposal will be approved by the Coordinators if they find it sufficiently biological in nature and content.
iii. Scientists outside IISc CANNOT act as Project Guides for the UG students.
iv. Students must inform the UG Biology Coordinators about their chosen project guide before the start of the 7th semester, students are encouraged to work in their chosen lab during both 7th and 8th semesters to work on longer-term projects.

INSTRUCTORS: Ramray Bhat and S.P. Arun

ADDITIONAL COURSES IN SEMESTERS 5, 6, 7 AND 8:

Please see courses listed in the Scheme of Instruction for postgraduate students and select appropriate courses in consultation with the faculty advisor and UG Biology Coordinators.

Do note that the following courses that are not part of the Division of Biological Sciences will be considered a part of UG-Biology major:

CH 248 (JAN) 3:0 MOLECULAR SYSTEMS BIOLOGY
INSTRUCTOR: Rahul Roy

DS 301 (AUG) 2:0 BIOINFORMATICS
INSTRUCTORS: K.Sekar & Debnath Pal

CH242 (AUG) 3:0 SPECIAL TOPICS IN THEORETICAL BIOLOGY
INSTRUCTOR: Narendra M Dixit

*BE 201 (AUG) 3:0 FUNDAMENTALS OF BIOMATERIALS AND LIVING MATTER
INSTRUCTOR: Bikramjit Basu

*Available only to the students belonging to the 2017 batch and later
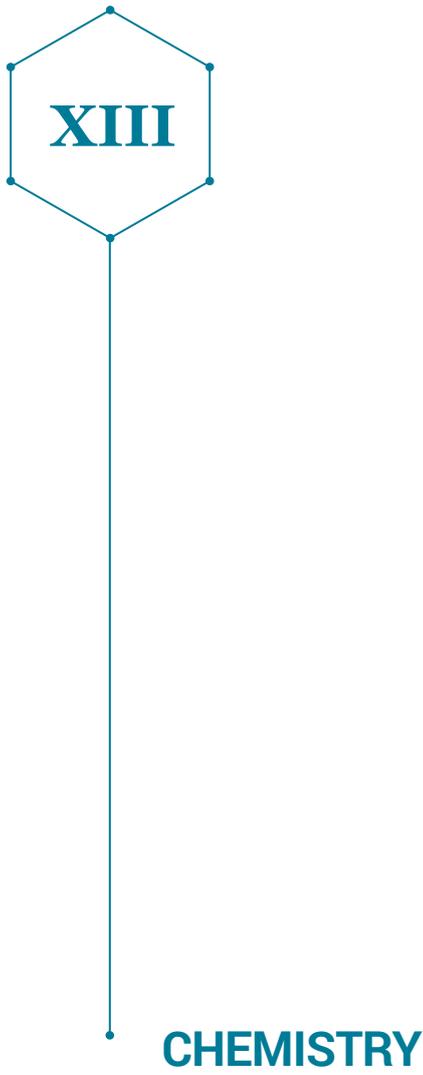
CHEMISTRY

INSTRUCTORS
Achintya Jana, Dayamani Allumolu, Tanaya Kundu

SEMESTER 1 (AUGUST)

UC 101T: PHYSICAL PRINCIPLES OF CHEMISTRY (2:0)

Overview of atoms, molecules and chemical bonding: Introduction to quantum mechanics, postulates, exemplary exact solutions. Chemical thermodynamics, state functions, spontaneity, reaction thermodynamics. Chemical equilibrium and chemical kinetics, reaction coordinate diagrams. Properties of solutions, colligative properties.

INSTRUCTORS: Anshu Pandey

SUGGESTED BOOKS:
1. McQuarrie, D. A. and Simon, J. D. Physical Chemistry, Viva Books
2. Gray, H.B. 1965 Electrons and Chemical Bonding, W. A. Benjamin Inc
3. Peter Atkins, and Julio De Paula, Elements of Physical Chemistry, 5/E, Oxford University Press, Indian Edition
4. Ira, N. and Levine, 2008 Physical Chemistry, Tata McGraw Hill
5. Barrow, G. M. 2007 Physical Chemistry, McGraw Hill

UC 101L (0:1)
INSTRUCTORS: Atanu Bhattacharyya and Chinmoy Ranjan

SEMESTER 2 (JANUARY)

UC 103T : BASIC INORGANIC CHEMISTRY (2:0)

Multi-electron atoms – periodic trends, Chemical bonding: ionic solids, CFT: d-orbital splitting, tetrahedral, square planar, cubic and octahedral crystal fields, covalent bonding, Lewis model (2 Dim), VSEPR (3 Dim) hybridization, Molecular orbital theory: heteronuclear diatomics, triatomics, Shapes of main group compounds, Acid-base chemistry: concepts, measures of acid-base strength, HSAB, Main group chemistry: carbon group compounds and noble gases.

INSTRUCTOR: Debasis Das

SUGGESTED BOOKS:
1. Lee, J. D. Concise Inorganic Chemistry, 5/E, Oxford University Press, Indian Edition
2. Miessler, G. L. and Tarr, D.A. Pearson Inorganic Chemistry, Third Edition
3. Shriver, D. F., Atkins, P. W. and Langford, C. H. Inorganic Chemistry, Oxford University Press
4. Huheey, J. E., Keiter, E.A. and Keiter, R. L. Inorganic Chemistry, 4/E, Pearson Education Asia

UC103 L
INSTRUCTORS: Partha Sarathi Mukheree and Subinoy Rana

SEMESTER 3 (AUGUST)

UC 206T: BASIC ORGANIC CHEMISTRY (2:0)

Part 1: Nomenclature of organic compounds, Orbital picture of molecular structure, Aromaticity, Acids and bases, Organic reactions and mechanism: substitution, aromatic substitution, elimination, addition and rearrangements, Oxidation-reduction etc.

Part 2: Introduction to chirality and stereochemistry; elements of symmetry; configurational nomenclatures; optical activity; chiral resolution and kinetic resolution; stereospecific and stereoselective reactions and mechanisms; conformation of acyclic and cyclic systems.

INSTRUCTORS: A.T.Biju, Durga Prasad Hari and T.K.Chakraborty

SUGGESTED BOOKS:
1. Solomons, T. W. G. and Fryhle, C. 2009 Organic Chemistry, John Wiley & Sons
2. McMurry, J. E. 2007 Organic Chemistry 7th edition, Thomson
3. Bruice, P. Y. Organic Chemistry, 6th edition, Pearson
4. Nasipuri, D. Stereochemistry of Organic Compounds, Principles and Applications
5. Eliel, E. L. Stereochemistry of Carbon Compounds

UC 206L (0:1)
INSTRUCTORS: Mrinmoy De and S.Ramakrishnan

UC 202: THERMODYNAMICS AND ELECTROCHEMISTRY (2:0) (CORE FOR MAJORS)

Intermolecular forces and interaction potentials, Equations of state, Laws of thermodynamics, State and path functions, Intensive and extensive quantities, Energy, Enthalpy, Specific heat, Chemical potential, Entropy, Free energy, Application to engines, Phase change, Mixtures, and chemical equilibrium, Colligative Properties, Activity and activity coefficient, Debye-Hückel theory and ionic conductivity, Nernst equation and cells, Electrode thermodynamics and kinetics, Interfacial phenomena.

INSTRUCTOR: Naga Phani Aetukuri

SUGGESTED BOOKS:
1. McQuarrie, and Simon, Physical Chemistry – A Molecular approach
2. Silbey, Alberty, and Bawendi, Physical Chemistry
3. Berry, Rice, and Ross, Physical Chemistry
4. Fermi, E., Thermodynamics
5. Crow, D. R. Principles and Applications of Electrochemistry

UC 204: INORGANIC CHEMISTRY: CHEMISTRY OF ELEMENTS (2:0)
(CORE FOR MAJORS)

Chemistry of d-block elements: bonding – VBT, CFT, MOT, Orgel diagrams, Descriptive chemistry of metals: periodic trends, chemistry of various oxidation states of transition metals, oxidation states and EMFs of groups, Iioinorganic chemistry: metals in biological systems, heme and non-heme proteins, metalloenzymes, Chemistry of f-block elements.

INSTRUCTOR: K.Geetharani

SUGGESTED BOOKS:

1. Shriver, D. F. and Atkins, P.W. Inorganic Chemistry, 4th edition, ELBS
2. Huheey, J. E., Lieter, E. and Leiter, K. Inorganic Chemistry, Harper International Edition
3. Greenwood, and Earnshaw, Chemistry of Elements, Maxwell Macmillan
4. Cottton, and Wilkinson, Advanced Inorganic Chemistry, Wiley International

UC 205: BASIC ORGANIC REACTIONS (2:0)
(CORE FOR MAJORS)

Acids and bases: effect of structure, kinetic & thermodynamic acidity, general & specific acid/ base catalysis; Reactions of carbon-carbon multiple bonds: addition of halogens, hydrogen halides & interhalogen compounds, hydration, epoxidation, dihydroxylation, ozonolysis, cyclopropanation, hydrogenation; Reactions of carbonyl compounds: addition to carbonyls, oxidation, reduction, rearrangements & their applications, C−C bond forming reactions involving carbonyls; Introduction to pericyclic reactions: cycloadditions, electrocyclic reactions, sigmatropic rearrangement and group transfer reactions. Introduction to organometallic reagents: Grignard reagents, organolithium, organocopper and organozinc compounds.

INSTRUCTOR: Garima Jindal

SUGGESTED BOOKS:
1. Norman, R. O. C. and Coxon, J. M. 1993 Principles of Organic Synthesis, 3rd edition
2. Carruthers, W. and Coldham, I. 2004 Modern Methods of Organic Synthesis, 4th edition, Cambridge University Press
3. Clayden, J., Greeves, N., Warren, S. and Wothers, P. 2000 Organic Chemistry, Oxford University Press

4. Carey, F. A. and Sundberg, R. J. 2007 Advanced Organic Chemistry, Part A & Part B, 5th edition, Springer

Pre-requisite: Successful completion of UC206

UC 207 T: INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS (2:)) (CORE FOR MAJORS AND MINORS)

Propagation of errors in measurement, statistical analysis of data, etc., Separation Techniques: extraction and separation, principles of chromatography, Electroanalytical Techniques: voltammetry and its variants, ion selective electrodes and electrochemical techniques for analysis, Spectroscopic Techniques: atomic absorption/emission, electronic, fluoresecence, and vibrational (IR and Raman), Spectroscopy: basic principles, operation and application to chemical problems, NMR Spectroscopy, Basic principles and operation, Application of one dimensional NMR for identification of chemicals, Mass Spectrometry: Principles and Applications.

INSTRUCTORS: K.Veerabhadrarao Kaliginedi and Anoop Thomas

SUGGESTED BOOK:
1. Skoog, Fundamentals of Analytical Chemistry, 8th edition, West, Holler and Crouch

UC 207 L: (0:1
INSTRUCTORS: K.Veerabhadrarao Kaliginedi and AnoopThomas

SEMESTER 5 (AUGUST)

CD 211: PHYSICAL CHEMISTRY I - QUANTUM CHEMISTRY AND GROUP THEORY (3:0) (CORE FOR MAJORS)

Postulates of Quantum Mechanics and introduction to operators; Exactly solvable problems Perturbational and Variational Methods, Hückel model, Many electron Atoms, Slater determinants, Har- tree-Fock Variational method for atoms; Molecular Quantum Mechanics, Symmetry and Group theory, Point Groups, Reducible and Irreducible Representations (IR), Great Orthogonality theorem, Projection operators, applications to molecular orbitals and normal modes of vibration and selection rules in spectroscopy.

INSTRUCTOR: Upendra Harbola

SUGGESTED BOOKS:
1. Levine, Quantum Chemistry
2. Griffiths, D., Introduction to Quantum Mechanics
3. Cotton, F. A., Chemical Applications of Group Theory

CD 212: INORGANIC CHEMISTRY-MAIN GROUP AND COORDINATION CHEMISTRY (3:0) (CORE FOR MAJORS)

Main Group: Hydrogen and its compounds – ionic, covalent, and metallic hydrides, hydrogen bonding; chemistry of lithium, beryllium, boron, nitrogen, oxygen and halogen groups; chains, rings, and cage compounds; Coordination chemistry: molecular orbital theory, spectral and magnetic properties; Tanabe- Sugano diagrams; inorganic reactions and mechanisms: hydrolysis reactions, substitution reactions trans-effect; isomerization reactions, redox reactions; mixed valence systems; chemistry of lanthanides and actinide elements.

