FACULTY COUNCIL OF SCIENCE
JADAVPUR UNIVERSITY

NOTICE

It is to notify for information of all concerned that the classes of Ph.D. Course Work for the year 2019 under the **Department of Physics** will commence from Wednesday, the 18th of day of September 2019 in the respective department. All registered candidates who are willing to do Ph.D. course work under the said Department are requested to submit Ph.D. Course registration form duly forwarded by the concerned Supervisor(s) and HoD of the respective Department to the Office of the undersigned within Wednesday, the 11th day of September 2019.

Candidates are requested further to contact the concerned course coordinators – (i) Prof. Joydeep Chowdhury & (ii) Dr. Saikat Kumar Seth for the schedule in detail.

The course work registration form and the available units are appended in the consecutive pages.

Date: 29/08/2019

Sd/-
(Dr. Atiskumar Chattopadhyay)
Principal Secretary,
Faculty Council of Science

যাদবপুর বিশ্ববিদ্যালয়

JADAVPUR UNIVERSITY
KOLKATA-700 032

FORM FOR COURSE REGISTRATION FOR PH.D.SCHOLARS
(UNDER ~~F.E.T.~~/F.SC./~~F.A.~~)

DEPARTMENT/~~SCHOOL~~/~~INSTITUTION~~: **PHYSICS**
(in which registered for Ph.D.)

(ENROLMENT FOR SEMESTER: JULY/DECEMBER, JANUARY/JUNE)

1. Name in full (in Block letters) : _____
2. Sex(Male/Female) : _____
3. Address for Communication: _____

   _____
4. Phone No._____ Mobile No._____
5. Course Taken:

Sl.No.	Name of Subject/course	Subject Code	Dept./~~School~~/~~Institution~~ under which subject offered
1.	Research Methodology	A	PHYSICS
2.	Review of Research Work	B	PHYSICS
3.			PHYSICS
4.			PHYSICS

Date: _____ Signature of the student in full

Head of the Department/Director of School **Supervisor(s)**

Signature of the Dean, Faculty of Science

Registration No._____ of _____

Date of Registration_____

Superintendent, Ph.D. Cell, Faculty of Science

SYLLABUS OF COURSE WORK OF PH.D(Sc.)

DEPARTMENT OF PHYSICS

Courses	Subject	Full Marks
Compulsory Units	1. Research Methodology	**50**
	2. Review of Research Work	**50**
Elective Units	1. Material Characterization Techniques. (1)	**50**
	2. Dynamical Systems.(4)	**50**
	3. Environmental Radiation and Health Physics Fundamentals.(8)	**50**
	4. Advanced X-ray crystallography.(9)	**50**
	5. Biophysics. (10)	**50**
	6. Monte Carlo methods in statistical physics.(12)	**50**

N.B. : Students to opt any 2 elective units out of the elective units offered. The numbers within the parenthesis () mentioned at the end of the units indicates the actual no. of the course.

Please visit the next few pages for the syllabus in detail.

COMPULSORY UNITS

1. Research Methodology (40 lectures)

Definition of the Problem: Identifying and formulating the problem.

Techniques involved in solving the problem:

a) Exact analytical solution of equations involved.

b) Numerically solving equations.

c) Simulating the problem on a computer. Monte Carlo or molecular dynamics approach.

d) Experimental observations and theoretical modeling

Developing a research plan: Research objective: information required for solving the problem: defining each major concept in operational terms: an overall description of approach, clearly stating any assumptions; details of techniques.

Methods of data collection: Experimental data, field data, data from other sources.

Analyzing data: Error analysis, statistical analysis

Using computers in research:

Basics of operating systems – handling different operating systems

1. Literature survey using web, handling search engines
2. Computer usage for collecting/analyzing data – simulations using fortran/ C/ Mathematica/ Matlab/Mathcad.
3. Preparing presentations:
   i) Research papers : Using word processing software – MS Word/Latex/others, Drawing graphs and diagrams – Origin/Xmgrace/Excel/others.
   ii) Seminar presentations – Power point for oral and poster presentations

2. Review of Research Work: (20 lectures)

The relevance of the research from perspective of the subject. Detailed review of state of the art. Scope of the work.

