Department of Physics

Physics is concerned with those aspects of nature which can be understood in a fundamental way in terms of elementary principles and laws. In the opinion of a non-physicist (J Mollere, French playwright), "Physics explains the properties of natural bodies and properties of matter; it discourses on the nature of elements, minerals, plants, rocks and animals, and teaches us the causes of all the meteors, rainbow, aurora borealis, comets, lightening, thunderbolts, rains, snows, hails and whirl winds". In course of time, various specialized sciences broke away from physics to form autonomous fields of investigation. In this process physics retained its original aim of understanding the structure of the natural world and explaining natural phenomenon. Physicists think about what exists and how it works; they also seek to understand reality from possible infinite vastness of the universe down to the infinitesimal particles that form the structure of an atom.

History

The Department of Physics, Rajshahi University, started functioning in March 1958 and its academic activity started in July 1958 in its own building in the university campus, under the leadership of Late Dr Ahmad Husain with a batch of 15 post-graduate students and three teaching staff members. The teaching was started in December, 1958. A three-year B.Sc. (Honours) course was introduced in 1962. Over the years, the department has grown in every sphere and now assumes the structure of a large department in the university.

The department has been offering a four-year B.Sc. (Honours) course since 1998. At present, there are 28 members of teaching staff and 28 supporting technical and office staff catering the needs of over 500 students including a number of research scholars.

Location

The Department of Physics is located in the first science building, which is surrounded by the scenic beauty of the university. It has a beautiful flower garden inside.

Research Activities

The department has a long tradition of research in various areas of physics under M.Sc., M.Phil. and Ph.D. programmes. The faculty members along with their research students pursue research in diverse fields which has resulted in a large number of research publications in

various journals of international repute, like Nature, Physical Review Letters, Physical Review, Nuclear Physics, Physica C, Journal of Superconductivity, Solid State Communications, Physics Letters, Journal of Materials Science, Journal of Non-Crystalline Solids, Physica Status Solidi, Journal of Physics and Chemistry of Solids, Journal of High Energy Physics, Physics and Chemistry of Glasses, Nuovo Cimento, Annals of Physics, etc. The department is also working under different international collaboration programmes with India, Japan, UK and USA. The current research areas are:

- Nuclear Physics: Nuclear Reaction & Nuclear Structure
- Radiation Physics and Medical Physics
- Atomic Physics
- Condensed Matter Physics:
  - Perfect and Defect Crystals- Computer Simulation studies (theoretical).
  - Solid State Reaction (experimental)
- Superconductivity
- Semiconductors: Thin Film Deposition and Characterization
- Structural properties of Glass and Glass Ceramics
- Solar Energy
- High Energy Physics: Lattice QCD.

Teaching Activities

The department is at present involved in teaching the following courses:

- Four-year B.Sc. (Honours) degree course (started from the session 1997-98).
- One-year M.Sc. course in General and Thesis group.

Mission and Objectives of the Department

Since its inception in 1958, the mission of the Department of Physics, University of Rajshahi has been to advance the knowledge in various branches of Physics via teaching-learning and research. The academic program is focused on the creation, translation, and dissemination of knowledge on the subject matter. The strategic goals of the Department are to:

- Support the aims and objectives of the University within the capacity of our Departmental program.
- Advance the academic, research, scholarship and service priorities, consistent with a top tier university, and continue to promote growth and national prominence in these areas.

- Train and produce high-quality graduates to meet up national and international requirements in scientific sectors of the job market.
- Enhance the teaching-learning and research capacities of the Department by retaining and recruiting outstanding faculty and staff.
- Enhance the Department's learning environment by attracting and retaining students of high intellectual ability and aptitude.