INSTRUCTORS: E. D. Jemmis and Abhishake Mondal

SUGGESTED BOOKS:
1. Shriver, and Atkins' Inorganic Chemistry by: Atkins, Overton, Rourke, Weller and Armstrong, Fifth Edition. South Asia Edition (paperback), Oxford University Press, 2010
2. Bochmann, M., Cotton, F. A., Wilkinson, G. and Murilla, C. A. 2007 Advanced Inorganic Chemistry, 6th edition, Wiley Student Edition, NY
3. Huheey, J. E., Keiter, E. A., Keiter, R. L. and Medhi, O. K. 2006 Inorganic Chemistry, Principles of Structure and Reactivity, 4th edition, Pearson

CD 213: ORGANIC CHEMISTRY – STRUCTURE & REACTIVITY (3:0) (CORE FOR MAJORS)

Stereochemistry and chirality; Conformation of acyclic and cyclic compounds including medium rings, effect of conformation on reactivity. Methods of deducing organic reaction mechanisms: Kinetic analysis, Hammond postulate, Curtin-Hammett principle. Linear free energy relationships – Hammett equation. Kinetic isotope effects. Solvent effects on reaction rates.
Reactive intermediates, classical and nonclassical carbocations, carbanions, free radicals, carbenes, nitrenes, arynes, radical ions, diradicals. Photochemistry. Concerted reactions. FMO theory, Woodward-Hoffman rules.

INSTRUCTORS: Uday Maitra and Mrinmoy De

SUGGESTED BOOKS:
1. Anslyn, E. V. and Dougherty, D. A. 2006 Modern Physical Organic Chemistry, University Science Books
2. Smith, M. B. and March J. 2007 March's Advanced Organic Chemistry: Reactions, Mechanisms and Structure, 6th edition, Wiley
3. Carey, F. A. and Sundberg, R. J. 2008 Advanced Organic Chemistry, Part A, 5th edition, Plenum
4. Lowry, T. M. and Richardson, K. S. 1998 Mechanism and Theory in Organic Chemistry, Third Edition, Addison - Wesley - Longman

UC 301: ORGANIC & INORGANIC CHEMISTRY LABORATORY (0:1) (CORE FOR MAJORS)

Common organic transformations such as esterification, Diels-Alder reaction, oxidation-reduction, Grignard reaction, etc. Isolation and purification of products by chromatographic techniques, characterization of purified products by IR and NMR spectroscopy. Synthesis of coordination complexes, preparation of compounds of main group elements, synthesis of organometallic complexes. Physicochemical characterization of these compounds by analytical and spectroscopic techniques.

INSTRUCTOR: P. Thilagar

SEMESTER 6 (JANUARY)

CD 221: PHYSICAL CHEMISTRY II: STATISTICAL MECHANICS (3:0) (CORE FOR MAJORS)

Review of thermodynamics, ensembles, partition functions, Classical and quantum statistics. Application to blackbody radiation, electron conduction, molecular systems, specific heats of solids, classical fluids and phase transitions.

INSTRUCTOR: Awadhesh Narayan

SUGGESTED BOOKS:
1. Callen, H. B., Thermodynamics and Introduction to Thermostatistics
2. Fermi, E., Thermodynamics
3. McQuarrie, D. A., Statistical Mechanics
4. Chandler, D., Introduction to Modern Statistical Mechanics

CD 222: MATERIALS CHEMISTRY (3:0) (CORE FOR MAJORS)

Structure of solids, symmetry concepts, crystal structure. Preparative methods and characterization of inorganic solids. Crystal defects and non-stoichiometry. Interpretation of phase diagrams, phase transitions. Kinetics of phase transformations, structure property correlations in ceramics, glasses, polymers. Composites and nano-materials. Basics of magnetic, electrical, optical, thermal and mechanical properties of solids.

INSTRUCTORS: Prabeer Barpanda and P. Rajamalli

SUGGESTED BOOKS:
1. West, A. R. 1984 Solid State Chemistry and its Applications, John Wiley and Sons
2. Shackelford, J. F. 1988 Introduction to Materials Science for Engineers, MacMillan

CD 223: ORGANIC SYNTHESIS (3:0) (CORE FOR MAJORS)

Synthetic methods, methodologies and mechanisms in reductions, oxidations of carbon-carbon and carbon-heteroatom bonds; Carbon-carbon bond-forming methodologies through ionic, radical, concerted and organometallic reaction mechanisms; Approaches to multi-step synthesis with examples of chosen natural and un-natural product synthesis, through anti-thetic analysis and logical synthesis.

INSTRUCTORS: A. T. Biju, Durga Prasad Hari and T. K. Chakraborty

SUGGESTED BOOKS:
1. House, H. O. 1972 Modern Synthetic Methods, W. A. Benjamin, Inc
2. Smith, M. B. 2002 Organic Synthesis, McGraw-Hill
3. Corey, E. J. and Chung, 1989 Logic in Chemical Synthesis, John-Wiley & Sons

Chosen primary literature and review articles.
PREREQUISITES: UG students having completed UC 205, CD 213;

UC 302: PHYSICAL AND ANALYTICAL CHEMISTRY LABORATORY (0:1) (CORE FOR MAJORS)

Chemical kinetics. Langmuir adsorption, chemical analysis by potentiometric and conductometric methods, cyclic voltametry, flame photometry, electronic states by UV-Visible spectroscopy, IR spectroscopy, solid state chemistry -synthesis of solids and chemical analysis. Thermogravimetry. X-ray diffraction, electrical and magnetic properties of solids. Vacuum techniques in preparative chemistry.

INSTRUCTOR: Vivek Tiwari

SUGGESTED BOOK:
1. Vogel, A. I. 1989 Vogel's text book of quantitative chemical analysis Longman.

UC 303: BASIC ORGANOMETALLIC CHEMISTRY (3:0) (CORE FOR MAJORS)

Structure and bonding in organometallic compounds – isolobal analogies, metal carbonyls, carbenes

and NHC complexes, olefin and acetylene complexes, alkyls and allyl complexes, metallocenes. Major reaction types − oxidative addition, reductive elimination, insertion, isomerization and rearrangement reactions. Catalytic reactions: metathesis, hydrogenation, allylic activation, C-C coupling reactions, C-X coupling.

INSTRUCTOR : Balaji R. Jagirdar

SUGGESTED BOOKS
1. Elschenbroich, Ch. 2005 Organometallics, 3rd edition, Wiley-VCH, Weinheim
2. Gupta, B. D. and Elias, A. J. 2013 Basic Organometallic Chemistry: Concepts, Syntheses and Applications (Second edition)

SEMESTER 7 (AUGUST)

UC 402: MOLECULAR SPECTROSCOPY, DYNAMICS AND PHOTOCHEMISTRY (3:0) (CORE FOR MAJORS)

Energy levels of molecules and their symmetry, Polyatomic rotations and normal mode vibrations. Electronic energy states and conical intersections (6); time-dependent perturbation theory and selection rules (6); microwave, infrared and Raman, electronic spectroscopy (12); energy transfer by collisions, both inter and intramolecular. Unimolecular and bimolecular reactions and relations between molecularity and order of reactions, rate laws (6); temperature and energy dependence of rate constants, collision theory and transition state theory, RRKM and other statistical theories (6); photochemistry, quantum yield, photochemical reactions, chemiluminescence, bioluminescence, kinetics and photo- physics (6).

INSTRUCTOR : Sai G. Ramesh

SUGGESTED BOOKS:
1. Levine, I. N., Molecular Spectroscopy
2. McHale, J. L., Molecular Spectroscopy
3. Steinfeld, J. I., Fransisco, J. S. and Hase, W. L., Chemical Kinetics and Dynamics
4. Laidler, K. J., Chemical Kinetics

SEMESTER 8 (JANUARY)

UC 400 : PROJECT (0:14) (CORE FOR MAJOR)

The final year research project aims to introduce undergraduate students to actual research. Students perform research under the supervision of a faculty member of the chemical sciences division. The project supervisor is decided by the mutual consent of the student and the concerned faculty member. The project is evaluated at the end of the eighth semester by a committee of faculty from the division of chemical sciences. Students are required to submit a project report towards the end of the semester as well as make a short presentation emphasizing their novel findings.

INSTRUCTORS : Santanu Mukherjee and Sai G. Ramesh

SEMESTER 10 (JANUARY)

UC 500 :PROJECT (0:20) (CORE FOR MAJORS)

INSTRUCTORS : Santanu Mukherjee and Sai G. Ramesh

EARTH AND ENVIRONMENTAL SCIENCES

SEMESTER 4 (JANUARY)

UES 202: INTRODUCTION TO EARTH SYSTEMS (2:1)
(CORE COURSE FOR EARTH & ENV. SCI. MAJOR)

Earth surface features, concept of geomorphology, weathering phenomena, physics and chemistry of earth's interior, internal processes, tectonics through time, geological time scale, bio-stratigraphy, early Earth, rock formation, rock classification, mineralogy, basics of crystal symmetry, composition of atmosphere and origin of atmosphere, Earth-like planetary bodies, evidence of life on other planets, basics of hydrosphere and its components, physical properties of water, elementary oceanography, chemical composition of ocean, evolution of life and its diversification.

INSTRUCTORS: Sambuddha Misra and Attreyee Ghosh

SUGGESTED BOOKS:
1. Patwardhan, The Dynamic Earth System, P. H. I. Learning Private Limited, New Delhi, ISBN -978-81-203-1496-2
2. Kump, L. R., Kasting, J. F. and Crane, R. G. The Earth System, Prentice Hall, ISBN 0-13-142059-3
3. Thompson, G. R. and Turk, J. Modern Physical Geology, Saunder College Publishing

UES 206: EXPERIMENTAL METHODS IN ENVIRONMENTAL CHEMISTRY (1:2)
(CORE COURSE FOR EARTH & ENV. SCI. MAJOR)

Characterization of Water Quality - Electrical conductivity, pH, Chlorides, Sulphates, Alkalinity, Hardness. Characterization of pollutants in water - Estimation using spectroscopic and chromatographic techniques; Determination of dissolved and suspended solids in water samples, determination of turbidity of water samples; Determination of chlorine in bleaching powder; Determination of the optimum dosage of coagulant for coagulation of suspended solids in water sample; Estimation of total coliforms by MPN and Membrane Filtration Method; Soil surface sorption properties - Cation exchange capacity, organic content, grain size distribution, pore water salinity; Sampling and measurement techniques in air quality - Gaseous pollutants and particulates, air quality standards, Instrumental techniques for gas analysis.

INSTRUCTOR: Sreenivasan Ramaswami

SUGGESTED BOOKS:
1. APHA, 1999. Standard methods for the examination of water and wastewater. American Public Health Association, 20th edition, Washington DC
2. SP 36: Part 1: 1987 Compendium of Indian standards on soil engineering: Part 1- Laboratory testing of soils for civil engineering purposes

UES 304: INTRODUCTION TO BASIC GEOLOGY (2:1)
(CORE COURSE FOR EARTH & ENV. SCI. MAJOR)

Classification of rocks; geology of southern India: tectonic concepts; the earth structures and its significance; shear/suture zones - identification, interpretation and implications, fluid influence in shear zones; petrological, geochemical and geochronological: methods, approaches and inferences, origin-exhumation weathering; the rock cycle, landforms, element mobility and interactions; linking rocks/mineral chemistry to tectonics with Indian examples. Laboratory component: Sample preparation of rock specimens, petrological observation of rock and mineral thin sections.

INSTRUCTOR: K. Sajeev

SUGGESTED BOOKS:
1. Vernon, R. H. and Clarke, G. 2008. Principles of Metamorphic Petrology, Cambridge University Press
2. Vernon, R. H. 2004. A Practical Guide to Rock Microstructure, Cambridge University Press
3. Rollinson, H. R. 1993. Using Geochemical Data: Evaluation, Presentation, Interpretation, Longman Publishing Group
4. Condie, K. C. 2004. Earth as an Evolving Planetary System, Academic Press; 1st edition
5. Pluijm, B. A. V. D. and Marshak, S. 2003. Earth Structure: An Introduction to Structural Geology and Tectonics, W. W. Norton & Co. Inc., 2nd edition
6. Philpotts, A. R. 2003. Petrography of Igneous and Metamorphic Rocks, Waveland Press, Inc

SEMESTER 5 (AUGUST)

UES 302: DESIGN PRINCIPLES IN ENVIRONMENTAL ENGINEERING (2:0)
(CORE COURSE FOR EARTH & ENV. SCI. MAJOR)

Laws of conservation: mass, energy and momentum balances. Fundamentals of chemical reaction engineering: thermodynamics, stoichiometry and kinetics of chemical reactions, chemical reactors – stirred tank and plug flow reactors. Design for waste water treatment processes: physical unit operations such as sedimentation and filtration, chemical and biological treatment processes. Design for air

pollution control: gas-liquid interactions, absorption and adsorption processes, particulate emission control.

INSTRUCTOR: Laxminarayan Rao

SUGGESTED BOOKS:
1. Davis, M. and Masten, S. 2004. Principles of Environmental Engineering, McGraw Hill
2. Davis, M. and Cornwell, D. 2006. Introduction to Environmental Engineering, McGraw Hill
3. Mihelcic, J. and Zimmerman, J. B. 2010. Environmental Engineering: Fundamentals, sustainability and Design, John Wiley
4. Spellman F. R. and Whiting, N. E. 2005. Environmental Engineer's Mathematics Handbook, CRC Press

UES 306 SURFACE & GROUNDWATER QUALITY (3:0)
(CORE COURSE FOR EARTH & ENV. SCI. MAJOR)

Basic characteristics of water quality, stoichiometry and reaction kinetics. Mathematical models of physical systems, completely and incompletely mixed systems. Movement of contaminants in the environment. Water quality modeling in rivers and estuaries - dissolved oxygen and pathogens. Water quality modeling in lakes and ground water systems.

