M.Sc.-Ph.D. Course Catalog

Bose Institute

and

University of Calcutta

2019-2021

Contacts

Main Campus
93/1, Acharya Prafulla Chandra Road
Kolkata-700009, West Bengal
Phone: +91-33-2350-2402 / 2403 / 6619 / 6702
EPABX No. 2303-0000
Director: +91-33-2350-7073
Fax: +91-33-2350-6790

Centenary Campus
P-1/12, C.I.T. Scheme VII (M)
Kolkata-700054, West Bengal
Phone: +91-33-2355-9219 / 9416 / 9544 / 7430
EPABX No. 2569-3200
Director: +91-33-2355-7434
Fax: +91-33-2355-3886

Unified Academic Campus
EN-80, Sec-V, Salt Lake City
Kolkata-700091, West Bengal
Phone: +91-33-2569-3123 / 28
EPABX No. 2569-3200
Director: +91-33-2569-3131
Fax: +91-33-2569-3127

Website : http://www.jcbose.ac.in

Bose Institute

and

University of Calcutta

Integrated M.Sc. - Ph.D Programme

LIFE SCIENCES

AND

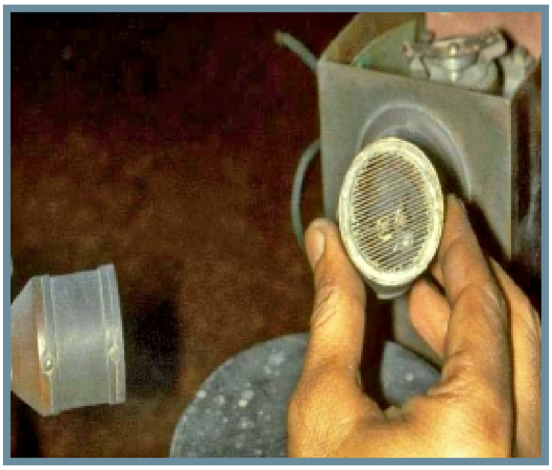
PHYSICAL SCIENCES

2019-2021

http://www.jcbose.ac.in/integrated-phd

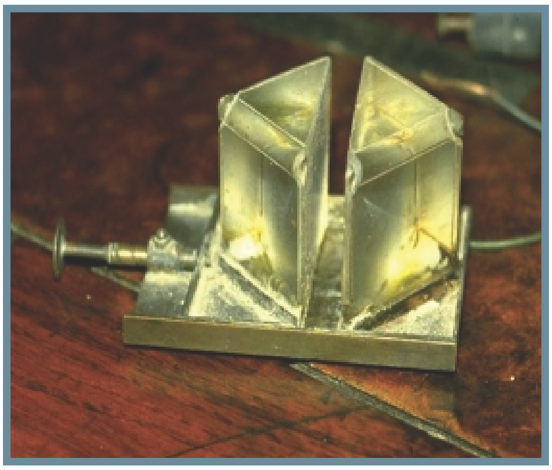
Contents

Integrated M.Sc.-Ph.D. programme in Life Sciences and Physical Sciences are being offered by Bose Institute, Kolkata in collaboration with the University of Calcutta, Kolkata. The Life Sciences programme was initiated in September 2011 and Physical Science in August 2012.



Bose Institute

Bose Institute was founded by Acharya Jagadish Chandra Bose on 30th November, 1917 with the purpose of fully investigating "the many and ever opening problems of the nascent science which includes both life and non-life." Bose Institute is one of the earliest modem institutes of India with a strong tradition of scientific research. The institute celebrated its centenary during 2016-17 through various workshops and conferences as well as several outreach programmes. On the 29th June, 2017, a state of the art Unified Academic Campus was inaugurated by the President of India.



Acharya Jagadish Chandra Bose

Acharya Jagadish Chandra Bose (November, 30, 1858 — November 23, 1937) was a Bengali polymath: a great physicist, biologist philosopher and at the same time a dreamer. He pioneered research in radio and microwave optics, made highly significant contributions to plant science and laid the foundations of experimental science in the Indian subcontinent. He is considered the father of radio science and is also considered the father of Bengali science fiction. He was the first from the Indian subcontinent to get a US patent in 1904.

University of Calcutta

Established on 24 January 1857, University of Calcutta is located in the city of Kolkata (previously Calcutta), and is one of the most renowned universities in the Indian subcontinent. Over time, it has played a vital role in the development of India's nationhood not only by spreading progressive social ideas and values but also by establishing the ability of Indian researchers to carry out advanced scientific and technological research and rediscover the great philosophical, cultural and literal heritage of the country. The university website is http://www.caluniv.ac.in

About the Program

The integrated M.Sc.-Ph.D. programme in Life Sciences and Physical Sciences are offered as a combination of a two-year (four semesters) M.Sc. course followed by a Ph. D. programme at Bose Institute, subject to qualifying conditions as mentioned later.

The M.Sc. curriculum of Life Sciences programme consists of following specializations: (i) Molecular & Cellular Biology, (ii) Plant Molecular Biology & Biotechnology, (iii) Biophysical Chemistry and (iv) Computational & Systems Biology.

In the M.Sc. curriculum of Physical Sciences programme specialization is available in the form of a one-semester project in one of the following areas: (i) High Energy Physics, Astrophysics and Cosmology, (ii) Space Science, Fluid Mechanics and Solar Physics and, (iii) Condensed matter Physics and Complex Systems.

Course Objectives

- To develop human resource with expertise in the areas of Physical and Life Sciences as mentioned above.
- To motivate young inspiring students to choose a career in basic sciences and its application to relevant fields.

Course Highlights

- The academicians of Bose Institute and other leading Institutes in Kolkata and across the country will teach and mentor the students for a Research Career in Modern Biology.
- Students will get extensive exposure to theory and experimental aspects of Modern Biology as well as computational techniques of Modem Biology.
- Extensive exposure to the theory, experimental methodologies of Modern Physics and computational techniques.
- Students will be encouraged to participate in the institutional and journal club seminars, interactive sessions and other relevant scientific activities.
- All necessary institutional facilities including Library and Internet facilities will be available for use by the students during the course.

Fellowship

- M.Sc. : During the first two years (M.Sc.) all students are offered a fellowship of Rs. 12000/- per month. Fellowship is continued if a student secures a minimum SGPA of B+ grade, and no F grade in any individual paper, of the previous semester. The student should also have at least 75% attendance in the classes in the previous semester.
- Ph.D. : Eligible students are expected to secure self funding for the Ph.D. Course through National tests.

Examination

There shall be following four examinations in the M. Sc. course in the span of two years.

Examination-I: On completion of the course specified for the first semester.

Examination II: On completion of the course specified for the second semester

Examination III: On completion of the course specified for the third semester

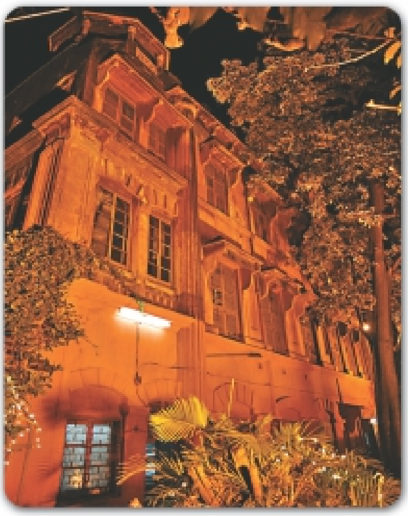
Examination IV: On completion of the course specified for the fourth semester and assigned project work and specialized subjects.

Attendance: Other than project work, no candidate shall be deemed to have pursued a regular course of study unless he/she has attended at least 75% of theory, practical and tutorial classes, in each course.

Dissertation: Dissertation shall consist of either original project work, or a detailed Review of Literature, or both, in thesis format, to be evaluated at the end of the second year.

Note: The medium of instruction and examination shall be English Practical paper will be based on continuous assessment throughout each semester.

Main Campus



Centenary Campus

Darjeeling Campus

Unified Academic Campus
EN-80, Sec-V, Salt Lake City
Kolkata – 700091, West Bengal
Phone: (+91)(33) 2569-3123
Fax: (+91)(33) 2569-3127

Centenary Campus
P-1/12, C.I.T. Scheme VII (M)
Kolkaya-700054, West Bengal
Phone: +91-33-2355-3271/9291/9416/9544/7430
Director: +91-33-2355-7434
Fax: +91-33-2355-3886

Main Campus
93/1, Acharya Prafulla Chandra Road
Kolkata - 700009
West Bengal, India
Phone: (+91)(33) 2350-2402/2403/
6619/6702
Fax: (+91)(-33) 2350-6790

ACADEMIC CALENDAR FOR M.Sc.

The academic session for M.Sc. curriculum in the Integrated M.Sc.-Ph.D. programme starts in August. The full session is divided into four semesters of 26 weeks each. The following is a generic academic calendar:

WEEK	SEMESTER 1	SEMESTER 2	SEMESTER 3	SEMESTER 4
01				
02				
03				
04	REGULAR	REGULAR	REGULAR	REGULAR
05	COURSES	COURSES	COURSES	COURSES
06				
07				
08				
09	MID-SEM	MID-SEM	MID-SEM	
10	EXAMINATION	EXAMINATION	EXAMINATION	MID-SEM EXAM
11	REGULAR	REGULAR	REGULAR	REGULAR
12	COURSES	COURSES	COURSES	COURSES
13				
14				
15				
16				
17				
18				SUBMIT PROJECT
19	STUDY BREAK	STUDY BREAK	STUDY BREAK	REPORT
20				STUDY BREAK
21				
22	EXAMINATIONS	EXAMINATIONS	EXAMINATIONS	
23				EXAMINATIONS
24	SEMESTER BREAK	SEMESTER BREAK	SEMESTER BREAK	SEMESTER BREAK
25	&	&	&	&
26	RESULTS	RESULTS	RESULTS	RESULT

FEE STRUCTURE FOR M.Sc.-Ph.D. Programme

The following are the fees to be paid by each student at the time of admission

(1)	Laboratory Caution Money (refundable after completion or dropping out of M.Sc.)		Rs.12,000.00
(2)	Library Caution Money (refundable after completion or dropping out of M.Sc.)		Rs. 3,000.00

COURSE STRUCTURE FOR M.Sc. | PHYSICAL SCIENCES

SEMESTER I **Class Weeks: 15 | Total Credits: 20 | Total Marks: 250**

Paper	Module	Subject	Contact Hours	Credits	Marks
MPHC 4101	CT-MP-I	*Mathematical Physics I*	2	2	25
	CT-MP-II	*Mathematical Physics II*	2	2	25
MPHC 4102	CT-CM	*Classical Mechanics*	3	3	35
	CT-NLD	*Nonlinear Dynamics*	1	1	15
MPHC 4103	CT-MP-III	*Mathematical Physics III*	1	1	15
	CT-QM-I	*Quantum Mechanics I*	3	3	35
MPHC 4104	CT-SP-I	*Statistical Physics I*	2	2	25
	CT-ED-I	*Electrodynamics I*	2	2	25
MPHC 4151	CE-GE-I	*General Experiments I*	8	4	50

SEMESTER II Class Weeks: 15 | Total Credits: 20 | Total Marks: 250

Paper	Module	Subject	Contact Hours	Credits	Marks
MPHC 4205	CT-QM-II	*Quantum Mechanics II*	2	2	25
	CT-QM-III	*Quantum Mechanics III*	2	2	25
MPHC 4206	CT-SP-II	*Statistical Physics II*	2	2	25
	CT-ED-II	*Electrodynamics II*	2	2	25
MPHC 4207	CT-SSP1	*Solid State Physics I*	2	2	25
	CT-SSP-II	*Solid State Physics II*	2	2	25
MPHC 4252	CC-NI	*Numerical & Interfacing*	8	4	50
MPHC 4253	CE-GE-II	*General Experiments II*	8	4	50

SEMESTER III Class Weeks: 15 | Total Credits: 20 | Total Marks: 250

Paper	Module	Subject	Contact Hours	Credits	Marks
MPHC 4308	CT-ATM	*Atomic Physics*	2	2	25
	CT-MOL	*Molecular & Laser Physics*	2	2	25
MPHC 4309	CT-NP	*Nuclear Physics*	2	2	25
	CT-PP	*Particle Physics*	2	2	25
MPHC 4310	CT-EL	*Electronics*	2	2	25
	CT-INT	*Instrumentation*	2	2	25
MPHC 4354	CE-EC	*Electronics & Communication Experiment*	8	4	50
MPHC 4355	CE-GE-III	*General Experiments III*	8	4	50

SEMESTER IV Class Weeks: 15 | Total Credits: 20 | Total Marks: 250

Paper	Module	Subject	Contact Hours	Credits	Marks
MPHS4401	SP-PRJ	*Project and Dissertation*	30	16	200
MPHS4402	CV	*Comprehensive Viva*	---	4	50

The above course structure is subject to modifications from time to time as decided by the Board of Studies.

COURSE STRUCTURE FOR M.Sc. | LIFE SCIENCES

(Explanation: T2:P1:L30 means 2 credits theory: 1 credit practical: 30 1h lectures)

All courses are Mandatory in Semesters I and II.