Intended Learning Outcomes (ILOs) of the Program

Knowledge and Understanding:

The B.Sc. and M.Sc. degree programs offered by the Department cover the fundamental topic of Physics. It also provides a selection of advanced topics and develops experimental, mathematical, computational, and other transferable skills. On successful completion of these programs students should have demonstrated-

1. Knowledge and understanding of most fundamental physical laws and principles and competence in the application of these principles to diverse areas of Physics.
2. An ability to solve problems in Physics using appropriate mathematical tools.
3. An ability to execute and analyze critically the results of an experimental investigation or theoretical modelling and to draw valid conclusions with an estimate of the uncertainty in the result. An ability to compare experimental results with the predictions of relevant theories.
4. A knowledge of the fundamental principles and applications of some advanced areas of Physics - the forefront of the discipline.
5. An ability to use IT packages and a competence of the usage of analytical software in problem solving.
6. An ability to communicate scientific information especially in the form of clear and accurate scientific reports.

Knowledge and understanding of areas 1 – 2, and 4 – 6 are acquired through lectures, tutorials, problem classes and guided independent study. The practically oriented knowledge of area 3 is acquired in practical classes, both experimental and computing, and in thesis work.

Resources

The department has 28 members of teaching staff consisting of Professors, Associate Professors, Assistant Professors and Lecturers, who cater the needs of nearly 500 undergraduates, post-graduates and

research students. A list of members of academic staff is given below:

Name	Specialization
Professor Emeritus	
Dr. Arun Kumar Basak *MSc(Raj), PhD(Birmingham), FInstP (London), CPhys*	Nuclear Physics, Atomic Physics
Professors	
Dr M Shafiqul Islam(PRL) *MSc(Raj), PhD(Nagpur)*	X-ray Spectroscopy and Crystallography
Dr M Obaidul Hakim *MSc(Raj), PhD(Raj)*	Condensed Matter Physics (Expt.) Thin Films
Dr Somnath Bhattacharjee *MSc(Raj), PhD(Banaras)*	Theoretical Physics, Fibre Optics
Dr M Enamul Haque *MSc(Raj), PhD(Raj)*	Theoretical Solid State Physics
Dr M Golam Mortuza *MSc(Raj), PhD(Warwick) C in Comp.(Coventry)*	Condensed Matter Physics, Glass and Glass Ceramics, Superconductivity
Dr M Mozibur Rahman *MSc(Raj), PhD(Ukraine)*	Condensed Matter Physics (Expt.), Electronics, Metallurgy
Dr M Khalilur Rahman Khan *MSc(Raj), PhD(Japan)*	Condensed Matter Physics, Mat. Science (Expt.), Thin films, Superconductivity
Dr Irine Banu Lucy *MSc(Raj), PhD(Brunel,UK)*	Condensed Matter Physics (Expt.)
Dr M Rafiqul Ahsan *MSc(Raj, PhD(Raj)*	Condensed Matter Physics, Glass and Glass Ceramics, X-ray Crystallography
Dr F Nazrul Islam *MSc(Raj), PhD(Raj)*	Cond. Matter Physics (Comp. simulation), Superconductivity, Nuclear Physics
Dr Saleh Hasan Naqib *MSc(Raj), PhD(Cambridge)*	Superconductivity
Dr Abul Kalam Fazlul Haque *MSc(Raj), PhD(Raj)*	Nuclear Physics

Dr Abdullah Shams Bin Tariq *MSc(Raj), PhD(Southampton)*	Particle Physics, Nuclear Physics

Associate Professors

Mr A F M Abdul Wahed *MSc(Raj)*	X-ray Crystallography
Dr Laila Arjumand Banu *MSc(Raj, PhD (Raj)*	Condensed Matter Physics (Expt.)
Dr M Rezaur Rahim *MSc(Raj), PhD(Brunel,UK)*	Condensed Matter Physics (Expt.), Electronics
Ms Dilruba Akhter Banu *MSc(Raj)*	Nuclear Physics
Dr Raihana Shams Islam *MSc (Raj), MPhil(Cambridge), PhD(Cambridge)*	Superconductivity
Dr Fahmida Parvin *MSc(Raj), PhD(Raj)*	Superconductivity
Dr M A Razzaque Sarker *MSc(Raj),PhD(Japan)*	Materials Science
Dr M Atiqur Rahman Patoary *MSc(Raj), PhD(Japan)*	Nuclear Physics, Condensed Matter Physics (Theory)
Dr M Samiul Islam Sarker *MSc(Raj), MSc(Adelaide, Australia), PhD(Tohoku, Japan)*	Nuclear Physics, Fibre-laser, Materials Science
Dr M Monirul Haque *MSc(Raj), PhD (Japan)*	Medical Physics, Radiation and Health Physics