INSTRUCTOR: M Sekhar

SUGGESTED BOOKS:
1. Chapra, S.C., Surface Water Quality Modeling, McGraw Hill, 1997
2. Tchobanoglous, G., and Schroeder, E.D., Water Quality, Addison, Wesley, 1987

UES 310: EXPERIMENTAL METHODS IN SOLID WASTE MANAGEMENT (1:2)
(CORE)

Solid waste characterization – Water leach test, Toxicity Characteristic Leach Procedure; Pollutant sorption capacity characterization – Kinetics & adsorption isotherms, Distribution coefficients; Pollutant transport – Column experiments to evaluate transport and partitioning in vadose and saturated zones, Diffusion coefficients. Laboratory determination of soil permeability for contaminant flow; Chemical solidification of contaminated wastes – Lime and cement stabilization, Leaching and compressive strength measurements.

INSTRUCTORS: P. Raghuveer Rao and Sreenivasan Ramaswami

SUGGESTED BOOKS:
1. US EPA Publication SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, 1996
2. BIS Compendium on Engineering Properties of Soils

SEMESTER 6 (JANUARY)

UES 303: INTRODUCTION TO GEOCHEMISTRY (2:1)
(ELECTIVE)

Geochemical Fundamentals/Chemistry Review, The Elements; basic principles of inorganic chemistry, periodic properties, thermodynamics and chemical reactions, solubility, Aquatic Chemistry, pH-pE, Biology and redox, Organic Chemistry; High temperature Geochemistry - Planetary geochemistry, Age

and Origin of the Solar System, Planet formation, differentiation of the Earth, igneous processes, Radiogenic isotope geology/ Geochronology; Low temperature Geochemistry - The hydrologic cycle and Sedimentary geochemistry, Chemical Processes, Photosynthesis/respiration, Aquatic Microbial Biochemistry in rain, rivers, lakes, estuaries, Chemical weathering, soil formation, geochemistry of clays, the oceans, marine chemistry, primary productivity, Gaia, Marine Sediments: a record of environmental global history, light isotope geochemistry, Global Climate: Present and Future, atmospheric CO. Lab component: It will involve exposure to instrumental methods which include (a) titration (b) chromatography using liquid and gas columns (c) analyses of cation and anion using Ion Chromatography, towards chemical analysis of rock samples, measurement of soil moisture contents, geo-chemical characterization of rock samples and determination of CO_2 concentrations in air.

INSTRUCTOR: Sambuddha Misra

SUGGESTED BOOKS:

1. Walther, J. V. 2009. Essentials of Geochemistry, Jones and Bartlett Publishers 2nd edition
2. Gill, R. 1995. Chemical Fundamentals of Geology, Springer, 2nd edition

CE 207 (JAN) 3:0 GEOENVIRONMENTAL ENGINEERING
(ELECTIVE)

Sources, production and classification of wastes, Environmental laws and regulations, physico-chemical properties of soil, ground water flow and contaminant transport, contaminated site characterization, estimation of landfill quantities, landfill site location, design of various landfill components such as liners, covers, leachate collection and removal, gas generation and management, groundwater monitoring, end uses of landfill sites, slurry walls and barrier systems, design and construction, stability, compatibility and performance, remediation technologies, stabilization of contaminated soils and risk assessment approaches.

INSTRUCTOR: G L Sivakumar Babu

SUGGESTED BOOKS:
1. Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004
2. Rowe, R. Kerry, Quigley, Robert M., Brachman, Richard W. I., and Booker, John R. Barrier Systems for Waste Disposal Facilities, 2nd edn 2004. Spon Press, Taylor & Francis Group, London
3. Tchobanoglous, G., Theisen, H. and Vigil, S.A., Integrated Solid Waste Management - Engineering Principles and Management Issues, McGraw Hill (1993)

SEMESTER 8 (JANUARY)

UES 400: RESEARCH PROJECT (0:16)

An independent research project will be performed by all UG-Earth & Environmental Science Major students under the supervision of faculty. It is recommended that students initiate laboratory/ computational work during the summer break post completion of the sixth semester. The progress of the project will be monitored at the end of the seventh semester by a committee comprising of project supervisor, common examiner and external examiner. The student shall submit project report at end of 8th semester and make a presentation to the committee. Based on the overall student's performance, final grade will be awarded to the research project by the committee.

INSTRUCTORS: Faculty members involved in Earth & Environmental Science Program

ENGINEERING

UG INSTRUCTOR
Vijaya Bhaskar Reddy

SEMESTER 1 (AUGUST)

UE 101: ALGORITHMS AND PROGRAMMING (2:1)

Notions of algorithms and data structures. Introduction to C programming. Importance of algorithms and data structures in programming. Notion of complexity of algorithms and the big-O notation. Iteration and Recursion. Algorithm analysis techniques. Arrays and common algorithms with arrays. Linked lists and common algorithms with linked lists. Searching with hash tables and binary search trees. Pattern search algorithms. Sorting algorithms including quick-sort, heap-sort, and merge-sort. Graphs: shortest path algorithms, minimal spanning tree algorithms, depth first and breadth first search, algorithm design techniques including greedy, divide and conquer, and dynamic programming.

INSTRUCTORS: Dr. Rekha Pai and Dr. Viraj Kumar

SUGGESTED BOOKS:
1. Brian W. Kernighan and Dennis M. Ritchie, The C Programming Language. Prentice Hall of India, 2009
2. Abhiram Ranade, An Introduction to Programming through C++. McGraw Hill, First Edition, 2017
3. Robert L. Kruse, Data Structures and Program Design in C. Prentice Hall of India, 2006

4. Steven S. Skiena, The Algorithm Design Manual. Springer, Second Edition, 2008
5. Sanjay Dasgupta, Christos Papadimitriou and Umesh Vazirani. Algorithms. McGraw Hill, 2017
6. Mark Allen Weiss, Data Structures and Algorithm Analysis in C. Pearson, Second Edition, 2002

SEMESTER 2 (JANUARY)

UE 102: INTRODUCTION TO ELECTRICAL AND ELECTRONICS ENGINEERING (2:1)

Ohm's law, KVL, KCL, resistors and their characteristics, categories of resistors, series parallel resistor networks, capacitors and their characteristics, simple capacitor networks, simple RC circuit and differential equation analysis, frequency domain analysis and concepts of transfer function, magnitude and phase response, poles, inductors and their characteristics, a simple LR circuit and differential equation analysis, frequency domain transfer function and time constant, LRC circuit and second order differential equation, frequency domain analysis, resonance and quality factor, introduction to Faraday's and Lenz's laws, magnetic coupling and transformer action for step up and step down, steady state AC analysis and introduction to phasor concept, lead and lag of phases in inductors and capacitors, con- cept of single phase and three phase circuits, semiconductor concepts, electrons & holes, PN junction concept, built-in potential, forward and reverse current equations, diode operation and rectification, Zener diodes, Simple Diode circuits like half-wave rectifier and full wave rectifier, NPN and PNP bipolar transistor action, current equations, common emitter amplifier design, biasing and theory of opera- tion, MOSFET as a switch, introduction to PMOS and NMOS. Introduction to Op-amp concept, char- acteristics of an ideal op-amp a simple realisation of op-amp using transistors, various op-amp based circuits for basic operations like summing, amplification, integration and differentiation, introduction to feedback concept.

LAB: Design of 3 transistor op-amp and its characterisation. Simple op-amp applications using 741, MOSFET circuits for some simple gates, simple combinational functions, Basic flip-flop operation and clocks in digital design, introduction to A/D conversion, introduction to 8051 microcontroller and assembly language programming.

INSTRUCTOR: K. Rajan

SUGGESTED BOOK:
1. Paul Horowitz and Winfield Hill, The Art of Electronics, Cambridge University Press, 2nd Edition, 1989

SEMESTER 3 (AUGUST)

UE 200: INTRODUCTION TO EARTH AND ITS ENVIRONMENT (2:0)

Nucleosynthesis, formation of planets, minerals, rocks and bulk earth composition; radioactivity and age of the earth; mantle convection and plate tectonics; introduction to stable isotope geochemistry; general application of stable isotopes; the carbon cycle; The S cycle; The nitrogen cycle; chemical weathering and global thermostat; short-term climate variation; wind and oceanic circulation; Ther- mohaline circulation and its role in climate change; surficial water cycle aqueous chemistry; redox chemistry in aquatic environment − implication and application; carbonate chemistry and its applica- tion; instrumentation in environmental and low-temperature geochemistry

INSTRUCTORS: Prosenjit Ghosh, Ramananda Chakrabarti, Sambuddha Misra and Sajeev Krishnan

SUGGESTED BOOKS:
1. Environmental and Low-temperature Geochemistry - Peter Ryan
2. How to Build a Habitable Planet - Langmuir and Broecker

UE 202: INTRODUCTION TO MATERIALS SCIENCE (2:0)

Bonding, types of materials, basics of crystal structures and crystallography, thermodynamics, thermo- chemistry, unary systems, methods of structural characterization, thermodynamics of solid solutions, phase diagrams, defects, diffusion, Solidification, Solid-solid phase transformations, mechanical be- haviour: elasticity, plasticity, fracture, Electrochemistry and corrosion, Band structure, electrical, mag- netic and optical materials, Classes of practical materials systems: metallic alloys, ceramics, semicon- ductors, composites.

INSTRUCTOR: T. A. Abinandanan

SUGGESTED BOOK:
1. Callister, W. D., Materials Science and Engineering, Wiley India, 2007

UE 201: INTRODUCTION TO SCIENTIFIC COMPUTING (2:1) (SEMESTER 5/7) (AUGUST)

Number representation, stability and convergence and error analysis; Interpolation: Lagrange, Newton's Divided Difference, Neville; Root finding: Bisection, Newton- Raphson, Secant, Regula falsi, Ridders, Steffensen; Data analysis and fitting: Goodness of fit, Chi-Square test; Numerical integration and differentiation: Newton-Cotes, Gaussian quadrature, Romberg integration, Importance sampling; Numerical solution of ODEs: Euler and Runge-Kutta methods; Fourier Series and Fourier Transforms, Basics of Sampling Theory, DFT and FFT; Simple computer implementation exercises.

INSTRUCTOR: Sashikumaar Ganesan

SUGGESTED BOOKS:
1. Kreyszig, E. Advanced Engineering Mathematics, John Wiley & Sons, 10th Edition, 2011
2. Press, W. H., Teukolsky, S. A., Vetterling, W. T. and Flannery, B. P. Numerical Recipes: The Art of Scientific Computing, Cambridge University Press, 3rd Edition, 2007
3. Hildebrand, F. B., Introduction to Numerical Analysis, 2nd edition, Dover Publications, 1987

UE 204: ELEMENTS OF SOLID MECHANICS (3:0) (SEMESTER 4/6) (JANUARY)

Elastic bodies. Axial and shear stresses, Hooke's Law, Stress resultants, Axially loaded members, Torsion of circular bars, Shear force, bending moment, and axial thrust, Theory of simple bending, Bending and shear stress distribution in beams, Two dimensional state of stress, Principal stresses and strains, Mohr's diagram, Pressure vessels, Combined states of stress and failure theories, Detection of beams, Statically indeterminate beams, Unsymmetrical bending, Shear centre, Buckling of columns, Energy methods, Principle of virtual work, Castigliano's theorems and applications.

INSTRUCTOR: Aloke Kumar

SUGGESTED BOOKS:
1. Gere, J. M. and Timoshenko, S. P., Mechanics of Materials, CBS Publishers, New Delhi, 2nd Edition, 1984
2. Popov, E. P., Engineering Mechanics of Solids, Prentice Hall, New Jersey, 1990
3. Utku, S., Norris, C. H. and Wilbur, J. B., Elementary Structural Analysis, McGraw-Hill, New York, 1991
4. Crandall, S. H. and Dahl, N. C., An Introduction to Mechanics of Solids, McGraw-Hill, New York, 1959
5. Burden, R. L. and Faires, J. D., Numerical Analysis: Theory and Applications, Indian Edition, Cengage Brooks, Cole Publishers, 2010

Note: UE 201 and DS 288 are equivalent courses and UG students are expected to register for UE`201 if they wish to take one of these courses

SEMESTERS 4, 5 AND 6

Students can choose to take courses from within pool of elective courses listed online in the One drive link https://tinyurl.com/pc87567e, towards their Engineering credits for this academic year.

HUMANITIES

INSTRUCTOR

The Humanities course as part of the Undergraduate Programme offered at the Indian Institute of Science is an opportunity to bring about synergy between the Humanities and Social Sciences (or 'Human Sciences') with the Natural Sciences. With this aim in mind, IISc offers one course in Humanities in the first six semesters of the eight semester-BS Programme. These courses are not designed to teach Humanities as a series of distinct disciplines but are designed to create an intellectual milieu in which the students learn science.