SEMESTER I **(Foundation Courses) Class Weeks: 15 | Total Credits: 18**

Paper	Module	Subject	Contact Hours	Credits
Course 401	Theory	**Mathematical, Statistical and Computational tools**	30	2
Course 402	Theory	**Chemical Principles**	15	1
Course 403	Theory	**Experimental Methods**	15	1
	Practical			1
Course 404	Theory	**Spectroscopy and Its Applications in Biology**	15	1
Course 405	Theory	**Biophysical Chemistry**	15	1
	Practical			1
Course 406	Theory	**Biochemistry**	30	2
	Practical			1
Course 407	Theory	**Cell Biology**	30	2
	Practical			1
Course 408	Theory	**Microbiology**	15	1
	Practical			1
Course 409	Theory	**Plant Biology**	15	1
	Practical			1

SEMESTER II (Advanced Courses) **Class Weeks: 15 | Total Credits: 18**

Paper	Module	Subject	Contact Hours	Credits
Course 501	Theory	**Immunology**	30	2
	Practical			1
Course 502	Theory	**Genetics and Genomics**	30	2
	Practical			1
Course 503	Theory	**Bioinformatics and Computational Biology**	30	2
	Practical			1
Course 504	Theory	**Chemical and Systems Biology**	30	2
	Practical			1
Course 505	Theory	**Cell Signaling**	30	2
	Practical			1
Course 506	Theory	**Plant Development**	15	1
	Practical			1
Course 507	Theory	**Animal Development**	15	1

EMESTER III **Core Courses (Compulsory to all students) Class Weeks: 15 | Total Credits: 13**

Paper	Module	Subject	Contact Hours	Credits
Course 601	Theory	**Biophysical Chemistry**	30	2
	Practical			1
Course 602	Theory	**Molecular and Cellular Biology**	30	2
	Practical			1
Course 603	Theory	**Plant Molecular Biology and Biotechnology**	30	2
	Practical			1
Course 604	Theory	**Computational and Systems Biology**	30	2
	Practical			1
Course 605	Theory	**Scientific Ethics and Soft Skills**		1

Specialized Course (any one) Class Weeks: 15 | Total Credits: 5

Course 606	Theory	**Biophysical Chemistry**	45	3
		Seminar and Term Paper		2
Course 607	Theory	**Molecular and Cellular Biology**	45	3
		Seminar and Term Paper		2
Course 608	Theory	**Plant Molecular Biology and Biotechnology**	45	3
		Seminar and Term Paper		2
Course 609	Theory	**Computational and Systems Biology**	45	3
		Seminar and Term Paper		2

SEMESTER IV (Only research project) **Class Weeks: 15 | Total Credits: 18**

Paper	Module	Subject	Contact Hours	Credits
Course 701		**Research Project (Dissertation and Presentation)**		14
Course 702		**Comprehensive Viva**		4

EXAMINATION STRUCTURE FOR M.Sc.

There are four mid-semester examinations and four end-semester examinations over the span of two years in M. Sc. In the first three semesters, each paper (may consist of more than one module) are of 50 marks. Each theory paper is allotted 2 hrs and 30 minutes for writing answers. Each other kind of module is allotted 4 hrs for writing answers. In the fourth semester 30 minutes are allotted for presentation and viva of project work and another 30 minutes are allotted for comprehensive viva for each student.

Evaluation

The evaluation of the students during the M.Sc. course is done as follows: -

Theory Papers:

Continuous Internal Assessment	:	10% (Attendance: 5%, Assignments: 5%)
Mid Semester Examination	:	20%
End Semester Examination	:	70 %

Experiment/Computation papers:

Continuous Internal Assessment	:	10% (Attendance: 5%, Assignments: 5%)
Mid Semester Examination	:	20%
End Semester Examination	:	60% (Theory: 10%, Data: 15%, Analysis: 15%, Viva: 20%)

Project and Dissertation:

Continuous Internal Assessment	:	10% (Attendance: 5%, Assignments: 5%)
Mid Semester Viva	:	15%
Mid Semester Presentation	:	15%
End Semester Viva	:	25%
End Semester Presentation	:	25%
End Semester Report	:	10%

Comprehensive Viva:

End Semester Examination	:	100%

Credits and Grade Points

Credits

One credit corresponds to 1 contact hour per week for theory courses and 2 contact hours per week for other courses, for 15 weeks. For biological sciences, 1 practical course is equivalent to 1 credit. In all semesters a candidate attending equal or more than 75% of classes in aggregate will receive full credit. Otherwise, the candidate has to continue from the same semester in the very next year.

In the exceptional cases, where aggregate attendance is less than 75%, but at least 60%, a competent authority may examine and give condonation of attendance in deserving cases.

Grades

Grading is done only for candidates eligible to appear in the end-semester examinations. A ten point credit system is adopted. Pass grade point is 4.000. If in a paper *i* a candidate secures a percentage of marks PM_i^E, where PM_i^E is at least 40, then the grade point of the candidate is $PM_i^E = 4.000 + 0.1(PM_i^E - 40)$ to be rounded off to two decimal places. Numerical grade point for a failed paper is zero. The grading table is as follows.

% of Marks (PM)	Grade Points (GP)	Letter Grades	
$90 \le PM \le 100$	$9.00 \le GP \le 10.00$	O	Outstanding
$80 \le PM < 90$	$8.00 \le GP < 9.00$	A+	Excellent
$70 \le PM < 80$	$7.00 \le GP < 8.00$	A	Very Good
$60 \le PM < 70$	$6.00 \le GP < 7.00$	B+	Good
$55 \le PM < 60$	$5.50 \le GP < 6.00$	B	Above Average
$50 \le PM < 55$	$5.00 \le GP < 5.50$	C+	Average
$40 \le PM < 50$	$4.00 \le GP < 5.00$	C	Below Average
40	4.00	P	Pass
< 40	0.00	F	Fail
Absent	0.00	AB	

If the credit in the i^{th} paper is C_i, and C_i^E is the credits earned and GP_i^E is the grade points earned, then credit point in the paper is $C_i^E GP_i^E$. The Semester Grade Point Average (SGPA) is given as $SGPA = \sum_{i=1}^{n} C_i^E GP_i^E / C_S$, where the total semester credit is $C_S = \sum_{i=1}^{n} C_i$, and there are total n individual papers in the semester. Similarly, if there are N papers in the entire M.Sc. course, then the Cumulative Grade Point Average (CGPA) is given as $CGPA = \sum_{i=1}^{N} C_i^E GP_i^E / C_T$, where the total course credit is $C_T = \sum_{i=1}^{N} C_i$. All the SGPA and CGPA is rounded off to three decimal places. On the basis of CGPA obtained by a candidate, final grade and class are awarded as follows:

CGPA	Grades		Class
$9.000 \le CGPA \le 10.000$	O	Outstanding	1st Class
$8.000 \le CGPA < 9.000$	A+	Excellent	1st Class
$7.000 \le CGPA < 8.000$	A	Very Good	1st Class
$6.000 \le CGPA < 7.000$	B+	Good	1st Class
$5.500 \le CGPA < 6.000$	B	Above Average	2nd Class
$5.000 \le CGPA < 5.500$	C+	Average	2nd Class
$4.000 \le CGPA < 5.000$	C	Below Average	2nd Class
CGPA < 4.000	F	Fail	Fail

Examination Regulations

(1) ***Attendance:***

(a) A candidate is eligible to appear in the end semester examination, provided that the candidate has attended at least 75% of the total number of classes* held in the semester.

(b) A candidate attending at least 60% but less than 75% of the total number of classes* held shall, however, be eligible to appear at the concerned semester examination upon obtaining condonation order from the competent authority.

(c) A candidate with less than 60% attendance is not allowed to appear in the respective semester examination. He/she must continue from the same semester in the very next year.

Such attendance will be calculated from the date of commencement of classes or date of admission, whichever is later.

(2) ***General Rules:***

(a) Passing criteria is to obtain **P** grade in each and every paper in all the four semesters. A candidate is required to clear all the semesters within a span of four years from the year of admission, failing which enrollment of the candidate shall stand cancelled.

(b) Internal Assessment has to be done in the semester in which a candidate becomes eligible to appear in the respective end-semester examination. Candidates remaining absent in the written examination for Internal Assessment are awarded zero (0) marks in the written part of internal examination. Marks obtained in Internal Assessment are retained for the entire duration of his/her enrollment.

(c) Marks for the papers in which the candidate secures at least pass marks as stated in Clause (2a), are retained for the entire duration of his/her enrollment.

(d) A candidate eligible to appear in any of the end-semester examinations of 1^{st} and 2^{nd} semester, but does not do so or fails to secure **P** grade in any paper(s), may reappear in the next equivalent end-semester examination. In case of such a situation in the 3^{rd} and / or 4^{th} semester, the candidate can appear in supplementary examinations for those paper(s) to be held after the declaration of the 4^{th} semester results, to be scheduled by competent authority.

(e) A candidate who is eligible to appear in any of the end-semester examinations, but does not do so or fails to secure **P** grade in any paper(s), will be allowed to attend the classes in the next higher semester, as applicable.

(f) A candidate may appear in an end-semester examination without appearing in the previous end-semester examinations subject to Regulation 1.

(3) ***Review Rules:***

a) Candidates seeking review may apply within seven (7) working days from the date of issue of Grade Card.

b) Application for review shall be restricted to theoretical papers only.

c) Maximum two (02) theoretical papers in any semester examination may be re-examined on request by the examinee subject to the condition that she / he secures a minimum of **P** grade in the rest of theoretical and computational papers in a semester.

d) In re-examination of scripts in a paper, the marks awarded by the re-examiner will be taken as the marks obtained by the examinee in that paper.

e) If on re-examination in a paper the marks get enhanced by more than 15% or get reduced by more than 5% than that awarded by the original examiner (the percentage be calculated on the basis of the full marks in that paper), the script of the paper will be referred to a third examiner and average of two marks (excluding the lowest one) as awarded by the three examiners shall be taken as the marks obtained by the examinee in that paper, provided that such a final award does not result in lowering of the Letter Grade of SGPA / CGPA / Class obtained by the examinee prior to re-examination in which cases the original award will be retained.

M.Sc. Degree:

On successful completion of the course, the M.Sc. degree will be awarded to the candidates.

Exit Option:

The candidates may leave the programme after the completion of the M.Sc. course.

Admission to Ph.D. Course

Candidates will be admitted for Ph.D. course at Bose Institute subject to the conditions:

(i) that the candidate secures self funding for the PhD course through eligible National Tests

(ii) an eligible faculty member at Bose Institute having vacancy for registration of Ph.D. student under his/her direct supervision, as per the guideline of the UGC, GoI, is willing to accept the student under his/her guidance.

Ph.D. Degree:

For every candidate enrolled for the Ph.D. course, the subsequent registration, conduct and conferment of the Ph.D. degree will be in accordance to the rules and regulations of the University of Calcutta.

SYLLABUS FOR M.SC. | PHYSICAL SCIENCES

SEMESTER I

Paper - MPHC4101

Module: CT-MP-I [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Mathematical Physics I

1. *Theory of second order linear homogeneous differential equations* :

   Singular points – regular and irregular singular points; Frobenius method; Fuch's theorem; Linear independence of solutions – Wronskian, second solution. Sturm-Liouville theory; Hermitian operators; Completeness.

2. *Inhomogeneous differential equations :* Green's functions

3. *Special functions :* Basic properties (recurrence and orthogonality relations, series expansion) of Bessel, Legendre, Hermite and Laguerre functions.

4. *Integral transforms :* Fourier and Laplace transforms and their inverse transforms, Bromwich integral [use of partial fractions in calculating inverse Laplace transforms]; Transform of derivative and integral of a function; Solution of differential equations using integral transforms.

Module: CT-MP-II [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Mathematical Physics II

1. *Complex variables* : Recapitulation: complex numbers, triangular inequalities, Schwarz inequality, Function of a complex variable – single and multivalued function. Limit and continuity. Differentiation – Cauchy-Riemann equations and their applications. Analytic and Harmonic Functions. Complex integrals. Cauchy's theorem (elementary proof only), converse of Cauchy's theorem, Cauchy integral formula and its corollaries, Series – Taylor and Laurent expansion, classification of singularities, branch point and branch cut, residue theorem and evaluation of some typical integrals using this theorem.

2. *Matrices and Tensors:* Representation of linear transformations and change of base; Eigenvalues and eigenvectors; Functions of a matrix; Cayley-Hamilton theorem; Commuting matrices with degenerate eigenvalues; Orthonormality of eigenvectors.

   Transformation of tensors, mathematical operation with tensors (addition, subtraction & multiplication), metric tensors, raising and lowering of indices, unit tensor.

Paper - MPHC4102

Module: CT- CM [Class weeks: 15 /\ Contact Hours: 3 /\ Credits: 3 /\ Marks 35]

Classical Mechanics

1. *An overview of the Lagrangian formalism :* Some specific applications of Lagrange's equation; small oscillations, normal modes and frequencies.