Assistant Professors

Mr M Masum Billah *MSc(Raj)*	Nuclear Physics
Mr K M Mahmudul Hasan *MSc(Raj)*	Nuclear Physics
Ms Monira Jannatul Kobra* *MSc(Raj), PGD(ICTP)*	Nuclear Physics
Mr M Leaket Ali *MSc(Raj)*	Condensed Matter Physics
Mr M Ismail Hossain *MSc(Raj)*	Theoretical Atomic Physics

Mr M Alamgir Hossain *MSc(Raj)*	Medical Physics

Lecturer

Mr M Saiful Islam* *MSc(Raj)*	Condensed Matter Physics

** on leave.*

Seminar Library

The department may boast to have the biggest seminar library in the university with text and reference books. It also has some international journals, such as Physical Review, Physical Review Letters, Reviews of Modern Physics, which the department has been receiving as a joint contribution from the Abdus Salam International Centre for Theoretical Physics, Italy and American Physical Society. The library is constantly being updated with reference books and other reading materials. The department is about to start a rental library for students. Groups of students will soon be able to borrow important textbooks through this service. Besides, a significant number of e-books and a very large number of e-journals are accessible online through the University Central Library.

Computer Facilities

The department has established a computer lab with internet facilities for students and teachers. Recently an NComputing system has been introduced in the student section of the lab on trial basis. If this is successful, there are plans for a major expansion of the student section in the near future. Research students also have access to computers and internet in their research labs.

Workshop

A mechanical workshop was established in the department from the beginning of the department. The students get training in the workshop on some instrumentation, as a part of their laboratory experiments. It also serves as a centre for minor repairing of laboratory equipment.

From the inception, the department of physics is known to be the most disciplined department in the university, both in administration and in academic activities. Academic members are very particular in completing their courses, conducting examinations and publishing results according to the calendar published by the department at the beginning of every academic year. It is the tradition of the department to

publish the examination results within the quickest possible time and thus it has become possible for the department to avoid the academic backlog in the university. The department constantly reviews its curriculum and takes steps to enhance facilities to match the present day need and thus prepares the students to face the challenges of the future.

Co- and Extra- Curricular Activities

Physics Club

Physics Club was established in 2011. Since then Physics Club has been providing the students and the faculty members with an open platform to discuss various topics in physics outside the class hour. This club is open to all the students of Department of Physics, University of Rajshahi (RU).

English Club

English Club has been functioning since 2010. This club was established with the aim to develop speaking, reading, and writing skills of the students of this department. Only the members of the English Club are permitted to participate in various club activities.

Study tour

The department arranges study tour within Bangladesh and abroad for the M.Sc. Students each year.

Picnic

Every year students of the department organize annual picnic in cooperation with the academic and non-academic staff.

Students' Association

There is a student association in the department called Physics Students' Association. All students of the department are the members of the association. This Students' Association regularly organizes farewell for the outgoing M.Sc. students and welcome reception for the fresher's admitted in the B.Sc. course. Besides, the Association arranges various cultural and sports related activities.

Physics Alumni Association

Department of Physics has an active Alumni Association. The objectives of this association are to build active communication network among all the present and ex-students of the Department of Physics through various programs and to contribute in the academic development of the department and to economic development of the country through the dissemination of new concepts in the relevant field.

Sports and Culture

Students of Department of Physics participate in all inter-department games organized by the RU. The department has achieved notable success in sports by winning matches in cricket, football, badminton, table tennis etc. The students of the department have also participated in various cultural events with distinction.

UNIVERSITY OF RAJSHAHI

FACULTY OF SCIENCE

——————DEPARTMENT OF PHYSICS ——————

M.Sc. Syllabus

Session: **2014 - 15** Examination: **2015**

The M.Sc. Examination in Physics is divided into two groups:

Group A: General

Group B: Thesis

All students will have to take six Theoretical courses including at least one course from PH501 and PH502 (subject to the approval of the Chairman of the Department). Additionally, the students of the General group will have to take the practical course, while the students of Thesis group will have to take a research topic approved by the Department.