SEMESTER 1: WAYS OF KNOWING

COURSE CODE: UH 101
INSTRUCTORS: Faculty

MODULE 1: ETHNOGRAPHIC METHODS

How are cultural practices and patterns reproduced and carried forward in time? Questions such as these can be explored with the help of qualitative ethnographic methods. Originating in cultural an- thropology, these are now widely used across human sciences. Typically, ethnography collects empirical data about human societies, using fieldwork, participant observation, questionnaires,

interviews, chain sampling, and the like, to understand how social meanings are created. Of special interest to science students would be the reflexive and interpretive emphasis of ethnography, since it has a bear- ing on how to read and write scientific findings. The module will expose students to some key debates in this area through short readings and documentary films.

MODULE 2: PSYCHOLOGICAL METHODS

How do we understand experience of the self in a way that is not purely subjective? How do we understand the experience of other people (eg: how do we know when someone is in pain?) What is the importance of language as a medium by which to comprehend things? What would be the challenge to experimental sciences when language is brought into the picture? This module introduces students to some of these important debates.

MODULE 3: HISTORICAL ANALYSIS

What is the past? Where may we draw a line differentiates the past and present: Is the past a millisecond ago or a century ago? The course will examine when and how this differentiation between past and present – and with it, the discipline and method of history – emerges. It would show that the past or present distinction is essential to the 'objectivity' of the historical method. The claim to objectivity is something that the social and human sciences share with the natural sciences. In India, postcolonial thinkers have critiqued history as a western way of knowing the past. Their contention is that professional history-writing is imbued with a "historical consciousness", which many Indians who inhabit epistemic worlds outside of the University and the social sciences do not share. For many Indians, the relationship to the 'past' may not be premised on questions of facticity, evidence, and 'truth' in the scientific sense. Is there a way of understanding the ancient Indian texts which go beyond this fact or myth dyad? The course will end with this question.

MODULE 4: TEXTUAL ANALYSIS

This module introduces students to key concepts and issues in textual analysis, a method not only adopted by students of literature but also History and other disciplines. It begins with the discussion of what a text is and the relationship of the writer to the text written by him or her. It then goes on to discuss how meaning is produced from a text and who produces it. It then returns to the problem of interpretation, discussed in the earlier modules, to focus on the reader's role in interpreting texts and generating meaning, examine how texts are, and what is the role of the reader in interpreting textual meaning? In this module, students will be introduced to methods of close reading drawn from literary criticism and cultural studies.

SEMESTER 2: WAYS OF SEEING

COURSE CODE: UH 102
INSTRUCTORS: Faculty

This course introduces students to (a) the ways in which cultural forms and genres represent the world around us and (b) how we see and understand the world as refracted by these forms. There will be three modules. In short, this is a course about seeing and interpreting the forms that show us the world. Each module discusses a particular cultural form and also focuses on one theme.

MODULE 1: VISUAL ARTS

How do paintings represent reality? Is realism more "scientific" than other ways of presenting the world? How does technology determine the evolution of art forms? What problems did artists face in the Indian context as they adopted western styles and forms? Special focus on mythology and its representation in modern Indian art.

MODULE 2: LITERATURE

What do we need to know in order to appreciate creative writing? How do we read and interpret literary works? Where does meaning lie? How do we 'learn' from literature? Special focus on science fiction: good science and bad science, space or distance and time or history, human and non-human, science & technology, and nature.

MODULE 3: CINEMA AND THEATRE

History of cinema as a technological form, technophobic reactions to film. Audiences and spectatorship. Film as an urban, democratic form. How fiction and non-fiction films "document" reality and what they can they tell us about society, how to "read" films. Special focus on the city, as subject of cinema, and site of film production and viewing.

SEMESTER 3: WAYS OF DOING: MAPPING SCIENCE-SOCIETY RELATIONSHIP

COURSE CODE: UH 201
INSTRUCTORS: Faculties

MODULE 1: ECONOMICS

The aim of this module is to introduce the study of Macroeconomics, which is concerned with the analysis of major economic problems such as unemployment, inflation, and economic growth. The module will introduce and analyse several theoretical models that are developed to address these issues. The module will highlight the fundamental differences in these theoretical models that give rise to diametrically opposite policy prescriptions as solutions for the macroeconomic problems of unemployment and economic growth. This module will also help locate various policy regimes that dominated various periods of the past century in the context of the theoretical models developed in macroeconomics.

MODULE 2: PEOPLE AND NATURE

This module will approach the theme of people and nature from different perspectives – natural science, social science, humanities, and arts. The course will discuss the evolution of our conception of nature, our understanding of our place in nature and how nature works, and our attempts to describe, appreciate, control and manipulate nature. This module will be more multidisciplinary than interdisciplinary and will attempt to showcase the significant variation across disciplines, historical time and geographical space in our approach to nature, and the inevitable conflicts such variation generates.

MODULE 3: SUSTAINABLE DEVELOPMENT

This module will approach the gradually evolving concepts of sustainable development from the Indi-

an to a Global perspective and in this process, bring about the various societal forces (local and global) that evolve(d) the meanings of sustainability and sustainable development, emerging debates and likely conflicts in the future. Is sustainability Science? Examining how people of natural, engineering and social sciences perceive sustainability in different perspectives or domains and the potential to integrate these perspectives for completeness, S&T in championing sustainable development. Measuring sustainability and evolving indices for sustainability.

MODULE 4: LAW AND SCIENCE

Law and science in various ways are constitutive of modernity. This course will examine the foundational authority of law in violence and how this is enmeshed with the authority of science. Law and justice are often assumed to bear the same meaning, but law, unlike justice, is about the application of general norms that are blinded to the unique, particular realities of people. This is again different from laws in science that are based on experiment and observation. The functioning of law in society is based on legal fictions especially that of the "reasonable man" that is borrowed from Western legal tradition. The figure of the reasonable man is emblematic of the hierarchies and exclusions inbuilt into the legal system. In this course, we will explore citizenship and gender as issues where questions of legal and scientific authority are raised, firstly biometric authentication in UID and the reliance on technology to resolve issues of poverty and crisis, secondly variance in gender or transgender described as a medical pathology by the courts.

SEMESTER 4: MAPPING INDIA THROUGH FOLK ARTS

COURSE CODE: UH 203
INSTRUCTOR: Faculty

The objective of this course is to understand the seven regions of India – North, West, East, South, Central, North-East and the Islands a little better – by looking at their folk arts. The course considers the art forms, as viewed in the discipline of Folkloristics, as means of knowing the regional cultures from "inside-out rather than outside-in". The aim of this seminar course is to provide the students a broad idea of India as a "nation", its diverse regional specificities and the relevance of the folk arts in understanding the "national" and the "regional". Every year a different folk art form is focused upon, which is narrative, visual or performative. The students get an opportunity to interact with folk artists and gain first-hand knowledge about various aspects of the arts. This is to enable the understanding of the synergy between artistic worldview and the contemporary social milieu. The course is useful in recognising how meaning is produced and expressed in folk domain, and at the same time, aids the students to gain cognizance of Indian multiculturalism. The assignments given in this course is a deliberate attempt to express science through the folk arts.

SEMESTER 5: JOURNALISM FOR SCIENTISTS

COURSE CODE: UH 301
INSTRUCTOR: Faculty

The Course will be useful in acquainting students with journalistic skills which they may apply in their own work to observe and communicate better for instance or to their field as future science reporters, perhaps or as indi- viduals who might have to explain science to the lay person. It also seeks to provoke thoughts on the practice of journalism, its tenets, its limitations and its influence with a view to encouraging a more critical engagement with media and to position science within the media.

Class 1: What is News?
The media shapes society's perception of what is newsworthy. How does one identify an event as news?

Class 2: Reporting
News gathering methods; an analysis of samples of reportage.

Class 3: How to investigate?
Innovative or extraordinary methods used in journalism to uncover truths not available by conventional means.

Class 4: New Media
Print, television, video, satellite TV, and the small screen of the cell phone. A discussion on how technological advance affects journalism.

Class 5: Reporting Science
How is science reported in the mainstream media? Is the coverage adequate and informed?

Class 6: Science Journalism
Trends and approaches in Indian and international science magazines.

Class 7: How to research and write an article for a newspaper or magazine?
Practical tips and guidelines.

Class 8: Expressing an opinion
Constructing and presenting a point of view as in a column or a review.

Class 9: The Art of the Interview
Practical tips and guidelines on conducting interviews.

Class 10: Ethics and Dilemmas
The media is both a public service and a business. What are the conflicts and compromises that journalists face?

Class 11: Preparing to write a book
Early steps in turning an idea into a book: laying the ground and writing a proposal.

Class 12:
Class Discussion possibly with Guest Speaker on dealing with the newsroom

Class 13:
Class Exercise in reading news or anchoring media debates, and so on

Class 14: Concluding Discussion
Elaborating points of interest raised in earlier classes and answering queries.

SEMESTER 6: INTRODUCTION TO GOVERNANCE - CORRECTED

COURSE CODE UH -302
6th Semester Introduction to Governance in India February - June 2021.

Course Description: The Semester programme on Introduction to Governance In India is a public policy and contemporary history programme running from the inception of the UG Programme.

The basic premise of this course is the need to be critically analytical rather than be subjectively judgemental of issues influencing governance in our country e.g. elections, defence & security, education, foreign policy, affirmative action among several others.

The course aim:
‣ Develop an appreciation of key issues and challenges to governance in India in their contemporary and historical contexts.
‣ Gain insights into how the Government of India works and relates to the people.

Every year the course will seek to make sense of current governance challenges. Thus, for the 2021 session the focus will be on defence and the security situation India faces, COVID and Government responses including vaccinations, economic consequences of the lockdown, measures to restore the economy, acceleration of infrastructure development especially in the transport sector, Indian agriculture, education etc.

Evaluation will be based on group projects and individual assignments. These will be announced during the introductory session to this course. All the sessions will have participation of experts drawn from the top echelons of public administration, strategy, the judiciary, medicine, and education labour among several others.

The Semester- long programme will be interactive and to facilitate this via Ms Teams, Zoom or Google Meets. Links to select reading material will be given ahead of each session and additionally a reading list will be recommended.

Over 12 online sessions* the course will explore the nature of governance challenges India faces as under:

1. Introduction To The Course And Assignments - Dr Uday Balakrishnan.

2. Covid – Handling A Pandemic: This session will draw on experts who will help us understand the nature of the pandemic, and the responses of the Central and state governments. The speaker & chief discussant will Dr V Raman Kutty M D, M Phil, M P H (Harvard), currently Director, Amala Cancer Research Centre, and Thrissur 680555.

3. An economy shaped by COVID: In this session the short- and long-term impact of Covid will be discussed. A panel discussion is planned comprising two distinguished economists – Dr. Vinod Vyasulu and Dr. Srinivasan Raghavendra.

4. Investing in infrastructure in India: view of the huge budget outlays for roads and railways in the present budget the role and importance of infrastructure in economic development will be covered. Mr Suresh Joseph formerly of the Indian Railways and an expert on multimodal transportation – will be the lead discussant.

5. Indian Agriculture, New Laws And Farmers Concerns: (These will be the highlight of a discussion on Indian Agriculture, its present status and prospects for the future. Professor Sukhpal Singh of IIM Ahmedabad and a one of India's leading experts on agriculture and Mr CK Ramachandran formerly of the IAS and adviser to several state governments in the social and economic sectors will participate.

6. Education India: The State of School education on which the competitiveness of the country lies has always posed a huge challenge to the country. Ms Achala Moulik, former Secretary MHRD and architect of Sarva Shiksha Abhiyan will be the principal discussant.

7. Jobs, Skills Training And The State Of Labour In India: The discussion will be led by Dr LR Krishnan who teaches in leading B-Schools including the IIMs and Dr Uday Balakrishnan who has been in charge of several labour related initiatives in the Government of India.

8. The role of the judiciary in a democracy: Former Supreme Court Justice, J. Chelemeswar is expected to be the chief discussant for this session.

9. The Social Media & Democracy: The resource persons for this will include the well-known journalist and public intellectual, Mr Amritlal of the Indian Express.

10. Article 370 and after The way forward in Kashmir: The Chief Discussant will be Mr CK Ramachandran formerly of the IAS J&K Cadre with an intimate knowledge of the former State of J&K.

11. India's Strategic Concerns: This will be covered with the help of one India's top strategic experts, Commodore Uday Baskar formerly of the Institute for Defence Studies and Analyses.

12. India, China And A Simmering Border Dispute: The long border standoff between India and China has along with Covid dominated the news. What are the reasons that India and China are confronting each other? is a resolution in sight? One of India's respected experts on China, Mr Muraleedharan Nair Distinguished Senior Fellow, Defence Research and Studies – New Delhi and who has served in China will talk and participate in a discussion on the issue.