ELECTIVE UNITS

1. Material characterization Techniques (Total 30 Lectures)

1. Introduction: Physical and chemical properties . Necessity of characterization.
   (a) Macroscopic properties: Optical. Electrical, dielectric, magnetic, mechanical
   (b) Microscopic properties – chemical structure, composition, surface characterization. (1)
2. Probing bulk and nano-structure – XRD, TEM, HRTEM, Neutron scattering. (8)
3. Surface structure and topography – SEM, STM, LEED, AFM(6)
4. Microstructure – UVVIS, Raman, FTIR, Optical microscopy, small angle scattering(6)
5. Phase changes, crystalline and amorphous fractions – DSC(2)
6. Thermo-gravimetric methods – TGA, DTA(2)
7. Mechanical properties: Elastic properties, strength measurements in bulk and thin films, nano-indentation, Physics of fracture – Griffith's theory of brittle fracture, ductile fracture, length scale issues and size effects (5)

4. DYNAMICAL SYSTEMS: (TOTAL 30 Lectures)

a) Basic Concepts of Phase Space trajectories. Dynamical Systems. Examples from Harmonic oscillators with Damping/Forcing. Differentiating between Dissipative Systems, Conservative Systems and Growing Systems.--(**2 lectures**)

b) One Dimensional Dynamical Systems: Fixed Points. Stability Analysis. Bifurcations: Transcritical, Pitchfork (Super/Sub-critical), Saddle Node. Examples. -- (**3 lectures**)

c) Two Dimensional Dynamical Systems**:** Spirals, Saddles, Centres. Bifurcations. Supercritical and Subcritical Hopf Bifurcations. Predator-Prey Model. --(**4 lectures**)

d) Limit Cycles: Definition. VanderPol Oscillator. Perturbativetreatment.
Existence of Limit Cycles: Poincare Benedixon Theorem.
The example of Glycolysis. Relaxation Oscillations. --(**4 lectures**)

e) Algebraic methods of dealing with Anharmonic Oscillations: First Integrals, Approximations methods: Pade, Linsdstedt-Poincare, Multiple time Scale, Coordinate Perturbation. Nonperturbative averaging methods. Rapidly Oscillating Forcing: Kapitza's Mean Field Method. --(**7 lectures**)

f) Three Dimensional Dynamical Systems: Lorenz model. Limit Cycles, Chaos. strange Attractors, Fractal Dimensions, Correlation Index, Mori Conjecture. Logistic Maps. Period Doubling, Cascading and Feigenbaum's study. --(**10 lectures**)

8. Environmental Radiation & Health Physics Fundamentals

(Total 30 Lectures)

a) Environmental Radiations & Interaction of Radiations With Matter (Lec-8)
b) Sources of Environmental Radiations(Lec.-3)
c) Dosimetric Quantities, Units and Applications(Lec.-3)
d) Measurement Techniques(Lec.-4)
e) Counting Statistics and Error Prediction(Lec.-3)
f) Biological Effects of Ionizing Radiations & Risk Models(Lec.-4)
g) Effects of Non-ionizing E-M Radiations(Lec.-3)
h) Standards and Regulations(Lec.-2)

9. Advanced X-ray crystallography

(Total 30 Lectures)

(i) Symmetry in crystals, space groups and cell transformation (Lec 2)

(ii) Principle of X-ray powder diffraction, Measurement of X-ray powder diffraction patterns, Powder diffractometers, Principles of goniometer design in powder diffractometry, Monochromatic radiation, Bragg-Brentano geometry, Debye-Scherrer geometry. (Lec 1)

(iii) Sample preparation for X-ray powder diffractometry, Sample mounting, Particle size requirement, Sample thickness and uniformity, Effects of sample preparation on powder diffraction data, Data acquisition, Quality of experimental data. (Lec 1)

(iv) Preliminary data processing and phase analysis, Use of crystallographic data base, Phase identification and quantitative analysis, Different methods of quantitative phase analysis. (Lec 2)

(v) Indexing powder diffraction pattern, Basic relations, The indexing problems, Geometrical ambiguities, Different indexing programs, Figures of merit, Precise lattice parameters and least-squares method. (Lec 5)

(vi) The Rietveld method, Rietveld method basics, Background contribution, Peak-shape function, profile parameters, Quality of Rietveld refinemet, Different R-factors. (Lec. 6)