A full-unit course shall carry 100 marks and a **half-unit** course 50 marks out of which 80% is for the Final Exam, 15% is for Tutorial/Terminal and 5% is for Class Attendance.

Total GPA Round off:

Total GPA shall be round off up to 2 (two) digits after decimal. For instance GPA=2.114 shall be round off as GPA=2.11 and GPA =2.115 shall be round off as GPA =2.12.

The M.Sc. curriculum in Physics shall consist of:

i) Theory courses (6 units),	$100 \times 6 = 600$ marks = 24 Credits
ii) Practical /Thesis (2 units)	= 200 marks = 08 Credits
iii) General Viva-voce (1 unit)	= 100 marks = 04 Credits
	Total (10 course units) = 900 marks = 36 Credits

Award of Degree:

The degree of M.Sc. shall be awarded on the basis of the Grade Point Average (GPA) obtained by a candidate in his/her M.Sc. examination. In order to qualify for the degree, a candidate must obtain (within three academic years from the date of first admission):

i) A minimum GPA of 2.50,

ii) A minimum Grade point (GP) of 2.00 in Practical/Thesis, and

iii) A minimum total Credit points (TCP) of 32.

Result Improvement:

A student obtaining GPA less than 3.00 shall be allowed to improve his/her courses up to 12 credits including 'F' Grade only once within 3 academic years. Here, it is noted that GP of courses, which he/she wants to improve should be less than 3.00.

Gradation of the Results:

Numerical Grade (NG)	Letter Grade (LG)	GP (Grade Point)
80% or above	A+ (A plus)	4.00
75% or above	A (A regular)	3.75
70% or above	A- (A minus)	3.50
65% or above	B+ (B plus)	3.25
60% or above	B (B regular)	3.00
55% or above	B- (B minus)	2.75
50% or above	C+ (C plus)	2.50
45% or above	C (C regular)	2.25
40% or above	D	2.00
Less than 40%	F	0.00
Incomplete	I	0.00

Eligibility for the M.Sc. examination:

Class attendance (both in theory and practical classes)

Below 75%: Non-collegiate;

Below 60%: Discollegiate (Discollegiate students will not be allowed to sit for the examination).

The Detailed Distribution of Courses

Course no.	Title	Marks	Exam. duration	Credit Point
PH501	Advanced Nuclear Physics	100	4 Hours	04
PH502	Advanced Solid State Physics	100	4 Hours	04
PH503	Electronic Communications	100	4 Hours	04
PH504	Advanced Medical Physics	100	4 Hours	04
PH505	Materials Science	100	4 Hours	04
PH506	Superconductivity	100	4 Hours	04
PH507	Physics of Environment	100	4 Hours	04
PH508	Crystallography and Spectroscopy	100	4 Hours	04
PH509	Particle Physics and Cosmology	100	4 Hours	04
PH510	Advanced Reactor Physics	100	4 Hours	04
PH511	Biomedical Instrumentation and Imaging System	100	4 Hours	04
PH512	Quantum Field Theory	100	4 Hours	04
PH513	Optical Fibre Physics	100	4 Hours	04
PH521	Field Trip -Industrial exposure	(Non Credit)		
PH522	General Viva-Voce	100		04
PH523	Practical (Compulsory for General Group)	200		08
	a) Continuous evaluation	*60*		
	b) Annual Examination (28×4)	*112*	*(Four days)*	
	c) Defense on Experiments	*28*	*(One day)*	
- OR - Thesis group (Compulsory for Thesis Group)		200		08
	a) Thesis evaluation	*150*		
	b) Defense on Thesis	*50*		

N.B. *Submission of Report on industrial trip is compulsory for all participants. Students unable to go outside Rajshahi may visit local Industries to have their experience. They have to also submit report on their visit.*