2. *Rigid bodies* : Independent coordinates; orthogonal transformations and rotations (finite and infinitesimal); Euler's theorem, Euler angles; Inertia tensor and principal axis system; Euler's equations; Heavy symmetrical top with precession and nutation.
3. *Hamilton's principle* : Calculus of variations; Hamilton's principle; Lagrange's equation from Hamilton's principle; Legendre transformation and Hamilton's canonical equations; Canonical equations from a variational principle; Principle of least action.
4. *Canonical transformations :* Generating functions; examples of canonical transformations; group property; Integral variants of Poincare; Lagrange and Poisson brackets; Infinitesimal canonical transformations; Conservation theorem in Poisson bracket formalism; Jacobi's identity; Angular momentum Poisson bracket relations.
5. *Hamilton-Jacobi theory :* The Hamilton Jacobi equation for Hamilton's principle function; The harmonic oscillator problem; Hamilton's characteristic function; Action angle variables.
6. *Lagrangian formulation for continuous systems :* Lagrangian formulation of acoustic field in gases; the Hamiltonian formulation for continuous systems; Canonical equations from a variational principle, Poisson's brackets and canonical field variables.

Module: CT-NLD [Class weeks: 15 /\ Contact Hours: 1 /\ Credits: 1 /\ Marks 15]

Nonlinear Dynamics

Why Nonlinear Dynamics --The basic differences of Nonlinear Systems with Linear ones--

Flows and Maps, Fixed Point Analysis in 1-D Systems, Fixed point analysis and Qualitative features of Phase Portraits in 2-D systems, Limit Cycles, Generalization of ideas in higher dimensions, Bifurcations-- 1-D systems, Bifurcations-- 2-D systems -- mainly local ones with some notions of Global Bifurcations, Hamiltonian systems- integrability and non-integrability-- onset of chaos in nearly integrable systems, Poincare Section and Maps along with Stroboscopic Maps , 1-D and 2-D Maps -- Logistic, Standard and Baker's Maps -- Chaos and Liapunov Exponents, Ideas of strange attractors and chaos – Nonlinear Oscillators, Fractals and Fractal dimensions.

Paper- MPHC4103

Module: CT-MP-III [Class weeks: 15 /\ Contact Hours: 1 /\ Credits: 1 /\ Marks 15]

Mathematical Physics III

1. *Linear Vector space :* Axiomatic definition, linear independence, bases, dimensionality, inner product, Gram Schmidt orthogonalization.
2. *Group Theory :* Symmetries, representation theory, broad overview of finite and continuous groups, rotation group, the nature of time-reversal and space-inversion operations, point groups and crystal tensors, application to X-ray analysis of structures and molecular vibrations, the Wigner-Eckart theorem, Lie groups and representations, Young tableaux, Dynkin diagrams, SU(2), Gauge invariance, equivalence with angular momentum, Clebsh-Gordan coefficients.

Module: CT-QM-I [Class weeks: 15 /\ Contact Hours: 3 /\ Credits: 3 /\ Marks 35]

Quantum Mechanics I

1. *Recapitulation of basic concepts* : Wave packet, Gaussian wave packet, Fourier transform, spreading of a wave packet, Fourier transforms of delta and sine function, co-ordinate and momentum space: co-ordinate and momentum representation, Parseval's theorem, eigenvalues and eigenvectors: Momentum and parity operators, commutativity and simultaneous eigenfunctions, complete set of eigenfunctions: expansion of wave functions in terms of a complete set, one dimensional problems: square well potential (E>0), delta function, double delta potential, application to molecular inversion, multiple potential well, Kronig-Penney model.

2. *Operator method in quantum mechanics* : Formulation of quantum mechanics in vector space language, uncertainty principle for two arbitrary operators, one dimensional harmonic oscillator by operator method.

3. *Quantum theory of measurement and time evolution* : Double Stern-Gerlach experiment for spin ½ systems, Schrodinger, Heisenberg and interaction pictures.

4. *Three dimensional problems* : Three dimensional problems in Cartesian and spherical polar co-ordinates, 3 d well and Fermi energy, radial equation for a free particle and 3 d harmonic oscillator, eigenvalue of a 3 d harmonic oscillator by series solution.

5. *Angular momentum :* Angular momentum algebra, raising and lowering operators, matrix representation of j = ½ and j = 1, spin, addition of two angular momenta: Clebsch-Gordan co-efficients, examples.

Paper- MPHC4104

Module: CT-SP-I [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Statistical Physics I

1. *Introduction :* Objective of statistical mechanics. Macrostates, microstates, phase space and ensembles. Ergodic hypothesis, postulate of equal a priori probability and equality of ensemble average and time average. Boltzmann's postulate of entropy. Counting the number of microstates in phase space. Entropy of ideal gas: Sackur-Tetrode equation and Gibbs' paradox. Liouville's Theorem.

2. *Canonical Ensemble :* System in contact with a heat reservoir, expression of entropy, canonical partition function, Helmholtz free energy, fluctuation of internal energy.

3. *Grand Canonical Ensemble :* System in contact with a particle reservoir, chemical potential, grand canonical partition function and grand potential, fluctuation of particle number. Chemical potential of ideal gas.

4. *Classical non-ideal gas* : Mean field theory and Van der Wall's equation of state; Cluster integrals and Mayer-Ursell expansion.

Module: CT-ED-I [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Electrodynamics I

1. *Electrostatics and Magnetostatics* : Scalar and vector potentials, gauge transformations, multipole expansion of (i) scalar potential and energy due to a static charge distribution, (ii) vector potential due to a stationary current distribution, electrostatic and magnetostatic energy, Poynting's theorem, Maxwell's stress tensor.

2. *Radiation from time dependent sources of charges and currents* : Inhomogeneous wave equations and their solutions, Radiation from localized sources and multipole expansion in the radiation zone.

3. *Special Relativity* : Lorentz transformations, four- vectors, tensors, transformation properties, metric tensor, raising and lowering of indices, contraction, symmetric and antisymmetric tensors, four dimensional velocity and acceleration, four- momentum and four-force, covariant equations of motion, relativistic kinematics (decay and elastic scattering), Lagrangian and Hamiltonian of relativistic particles.

4. *Relativistic electrodynamics:* Equation of motion in an electromagnetic field, electromagnetic field tensor, covariance of Maxwell's equations, Maxwell's equations as equations of motion, Lorentz transformation law for the electromagnetic fields and the fields due to a point charge in uniform motion, field invariants, covariance of Lorentz force equation and the equation of motion of a charged particle in an electromagnetic field, the generalized momentum, energy-momentum tensor and the conservation laws for the electromagnetic field, relativistic Lagrangian and Hamiltonian of a charged particle in an electromagnetic field.

Paper- MPHC4151

Module: CE-GE-I [Class weeks: 15 /\ Contact Hours: 8 /\ Credits: 4 /\ Marks 50]

General Experiments I

1. Michelson's Interferometer
2. Planck's Constant by Photoelectric effect / By means of LED characteristics
3. Franck-Hertz experiment
4. Measurement of e/m with Bar magnets/ with He filled tube and Helmoltz's coil
5. Audio oscillators
6. Stefan's Law

SEMESTER II

Paper- MPHC4205

Module: CT-QM-II [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Quantum Mechanics II

1. *Approximation Methods :* Time independent perturbation theory: First and second order corrections to the energy eigenvalues; First order correction to the eigenvector; Degenerate perturbation theory; Application to one-electron system – Relativistic mass correction, Spin-orbit coupling (L-S and j-j), Zeeman effect and Stark effect. Variational method: He atom as example; First order perturbation; Exchange degeneracy; Ritz principle for excited states for Helium atom.
2. *WKB Approximation :* Quantisation rule, tunnelling through a barrier, qualitative discussion of α-decay.
3. *Time-dependent Perturbation Theory :* Time dependent perturbation theory, interaction picture; Constant and harmonic perturbations – Fermi's Golden rule; Sudden and adiabatic approximations.
4. *Scattering theory :* Laboratory and centre of mass frames, differential and total scattering cross-sections, scattering amplitude; Scattering by spherically symmetric potentials; Partial wave analysis and phase shifts; Ramsauer-Townsend effect; Relation between sign of phase shift and attractive or repulsive nature of the potential; Scattering by a rigid sphere and square well; Coulomb scattering; Formal theory of scattering – Green's function in scattering theory; Lippman-Schwinger equation; Born approximation.

Module: CT-QM-III [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Quantum Mechanics III

1. *Symmetries in quantum mechanics :* Conservation laws and degeneracy associated with symmetries; Continuous symmetries – space and time translations, rotations; Rotation group, homomorphism between SO(3) and SU(2); Explicit matrix representation of generators for j = 2 and j = 1; Rotation matrices; Irreducible spherical tensor operators, Wigner-Eckart theorem; Discrete symmetries — parity and time reversal.
2. *Identical Particles* : Meaning of identity and consequences; Symmetric and antisymmetric wavefunctions; Slater determinant; Symmetric and antisymmetric spin wavefunctions of two identical particles; Collisions of identical particles.
3. *Relativistic Quantum Mechanics :* Klein-Gordon equation, Feynman-Stuckelberg interpretation of negative energy states and concept of antiparticles; Dirac equation, covariant form, adjoint equation; Plane wave solution and momentum space spinors; Spin and magnetic moment of the electron; Non-relativistic reduction; Helicity and chirality; Properties of γ matrices; Charge conjugation; Normalisation and completeness of spinors.

Paper- MPHC4206

Module: CT-SP-II [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Statistical Physics II

1. *Quantum statistical mechanics :* Density Matrix; Quantum Liouville theorem; Density matrices for microcanonical, canonical and grand canonical systems; Simple examples of density matrices — one electron in a magnetic field, particle in a box; Identical particles — B-E and F-D distributions.
2. *Ideal Bose and Fermi gas :* Equation of state; Bose condensation; Equation of state of ideal Fermi gas; Fermi gas at finite T.
3. *Special topics :* Ising model: partition function for one dimensional case; Chemical equilibrium and Saha ionisation formula. Phase transitions: first order and continuous, critical exponents and scaling relations. Calculation of exponents from Mean Field Theory and Landau's theory, upper critical dimension.
4. *Irreversible Thermodynamics :* Flux and affinity. Correlation function of fluctuations. Onsager reciprocity theorem (including proof). Thermoelectric effect.

Module: CT-ED-II [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Electrodynamics II

1. *Radiation from moving point charges :* Lienard-Wiechert potentials; Fields due to a charge moving with uniform velocity; Fields due to an accelerated charge; Radiation at low velocity; Larmor's formula and its relativistic generalisation; Radiation when velocity (relativistic) and acceleration are parallel, Bremsstrahlung; Radiation when velocity and acceleration are perpendicular, Synchrotron radiation; Cherenkov radiation (qualitative treatment only). Thomson and Compton scattering.
2. *Radiation reaction :* Radiation reaction from energy conservation; Problem with Abraham-Lorentz formula; Limitations of CED.
3. *Plasma physics :* Definition of plasma; Its occurrence in nature; Dilute and dense plasma; Uniform but time-dependent magnetic field: Magnetic pumping; Static non-uniform magnetic field: Magnetic bottle and loss cone; MHD equations, Magnetic Reynold's number; Pinched plasma; Bennett's relation; Qualitative discussion on sausage and kink instability.

Paper- MPHC4207

Module: CT-SSP-I [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Solid State Physics I

1. *Crystal structure :* Bravais lattice – primitive vectors, primitive unit cell, conventional unit cell, Wigner-Seitz cell; Symmetry operations and classification of 2- and 3-dimensional Bravais lattices; Crystal structures: basis, crystal class, point group and space group (information only); Common crystal structures: NaCl and CsCl structure, crystals of alkali and noble metals, close-packed structure, cubic ZnS structure; Reciprocal lattice and Brillouin zone; Bragg-Laue formulation of X-ray diffraction by a crystal; Atomic and crystal structure factors; Experimental methods of X-ray diffraction: Laue, rotating crystal and powder method; Electron and neutron diffraction by crystals (qualitative discussion); Intensity of diffraction maxima; Extinctions due to lattice centering.
2. *Band theory of solids :* Bloch equation; Empty lattice band; Nearly free electron bands; Band gap; Number of states in a band; Tight binding method; Effective mass of an electron in a band: concept of holes; Band structures in copper, GaAs and silicon; Classification of metal, semiconductor and insulator; topology of Fermi-surface; cyclotron resonance – de Haas - van Alphen effect; Boltzmann transport equation – relaxation time approximation, Sommerfeld theory of electrical conductivity.

3. *Lattice dynamics :* Classical theory of lattice vibration under harmonic approximation; Vibrations of linear monatomic and diatomic lattices, acoustical and optical modes, long wavelength limits; Optical properties of ionic crystal in the infrared region; Adiabatic approximation (qualitative discussion); Normal modes and phonons; Inelastic scattering of neutron by phonon; Lattice heat capacity, models of Debye and Einstein, comparison with electronic heat capacity; Anharmonic effects in crystals — thermal expansion and thermal conductivity; Mossbauer effect.

4. *Dielectric properties of solids :* Static dielectric constant: electronic and ionic polarisation of molecules, orientational polarisation, static dielectric constant of gases; Lorentz internal field; Static dielectric constants of solids; Complex dielectric constant and dielectric losses, relaxation time; Classical theory of electronic polarisation and optical absorption; Ferroelectricity — dipole theory, case of BaTiO.