* The above list of sessions will be subject to modifications in some cases e.g. when expected speakers decline or when something more topical will replace a less topical one.
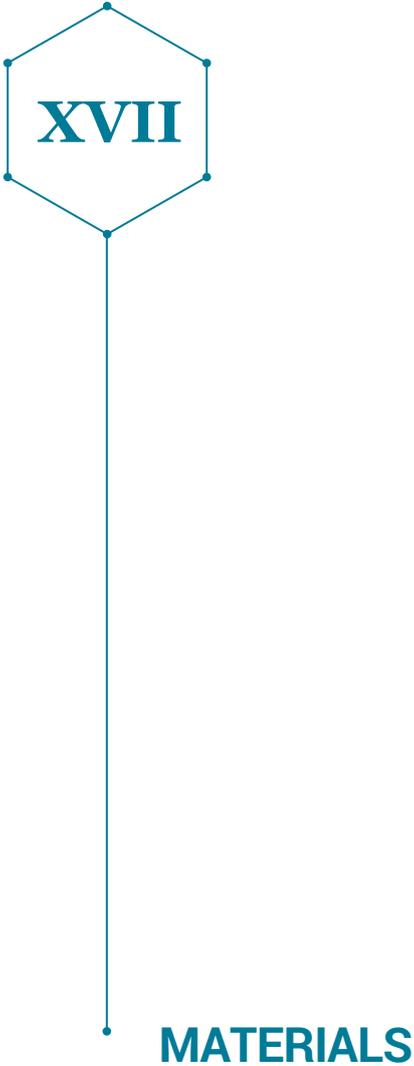
MATERIALS

UG INSTRUCTORS
Avadhani G. S., Srinivasa Reddy

SEMESTER 4 (JANUARY)

UMT 202 T: STRUCTURE OF MATERIALS (2:0) (CORE FOR MATERIALS MAJORS AND MINORS)

Elements of bonding, structures of simple metallic, ionic and covalent solids; Coordination polyhedra, projections of structures, stacking; Lattices, symmetry operations, stereographic projection; Structure and thermodynamics of point defects and solid solutions, non-stoichiometry, ordered structures; Dislocations and slip, twinning and interfaces.

INSTRUCTOR: N. Ravishankar

SUGGESTED BOOKS:
1. Kelly, A. and Groves, G. W., Crystallography & Crystal Defects, Addison Wesley
2. Barrett, C.S. and Massalski, T. B., Structure of Metals, Pergamon
3. West, A. R., Introduction to Solid State Chemistry, John Wiley

UMT 202 L STRUCTURE OF MATERIALS (0:1)

UMT 203: MATERIALS THERMODYNAMICS (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

First law, enthalpy, thermochemistry; Second law, entropy, statistical interpretation; Helmholtz and Gibbs free energies, chemical potential; Solution thermodynamics; Conditions for equilibrium, phase rule, phase diagrams; Chemical reactions and equilibria; Surfaces and interfaces.

INSTRUCTOR: T. A. Abinandanan

SUGGESTED BOOKS:
1. DeHoff, R. T. 2006. Thermodynamics in Materials Science, Taylor & Francis
2. Gaskell, D. R. 2003. Introduction to the Thermodynamics of Materials (4th Ed), Taylor & Francis

UMT 205: MECHANICAL PROPERTIES OF MATERIALS (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Structures, vector mechanics (statics) and types of loads; Introductory concepts in stress and strain and their transformation; Linear elasticity in single and poly-crystals and in amorphous solids; Stresses in constrained systems – thermal and misfit stresses; Viscoelasticity and hyperelasticity in polymers; Stress concentration; Fracture mechanics and toughening mechanisms; Introduction to plastic defor- mation; Uniaxial stress-strain curve and flow instabilities; Effect of strain, strain-rate and temperature of flow stress; Continuum-based yield criteria; Plastic deformation mechanisms – slip, twinning and diffusion; Introduction to dislocation theory – slip systems, critical resolved shear stress, strengthening mechanisms; Creep and fatigue.

INSTRUCTOR: S. Karthikeyan

SUGGESTED BOOKS:
1. Beer, F. P., Johnston, E. R., DeWolf, J. T., and Mazurek, D.F. 2014. Mechanics of Materials, 7th edition, McGraw Hill
2. Hosford, W. 2010. Mechanical Behavior of Materials, 2nd edition, Cambridge University Press
3. Courtney, T. H. 2001. Mechanical Behavior of Materials, 2nd edition, Tata McGraw Hill
4. Ward, I. M. and Sweeney, J. 2012. Mechanical Properties of Solid Polymers, 3rd edition, Wiley

SEMESTER 5 (AUGUST)

UMT 301: MATERIALS KINETICS (3:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Point defects, Fick's laws of diffusion, concept of jump frequency, activation energy, Kirkendall effect, solidification, nucleation, constitutional supercooling, sintering, interfaces, grain growth, solid state transformations, JMA theory, GP zone, Spinodal decomposition, ordering and martensitic transformations, effect of stress and electric current.

INSTRUCTORS: Aloke Paul and C. Srivastava

SUGGESTED BOOKS:
1. Reed-Hill, R. E. and Abbaschian, R. 2009. Physical Metallurgy Principles, Cengage
2. Porter, D. A. and Easterling, K. E. 2009. Phase Transformations in Metals and Alloys, Taylor and Francis

UMT 302 T: INTRODUCTION TO MATERIALS PROCESSING (2:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Metals: Principles of extraction of metals, hydrometallurgy, electrometallurgy, pyrometallurgy. Solidification processing.
Ceramics: Synthesis of ceramic powders, consolidation, sintering.
Polymers: Introduction to polymer science and engineering, polymer synthesis, introduction to polymer processing.

INSTRUCTOR : Surendra Makineni

UMT 302 L: MATERIALS PROCESSING LAB (0:1)

INSTRUCTORS : Surendra Makineni and R. J. Deshpande

SUGGESTED BOOKS:
1. Alcock, C. B. 1976. Principles of Pyrometallurgy, Academic Press, London
2. Venkatachalam, S. 1998. Hydrometallurgy, Narosa, New Delhi
3. Kingery, W. D., Bowen, H. K. and Uhlmann, D. R. 1976. Introduction to Ceramics, Wiley
4. Billmeyer, F. W. Textbook of Polymer Science
5. Gowarikar, V. R., Vishwanathan, N. V. and Sreedhar, J., Polymer Science

UMT 312 T: MECHANICAL TESTING AND FAILURE OF MATERIALS (2:0)
(CORE FOR MATERIALS MAJORS)

Overview of solid mechanics, Introduction to instrumentation, controls and data acquisition, Mechanical testing techniques: Tensile and compression, hardness, fatigue, impact, creep, fracture.

INSTRUCTOR: S. Karthikeyan

UMT 312 L: MECHANICAL TESTING AND FAILURE OF MATERIALS (0:1)

INSTRUCTORS: S. Karthikeyan and R. Ravi

Suggested Book:
Dieter, G. E. 1988. Mechanical Metallurgy, McGraw-Hill

SEMESTER 6 (JANUARY)

UMT 309: FUNCTIONAL PROPERTIES OF MATERIALS I (2:0)
(CORE FOR MATERIALS MAJORS + SOFT CORE FOR MATERIALS MINORS)

Brief review of the fundamentals of quantum mechanics, statistical mechanics, electrostatics and electrodynamics; Energy bands in crystals, density of states, electric conduction in metals and alloys, thermoelectric phenomenon and applications, semiconductors and devices, electrical properties of polymers, ceramics, dielectric and amorphous materials, classical and quantum mechanical description of optical properties, lasers, LEDs, photonics, magnetic phenomenon and applications, thermal properties of materials.

INSTRUCTOR: Rajeev Ranjan and B.Prasad

SUGGESTED BOOKS:
1. Kittel, C., Introduction to Solid State Physics, McGraw-Hill
2. Solymar, L. and Walsh, D., Lectures on Electrical Properties of Materials
3. Omar, M. A., Elementary Solid State Physics
4. Hummel, R. E., Electronic Properties of Materials

UMT 310 T: INTRODUCTION TO MATERIALS MANUFACTURING (2:0)
(CORE FOR MATERIALS MAJORS)

Processing of metallic materials: Principles of hot, warm and cold working of metallic materials; Fundamentals of metal forming processes – rolling, forging, extrusion, wire drawing and sheet metal forming, defects in forming; Introduction to metal casting and joining; Powder processing of metallic and ceramic
Materials: Powder production, compaction and sintering.
Polymer processing: Basic concepts of compounding and processing; concept of master batches; classification and type of additive for plastics: antioxidants, light stabilizers, UV stabilizers; Processing techniques: Basics of various processing techniques, Extruders: single screw and twin screw extruders, film blowing, fiber spinning, thermoforming; Molding: Injection molding, blow molding, compression molding, injection stretch blow molding, gas and water assisted injection molding.

INSTRUCTORS: S. Suwas, S. Bose and G. S. Avadhani

UMT 310 L: MATERIALS MANUFACTURING LAB (0:1)

INSTRUCTORS: S. Suwas, S. Bose and G. S. Avadhani

SUGGESTED BOOKS:
1. Grover, M. P. 2011. Introduction to Manufacturing Processes, Wiley
2. Dieter, G. E. 1988. Mechanical Metallurgy, McGraw-Hill
3. Billmeyer, F. W. Textbook of Polymer Science, 3rd Edition
4. Gowarikar, V. R., Vishwanathan, N. V. and Sreedhar, J., Polymer Science

UMT 311: FUNCTIONAL PROPERTY CHARACTERIZATION LABORATORY (0:1)
(CORE FOR MATERIALS MAJORS)

Resistivity measurement by different methods, four probe method, determination of B-H curve, Curie point measurement Hall effect experiment, magnetostriction measurement, measurement of dielectric constant as function of temperature, Seebeck effect, efficiency of solar Cell.

INSTRUCTOR: S. Dasgupta

SEMESTERS 7 (AUGUST)

UMT 401: FUNCTIONAL PROPERTIES OF MATERIALS II (3:0)
(CORE FOR MATERIALS MAJORS)

Crystal chemistry, point defects and associated thermodynamic equilibria, microstructural control (texture, porosity and grain size), energy levels (band structure in metals and semiconductors, junctions, electrical double layers), thermodynamic relationships, symmetry dependence and tensorial representation of properties; Introduction to properties: dielectric (piezoelectric, ferroelectric, pyroelectric),

magnetic (ferro-, ferri-, magnetostriction), electrical conductivity (ionic and electrical), thermoelectricity; Specific examples of systems: piezoelectric, ferro -electric and -magnetic materials (domain structure, poling, influence on endurance, soft and hard materials), Actuator materials, Energy conversion devices (common batteries, fuel cells, supercapacitors).

INSTRUCTOR: V. Jayaram

SUGGESTED BOOKS:
1. Kingery, D.W., Bowen, H.K., Uhlmann, D.R, Introduction to Ceramics, Wiley (2nd Ed.)
2. Solymar, L. and Walsh, D. Electrical Properties of Materials, Oxford University Press (8th ed.)
3. Newnham, R.E. 2004. Properties of Materials, Oxford University Press
4. Hench, L.L, West, J.K. 1990. Principles of Electronic Ceramics, Wiley

5. West, A.F., Solid State Chemistry and its Applications, Wiley (2nd ed.)

SEMESTERS 8 (JANUARY)

UMT 400: BACHELOR OF SCIENCE (RESEARCH) PROJECT (0:13)

INSTRUCTORS: Faculty from Department of Materials Engineering OR Materials Research Centre

ELECTIVES

An indicative list of graduate-level elective courses is given below; specific recommendations will be made at the beginning of each semester.

FOR THE THIRD YEAR:

‣ Fundamentals of Biomaterials and Living Matter (Bio-Engineering) Introduction to Biomechanics of Solids (Bio-Engineering)
‣ Defects in Materials (MT)
‣ Corrosion Technology (MT)
‣ Polymer Science and Engineering-I (MT)
‣ Topics in Basic and Applied Electrochemistry (IPC) Phase Transformations (MT)
‣ Interfacial Phenomena in Materials Processing (MT) Fracture (MT)
‣ Solidification Processing (MT)
‣ Defects and Materials Properties (MRC) Functional Materials Lab (MRC) Introduction to Biomaterials (MRC)
‣ Thin Films, Nanomaterials and Devices: Science and Engineering (MRC)

FOR THE FOURTH YEAR:

‣ Semiconductor Devices and Integrated Circuit Technology (CeNSE)
‣ Crystal Growth and Thin Films (CeNSE)
‣ Elements of Solid and Fluid Mechanics (CPDM)
‣ Design and Selection of Materials (MT)
‣ Defects in Materials (MT)
‣ Modeling and Simulations in Materials Engineering (MT)
‣ Introduction to Biomaterials Science and Engineering (MT)
‣ Electron Microscopy (MRC)
‣ Computational Modeling of Materials (MRC)
‣ Nanostructured Materials (MRC)
‣ Solidification Processing (MT)
‣ Fracture (MT)

LIBRARY

MATHEMATICS

UM 101 Analysis and Linear Algebra I (3:0)
T. Gudi

One-variable calculus: Real and Complex numbers; Convergence of sequences and series; Continuity, intermediate value theorem, existence of maxima and minima; Differentiation, mean value theorem, Taylor series; Integration, fundamental theorem of Calculus, improper integrals. Linear Algebra: Vector spaces (over real and complex numbers), basis and dimension; Linear transformations and matrices.