(vii) Crystallite size and lattice strain determination from line broadening, The Scherrer equation, The Fourier method of Warren and Averbach, Method of integral breadths. (Lec. 2)

(viii) Radial distribution studies of non-crystalline materials, Experimental requirements, Correction and Scaling of experimental intensities to absolute (electron) units, Practical examples. (Lec. 2)

(ix) EXAFS, EDX, XFS, XPS. (Lec. 2)

(x) Diffraction of X-rays by liquids and liquid crystals, Information obtained from X-ray studies of liquid crystalline materials. (Lec. 2)

(xi) Protein crystallography: Basics of protein structure, Secondary structure elements, α-helix and β-sheet, Tertiary structure; Phasing methods: Isomorphous replacement, Molecular replacement, Multiple anomalous dispersion; Non-crystallographic symmetry and density modifications. (Lec. 5)

10. Biophysics

(Total 30 Lectures)

i) **Physics of self assembly of amphiphiles**: (2 Lec.)
Monolayer, micelles, bilayers etc.

ii) **Intermolecular and surface forces relevant to bio-systems**: (1 Lec)
Vander Waals, hydration, steric, hydrophobic forces etc.

iii) **Cell & its organelles - structure and function (2 Lec)**

iv) **DNA/RNA/Protein - structure and function (5 Lec)**

v) **Physico-chemical processes and techniques- (3 Lec)**
Diffusion/Osmosis/Centrifugation/Viscosity/Column chromatography/Gel electrophoresis/Autoradiography.

vi) **Physics of Membranes**- (6 Lec)

a) Cell Membranes

b) The Structure of Membranes

c) Model membranes as biomimetic systems: liposomes or vesicles, methods for preparing giant unilamellar and large unilamellar vesicles. Measurement of mechanical properties of membranes using micropipette aspiration. Effect of additives, such as cholesterol, peptides etc on the membranes. Active membranes.

d) Conformational Properties of Membranes

e) Passive Membrane Transport
f) Active Membrane Transport
g) Transport of Charged Particles through Membranes
h) Molecular Reception.

vii) **Physics of the Nerve Impulse**- (3 Lec)
a) The Axon and the Nerve Impulse,
b) Propagation of the Nerve Impulse
c) Generation of the Nerve Impulse
d) Ionic Channels
e) Synaptic Transmission.

viii) **Photo biological Process**- (3 Lec)
a) Photosynthesis
b) Two Photochemical Systems
c) Chloroplasts
d) The Mechanism of Photosynthesis
e) Vision
f) The Molecular Mechanism of Photosynthesis
g) Bacteriorhodopsin

ix) **Experimental techniques**- (3 Lec)
a) Electron Microscopy
(i) Scanning Electron Microscopy
(ii) Transmission Electron Microscopy
b) Confocal fluorescence microscopy, Fluorescence spectroscopy.

x) **Bio-Instrumentation** - (2 Lec)
a) X-Ray Diffractometer (XRD)
b) Dynamic Thermal Analyser/Thermogravimetric Analyzer (DTA/TGA)
c) Fourier Transform Infrared (FTIR) Spectrometer
d) UV-Vis Spectrophotometer
e) Fluorimeter

12. MONTE CARLO METHODS IN STATISTICAL MECHANICS

(Total 30 Lectures)

i) Principles of equilibrium thermal Monte Carlo Simulation – importance sampling, Markov process, ergodicity, detailed balance. [2 periods]

ii) The Ising model and the Metropolis algorithm-implementing the Metropolis algorithm, equilibration, measurement, auto correlation functions. [6 periods]

iii) Other algorithms for the Ising model – critical exponents and their measurement, the Wolff algorithm and its properties, the Swendsen-Wang algorithm. [6 periods]

iv) Other spin models – Potts models, cluster algorithm for Potts models, continuous spin models. [4 periods]

v) Analyzing Monte Carlo data – Single and Multiple histogram methods of Ferrenberg and Swendsen Implementation. Finite size scaling – direct measurement of critical exponents. [5 periods]

vi) Monte Carlo Renormalization group – real space renormalization, calculating critical exponents. [4 periods] vii) Random numbers – generating uniformly distributed random numbers, True random numbers, pseudo-random numbers. [3 periods]