Module: CT-SSP-II [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Solid State Physics II

1. *Magnetic properties of solids :* Origin of magnetism; Diamagnetism: quantum theory of atomic diamagnetism; Landau diamagnetism (qualitative discussion); Paramagnetism: classical and quantum theory of paramagnetism; case of rare-earth and iron-group ions; quenching of orbital angular momentum; Van-Vleck paramagnetism and Pauli paramagnetism; Ferromagnetism: Curie-Weiss law, temperature dependence of saturated magnetisation, Heisenberg's exchange interaction, ferromagnetic domains; Ferrimagnetism and anti-ferromagnetism.

2. *Magnetic resonances :* Nuclear magnetic resonances, Bloch equation, longitudinal and transverse relaxation time; Hyperfine field; Electron-spin resonance.

3. *Imperfections in solids and optical properties :* Frenkel and Schottky defects, defects in growth of crystals; The role of dislocations in plastic deformation and crystal growth; Colour centers and photoconductivity; Luminescence and phosphors; Alloys – order-disorder phenomena, Bragg-Williams theory; Extra specific heat in alloys.

4. *Superconductivity :* Phenomenological description of superconductivity – occurrence of superconductivity, destruction of superconductivity by magnetic field, Meissner effect; Type-I and type-II superconductors; Heat capacity, energy gap and isotope effect; Outlines of the BCS theory; Giaver tunnelling; Flux quantisation; a.c. and d.c. Josephson effect; Vortex state (qualitative discussions); High Tc superconductors (information only).

Paper- MPHC4252

Module: CC-NI [Class weeks: 15 /\ Contact Hours: 8 /\ Credits: 4 /\ Marks 50]

Numerical Techniques and Computer Interfacing

Recapitulation of the following in a popular programming language:

Constants and variables. Assignment and arithmetic expressions. Logical expressions and control statements, DO loop, array, input and output statements, function subprogram, subroutine. Processing of text and strings.

Numerical analysis: Computer arithmetic and errors in floating point representation of numbers, different numerical methods for (i) finding zeros of a given function (ii) solution of linear simultaneous equations (iii) numerical differentiation and integration (iv) solution of first-order differential equations (v) interpolation and extrapolation (vi) least square fitting. Random number generation, sorting.

Computer Interfacing

Scientific Computing using Python/Numeric/Scipy/Matplotlib: Language essentials.

Principles of Computer interfaced experiments: Sensors, Sampling, ADC width and delay, DAC limitations, Precision in digitized experiments. Components of the IUAC Phoenix/Expeyes box: Digital I/O, DAC, PWG, Counter, ADC, Amplifiers.

Familiarization with the python API. Software and Hardware triggers, Hardware control, Data acquiring and analysis using unipolar and bipolar signals: Fast Vs. Precision experiments, Design / Coding for simple experiments using available thermo/mechanical/audio sensors.

Paper- MPHC4153

Module: CE-GE-II [Class weeks: 15 /\ Contact Hours: 8 /\ Credits: 4 /\ Marks 50]

General Experiments II

1. Hall Effect I
2. Hall Effect II
3. Resistivity measurement using four-probe
4. Dielectric constant as a function of frequency for different solids
5. Dielectric constant and Curie temperature of ferromagnetic ceramics
6. Study of optical absorption and optical band gap determination of semiconductors
7. Determination of precise lattice parameter and crystallite size of materials by X-Ray powder diffractometer.

SEMESTER III

Paper- MPHC4308

Module: CT-ATM [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Atomic Physics

1. *One Electron Atom :* Introduction: Quantum States; Atomic orbital; Parity of the wave function; Angular and radial distribution functions.
2. *Interaction of radiation with matter :* Time dependent perturbation: Sinusoidal or constant perturbation; Application of the general equations; Sinusoidal perturbation which couples two discrete states – the resonance phenomenon. Interaction of an atom with electromagnetic wave: The interaction Hamiltonian - Selection rules; Nonresonant excitation – Comparison with the elastically bound electron model; Resonant excitation - Induced absorption and emission.
3. *Fine and Hyperfine structure :* Solution of Dirac equation in a central field; Relativistic correction to the energy of one electron atom. Fine structure of spectral lines; Selection rules; Lamb shift. Effect of external magnetic field - Strong, moderate and weak field. Hyperfine interaction and isotope shift; Hyperfine splitting of spectral lines; selection rules.
4. *Many electron atom :* Independent particle model; He atom as an example of central field approximation; Central field approximation for many electron atom; Slater determinant; L-S and j-j coupling; Equivalent and nonequivalent electrons; Energy levels and spectra; Spectroscopic terms; Hunds rule; Lande interval rule; Alkali spectra.

Module: CT-MOL [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Molecular Physics & Laser Physics

1. *Molecular Electronic States :* Concept of molecular potential, Separation of electronic and nuclear wave functions, Born-Oppenheimer approximation, Electronic states of diatomic molecules, Electronic angular momenta, Approximation methods for the calculation of electronic Wave function, The LCAO approach, States for hydrogen molecular ion, Coulomb, Exchange and Overlap integral, Symmetries of electronic wavefunctions; Shapes of molecular orbital; π and σ bond; Term symbol for simple molecules.

2. *Rotation and Vibration of Molecules :* Solution of nuclear equation; Molecular rotation: Non-rigid rotator, Centrifugal distortion, Symmetric top molecules, Molecular vibrations: Harmonic oscillator and the anharmonic oscillator approximation, Morse potential.

3. *Spectra of Diatomic Molecules :* Transition matrix elements, Vibration-rotation spectra: Pure vibrational transitions, Pure rotational transitions, Vibration-rotation transitions, Electronic transitions: Structure, Franck-Condon principle, Rotational structure of electronic transitions, Fortrat diagram, Dissociation energy of molecules, Continuous spectra, Raman transitions and Raman spectra.

4. *Vibration of Polyatomic Molecules: Application of Group Theory :* Molecular symmetry; Matrix representation of the symmetry elements of a point group; Reducible and irreducible representations; Character tables for C2v and C3v point groups; Normal coordinates and normal modes; Application of group theory to molecular vibration.

Laser Physics:

Basic elements of a laser; Threshold condition; Four-level laser system, CW operation of laser; Critical pumping rate; Population inversion and photon number in the cavity around threshold; Output coupling of laser power. Optical resonators; Cavity modes; Mode selection; Pulsed operation of laser: Q-switching and Mode locking; Experimental technique of Q-switching and mode locking . Different laser systems: Ruby, CO_2 , Dye and Semiconductor diode laser.

Paper- MPHC4309

Module: CT-NP [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Nuclear Physics

1. *Nuclear Properties* : Nuclear size, Rutherford scattering, nuclear radius and charge distribution, nuclear form factor, mass and binding energy, angular momentum, parity and symmetry, magnetic dipole moment and electrical quadrupole moment, experimental determination, Rabi's method.

2. *Two-body state* : Properties of deuteron, Schrodinger equation and its solution for ground state of deuteron, rms radius, spin dependence of nuclear forces, electromagnetic moment and magnetic dipole moment of deuteron and the necessity of tensor forces.

3. *Two-body scattering* : Experimental n-p scattering data, partial wave analysis and phase shifts, scattering length, magnitude of scattering length and strength of scattering, significance of the sign of scattering length, scattering from molecular hydrogen and determination of singlet and triplet scattering lengths, effective range theory, low energy p-p scattering, nature of nuclear forces: charge independence, charge symmetry and isospin invariance of nuclear forces.

4. *Nuclear structure*: Liquid drop model, Bethe-Weizsacker binding energy/mass formula, Fermi model, Shell model and collective model.

5. *Nuclear reactions and Fission* : Different types of reactions, quantum mechanical theory, resonance scattering and reactions – Breit-Wigner dispersion relation, compound nucleus formation and break-up, statistical theory of nuclear reactions and evaporation probability, optical model, principle of detailed balance, transfer reactions, nuclear fission: experimental features, spontaneous fission, liquid drop model, barrier penetration, statistical model, super-heavy nuclei.

Module: CT-PP [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Particle Physics

1. *Symmetry:* Symmetries and conservation Laws. Elementary ideas about electroweak unification and Standard Model. SU(2) and SU(3) Groups, algebras and generators, Young tableaux rules for SU(2) and SU(3).

2. Weak interactions: Energetics of various β decays, V − A theory of allowed β decay, Selection rules for Fermi and Gamow-Teller transitions, Parity non-conservation and Wu's experiment, Goldhaber's experiment; Elementary

ideas about the gauge theory of weak interaction. The problem of mass generation and the need for the Higgs mechanism.

3. *Strong interactions:* Hadron classification by isospin and hypercharge, quarks, colour. Elementary ideas about gauge theory of strong interactions - quantum chromodynamics.
4. *Big Bang theory:* Elementary ideas about Big Bang cosmology. Big Bang neucleosynthesis, relative abundance of chemical elements, neutron star.

Paper- MPHC4310

Module: CT-EC [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Electronics

1. Carrier concentration in semiconductors, p-n junction band diagram, I-V and C-V Characteristics; basic semiconductor equations, depletion and diffusion capacitance, Reverse Breakdown; Noise; Bipolar Junction Transistors (BJT); Ebers-Moll equation. Frequency response;
2. *Digital MOS circuits :* NMOS and CMOS gates (AND, NAND and NOT), Dynamic MOS circuits, ratioinverter, two phase inverter; dynamic MOS shift register, static MOS shift registers, four phase shift registers. Memory Devices; Static and dynamic random access memories (SRAM and DRAM)
3. Metal semiconductor junctions: Schottky barriers; Rectifying and ohmic contacts; Tunnel diode; Uni-junction transistor (UJT); Field Effect Transistor (FET): types, structure, JFET, MESFET, MOSFET: characteristics, threshold voltage.

Module: CT-INT [Class weeks: 15 /\ Contact Hours: 2 /\ Credits: 2 /\ Marks 25]

Instrumentation

1. *Analog circuits :* Comparators, Multivibrators, Waveform generators: Square wave, triangle wave and pulse generators.
2. *Transmission line :* Transmission line equation and solution; Reflection and transmission coefficient; Standing wave and standing wave ratio; Line impedance and admittance; Smith chart.
3. Production and measurement of high vacuum: Rotary pump, Diffusion pump, Turbomolecular pump, Ion pump; McLeod gauge, Pirani gauge, Penning gauge.
4. Introduction to cryogenics.
5. *Communication :* Introduction to signals; Concepts of Voice & Data Communication; Transmission lines, Transmission Channels; Modulation & Multiplexing of Analog and Digital Signals; CCITT / ITU Standards of Voice & Data Communication Systems; Pulse Code Modulation (PCM); Digital Multiplexing (PDH&SDH).
6. *Experimental design:* Scintillation detectors; Solid state detectors (Si and HPGe). Measurement of energy and time using electronic signals from the detectors and associated instrumentation, Signal processing; Multi channel analyzer; Time of flight technique; Coincidence measurements true-to-chance ratio.

Paper- MPHC4354

Module: CE- EC [Class weeks: 15 /\ Contact Hours: 8 /\ Credits: 4 /\ Marks 50]

Electronics & Communication Experiments

1. Determination of band gap and reverse saturation current of a p n junction diode
2. Construction of Astable Multi-vibrator and VCO
3. To study UJT Characteristics
4. To study Active Filters (High pass, Low pass, Band pass, Notch)

5. To study T Filters (High and Low pass filter)
6. To study Pi Filters (High and Low pass filter)
7. Pulse Width Modulation and Demodulation
8. Study of Frequency Modulation and its Demodulation using IC PLL565
9. Pulse Position Modulation and Demodulation
10. Study of Amplitude Shift Keying and Demodulation
11. Study of Frequency Shift keying and Demodulation [IC 8038 Function Generator used]
12. Study of Amplitude Modulation and Demodulation [IC Version 1496]

Paper- MPHC4355

Module: CE-GE-III [Class weeks: 15 /\ Contact Hours: 8 /\ Credits: 4 /\ Marks 50]

General Experiments III

1. Iodine absorption spectra
2. Laser: Parametric down conversion
3. Detection of single photon
4. Single photon interference
5. Two photon interference and/or quantum eraser
6. Plasma Physics: Determination of basic parameters of plasma using Plasma discharge tube.
7. Determination of energy peaks of γ rays from radioactive sources using NaI detector.

SEMESTER IV

Paper- MPHS4401

Module: SP-PRJ [Class weeks: 15 /\ Contact Hours: 30 /\ Credits: 15 /\ Marks 200]

Project and Dissertation

Each student is required to undertake a research project on an advanced topic to be chosen in consultation with a supervisor. The topic will be usually centered around the research activities carried out in the institute. Apart from advanced learning it is expected that each project shall have a research component. The progress of the student will be examined in the mid-semester and in the end-semester examinations. At the end of the project the students have to submit a detailed project report (dissertation) and deliver a seminar in support of their work. Submission of the dissertation has to be done ten days before (excluding) the seminar date. 20% marks will be deducted from the project report component of the marking scheme for each day of delay in submission of the report.

The broad area of research will be considered as the area of specialization in the M.Sc. course.

Paper- MPHS4402

Module: CV [Class weeks: 15 /\ Contact Hours: 6 /\ Credits: 3 /\ Marks 50]

Comprehensive Viva

Each student is required to develop an overall understanding of various aspects of physics as well as acquire general knowledge in physics research around the world as much as possible. Comprehensive Viva aims to examine the student's overall understanding and grasp of basic and advanced (as applicable) topics in Physics and Mathematical Physics. The student will be required to answer conceptual questions and solve problems.