SUGGESTED BOOKS:
1.T M Apostol, Calculus, Volume I, 2nd. Edition, Wiley, India, 2007
2.G. Strang, Linear Algebra and Its Applications, 4th Edition, Brooks/Cole, 2006

UM 201 Probability and Statistics (3:0)
Vamsi Pingali

Basic notions of probability, conditional probability and independence, Bayes' theorem, random vari-

ables and distributions, expectation and variance, conditional expectation, moment generating functions, limit theorems. Samples and sampling distributions, estimations of parameters, testing of hypotheses, regression, correlation and analysis of variance.

SUGGESTED BOOKS:

1. Sheldon Ross, A First Course in Probability, 2005, Pearson Education Inc., Delhi, Sixth Edition
2. Sheldon Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier, 2010, Fourth edition
3. William Feller, An Introduction to Probability Theory and Its Applications, Wiley India, 2009, Third edition
4. R. V. Hogg and J. Ledolter, Engineering Statistics, 1987, Macmillan Publishing Company, New York

MA 200 Multivariable Calculus (3:1)
Subhojoy Gupta

Prerequisite courses for Undergraduates: UM 204

Functions on R^n, directional derivatives, total derivative, higher order derivatives and Taylor series. The inverse and implicit function theorem, Integration on R^n, differential forms on R^n, closed and exact forms. Green's theorem, Stokes' theorem and the Divergence theorem.

Suggested books and references:
1. Rudin, Principles of Mathematical Analysis, McGraw-Hill, 1986
2. B. V. Limaye and S. Ghorpade, A course in Calculus and Real Analysis, Springer
3. Spivak, M., Calculus on Manifolds, W.A. Benjamin, co., 1965

MA 212 Algebra I (3:0)
Mahesh Kakde

Prerequisite courses for Undergraduates: UM 205

Part A: Group theory
1. Basic definitions, examples
2. Cyclic groups and its subgroups
3. Homomorphisms, quotient groups, isomorphism theorems
4. Group actions, Sylow's theorems, simplicity of A_n for $n \geq 5$
5. Direct and semi-direct products
6. Solvable and nilpotent groups
7. Free groups

Part B: Ring theory
1. Basic definitions, examples
2. Ring homomorphisms, quotient rings, properties of ideals
3. Localization, ring of fractions
4. The Chinese remainder theorem
5. Euclidean domains, principal ideal domains, unique factorization domains
6. Polynomial rings over fields, irreducibility criteria

Part C: Module theory
1. Basic definitions and examples
2. Homomorphisms and quotient modules
3. Direct sums and free modules

4. Tensor product of modules
5. Structure theorem of modules over PID's and consequences
6. Noetherian rings and modules, Hilbert basis theorem

Suggested books and references:
1. Artin, Algebra, M. Prentice-Hall of India, 1994
2. Dummit, D. S. and Foote, R. M., Abstract Algebra, McGraw-Hill, 1986
3. Lang, S., Algebra (3rd Ed.), Springer, 2002
4. Hungerford, Algebra, Graduate Texts in Mathematics 73, Springer Verlag, 1974
5. Nathan Jacobson, Basic Algebra I & II, Dover, 2009
6. Nathan Jacobson, Lectures in Abstract Algebra I, II & III, Graduate Text in Mathematics, Springer Verlag, 1951

MA 219 Linear Algebra (3:1)
Apoorva Khare

Prerequisite courses for Undergraduates: UM 102

Vector spaces: Definition, Basis and dimension, Direct sums. Linear transformations: Definition, Rank-nullity theorem, Algebra of linear transformations, Dual spaces, Matrices.

Systems of linear equations: Elementary theory of determinants, Cramer's rule. Eigenvalues and eigenvectors, the characteristic polynomial, the Cayley- Hamilton Theorem, the minimal polynomial, algebraic and geometric multiplicities, Diagonalization, The Jordan canonical form. Symmetry: Group of motions of the plane, Discrete groups of motion, Finite groups of SO(3). Bilinear forms: Symmetric, skew symmetric and Hermitian forms, Sylvester's law of inertia, Spectral theorem for the Hermitian and normal operators on finite dimensional vector spaces.

Suggested books and references:
1. Artin, M., Algebra, Prentice_Hall of India, 1994
2. Halmos, P., Finite dimensional vector spaces, Springer-Verlag (UTM), 1987
3. Hoffman, K. and Kunze, R., Linear Algebra (2nd Ed.), Prentice-Hall of India, 1992

MA 231 Topology (3:1)
Siddhartha Gadgil

Prerequisite courses for Undergraduates: UM 204

Point-set topology: Open and closed sets, continuous functions, Metric topology, Product topology, Connectedness and path-connectedness, Compactness, Countability axioms, Separation axioms, Complete metric spaces, Quotient topology, Topological groups, Orbit spaces.

The fundamental group: Homotopic maps, Construction of the fundamental group, Fundamental group of the circle, Homotopy type, Brouwer's fixed-point theorem, Separation of the plane.

Suggested books and references:
1. Armstrong, M. A., Basic Topology, Springer (India), 2004
2. Munkres, K. R., Topology, Pearson Education, 2005
3. Viro, O.Ya., Ivanov, O.A., Netsvetaev, N., and Kharlamov, V.M., Elementary Topology: Problem Textbook, AMS, 2008

ELECTIVES OFFERED IN JANUARY – APRIL SEMESTER

Course No.	Course Title	Instructor
MA 221	Real Analysis (3:0)	Purvi Gupta
MA 261	Probability Models (3:0)	Sanchayan Sen
MA 223	Functional Analysis (3:0)	Tirthankar Bhattacharyya
MA 232	Introduction to Algebraic Topology (3:0	Gautam Bharali
MA 242	Partial Differential Equations (3:0)	Swarnendu Sil
MA 361	Probability Theory (3:0)	Srikanth Iyer
MA 386	Coxeter Groups (3:0)	R. Venkatesh
MA 333	Riemannian Geometry (3:0)	Ved Datar
MA 328	Introduction to Several Complex Variables (3:0)	E. K. Narayanan
MA 350	Topics in Analytic Number Theory (3:0)	Soumya Das
MA 220	Representation Theory of Finite Groups (3:0)	Shaunak Deo
MA 326	Fourier Analysis (3:0)	Manjunath
MA 353	Elliptic Curves (3:0)	Radhika Ganapathy
MA 304	Topics in Harmonic Analysis (3:0)	Thangavelu
MA 312	Commutative Algebra (3:0)	Abhishek Banerjee
MA 323	Operator Theory (3:0)	Srijan Sarkar

SEMESTER - JANUARY

UM 102 Analysis and Linear Algebra II (3:0)
Arvind Ayyer

Linear Algebra continued: Inner products and Orthogonality; Determinants; Eigenvalues and Eigen-vectors; Diagonalisation of Symmetric matrices. Multivariable calculus: Functions on Rn Partial and Total derivatives; Chain rule; Maxima, minima and saddles; Lagrange multipliers; Integration in Rn, change of variables, Fubini's theorem; Gradient, Divergence and Curl; Line and Surface integrals in R2 and R3; Stokes, Green's and Divergence theorems. Introduction to Ordinary Differential Equations; Linear ODEs and Canonical forms for linear transformations

SUGGESTED BOOKS:

1. Sheldon Ross, A First Course in Probability, 2005, Pearson Education Inc., Delhi, Sixth Edition
2. Sheldon Ross, Introduction to Probability and Statistics for Engineers and Scientists, Elsevier, 2010, Fourth edition
3. William Feller, An Introduction to Probability Theory and Its Applications, Wiley India, 2009, Third edition
4. R. V. Hogg and J. Ledolter, Engineering Statistics, 1987, Macmillan Publishing Company, New York

UM 204 Introduction to Basic Analysis (3:1)
Gautam Bharali
(CORE COURSE FOR MATHEMATICS MAJOR AND MINOR)

Basic notions from set theory, countable and uncountable sets. Metric spaces: definition and examples, basic topological notions. The topology of : topology induced by norms, the Heine-Borel theorem, connected sets. Sequences and series: essential definitions, absolute versus conditional convergence of series, some tests of convergence of series. Continuous functions: properties, the sequential and the open-set characterizations of continuity, uniform continuity. Differentiation in one variable. The Riemann integral: formal definitions and properties, continuous functions and integration, the Fundamental Theorem of Calculus. Uniform convergence: definition, motivations and examples, uniform convergence and integration, the Weierstrass Approximation Theorem.

SUGGESTED BOOKS:
1. Tao, T. 2014. Analysis I, 3rd edition, Texts and Readings in Mathematics, vol. 37, Hindustan Book Agency
2. Tao, T. 2014. Analysis II, 3rd edition, Texts and Readings in Mathematics, vol. 38, Hindustan Book Agency
3. Apostol, T. M., Mathematical Analysis, 2nd edition, Narosa

UM 205 INTRODUCTION TO ALGEBRAIC STRUCTURES (3:1)
(CORE COURSE FOR MATHEMATICS MAJOR AND MINOR)

Set theory : equivalence classes, partitions, posets, axiom of choice/Zorn's lemma, countable and uncountable sets.

Combinatorics: induction, pigeonhole principle, inclusion-exclusion, Möbius inversion formula, recurrence relations.

Number theory: Divisibility and Euclids algorithm, Pythagorean triples, solving cubics, Infinitude of primes, arithmetic functions, Fundamental theorem of arithmetic, Congruences, Fermat's little theorem and Euler's theorem, ring of integers modulo n, factorisation of polynomials, algebraic and transcendental numbers

Graph theory: Basic definitions, trees, Eulerian tours, matchings, matrices associated to graphs. Algebra: groups, permutations, group actions, Cayley's theorem, dihedral groups, introduction to rings and fields.

INSTRUCTOR: Radhika Ganapathy

SUGGESTED BOOKS:
1. A Concrete Introduction to Higher Algebra by L. Childs.
2. Groups and Symmetry by Mark A. Armstrong.
3. A Walk Through Combinatorics: An Introduction to Enumeration and Graph Theory by Miklós Bóna.
4. Elementary Number Theory by D. M. Burton.
5. A First Course in Abstract Algebra by G. Fraleigh

MA 213 Algebra II (3:1)
Shaunak Deo

Prerequisite courses: MA 212

Part A: Field theory
1. Theory of symmetric polynomials – Newton's theorem
2. Basic theory of field extensions
3. Algebraic and transcendental extensions (and transcendence degree)
4. Construction with straight edge and compass; Gauss-Wantzel theorem
5. Algebraic closure – Steinitz's theorem
6. Splitting fields, normal extensions
7. Separable extensions
8. Finite fields: construction, subfields, Frobenius
9. Primitive element theorem
10. Dedekind-Artin linear independence of (semi)group characters

Part B: Galois theory
1. Fundamental theorem of Galois theory (including Normal Basis Theorem)
2. Composite extensions and Galois group
3. Galois group of cyclotomic extensions, finite fields
4. Galois groups of polynomials, Fundamental theorem of Algebra
5. Solvable and radical extensions, insolvability of a quintic

Suggested books and references:
1. Artin, M., Algebra, Prentice_Hall of India, 1994
2. Dummit, D. S. and Foote, R. M., Abstract Algebra, McGraw-Hill, 1986
3. Lang, S., Algebra (3rd Ed.), Springer, 2002
4. Jonathan Alperin and Rowen Bell, Groups and Representations, Graduate Texts in Mathematics 162, Springer Verlag, 1995
5. Hungerford, Algebra, Graduate Texts in Mathematics 73, Springer Verlag, 1974
6. Galois Theory, Artin, E., University of Notre Dame Press, 1944
7. Nathan Jacobson, Basic Algebra I & II, Dover, 2009
8. Nathan Jacobson, Lectures in Abstract Algebra I, II & III, Graduate Text in Mathematics, Springer Verlag, 1951

MA 222 :Analysis II -Measure and Integration (3:1)
Manjunath Krishnapur

Prerequisite courses: MA 221

(Additional) Prerequisite courses for Undergraduates: UM 204

Construction of Lebesgue measure, Measurable functions, Lebesgue integration, Abstract measure and abstract integration, Monotone convergence theorem, Dominated convergence theorem, Fatou's lemma, Comparison of Riemann integration and Lebesgue integration, Product sigma algebras, Product measures, Sections of measurable functions, Fubini's theorem, Signed measures and Radon-Nikodym theorem, Lp-spaces, Characterization of continuous linear functionals on Lp - spaces, Change of variables, Complex measures, Riesz representation theorem.

Suggested books and references:
1. Royden, H. L., Real Analysis, Macmillan, 1988
2. Folland, G.B., Real Analysis: Modern Techniques and their Applications (2nd Ed.), Wiley
3. Hewitt, E. and Stromberg, K., Real and Abstract Analysis, Springer, 1969

MA 224 Complex Analysis (3:1)
E. K. Narayanan

Prerequisite courses: MA 221

(Additional) Prerequisite courses for Undergraduates: UM 204

Complex numbers, holomorphic and analytic functions, Cauchy-Riemann equations, Cauchy's integral formula, Liouville's theorem and proof of fundamental theorem of algebra, the maximum-modulus principle. Isolated singularities, residue theorem, Argument Principle. Mobius transformations, conformal mappings, Schwarz lemma, automorphisms of the disc and complex plane. Normal families and Montel's theorem. The Riemann mapping theorem. If time permits - analytic continuation and/or Picard's theorem.