Reference Books (Core Courses)

(Only a few are suggested here. Make your own search)

Mathematical Methods

1. G. Arfken: Mathematical Methods for Physicists
2. J. Mathews and R.L. Walker : Mathematical Methods of Physics
3. P. Dennery and A. Krzywicki: Mathematics for Physicists
4. R.V. Churchill and J.W. Brown: Complex variables and Applications
5. M.R. Spiegel: Theory and Problems of Complex Variables
6. W.W. Bell: Special Functions for Scientists and Engineers
7. A.W. Joshi: Matrices and Tensors in Physics
8. A.W. Joshi: Elements of Group Theory for Physicists
9. M. Tinkham: Group Theory and Quantum Mechanics
10. S.L. Ross: Differential Equations

Classical and Relativistic Mechanics

1. H. Goldstein: Classical Mechanics
2. K.C. Gupta: Classical Mechanics of Particles and Rigid Bodies
3. S.N. Biswas: Classical Mechanics
4. N.C. Rana and P.S. Joag: Classical Mechanics
5. A.P. French: Special Relativity
6. R. Resnick : Introduction to Special Relativity

Quantum Mechanics I

1. S. Gasiorowicz : Quantum Physics
2. P.M. Mathews and K. Venkatesan: A Text Book of Quantum Mechanics
3. E. Merzbacher: Quantum Mechanics
4. J.J. Sakurai : Modern Quantum Mechanics
5. R. Eisberg and R. Resnick : Quantum Physics for Atoms, Molecules, Solid, Nuclei and Particles
6. S. Fluegge : Practical Quantum Mechanics

Electrodynamics

1. J.D. Jackson: Classical Electrodynamics
2. W.K.H. Panofsky and M. Phillips: Classical Electricity and Magnetism
3. J.R.Reitz, F.J. Milford and R.W. Christy: Foundations of Electromagnetic theory
4. D.J. Griffiths: Introduction to Electrodynamics
5. J.B. Marion : Classical Electromagnetic Radiation

Statistical Mechanics

1. F. Reif: Fundamentals of Statistical and Thermal Physics
2. R.K. Pathria: Statistical Mechanics
3. K. Huang: Statistical Mechanics

4. F. Mandl: Statistical Physics
5. H.B. Callen: Thermodynamics and an Introduction to Thermostatics
6. H.E. Stanley: Introduction to Phase Transitions and Critical Phenomena
7. D. Mattis: Theory of Magnetism vol. II
8. J.M. Yeomans: Statistical Mechanics of Phase Transitions

Computation and Numerical Techniques

1. V. Rajaraman: Computer Programming in Fortran IV
2. V. Rajaraman: Computer Oriented Numerical Methods
3. J.M. McCulloch and M.G. Salvadori: Numerical Methods in Fortran
4. Harvey Gould, Jan Tobochnik and Wolfgang Christian: An Introduction to Computer Simulation Methods: Applications to Physical Systems, Third edition, Addison-Wesley (2006).
5. WH Press, SA Teukolsky, WT Vetterling, and BP Flannery (2007). Numerical recipes: The art of scientific computing, 3'rd ed. Cambridge University Press.

Quantum Mechanics II and III

1. L.I. Schiff: Quantum Mechanics
2. J.J. Sakurai: Modern Quantum Mechanics
3. P.M. Mathews and K. Venkatesan: A Text Book of Quantum Mechanics
4. E. Merzbacher: Quantum Mechanics
5. Messiah: Quantum Mechanics, Vol. II
6. J.D. Bjorken and S.D. Drell: Relativistic Quantum Mechanics
7. F. Halzen and A.D. Martin: Quarks and Leptons
8. W. Greiner: Relativistic Quantum Mechanics
9. A. Lahiri and P.B. Pal: A First Book of Quantum Field Theory
10. M. Tinkham: Group Theory and Quantum Mechanics
11. R. Eisberg and R. Resnick : Quantum Physics for Atoms, Molecules, Solid, Nuclei and Particles
12. S. Fluegge : Practical Quantum Mechanics

Electronics and Instrumentation

1. J.D. Ryder: Network, Lines and Fields
2. J. Millman and C. Halkias: Integrated Electronics
3. J.D. Ryder: Electronic Fundamental and Applications
4. J. Kennedy: Electronic Communication Systems
5. J. Millman and A. Grabel: Microelectronics
6. B.G. Streetman, S. Banerjee: Solid State Electronic Devices
7. G.F. Knoll: Radiation, Detection and Measurement
8. Sedra and Smith: Microelectronic Devices
9. Taub and Schilling: Digital Integrated Electronics
10. S.Y. Liao: Microwave Devices and Circuits

11. H.J. Reich: Microwave Principles
12. P. Bhattacharyya: Semiconductor Optoelectronic Devices
13. S.M. Sze: Physics of Semiconductor Devices
14. Boylestad and Nashelski: Electronic Devices and Circuit Theory
15. Horowitz and Hill : The Art of Electronics

Communication

1. Samuel Y. Liao: Microwave Devices and Circuits
2. Herbert J. Reich: Microwave Principles
3. K.C. Gupta: Microwaves
4. M.L. Sisodia and G.S. Raghubanshi: Microwave Circuits and Passive Device
5. N. Mercuvitz: Waveguide Handbook
6. S.M. Sze: Physics of Semiconductor Devices
7. R.E. Collins: Foundations of Microwave Engineering
8. J.D. Ryder: Network Lines and Fields
9. Royal Signals: Handbook of Line Communication
10. W. Frazer; Telecommunications
11. J.D.Kraus: Antenna

Solid State Physics

1. N.W. Ashcroft and N.D. Mermin: Solid State Physics
2. J.R. Christman: Fundamentals of Solid State Physics
3. A.J. Dekker: Solid State Physics
4. C. Kittel: Introduction to Solid State Physics
5. H. Ibach and H. Luth: Solid State Physics: An Introduction to Theory and Experiment
6. J.P. Srivastava: Elements of Solid State Physics
7. J.P. McKelvey: Solid State and Semiconductor Physics
8. D. Pines: Elementary Excitations in Solids
9. S. Raimes: Many Electron Theory
10. O. Madelung: Introduction to Solid State Theory
11. N.H. March and M. Parrinello: Collective Effects in Solids and Liquids
12. J.M. Ziman: Principles of the Theory of Solids
13. C. Kittel: Quantum Theory of Solids
14. M. Sachs: Solid State Theory
15. A.O.E. Animalu: Intermediate Quantum Theory of Crystalline Solids

Atomic, Molecular and Laser Physics

1. B.H. Bransden and C.J. Joachain: Physics of Atoms and Molecules
2. C. Cohen-Tannoudji, B. Dier, and F. Laloe: Quantum Mechanics vol. 1 and 2
3. R. Shankar: Principles of Quantum Mechanics
4. C.B. Banwell: Fundamentals of Molecular Spectroscopy

5. G.M. Barrow: Molecular Spectroscopy
6. K. Thyagarajan and A.K. Ghatak: Lasers, Theory and Applications
7. O. Svelto: Principles of Lasers
8. B.H. Eyring, J. Walter and G.E. Kimball: Quantum Chemistry
9. W. Demtroder: Molecular Physics
10. H. Herzberg: Spectra of Diatomic Molecules
11. J.D. Graybeal: Molecular Spectroscopy
12. M.C. Gupta: Atomic and Molecular Spectroscopy
13. B.B. Laud: Lasers and Non-linear Optics
14. A. Thorne, U. Litzen and J. Johnson: Spectrophysics
15. M. Sargent, M.O. Scully and W.E. Lamb: Laser Physics
16. S. Stenholm: Foundations of Laser Spectroscopy
17. P. Meystre: Atom Optics
18. H. Metcalf and P. Straten: Laser Cooling and Trapping
19. P. Meystre and M. Sargent III: Elements of Quantum Optics
20. R. Loudon: Elements of Quantum Optics

Nuclear and Particle Physics

1. K.S. Krane : Introductory Nuclear Physics
2. J.S. Lilley : Nuclear Physics
3. M.K. Pal: Theory of Nuclear Structure
4. R.R. Roy and B.P. Nigam: Nuclear Physics
5. S.N. Ghoshal: Atomic and Nuclear Physics (Vol. 2)
6. D.H. Perkins: Introduction to High Energy Physics
7. D.J. Griffiths: Introduction to Elementary Particles
8. W.E. Burcham and M. Jobes: Nuclear and particle Physics
9. M.A. Preston and R.K. Bhaduri: Structure of the Nucleus
10. W. Greiner and J.A. Maruhn: Nuclear Models
11. R.D. Evans : The Atomic Nucleus
12. R. Bhaduri : Models of Nucleons
13. J.M. Blatt and V.F. Weisskopf : Theoretical Nuclear Physics
14. J.D. Walecka : Theoretical Nuclear and Subnuclear Physics

Nonlinear Dynamics

1. S. Strogatz: Nonlinear Dynamics and Chaos
2. E. Ott: Chaos in Dynamical Systems
3. Jordan and Smith: Differential Equations and Nonlinear Dynamics
4. Alligood, Sauer, Yorke: Chaos: An introduction to dynamical systems
5. F. Reif: Statistical and Thermal Physics
6. J.K. Bhattacharjee: Statistical Physics
7. J.K. Bhattacharjee and S. Bhattacharyya : Nonlinear Dynamics

Reference Books (Advanced Topics)

(Only a few are suggested here. Make your own search)

Quantum Field Theory

1. M. Peskin and F. Schroeder: Quantum Field Theory
2. J.D. Bjorken and S.D. Drell: Relativistic Quantum Fields
3. D. Bailin and A. Love: Introduction to Gauge Field Theory
4. A. Lahiri and P.B. Pal: A First Book of Quantum Field Theory
5. F. Mandl and G. Shaw: Quantum Field Theory
6. P. Ramond: Field Theory: A Modern Primer
7. C. Itzykson and J.B. Zuber: Quantum Field Theory

Materials Physics

1. C. Kittel: Introduction to Solid State Physics
2. R. Zallen: The Physics of Amorphous Solids
3. N.F. Mott and E.A. Davies: Electronic Processes in Non-crystalline Materials
4. C.N.R. Rao and B. Raveau: Colossal Magnetoresistance, Charge Density and Related Properties of Manganese oxides
5. J.M. Yeomans: Statistical Mechanics of Phase Transitions
6. R.E. Prange and S.M. Girvin (editors): The Quantum Hall Effect
7. H.P. Klug and L.E. Alexander: X-ray Diffraction Procedures

Nuclear Reactions and Nuclear Astrophysics

1. G.R. Satchler: Introduction to Nuclear Reactions
2. K.S. Krane: Introductory Nuclear Physics
3. R.R.Roy and B.P. Nigam: Nuclear Physics
4. J.L. Basdevant, J Rich and M. Spiro: Fundamentals in Nuclear Physics
5. C Iliadis: Nuclear Physics of Stars
6. B.E.J. Pagel: Nucleosynthesis and Chemical Evolution of Galaxies
7. G.F. Knoll: Radiation Detection Measurement

Particle Physics

1. F. Halzen and A.D. Martin: Quarks and Leptons
2. J. Donoghue, E. Golowich and B. Holstein: Dynamics of the Standard Model
3. T.-P. Cheng and L.-F. Li: Gauge Theories in Particle Physics
4. E. Leader and E. Predazzi: An Introduction to Gauge Theories and Modern Particle Physics
5. F.E. Close: An Introduction to Quarks and Partons

Solid State Electronics

1. S.M. Sze: Physics of Semiconductor Devices
2. A. Ghatak and K. Thyagarajan: Optical Electronics

3. J. Millman and A. Grabel: Microelectronics
4. R.S. Gaonkar: Microprocessor Architecture, Progamming and Application with 8085/8086
5. John H. Davies: Physics of Low Dimensional Semiconductors
6. J.H. Fendler: Nanoparticles and Nanostructured Films: Preparation, Characterization and Applications
7. B.G. Streetman and S. Banerjee: Solid State Electronic Devices

Astrophysics and Cosmology

1. T. Padmanabhan: Theoretical Astrophysics, vols. 1-3
2. S. Weinberg: Gravitation and Cosmology
3. M. Rowan-Robinson: Cosmology
4. E.W. Kolb and M.S. Turner: The Early Universe
5. J.V. Narlikar: Introduction to Cosmology
6. T.T. Arny: Explorations, An Introduction to Astronomy
7. M. Zeilik and E.V.P. Smith: Introductory Astronomy and Astrophysics
8. D. Clayton: Introduction to Stellar Evolution and Nucleosynthesis
9. A. Liddle: An Introduction to Modern Cosmology
10. J.B. Hartle: Gravity
11. V. Mukhanov: Physical Foundations of Cosmology

General Theory of Relativity

1. J.V. Narlikar: Lectures on General Relativity and Cosmology
2. S. Weinberg: Gravitation and Cosmology
3. P.A.M. Dirac: General Theory of Relativity
4. L.D. Landau and E.M. Lifshitz: The Classical Theory of Fields
5. C.W. Misner, K.S. Thorne and J.A. Wheeler: Gravitation
6. R.M. Wald: General Theory of Relativity
7. A. Raychaudhuri, S. Banerjee and A. Banerjee: General Theory of Relativity

Many Body Theory

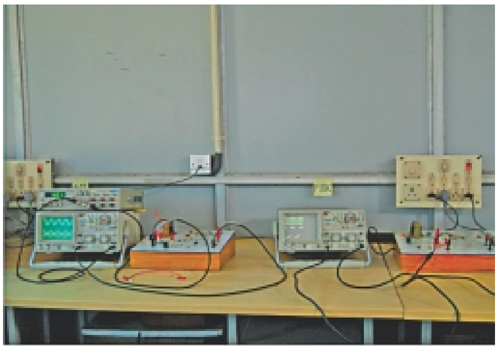
1. S. Raimes: Many Electron Theory
2. Fetter and Walecka: Quantum Theory of Many Particle System
3. G.D. Mahan: Many Particle Physics
4. Negele and Orland: Quantum Many Particle System
5. A.A. Abrikosov et al. : Methods of Quantum Field Theory in Statistical Physics

Physics of Liquid Crystals

1. E.B. Priestley, P.J. Wojtowich and P. Sheng: Introduction to Liquid Crystals
2. P.G. de Gennes: Physics of Liquid Crystal
3. S. Chandrasekhar: Liquid Crystals
4. P.J. Collings and M. Hand: Introduction to Liquid Crystals

FACILITIES AVAILABLE

The following are some of the facilities available to students.



Laboratory on communications

Plasma Physics Laboratory

Space Science Laboratory

Cosmic Ray Laboratory

Library

Raman Spectroscopy Laboratory

Central Instrument Facility

Madhyamgram Experimental Farm

SYLLABUS FOR M.Sc. | LIFE SCIENCES

SEMESTER I

Course - 401 Mathematical, Statistical and Computational Tools (T2:L30)

Coordinator: **SUMAN K. BANIK**

Mathematical Tools (10 Lectures):

Functions, Differentiation (including Maxima and Minima), Integration, Differential equation (1st order), Matrix and Determinant.

Statistical Tools (15 Lectures):

Sample vs. Population, Data display (frequency distributions), Statistical properties (mean, standard deviation, coefficient of variation), Error analysis, Meaning of confidence interval, Elements of probability, Probability distributions (binomial and normal distribution), Statistical Tests, Correlation and Regression, Hypothesis Testing.

Computational Tools (5 Lectures):

Data Types (Integer, Real, Complex and Double Precision), Variables and Simple Input/Output, Library Functions, Decision Based Control Structures (GO TO, IF, IF THEN ELSE), Relational (LT, LE, EQ, NE, GT, GE) and Logical (NOT, AND, OR) Operators, Loops (DO Loops, Nesting), Variables and Arrays.

Course – 402 Chemical Principles (T1:L15)

Coordinator : **SHUBHRANGSU CHATTERJEE**

Chemical Thermodynamics: *Law of Mass action and Chemical Equilibrium; Association and Dissociation constants; Enthalpy; Second law of thermodynamics and Entropy; statistical interpretation of entropy; Concept of free energy.*

Chemical Kinetics: *Different orders of reaction; simultaneous and parallel reactions; Activation energy and Arrhenius equation.*

Solutions: *Concept of Moles, Molar concentrations. pH and ionic strength. Buffers and Buffer strength; acid and base dissociation constants; Henderson-Hasselbach equation.*

***Basic concepts of Organic Chemistry**: Different types of chemical reactions important in Biology (Substitution, Elimination etc.); Aromaticity; Stereochemistry and optical activity.*

Course - 403 Experimental Methods (T1:P1:L15)

Coordinator: **ABHRAJYOTI GHOSH**

Chromatography

General principles of separation, Concept of plate number, Importance of the different steps involved in Column Chromatography (preparation of column, sample loading, wash and elution).

***Ion-exchange chromatography**: Operating principles, various cation and anion exchangers, adsorptive capacities and conditions of adsorption, buffers, methods of elution.*

Affinity chromatography: *principles and selected applications*

Gel filtration chromatography: *principles and applications including measurement of molecular weight.*

Reverse phase chromatography: *general principles.*

Discussion on merits and demerits of each type of chromatography.

Centrifugation

Basic equations, sedimentation coefficient, S-value and k-factor, different types of centrifugation (differential pelleting, rate zonal, isopycnic), types of rotors (fixed angle, swinging bucket and vertical) and their applications, care of rotors.

Electrophoresis

Basic principles, components of an electrophoretic unit, types of support media (agarose and polyacrylamide), pore size and resolution, buffers, dyes (loading, staining), native and denaturing gels, SDS PAGE, principles of isoelectric focusing and 2D gels.

Practical

1. *Understanding the formation of an acrylamide gel, preparing an acrylamide gel and running a sample.*
2. *Paper chromatography with simple dyes/ inks.*
3. *Determination of void volume/ analyzing a 2D gel*

Course – 404 Spectroscopy and Its Applications in Biology (T1:P1:L15)

Coordinators: **AJIT B. DATTA & SMARAJIT POLLEY**

Mass Spectrometry: *Basic Principle, components of mass spectrometer, MALDI and ESI ionization, sample preparation and data analysis. 2 lectures*

Radiochemical Methods. Basic concepts, radioactive decay, units of radioactivity, detection and measurement of radioactivity, Geiger-Muller counters, scintillation counters, applications of radioisotopes in biology.

***Absorption spectroscopy**: Light-matter interaction, Electronic states, and absorption of light. Allowed (pi-pi*) and dis-allowed (n-pi*) transitions with amide bond as an example. UV-vis spectra of peptides, aromatic side chains and DNA. Beer's law – its application and limitations. Applications: concentration measurement, relative stabilities of DNA, DNA/protein ratio.*

Vibrational spectroscopy: *Introduction to IR and Raman spectroscopy with emphasis of complementary selection rules. Applications to select problems. 1 lecture*

***Circular dichroism spectroscopy**: Polarization of light and 'handed-ness' of macromolecular structure. Different absorption of circularly polarized light by peptide bonds in proteins and its correlation with secondary structure. CD spectra of nucleic acid and induced CD of DNA-bound drugs.*

***Fluorescence spectroscopy**: Origin of fluorescence vis-à-vis deactivation processes associated with electronic states. Fluorescence yield, position of emission maximum and its variation with solvent polarity. Fluorescence spectrum of Trp and simple applications (protein unfolding and ligand binding). Basic idea of FRET with examples. Basic idea of fluorescence polarization and some applications.*

Biological calorimetry. Isothermal calorimetry and differential scanning calorimetry and some examples.

Surface plasmon resonance. Basic idea of surface plasmon resonance and its application.

Practical

404.E1. Absorption spectra of amino acids and nucleic acids

404.E2. Fluorescence spectra of amino acids and nucleic acids

404.E3. Melting of dsDNA by absorption spectroscopy

Course – 405 Biophysical Chemistry (T1:P1:L15)

Coordinator: GAUTAM BASU

Molecular Interactions:

Covalent and non-covalent interactions, electrostatic interactions, Van der Waal's interactions, hydrogen bonds, hydrophobic interactions, Force fields, Thermodynamics signatures of molecular interactions

Macromolecular Structure:

Amino acids, peptides, Proteins; Primary, Secondary, Tertiary and Quaternary structures; Domains; Intrinsically disordered proteins; Protein conformation Bases, Nucleosides and Nucleotides; Canonical and non-canonical DNA structures; RNA structures

Lipids and Membranes:

Different kinds of lipids present in the cell; Membrane structure, fluid-mosaic model; Rafts; membrane potential and electron transfer

Protein folding:

Basic concepts of Protein folding; hierarchical model of protein folding; Thermodynamics of protein folding; Kinetics of protein folding; Protein unfolding and denaturation; Single-state versus multi-state unfolding.

Macromolecule-Ligand interaction:

Binding isotherms; Single site binding and binding of multiple ligands to a receptor; Analysis of ligand binding to macromolecules; Cooperativity and different models of cooperativity

Practical:

1. *405.E1. Equilibrium Protein Unfolding using CD and fluorescence spectroscopy*
2. *405.E2. Measuring DAPI-DNA equilibrium binding using Fluorescence Spectroscopy*
3. *405.E3. In-silico construction of biomolecules and energy minimization*

Course - 406 Biochemistry (T2:P1:L30)

***Coordinator:* MAHADEB PAL**

***Proteins and Enzymes:** Protein isolation, purification and characterization, Chemical modification of proteins including post-translational modification, Enzyme Kinetics and Regulation, Enzyme inhibition*

Metabolism: *Basic principles of metabolic inter-conversions, Glycolysis and other catabolic pathways, Citric acid cycle, Biosynthetic pathways, Regulation of metabolic pathways, Evolution of metabolic pathways.*

Replication, Transcription and Translation

Chromosome organization in prokaryotes, DNA replication in prokaryotes, repair

Bacterial transcription- component and methodologies. Organization of genetic material: split genes, overlapping genes, pseudo genes, cryptic genes. Prokaryotic gene expression (lac, his, trp operon, catabolite repression). Introduction to Archaeal transcription-the Third way.

Prokaryotic translation- components and methodologies. Properties of genetic code, codon assignments, chain initiation and chain termination codons, wobble hypothesis.

Eukaryotic Transcription regulation

RNA polymerases, Basic transcription, core promoters; general transcription factors;

Transcription activation: activators; DNA binding specificities of activators; functional domains of activators; nucleosomes; transcription through nucleosomes; chromatin remodelers; epigenetic gene regulation, codes, writers and readers. Insulators.

Practical

Protein estimation, standard curve of protein, protein isolation, ammonium sulfate precipitation, enzyme activity assay, determination of Km and Vmax, determination of IC50 / IS50, reversible and irreversible type of binding of inhibitor to enzyme.

Course - 407 Cell Biology (T2:P1:L30)

Coordinator : **KAUSHIK BISWAS**

Cell: *The unit of life; structure and function of prokaryotic, eukaryotic and plant cells. An overview of stem cells, i.e., the origin of all cells, including specialized cells.*

Cell differentiation: *Waddington's landscape of differentiation, de-differentiation and trans-differentiation; factors regulating differentiation, e.g., gene expression, epigenetic regulation etc.*

Membrane structure and cytoskeleton: *Cell wall, biomembranes, constituents and fluidity of plasma membrane, endo-membrane system - structure and function of microbodies, membrane maturation and specialization. Active and passive membrane transport, plasmodesmata and its structural and functional significance; ion channels, vesicular trafficking.*

Structure and function of cytoskeleton, cytoskeletal proteins, e.g., actin, tubulin etc., microtubules and microfilaments.

Organelles and their functions: *Mitochondria-structure and function, Electron transport complexes; structure and function of chloroplast: photosynthetic electron transport chain; structure and functions of ribosomes, endoplasmic reticulum, golgi apparatus, lysosomes and nucleus.*

Cellular processes: *Overview of cell proliferation, adhesion, motility etc., and communication through cell signaling.*

The basic events of the cell cycle: Overview of the cell cycle and its control, molecular mechanisms for regulating mitotic events, meiotic division, cell cycle control in mammalian cells, checkpoints in cell cycle regulation, cellular homeostasis, disorders of cell cycle - cancer and apoptosis. The relevance of cell biology in human health and disease.

Integrating cells into tissue: *Extracellular matrix, basement membranes, proteoglycans, collagen, integrins, fibronectin, cellular junctions.*

Practical

Cell counting using haemocytometer; Cell viability assay by trypan blue exclusion.

Histology: Haematoxylin and eosin staining techniques of histological slides to identify cells of different tissues.

Flow cytometry: Differentiation of cells, e.g., RBC, neutrophils, eosinophils, basophils, monocytes, depending on their size and shape; Analysis of different phases of cell cycle.

Fluorescence microscopy: To study cytoskeletal proteins, e.g., actin, by immunofluroscence microscopy.

Course - 408 Microbiology (T1:P1:L15)

Coordinator: SUJOY K. DASGUPTA

Microbial diversity:

Prokaryotic and eukaryotic microbes; Identification and classification of prokaryotes (bacteria and archaea); Polyphasic taxonomy.

Microbial ecology and evolution:

Microbial habitats; Community concept; community exploration; Geomicrobiology and evolution of the biosphere; Molecular phylogeny; Microbial paleontology.

Prokaryotic metabolism:

Mechanisms of bacterial and archaeal nutrition; Ancient metabolisms; Chemotrophy versus phototrophy.

Medical microbiology:

Host- pathogen interactions, Public health microbiology.