Suggested books and references:
1. Ahlfors, L. V., Complex Analysis, McGraw-Hill, 1979
2. Conway, J. B., Functions of One Complex Variable, Springer-veriag, 1978

MA 241: Ordinary Differential Equations (3:1)
Harish Seshadri

Prerequisite courses: MA 221

(Additional) Prerequisite courses for Undergraduates: UM 204

Basics concepts:Introduction and examples through physical models, First and second order equations, general and particular solutions, linear and nonlinear systems, linear independence, solution techniques. Existence and Uniqueness Theorems :Peano's and Picard's theorems, Grownwall's inequality, Dependence on initial conditions and associated flows. Linear system:The fundamental matrix, stability of equilibrium points, Phase- plane analysis, Sturm-Liouvile theory . Nonlinear system and their stability:Lyapunov's method, Non-linear Perturbation of linear systems, Periodic solutions and Poincare- Bendixson theorem.

Suggested books and references:
1. Hartman, Ordinary Differential Equations, P. Birkhaeuser, 1982
2. Coddington, E. A. and Levinson, N., Theory of Ordinary Differential Equations, Tata McGraw-Hill, 1972
3. Perko, L., Differential Equations and Dynamical Systems, Springer-Verlag, 1991

ELECTIVES OFFERED

Course No.	Course Title	Instructor
MA 235	Differentiable Manifolds (Instead of 229/235) (3:0)	Ved Datar
MA 332	Algebraic Topology (3:0)	Siddhartha Gadgil
MA 313	Algebraic Number Theory (3:0)	Soumya Das
MA 390	Percolation and Random Graphs (3:0)	Sanchayan Sen
MA 324	Topics in Complex Analysis(3:0)	Purvi Gupta
MA 347	Advanced PDE and FEM (3:0)	T. Gudi
MA 263	Stochastic Finance (3:0)	Srikanth Iyer
MA 322	Harmonic Analysis (3:0)	Thangavelu
MA 374	Introduction to Calculus of Variations(3:0)	Swarnendu Sil
MA 310	Algebraic Geometry I (3:0)	Abhishek Banerjee
MA 319	Algebraic Combinatorics (3.0)	R. Venkaesh

INDIAN INSTITUTE OF SCIENCE

THIS PLAQUE WAS UNVEILED BY
SMT. PRATIBHA DEVISINGH PATIL
PRESIDENT OF INDIA
AT THE CLOSE OF THE CENTENARY YEAR
TO REDEDICATE THE INSTITUTE TO THE NATION
FOR THE ADVANCEMENT OF
SCIENCE AND TECHNOLOGY
1909-2009

PHYSICS

UG INSTRUCTORS
Dr. Jayachandraiah, Dr. A. Simimol, Dr. Haritha Pamuluri

SEMESTER 1 (AUGUST)
UP 101 T (2:0): INTRODUCTORY PHYSICS I – MECHANICS, OSCILLATIONS AND WAVES

Kinematics, laws of motion. Circular motion, work. Kinetic and potential energy. Line integrals. Conservative forces. Friction, terminal velocity in air. Systems of particles. Conservation of linear momentum. Scattering in one and two dimensions. Angular momentum. Moment of inertia. Rotation about one axis. Precession of gyroscope. Central force. Reduction of two- body problem to one-body problem and effective one-body potential. Planetary motion and Kepler's laws. Simple pendulum, damped and forced, resonance. Coupled oscillators, normal modes. Small oscillations. Transverse waves on a string. Linear superposition, interference, beats. Fourier series. Sound waves in air. Doppler effect.

INSTRUCTOR: Asha Bharadwaj

UP 101 L (1:0)
INSTRUCTORS: Jaydeep Kumar Basu and K. Ramesh

SUGGESTED BOOKS:
1. Kittel, C., Knight, W.D., Ruderman, M.A., Helmholz, A.C. and Moyer, B.J. 2011 Mechanics, Berkeley Physics Course: Volume 1, 2nd edition

2.   Kleppner, D. and Kolenkow, R.J. 2007 An Introduction To Mechanics (Special Indian Edition)

SEMESTER 2 (JANUARY)
UP 102 T (2:0): INTRODUCTORY PHYSICS II – ELECTRICITY, MAGNETISM AND OPTICS

Introduction, review of vector algebra, vector calculus: gradient, divergence, curl, Gauss' theorem and Stokes' theorem, Laplacian etc. Coulomb's law, electric field, electrostatic potential, Uniqueness theorem, conductors, capacitance, method of images, bound charges and dipole moment density, energy stored in electric fields. Magnetostatics: electric currents, Biot-savart law, Ampere's law, mag- netic fields of straight wires, circular loops and infinite solenoids, vector potential, magnetic dipole moment and bound currents. Lorentz force and Faraday's law, inductance, energy stored in a magnetic field. Linear dielectric and magnetic materials, charge conservation, displacement current, Maxwell's equations and gauge invariance, Classical wave equation and plane monochromatic waves, energy of EM waves and Poynting's theorem.

INSTRUCTOR: Srimanta Middey

UP 102 L (1:0)
INSTRUCTORS: K. Ramesh and P.S. Anil Kumar

SUGGESTED BOOKS:
1.   Purcell, E.M. 2011 Electricity and Magnetism, Berkeley Physics Course - Volume 2, 2nd edition, Tata McGraw Hill
2.   Griffiths, D.J. 2003 Introduction to Electrodynamics, 3rd edition, Prentice-Hall of India.SICS

SEMESTER 3 (AUGUST)
UP 201 T (2:0): INTRODUCTORY PHYSICS ILL - THERMAL AND MODERN PHYSICS

Temperature, The First Law of Thermodynamics, Kinetic Theory of Gases and Maxwell-Boltzmann Statistics, Heat Engines, Entropy and the Second Law of Thermodynamics, Relativity,Introduction to Quantum Physics, Basics of Quantum Mechanics, Atomic, Molecular and Solid state physics, Nuclear Physics, Particle Physics and Cosmology.

INSTRUCTORS: Baladitya Suri

UP 201 L (1:0)
INSTRUCTORS: Arindam Ghosh and R.Ganesan

SUGGESTED BOOKS:
1.   Serway, and Jewett, Physics for Scientists and Engineers (7th Edition)
2.   Young, and Freedman, University Physics (12th Edition)
3.   Halliday, Resnick and Walker, Fundamentals of Physics, Extended (8th Edition)
4.   Harris Benson, University Physics, Revised Edition
5.   Kenneth Krane, Modern Physics, Second Edition

SEMESTER 4 (JANUARY)
UP 202 T (2:0): INTERMEDIATE MECHANICS, OSCILLATIONS AND WAVES
(Core Course for Physics Major)

Special theory of relativity. Lorentz transformations. Energy-momentum relation. Lorentz four-vectors. Motion in non-inertial frames. Fictitious forces. Coriolis force. Focault pendulum. Basic scattering the- ory.Vibrations of particles on a circle and a line. Orthonormal basis. Wave equation. Fourier transform.

Phase space. Hamiltonian equations, fixed points and stability. Nonlinear equations. Chaos. Logistics map and period doubling. Fluid mechanics. Euler equation. Bernoulli's equation. Waves in fluids. Gravity waves.Viscosity. Navier-Stokes equation. Basic ideas about turbulence. Elasticity. Strain and stress tensors.Elastic moduli. Bending of rods. Waves in solids.

INSTRUCTOR: Ranjan Laha

UP 202 L (1:0)
INSTRUCTORS: Suja Elizabeth and Tapajyoti Das Gupta.

SUGGESTED BOOKS:
1. Kleppner, D. and Kolenkow, R.J. 2007 An Introduction To Mechanics (Special Indian Edition)
2. Rana, N.C. and Jog, P.S. 1991 Classical Mechanics, Tata McGraw-Hill, New Delhi
3. Landau, L.D. and Lifshitz, E.M. Fluid Mechanics and Theory of Elasticity (Vols. 6 and 7 of Course ofTheoretical Physics)

UP 203 T (2:0) : INTERMEDIATE ELECTROMAGNETISM AND THE QUANTUM PHYSICS OF RADIATION
(Core Course for Physics Major)

Electromagnetic Waves: Wave equation from Maxwell's equations, polarization, energy and momentum in EM waves, propagation in linear media, reflection and refraction, Snell's law and Fresnel's equations,Brewster angle and total internal reflection. EM waves in conductors, skin depth, simple theories for dispersion of EM waves. Wave guides and coaxial cables, optical fibers Geometrical optics: Fermat'sprinciple, Snell's law, reflection and refraction at spherical surfaces, convex and concave mirrors andlenses, real and virtual images.

Physical Optics: Coherence, Young's two slit experiment, multiple slits, diffraction grating, wavelength resolution and fringe visibility, Newton's rings, Michelson and Fabry-Perot interferometer, diffraction from rectangular and circular apertures, Airy disc and resolving power of microscopes.

Quantum optics:Photons, spontaneous and stimulated emission, Einstein A and B coefficients and relation to the Planck distribution, rate equations for absorption and emission, two level and three level systems, population inversion and light amplification, optical resonators and the basic working principle of a laser, examples of lasers: Ruby, He-Ne, semiconductor etc.

INSTRUCTOR: Nirupam Roy

UP 203 L (1:0) :
INSTRUCTORS: R. Ganesan and Akshay Singh

SUGGESTED BOOKS:
1. Griffiths, D. J. 2003 Introduction to Electrodynamics, 3rd edition, Prentice-Hall of India
2. Hecht, E. and Ganesan, A. R. 2008 Optics, 4th edition, Pearson
3. Ghatak, A. and Thyagarajan, K. 1991 Optical Electronics, Cambridge University Press

UP 204 T (2:0) : INTERMEDIATE THERMAL PHYSICS AND THE PHYSICS OF MATERIALS
(Core Course for Physics Major and Minor)

Review of kinetic theory and thermodynamics, Free energies, Phases and phase transitions, Van der Waals gas and the liquid gas transition, Thermodynamics of magnetic systems, Ensembles and rules of Statistical Mechanics, The Ideal Maxwell-Boltzmann Gas, The Ideal Fermi Gas, The Ideal Bose Gas, Crystal Structure, Lattice Vibrations, Band theory of electrons in crystalline solids, Thermal properties of crystalline solids.

INSTRUCTOR: Tarun Deep Saini

UP 204 L (1:0)
INSTRUCTORS: R.C. Mallik and Arindam Ghosh

SUGGESTED BOOKS:
1. Callen, H.B. Thermodynamics and Introduction to Thermostatistics (2nd edition), Wiley Student Edition
2. Reif, F. Statistical Physics, Berkeley Physics Course Volume 5, Tata McGraw Hill
3. Kittel, C. Introduction to Solid State Physics, 5th/6th/7th edition, Wiley International

SEMESTER 5 (AUGUST)

PH 201: CLASSICAL MECHANICS (3:0)
(Core Course for Physics Major)

Newton's laws, generalized co-ordinates. Lagrange's principle of least action and equations. Conservation laws and symmetry. Integrable problems, elastic collisions and scattering. Small oscillations including systems with many degrees of freedom, rigid body motion. Hamilton's equations. Poisson brackets.Hamilton Jacobi theory. Canonical perturbation theory, chaos, elements of special relativity. Lorentz transformations, relativistic mechanics.

INSTRUCTOR: Animesh Kuley

SUGGESTED BOOKS:
1. Goldstein, H. 1989 Classical Mechanics, 2nd edition, Narosa, New Delhi
2. Landau, L. D. and Lifshitz, E. M. 1976 Mechanics, Pergamon, UK
3. Rana, N. C. and Jog, P. S. 1991 Classical Mechanics, Tata McGraw-Hill, New Delhi

PH 203: QUANTUM MECHANICS I (3:0)
(Core Course for Physics Major)

Historical foundations. Wave function for a single particle. Hamiltonian. Schrodinger equation. Probability current. Wave packets. One-dimensional problems: step, barrier and delta-function po- tentials. Tunneling, scattering and bound states. Harmonic oscillator, operator approach. Matrix for- mulation of quantum mechanics. Hermitian and unitary operators. Orthonormal basis. Momentum representation.Uncertainty relations. Postulates of quantum mechanics. Heisenberg representation. Ehrenfest's theorem. Three-dimensional problems. Rotations, angular momentum operators, commu- tation relations.Spherical harmonics. Hydrogen atom, its spectrum and wave functions. Symmetries and degeneracies.Spin angular momentum. Spin-1/2 and two-level systems. Addition of angular mo- mentum. Spin-orbit and hyperfine interactions. Time-independent perturbation theory. Stark and Zee- man effects. Variational methods, ground state of helium atom.