Practical 3 X 5

1) *Bacterial growth curves, exponential and synchronous growth*
2) *Isolation of bacteria from soil, and environment*
3) *Molecular Phylogeny*
4) *Simple, Gram, and Acid fast staining, DAPI staining and confocal/fluorescence microscopy*
5) *Assays for enzymes elaborated by bacteria .*

Course - 409 Plant Biology (T1:P1:L15)

***Coordinator:* GAURAB GANGOPADHYAY**

Plant Kingdom: *Cyanobacteria, Algae, Fungi, Bryophytes, Pteridophytes and Gymnosperm, Angeosperm; Dicot and monocots; life cycle patterns, alternation of generations (1 lecture GG)*

Plant organs: *Root system; Shoot system - branching, - Aerial, sub-aerial and underground; simple and compound leaves, Phyllotaxy, Inflorescences- Definition and types- Racemose, Cymose etc., Mixed and special types; Flower is a modified shoot, Types of stamen and carpel, Types of fruits.*

Plant Anatomy: *Fundamental or ground tissue system; Vascular tissue system, Types of vascular bundles; (1 lecture GG)*

Embryology :Microsporogenesis, Development of male gametophyte; Megasporogenesis, Development of female gametophyte; Gametic fusion; Triple fusion; Development of dicot embryo- Development of monocot embryo

Plant Physiology: *Chlorophyll and other plant pigments Photosynthesis, Photorespiration,; Solute transport across the membrane, Long distance transport through xylem and phloem; transpiration; Biological nitrogen fixation; Plant growth regulators their transport and application; photoperiodism, vernalization, Seed dormancy, Senescence.*

Plant beneficial microbes interaction: *types of association with a plant and biochemical/genetic aspect of mutual exchange*

Plant stress response: *Plants' response to abiotic and biotic stresses; Disease concept; disease cycle and control measures - Blast disease of rice, brown spot of rice, black stem rust of wheat, early blight of potato, late blight of potato, wilt of pigeon pea, stem rot of jute, red rot of sugarcane.*

Practical

Analysis of plant tissue architecture - root, stem, leaf, meristem, flower bud, anther etc.

Analysis of stages of plant cell division via microscopic studies.

Analysis of plants' response to stress

SEMESTER II

Course - 501 Immunology (T2:P1:L15)

Coordinator: **GAURISANKAR SA**

IM-1: *Introduction to immune system: Cells and organs of immune system.*

IM-1.1. *Lymphoid tissue, origin and development: Structure and function of lymphoid tissue.*

IM-1.2. *Differentiation of lymphocytes, lymphocyte sub populations.*

IM-1.3. *T and B cells and their antigens.*

IM-1.4. *APC cells, lymphokines, Phagocytic cells, macrophage, dendritic cells, K and NK cells.*

IM-2. *Innate immunity: Properties. components interactions. Major histocompatibility complex, antigen processing and presentation.*

IM-3. *Antigen Presentation and recognition*

IM-4. *Cell mediated immune Response*

IM-5. *Humoral Immune Response*

IM-6. *Hypersensitivity reactions.*

IM-7. *Autoimmune Disorder*

IM-8. *Immunodeficiency*

IM-9. *Transplantation*

IM-10. *Vaccines.*

IM-11. *Tumor-immunology, cancer & immunotherapy.*

IM-12. *Critical review and hands-on training: Basic immunological technique like agglutination, single and double immune-diffusion, immuno-fluorescence, RIA and ELISA CD4+/CD8+ phenotyping, Th-1/Th2 intracellular cytokines assay, specialized T cell phenotyping, etc.*

Recommended Books

Immunology - Kuby

Immunology by I. Roitt, J. Brostoff, and David Mole (4th Ed.).

Course - 502 Genetics and Genomics (T2:P1:L30)

Coordinator: **SRIMONTI SARKAR**

Historical perspective*: Prokaryotic genetics and advent of recombinant DNA technology; Mendelian genetics*

Chromatin Structure and Chromosome Organization: *Histones, DNA, nucleosome morphology and higher level organization; Functional states of chromatin and alterations in chromatin organization, Metaphase chromosomes: centromere and kinetochore, telomere and its maintenance; Heterochromatin and euchromatin, position effect variegation; Chromosomal domains (matrix, loop domains) and their functional significance; non-coding DNA and its significance; Bacterial and eukaryotic transposons; Chromosome abnormalities and human diseases*

Organelle DNA*: Variance in size and coding capacity of mitochondrial DNA; Cytoplasmic inheritance of the petite mutation in yeast; Mitochondrial genetic code; Genetic diseases associated with mitochondrial DNA*

Model Systems in Genetic Analysis: *Bacteriophage, E. coli, Neurospora crassa, Saccharomyces cerevisiae, Schizosaccharomyces pombe, Arabidopsis thaliana, maize, Drosophila melanogaster, Caenorhabditis elegans, Zebra fish, Mouse - General outline of life cycle and importance in genetic analysis*

***Uncovering pathways and determining gene functions**: Selections and screens; Forward and reverse genetics; Genetic versus physical interaction; Suppressor, multi-copy suppressor and synthetic lethality to uncover functionality*

***Population Genetics:** Allele frequencies and genotype frequencies; Hardy-Weinberg Principle; Inbreeding; Mutation and migration; Natural Selection; Random genetic drift; Tracing human history*

***Genomics:** Genome sequencing and assembly; Genome annotation; Comparative genomics; Protein structural genomics; Global expression profiling; Comprehensive mutant libraries; Mapping protein interactions; Biochemical genomics; Next-generation sequencing technology and related applications*

Suggested text books:

Molecular Cell Biology (7th Edition); Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krienger, Anthony Bretscher, Hidde Ploegh, Angelika Amon, Matthew P. Scott

Principles of Genome Analysis and Genomics (3rd Edition) S. B. Primrose and R. M. Twyman

Introduction to Genomics (2nd Editions) Arthur M. Lesk

Practical

1. *Prototrophy and auxotrophy*
2. *Low- and high-efficiency transformations*
3. *Mating experiment*
4. *Yeast two hybrid interaction*
5. *Differentiating between selections and screens*
6. *Isolation of genomic DNA and PCR amplification of target gene*

Course - 503 Bioinformatics and Computational Biology (T2:P1:L30)

Coordinators: **ZHUMUR GHOSH and SHUBHRA GHOSH DASTIDAR**

***Module I:** Introduction to computational biology & bioinformatics. Branches of bioinformatics.*

Module II: Biological Databases

Nature of biological data. Biological data formats. Bioinformatics databases: Literature databases (PubMed), Primary nucleotide sequence databases (NCBI, EMBL, DDBJ), Secondary nucleotide sequence databases (UniGene, SGD etc.), Protein sequence databases (SwissProt/TrEMBL, PIR), Sequence motif databases (Pfam, PROSITE), Structure databases (PDB, NSD, SCOP, CATH), Gene Expression databases.

Module III: Basics of algorithms and bio-tools

Basics of sequence alignment. Scoring matrix, BLAST series, FASTA. Pairwise Sequence Alignments and Multiple sequence alignments (ClustalW). Global Alignments – Needleman Wunsch Algorithm, Local Alignments – Smith Waterman

Algorithm. Multiple sequence alignments (ClustalW). Basic concepts on phylogenetic markers and molecular phylogeny. Comparative genomics and gene prediction tools.

Module IV: Basics of molecular modelling

Parameters to represent a macromolecule in computer, empirical estimation of stabilities (or energy) of macromolecular conformations, potential energy landscape, simple methods of searching stable conformations (energy minimization). Solvent models, use of periodic boundaries, implicit solvent techniques. Notes on the degree of accuracy of the models, force-field and parameters. Advantages and common pitfalls.

Module V: Practical implications of molecular models

Qualitative understanding of the link between microscopic world (molecular model) and macroscopic events (experiments) and the principles to correlate them, Ergodic Hypothesis. Ideas of conformational sampling to predict macroscopic behavior of the molecular systems. Elementary concepts of the deterministic and stochastic methods of *sampling (without much mathematical details): Molecular dynamics and monte-carlo methods. Exposure to the domains of applications. Strategies to overcome computing challenges.*

Practical: *Visualizing and understanding biological data formats, such as genbank flat file, fasta, nexus, pdb etc. Exploring nucleotide and protein databases (2 classes)*

Hand's on exposure to all items in module IV and V

Course - 504 Chemical and Systems Biology (T2:P1:L30)

Coordinator: **SUMAN K. BANIK**

Basic premises of Chemical and Systems Biology*: Integrative view of biology, non-linear dynamics in biology, non-equilibrium thermodynamics in biology.*

Interrogating the system: *Chemical genetics approach, how to design or select specific ligands, using high-throughput omics methods.*

Tools of Chemical Biology: *Biological mass spectrometry, imaging (confocal and super resolution microscopy), MRI, fluorescence imaging.*

Biology from network perspective: *Network properties, gene regulatory networks, protein-protein interaction networks, neural networks.*

Modeling biological systems: *Building blocks of biochemical networks (motifs and switches), Boolean representations, graphical analysis.*

Drug discovery: *Validating drug targets, designing molecules to inhibit enzymes and receptors, new generation of drug targets, Pharmacokinetics and Pharmacodynamics, biologicals as drugs.*

Practical: *Modeling of simple biological motif using Mathematica.*

Suggested Text:

1. *Fundamentals of Systems Biology by Markus W Covert (CRC Press).*
2. *An Introduction to Systems Biology by Uri Alon (CRC Press).*

Course - 505 Cell Signaling (T2:P1:L15)

Coordinator: MAHADEB PAL

An Overview of cell signaling

Basic characteristics of cell communication systems: Aspects of cellular signaling*:* The main principles of cell signaling. Different ways in which cells signal to each other - *paracrine, endocrine, autocrine signaling,* amplification and physical architectures, coordination of signaling domains and modules

Pathways are the key to signaling: Simplified examples of signaling pathways, components that comprise signaling pathways. Extracellular signals - hormones, cytokines and growth factors*:* Hormones, cytokines, growth factors, neurotransmitters, pheromones. Receptors*:* Types of receptors, ligand binding to their receptors, receptor sensitivity and receptor density, *ion channel receptors,*

Different signaling pathways: *Growth factor and cytokine signaling, G-protein coupled receptor signaling,* photodetection in the eye, *steroid signaling,* redox signaling, regulation of gene expression

Protein phosphorylation, kinases and phosphatases, *relevance of phosphorylation and dephosphorylation in signal transduction*

Intracellular calcium: its control and role as an intracellular signal: Calmodulin, *plasma membrane and its role in calcium concentration maintenance,* intracellular stores, gradients, waves and oscillations, sphingosine-1-phosphate, cyclic ADP-ribose, nicotinate adenine-dinucleotide phosphate, *Ca-ATPase*

Apoptosis: An overview of apoptosis, caspases, *intrinsic and extrinsic pathways, related methodologies.*

Bacterial cell signaling, response to environmental stress - a bacterial perspective

Critical review and hands-on training

Practical

Western blot analysis of factors involved in a specific signaling pathway, e.g., PI3K/AKT pathway; Alteration in signaling pathway due to application of some drug/phytochemicals.

To study the interaction between two proteins in a signaling pathway by co-immunoprecipitation, e.g., p53 and mdm2.

Identification of apoptotic cells by (i) Annexin-V binding assay, (ii) nuclear blebbing by DAPI staining and DNA ladder formation by apoptotic DNA in agarose gel.

Determination of pro/anti apoptotic protein levels, i.e., Bax/Bcl2, under control and drug-treated conditions by Western blotting.

Course - 506 Plant Development (T2:P1:L15)

Coordinator: **GAURAB GANGOPADHYAY**

Concept of plasticity in plant development

Molecular mechanism of Hormone action on plant development

Organization of shoot apical meristem (SAM) and root apical meristem (RAM), Inflorescence and floral determination

Molecular genetics of floral development and floral organ differentiation

Molecular mechanisms of light perception, signal transduction and gene regulation

Embryonic Pattern Formation, embryogenesis and early pattern formation in plants

Molecular and genetic control of Senescence and its Programmed Cell Death in plants

Recommended text: *Plant Physiology and Development, Sixth Edition, by Lincoln Taiz , Eduardo Zeiger , Ian Max Moller, Angus Murphy*

Course - 507 Animal Development (T1:L15)

Coordinator: ATIN K. MANDAL

Developmental Biology: *basic concepts, techniques and model organisms. Cell commitment and differentiation, regulation of differentiation, maternal information, positional information in development,morphogenetic gradients; cell fate and cell lineages stem cells; genomic equivalence and the cytoplasmic determinants; imprinting mutants and transgenic in analysis of development.*

Gametogenesis,fertilization and early development: *spermatogenesis and oogenesis, cell surface molecules in sperm-egg recognition; structure of sperm, regulation of sperm locomotion, fertilization, cleavage, blastula formation, embryonic fields, gastrulation and formation of germ layers in animals; Cellular and Biochemical process during fertilization and strategies for monospermy and conservation of species specificity. Acrosome reaction and signal transduction. Egg activation*

Morphogenesis and organogenesis in animals: *Cell aggregation and differentiation in Dictyostelium; axes and pattern formation in Drosophila, amphibia and chick, eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.*

SEMESTER III

Core Courses (Compulsory to all students)

Course - 601 Biophysical Chemistry (T2:P1:L30)

Coordinator: **GAUTAM BASU**

Protein conformation and dynamics (5 Lectures): Proteins as dynamic entities; translational and rotational motions of proteins; hydrodynamic properties of proteins and relationship with conformation; internal motions of proteins and its importance in protein function.

Nucleic acid conformation and dynamics (5 Lectures): Forces behind association of DNA strands; RNA folding; melting of DNA and its kinetics, thermodynamics of DNA melting; base-mobility and base-flipping.

Macromolecular interactions (10 Lectures): Protein-ligand interactions; entropy-enthalpy compensation; conformational pre-selection; induced-fit; thermodynamic origin of affinity and specificity; protein-protein interactions.

Advanced protein folding (5 Lectures): Protein folding in vivo; chaperones; protein aggregation.

Studying Biological molecules at Single-molecule resolution (5 Lectures):

Optical tweezers; fluorescence correlation spectroscopy.

Course - 602 Molecular and Cellular Biology (T2:P1:L30)

Coordinator: **KAUSHIK BISWAS**

Signaling Events (10 Lectures):

Inter- and intracellular signaling responses for various cellular processes like proliferation, differentiation, angiogenesis, migration and apoptosis, specialized signaling, e.g., immune cell signaling, neuronal cell signaling etc.; errors in signal transduction and its relevance to human diseases

Roles of mitochondria in health and diseases (2 Lectures):

Origin and evolution, mitochondria-associated endoplasmic reticulum membrane, organization and distribution, function, genome, population genetics study, mitochondrial bioenergetics, dysfunction and diseases

How to combat cell stress (4 Lectures):

Protein transport, protein folding and sensing of unfolded proteins – relation to diseases

Human genetic disorders (3 Lectures):

Chromatin biology, epigenetics, single gene disorders and their pattern of inheritance; chromosomal diseases; understanding genetic diseases through gene mapping, SNPs and microarray data.

Nanomedicine (2 Lectures):

Use of nanomaterials in medicine and medical devices

Genetic modification in Medicine (5 Lectures):

Gene therapy: types of gene therapy, vectors in gene therapy, molecular engineering, human genetic engineering, problems &ethics.

Application of molecular tools in modern medicine (4 Lectures):

Restriction enzymes and modified enzymes in medical biotechnology. Development of diagnostic tools for various diseases.

Course - 603 Plant Molecular Biology and Biotechnology (T2:P1:L30)

Coordinator: **PALLOB KUNDU**

Molecular aspect of Plant Metabolism (15 lectures)

Water relations of plants: Physico-chemical properties of water, water potential; mechanism of absorption of water - active and passive transport - Apoplast and symplast concept; stomatal mechanism; ascent of sap; mineral nutrition - macro and micro nutrients, their role and deficiency symptoms; absorption of solutes - passive, active diffusion and facilitated diffusion antiport - translocation of solutes (photosynthates).

Genetics of the biogenesis and dynamics of the photosynthetic machinery in plants: Ultrastructure of chloroplast - Light harvesting systems. Reaction center, P680, P700, water oxidation complex, electron transport system - photophosphorylation cyclic - non cyclic mechanism - photosynthetic carbon reduction pathways in C3, C4 and CAM plants - Biochemical variants of C3-C4 intermediates. Biochemistry of RUBISCO; photorespiration and its significance.

Genetics and regulation of symbiotic and in free-living bacteria nitrogen fixation: Source of soil nitrogen; nitrogen fixing organisms - Legume - Rhizobium symbiosis, biochemistry and physiology; nitrogenase, characteristics and functions of leghaemoglobin; nitrate reduction - biochemistry and characteristics of NR and NiR - assimilation of ammonia; transamination, reductive amination; synthesis of amino acids, interaction between photosynthesis and nitrogen metabolism.

Effect of light on growth, development and immunity: Phytochrome - properties and phytochemical transformation movement - nastic and tropic movements, photoperiodism; circadian rhythm in plants.

Signaling Mechanisms in Plants (15 Lectures) Developmental signaling: Mode of action of plant growth regulators - Auxins, Gibberellins, Cytokinins, Abscisic acid, Ethylene, Brassinosteroid, Jasmonic acid.

Plant Stress signaling: Biotic stresses and signaling (stress physiology of virus, bacteria, fungus, oomycete, nematode, insect and pest infection/infestation; mechanisms of natural resistance; programmed cell death); abiotic stresses and signaling (stress physiology of drought, salinity, thermal, submergence, UV stress, etc.; mechanisms of natural tolerance); signaling crosstalk during stress.

Course - 604 Computational and Systems Biology (T2:P1:L30)

Coordinator: **SUMAN K. BANIK**

Transcription regulatory networks (6 Lectures): The Lac operon; the lambda phage genetic network

Signal transduction motifs (6 Lectures): Two component system; MAP kinase cascades, cross talk

Stochastic gene expression (4 lectures): Origins and consequences

Single cell analysis of gene expression and information processing (4 Lectures) Functional roles of noise (4 Lectures): Cell differentiation and phenotypic heterogeneity

Synthetic biology (2 Lectures): Synthetic biology with focus on genetic toggle switch and repressilator

Elements of network theory (4 Lectures): Concepts of graphs, directed and undirected networks, degree distribution; different metrics in networks

Course – 605 Scientific Ethics and Soft Skills (T1:L15)

Coordinator: **SRIMONTI SARKAR**

Lectures on scientific ethics, personality development and communication skills.

SEMESTER III

Specialized Course (any one)

Course - 606 Biophysical Chemistry (T3:L45)

Coordinator: ANIRBAN BHUNIA

Methods of High-resolution Structure Determination

X-ray crystallography (15 lectures):

1. Comparison of different methods for determining macromolecular structures. Basics of X-ray diffraction, Bragg's law, concept of reciprocal space &Ewald sphere construction. Crystal symmetry, symmetry in the reciprocal space, systematic absences and space group determination.
2. Crystallization techniques, practical limitations, sample purity, precipitating agents, crystal nucleation and growth, crystal visualization.
3. X-ray data collection – handling of protein crystals, mounting techniques, X-ray sources and detectors, diffraction limit and mosaicity, autoindexing, data processing - integration and scaling, determination of data quality - calculation of R-factors, multiplicity and completeness.

4. Phase problem and its solutions. Molecular replacement- principles and practice.
5. Isomorphous replacement- principles and practice, heavy atom derivatives and usefulness. Multiple anomalous dispersion-basis of anomalous diffraction, absorption edges, f and f"values. 6. Introduction to structure solution, refinement and validation. Calculation of electron density maps and model building, automated and manual building procedures using available tools, refinement strategies, optimum model refinement and validation of the structure.

NMR spectroscopy (15 lectures)

1. Basic NMR phenomenon; rotating frame description; pulse Fourier transform NMR; chemical shift; scalar coupling
2. Relaxation and relationship with motion; Nulcear Overhauser Effect and distance determination
3. Polarization transfer; selective excitation; spin-echo
4. Important NMR experiments: two-dimensional NMR, COSY, NOESY, TOCSY, heteronuclear shift-correlation.
5. Some examples of Protein and Nucleic acids NMR.

Cryo-Electron Microscopy (5 lectures)

1. Basic anatomy of the electron microscope (electron guns, lenses, energy filters, detectors etc.).
2. Challenges in Biological EM (sample preparation, freezing, grids), Image formation (amplitude and phase contrast, wave propagation, the Contrast Transfer Function, Defocus and its importance, Envelopes and CTF correction).
3. Introduction to Tomography, Introduction to Single Particle analysis (imaging, reconstruction and interpretation).

Advanced Fluorescence (10 lectures):

1. FRET, fluorescence polarization, Time-resolved fluorometry
2. Different fluorescence probes and their applications in life science.
3. Fluorescence Microscopy, Super-resolution microscopy.

Course - 607 Molecular and Cellular Biology (T3:L45)

Coordinator: **KAUSHIK BISWAS**

Signaling hubs and interactomics (12 Lectures): Genetic changes, onset and progression of diseases, errors in cell signaling in virally infected diseases; diseases due to metabolic disorder; free radicals and disease; inborn errors of metabolism; molecular targets in relation to novel therapeutic applications, use of bioinformatics and molecular docking tools to analyze signaling cross-talks in normal and diseased cells and to predict target-specific drugs.

Drugs and disease (6 Lectures): Strategies to overcome drug resistance; antimetabolite drugs and alkylating agents; drugs interacting with DNA; drugs targeting signaling hubs, targeted drug delivery; antibody-directed agents and their associated problems; photodynamic agents, redox-activated drugs, antibacterial therapies, and mechanisms of drug action.

Pathophysiology of diseases (6 Lectures): Cause/etiology, mechanisms of development (pathogenesis), morphologic changes and the clinical manifestations, anatomical pathology and clinical pathology, cytopathology, hematopathology, histopathology, forensic pathology, molecular pathology: from molecule to disease and disease to molecule.

Stem Cells (9 Lectures): Overview of stem cells; types of stem cells; signaling pathways governing stem cell fate; mechanisms of selfrenewal, pluri/multipotency and lineage differentiation; epigenetics and reprogramming in stem cell biology; application of stem cells in therapy; cancer stem cells and their role in cancer development and progression; relationship between stem cell and cancer stem cells; role of niches in stem cells, ethical issues in stem cell research.

RNA world (4 Lectures): Tools and targets for drug discovery; genetic engineering in therapeutic application.

Antimicrobial agents and chemotherapy (6 Lectures): Bacterial resistance to antibiotics and toxic compound; bacterial energetics (energy yielding life processes); antiviral agents and chemotherapy; mode of action of anti-viral drugs and their targets, highly active antiretroviral therapies (HAART).

Ethical and legal issues in biomedical research (2 Lectures): Legal, ethical and regulatory issues in biomedical research; related techniques

Course - 608 Plant Molecular Biology and Biotechnology

(T3:L45) Coordinator: PALLOB KUNDU

1. Crop improvement: Identification and use of beneficial genes/traits Gene expression, and regulation in plants (6 Lectures): An overview of nuclear and organelle gene function, and expression, with emphasis on aspects that are unique to plant genes. Epigenetic components for plant gene regulation

Approaches to study gene expression (14 Lectures):

Gene expression analysis: SAGE, Microarray; Next generation sequencing

Functional genomics: Gene targeting/tagging, gene silencing.

Proteomics: Proteome analysis, Protein mass analysis; Peptide fingerprinting; Identification of gene from protein. Protein-protein interaction studies.

Metabolomics and Nutrigenomics

Genetics (3 Lectures):

Quantitative genetics: Polygenic inheritance, heritability and QTL mapping.

Extra chromosomal inheritance: Inheritance of mitochondrial and chloroplast genes, maternal inheritance.

2. Plant biotechnology

Gene mapping methods and analysis (6 Lectures):

Development of Linkage maps: Tetrad analysis; development of mapping poulation.

Molecular marker assisted approach: RAPD, RFLP, SSR library preparation, ISSR, SNPs, SNP detection using TaqMan/molecular Beacon tools. Plant phenomics in marker assisted breeding. Marker assisted breeding for quality improvement.

Plant genetic engineering and gene transfer technology (14 Lectures):

Agrobiology: Agrobacterium plant interaction; Virulence; Ti and Ri plasmids; Opines and their significance; T-DNA transfer.

Genetic Transformation: Cointegrate and binary Vectors and their utility; Agrobacterium mediated gene delivery; characterization of transgenics.

Direct gene transfer: PEG-mediated, electroporation, particle bombardment and other alternative methods, Chloroplast transformation.

Genetic engineering for crop improvement: Marker- free transgenics methodologies; Protein engineering; Value addition compounds; yield increase; Post-harvest bioengineering; Plant architecture; Phytoremediation.

Plants as Biofactories (2 Lectures): Concept of biofactories; Fermentation and production of industrial enzymes, biomolecules; Cell cultures for secondary metabolite production; Bioenergy generation.

Course - 609 Computational and Systems Biology (T3:L45)

Coordinator: SUMAN K. BANIK

Dynamical systems (15 Lectures): Fixed points; linear stability analysis; bifurcation; phase plane analysis; limit cycles

Applications of dynamical systems in biology (5 lectures):

Advanced course in Probability (10 lectures): Discrete and continuous variables, joint probability distribution, moment generating functions

Introduction to stochastic theories and techniques (15 lectures): Birth-death processes, Master equation, Fokker Planck equation, Langevin equation

SEMESTER IV

Course 701 Research Project (Dissertation and Presentation) [Class weeks: 15, Credits: 14]

Each student is required to undertake a research project on an advanced topic to be chosen in consultation with a supervisor. The topic will be usually centered on the research activities carried out in the respective laboratory. The progress of the student will be examined in the mid-semester and in the end-semester examinations. At the end of the project the students have to submit a detailed project report (dissertation) and deliver a seminar in support of their work. Submission of the dissertation has to be done ten days before (excluding) the seminar date.

Course 702 Comprehensive Viva [Credits: 4]

Each student is required to develop an overall understanding of various aspects of biological sciences as well as acquire knowledge about advanced research topics, as much as possible. Comprehensive Viva aims to examine the student's overall understanding and grasp of basic and advanced (as applicable) topics in biological sciences and his/her research topic. The student will be required to answer conceptual questions.

Contact

Dean, Student Affairs	Prof. Gautam Basu	dean_office@jcbose.ac.in Tel: 033-25693311
Registrar	registrar_office@jcbose.ac.in	
Course Co-ordinators	Prof. Atin Kumar Mandal Prof. Rajarshi Ray	mandalak@jcbose.ac.in, int.physics@jcbose.ac.in
M.Sc.-Ph.D. Office	Mr. Binoy Modak	binoy@jcbose.ac.in Tel: 033-25693311
Internal Complaints Committee	Prof. Tanya Das	tanya@jcbose.ac.in
Hostel Warden	Prof. Sanjay Kumar Ghosh	sanjay@jcbose.ac.in
Security	Centenary Building: Main Campus: Hostel:	033-25693271 033-23031112 033-25760069