INSTRUCTOR: Tanmoy Das

SUGGESTED BOOKS:
1. Cohen-Tannoudji, C., Diu, B. and Laloe, F. 1977 Quantum Mechanics, Vol.1, John Wiley.
2. Landau, L.D. and Lifshitz E.M. 1974 Quantum Mechanics, Pergamon, NY
3. Shankar, R. 2010 Principles of Quantum Mechanics, Springer
4. Schwabl, F. 1995 Quantum Mechanics, Springer

PH 205: MATHEMATICAL METHODS OF PHYSICS (3:0)
(Core Course for Physics Major)

Linear vector spaces, linear operators and matrices, systems of linear equations. Eigen values and Eigenvectors, classical orthogonal polynomials. Linear ordinary differential equations, exact and se- ries methods of solution, special functions. Linear partial differential equations of physics, separation of variables method of solution. Complex variable theory; analytic functions. Taylor and Laurent ex- pansions,classification of singularities, analytic continuation, contour integration, dispersion relations. Fourier and Laplace transforms.

INSTRUCTOR: Sriram Ramaswamy

SUGGESTED BOOKS:
1. Mathews, J. and Walker, R.L. 1973 Mathematical Methods of Physics, Benjamin, Menlo Park, California
2. Dennery, P. and Krzywicki, A. 1967 Mathematics for Physicists, Harper and Row, NY
3. Wyld, H.W. 1976 Mathematical Methods for Physics, Benjamin, Reading, Massachusetts

PH 211 L (3): GENERAL PHYSICS LABORATORY (0:3)

Diffraction of light by high frequency sound waves, Michelson interferometer, Hall effect, band gap of semiconductors, diode as a temperature sensor, thermal conductivity of a gas using Pirani gauge, normalmodes of vibration in a box, Newton's laws of cooling, dielectric constant measurements of tri-glycerineselenate, random walk in porous medium.

INSTRUCTORS: Vishnu Prasad Botla and DVS Muthu

SEMESTER 6 (JANUARY)

PH 202 T (3): STATISTICAL MECHANICS (3:0)
(Core Course for Physics Major)

Basic principles of statistical mechanics and its application to simple systems. Probability theory, funda- mental postulate, phase space, Liouville's theorem, ergodicity, micro-canonical ensemble,connection with thermodynamics, canonical ensemble, classical ideal gas, harmonic oscillators,paramagnetism, Ising model, physical applications to polymers, biophysics. Grand canonical ensemble,thermodynamic potentials, Maxwell relations, Legendre transformation. Introduction to quantum statistical mechanics, Fermi, Bose and Boltzmann distribution, Bose condensation, photons and phonons,Fermi gas, classi- cal gases with internal degrees of freedom, fluctuation, dissipation and linear response,Monte Carlo and molecular dynamics methods.

INSTRUCTOR: Justin David

SUGGESTED BOOKS:
1. Pathria, R.K. 1996 Statistical Mechanics, Butterworth Heinemann, Second edition
2. Reif, F. 1965 Fundamentals of Statistical and Thermal Physics, McGraw Hill
3. Landau, L.D. and Lifshitz, E.M. 1980 Statistical Physics, Pergamon

PH 204 T (3): QUANTUM MECHANICS II (3:0)
(Core Course for Physics Major)

Time dependent perturbation theory. Fermi golden rule. Transitions caused by a periodic external field.

Dipole transitions and selection rules. Decay of an unstable state. Born cross section for weak poten-tial scattering. Adiabatic and sudden approximations. WKB method for bound states and tun- neling. Scattering theory: partial wave analysis, low energy scattering, scattering length, Born ap- proximation, optical theorem, Levinson's theorem, resonances, elements of formal scattering theory. Minimal cou-pling between radiation and matter, diamagnetism and paramagnetism of atoms, Landau levels and Aharonov-Bohm effect. Addition of angular momenta, Clebsch Gordon series, WignerEck- art theorem, Lande's g factor. Many particle systems: identity of particles, Pauli principle, exchange interaction, bosons and fermions. Second quantization, multielectron atoms, Hund's rules. Binding of diatomic molecules. Introduction to Klein Gordon and Dirac equations, and their non-relativistic reduction, g factor of the electron.

INSTRUCTOR: Diptiman Sen

SUGGESTED BOOKS:
1. Landau, L.D. and Lifshitz, E.M. 1974 Quantum Mechanics, Pergamon, NY
2. Cohen-Tannoudji, C., Diu, B. and Laloe, F. 1977 Quantum Mechanics (2 Vols.), John Wiley

UP 400 0:16

This is a 16 credit project course of six months duration and is compulsory for the completion of the BSc Research course. The student can choose any faculty of his or her choice from any of the three departments: Physics, Centre for High Energy Physics (CHEP), Instrumentation and Applied Physics (IAP)with mutual consent and take up an advanced topic of research either in the experimental or the-oretical stream. At the end of the term, the student will submit a hard copy of the report with proper binding. The viva-voce examination will be conducted with two examiners and evaluated accordingly.

CO-ORDINATOR:

UP 500 0:20

This is a 20 credit project course of six months duration and is compulsory for the completion of the MSc course. The student can choose any faculty of his or her choice from any of the three depart-ments: Physics,Centre for High Energy Physics (CHEP), Instrumentation and Applied Physics (IAP) with mutual consent and take up an advanced topic of research either in experimental or theoretical stream. At the end of the term, the student will submit a hard copy of the report with proper binding. The viva-voce examination will be conducted with two examiners and evaluated accordingly.

CO-ORDINATOR:

OPTIONAL COURSES FOR PHYSICS MAJOR

Course Number	GP	Title	Faculty
PH 206	3:0	Electromagnetic Theory	Prasad Hegde
PH 207	1:2	Analog Digital and Microprocessor Electronics-1	Vinhor Singh
PH 208	3:0	Condensed Matter Physics -1	Vijay Shenoy
PH 212	0:3	Experiments in Condensed Matter Physics	Akshay Singh and Anindya Das
PH 213	0:4	Advanced Experiments in Condensed Matter Physics	R. Ganesan/ P. S. Anil Kumar
PH 217	3:0	Fundamentals of Astrophysics	B.Mukhopadhyay and Nirupam Roy
PH 231	0:1	Workshop practice	Vasant Natarajan
PH 320	3:0	Condensed Matter Physics II	Chandan Dasgupta
PH 325	3:0	Advanced Statistical Physics	Subroto Mukerjee and Sriram Ramaswamy
PH 330	0:3	Advanced Independent Project	Faculty
PH 351	3:0	Crystal Growth, Thin Films and Characterization	Suja Elizabeth and Anil Kumar
PH 352	3:0	Semiconductor Physics and Technology	Ramesh Mallik
PH 359	3:0	Physics at the Nanoscale	Arindam Ghosh and Ambarish Ghosh
PH 364	3:0	Topological Phases of Matter (Theory and experiment)	Tanmoy Das
PH371	?	General Theory and Cosmology	Rajeev Kumar Jain
PH365	?	Galaxies and Interstellar Medium	Mousumin Das (IIA)
HE215	3:0	Nuclear and Particle Physics	Sudhir Vempati
HE 391	3:0	Quantum Mechanics III	Apoorva Patel
HE 395	3:0	Quantum Field Theory 1	Aninda Sinha
HE 396	3:0	Quantum Field Theory 2	B.Ananthanarayan
HE 392	3:0	Standard Model Particle Physics	
HE 316	3:0	Advanced Mathematical Methods in Physics	Sachin Vaidya
HE 384	3:0	Quantum Computation	
AA 363	3:0	Fluid Mechanics and Plasma Physics	Arun Mangalam (IIA)
HE 385	3:0	Experimental high energy physics	Jyothsna Komaragiri
IN 201	3:0	Analytical Instruments	S. Asokan
IN 227	3:0	Control System Design	G.R. Jayanth

OPTIONAL COURSES FOR PHYSICS MAJOR

Course Number	GP	Title	Faculty
IN 224	3:0	Nanoscience and Device fabrication	Asha Bharadwaj
IN 229	3:0	Advanced Instrumentation Electronics	A.K. Mohanty
IN 232	2:1	Concepts in solid state physics	Chandini U
IN 234	3:0	High-Vacuum Technology and Applications	
IN 266	?	Introduction to Quantum Measurement and Control	Baladitya Suri

Minor in Bioengineering for IISc Undergraduates

Bioengineering is a thriving interdisciplinary field in academic research and industrial practice today. On one hand, Bioengineering is the engineering counterpart to life sciences just as aerospace, chemical, civil, electrical, material, and mechanical engineering disciplines are engineering extensions of physics and chemistry. On the other hand, bioengineering is much more expansive. At one end of its broad spectrum, it deals with quantitative aspects of biomolecules and cells to organs and systems. In a nutshell, bioengineering is engineering of biology, for biology, and with biology.

Understanding biology at the fundamental level using engineering principles and techniques is a hallmark of bioengineering. Emerging areas of systems and synthetic biology, which use computa- tional methods, are also within the ambit of bioengineering. Biomaterials, cell and tissue engineering, immunoengineering, and regenerative medicine are pursued within bioengineering towards the de- velopment of novel drug-delivery techniques, implants, prosthetics, and artificial organs. Neuroengi- neering interfaces neuroscience to not only understand how brain works but also to study neurological diseases and their treatment.

Development of novel diagnostic and therapeutic devices, orthotics, human-assistive devices, etc., lie at the other end of the spectrum of bioengineering. Biosensors and implantable prostheses involve micro and nano technologies. Developing novel instruments from microscopes to biochemical assays is an integral part of bioengineering. Development biomedical instruments that are crucial for medical diagnosis and treatment is also an important component of bioengineering. Signal processing, bio-electronics, medical imaging, etc., also come within the purview of bioengineering.

Working with clinicians and clinical researchers is also an aspect of bioengineering or its extension called biomedical engineering. Familiarity with physiology and anatomy empowers engineers to work on the unmet needs of clinical practice and explore careers in biomedical industry. Bioengineering also has organic links to biopharma industry.

IISc undergraduates who opt for a minor in bioengineering will become familiar with the basics of bioengineering and touch upon its multiple facets. This minor programme is administered by BioSystems Science and Engineering (BSSE), a full-fledged academic department at IISc. BSSE was founded in 2015 based on the critical mass that became evident due in response to the Interdisciplinary PhD programme in Bioengineering that started in 2012. BSSE is an inclusive department that works with several other departments as well as it numerous clinical partners. BSSE is a place of confluence of biologists, clinicians, designers, and engineers. It has primary faculty of its own, associate faculty, adjunct faculty, research staff, and PhD students. Its thematic common laboratories support research and teaching.

BSSE has a well-thought-out and growing curriculum to train and nurture students with different backgrounds to become bioengineers with expertise and appreciation for biology and engineering. In view of bioengineering minor, a few courses are selected from BSSE's curriculum to serve as core and elective courses, as shown in two tables to fulfil 15 credits required for the minor in the undergraduate programme of IISc. The core courses provide basics of traditional and emerging areas of biomaterials, biosensors, biomechanics, cell mechanics, microfluidics, and systems biology. The electives provide an opportunity to study these topics in depth, depending on the interests of the students after taking the core courses. It may be noted that the core courses are offered by BSSE while the electives are taught by BSSE and other departments at IISc. While most courses are lecture oriented, some have hands-on laboratories.

	Course Number	Course Title
CORE COURSES (10 CREDITS)	BE 213 (AUG) 2:0	Fundamentals of Bioengineering 1
	BE 214 (JAN) 2:0	Fundamentals of Bioengineering 2
	BE 210 (AUG) 3:0	Drug Delivery: Principles and Applications
	BE 211 (AUG) 3:0	Cell Mechanics
ELECTIVE COURSES (5 CREDITS)	BE 215 (JAN) 3:0	Dynamical Systems Biology
	MT 271 or MR 203 (AUG/JAN) 3:0	Introduction to Biomaterials
	ME251 (JAN) 3:0	Biomechanics
	NE203 (AUG) 3:0	Advanced micro- and nanofabrication technology and processes
	NE231 (AUG) 3:0	Microfluidics
	EC 303	Stochastic and spatial dynamics in Biology

Resistance: Tales from a Post-Antibiotic World

Aditi Pujar, Preetham Venkatesh, Gopika Ranjith,
Vidhi Sinha, Bhaskar Kumawat,
Ashim Kumar Dubey and Hari Narayanan.
Edited by Julian D'Costa
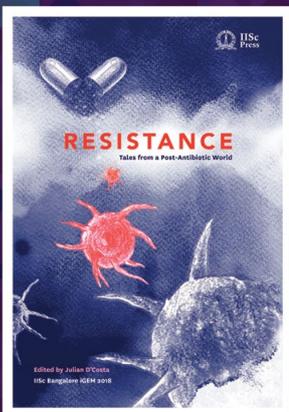
An anthology of short fiction centered on the theme of antimicrobial resistance. As pathogenic bacteria evolve to defend themselves from the antibiotics we use -and overuse - against them, this volume seeks to bring the crisis further into public consciousness with stories that illuminate, provoke, and entertain.

भारतीय विज्ञान संस्थान

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