PH501 ADVANCED NUCLEAR PHYSICS *(~75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Direct Nuclear Reactions:** Reaction kinematics: non-relativistic and relativistic; Theory of transfer reactions; Selection rules in a transfer reaction; Theory of inelastic scattering; Importance of direct reactions.
2. **Nuclear Shell Models:** Single particle shell model; Iso-spin formalism; Two-particle system; Shell model Hamiltonian; Perturbation theory and configuration mixing, Allowed states; Anti-symmetric wave functions, More than two particles in one orbit; Coefficient of fractional parentage; Spectroscopic factors; Spectroscopic factors for mixed configurations; Sum rules for single particle transfer reactions.
3. **Collective Models:** Shortcomings of the shell model and the nuclear collective models; Nuclear rotational motion; Rotational energy spectra and nuclear wave functions for even and odd A nuclei; Nuclear deformation; Collective oscillation; Quadrupole deformation; Electromagnetic properties.
4. **Electromagnetic Interactions with Nuclei:** Infinitesimal rotations in vector fields; Intrinsic angular momentum of vector fields; Total angular momentum of vector fields and vector spherical harmonics; Multipole fields; Sources of multipole fields; Transition probability of a multipolar radiation; Multipole moments; Selection rules in a gamma transition; Angular distribution of a gamma transition; Angular correlations; Relative strengths of different multipolar radiations in a transition between two low-lying states of an excited nucleus.
5. **Nuclear Astrophysics:** Primordial nucleosynthesis, Stellar synthesis of light elements; CNO cycle, Synthesis of heavy elements; Stellar evolution and different stages of burning; White dwarfs and neutron stars, Supernova explosions.
6. **Rare or Exceptional Nuclei:** Driplines and nuclei far from stability; Exceptional light nuclei: Halo nuclei, Borromean nuclei; Transuranic nuclei.

Books recommended:

Satchler, GR	Direct Nuclear Reactions
Glendenning, NK	Direct Nuclear Reactions
Roy, RR and Nigam, BP	Nuclear Physics
Blatt, JM and Weiskopff, VF	Theoretical Nuclear Physics
Thompson, IJ and Nunes, FM	Nuclear Reactions for Astrophysics
Brussaard, PJ and Glaudemans, PWM	Shell Model Applications in Nuclear Spectroscopy
Lawson, RD	Theory of the Nuclear Shell Model
Pal, MK	Theory of Nuclear Structure
Sen Gupta, HM	Nucleo Padartha Bidya (in Bangla)
Greiner, W and Maruhn, JA	Nuclear Models
Bertulani, DA and Danielewicz, P	Nuclear Reactions
Bertulani, DA	Nuclear Physics in a Nutshell
Iliadis, C	Nuclear Physics of Stars
Krane, K	Nuclear Physics

PH502 ADVANCED SOLID STATE PHYSICS *(~ 75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)

(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Periodic Structure:** Symmetry operations; Groups; Function spaces; Bravais lattice; Periodic functions; Bloch's theorem; Brillouin zones and crystal symmetry; Fermi surface construction; Experimental method: de-Hass-van Alphen oscillation.
2. **Electron States and Energy Bands in Solids:** The nearly free electron model; Tight binding method; Cellular method; Muffin-Tin potentials; Orthogonalized plane wave method; Pseudopotentials; Wannier function and its uses.
3. **Energy Band beyond the Independent Electron Approximation:** Hartree equation; Hartree-Fock equation: Hartree-Fock theory of free electrons; Density functional theory for band structure calculations; Screening; Dielectric function; Thomas-Fermi theory of screening; Lindhard theory of screening.
4. **Theory of Electronic Processes in Semiconductors:** Carrier effective mass and band structure; Effects of temperature and pressure on band gap; Carrier scattering phenomena; Semiconductor statistics: Energy

distribution function; Density of states; Density of carriers in intrinsic and extrinsic semiconductors; Compensation of carriers; Charge neutrality condition; Consequences of heavy doping; Conduction processes in intrinsic and extrinsic semiconductors.

5. **Theory of Optical Processes:** Reflectivity at an interface; Absorption of radiation; Kramers-Kronig relations; Determination of optical constants; Free carrier absorption: Experimental results for metals and semiconductors; Interband transition: Fundamental absorption near band gap; Theory of vertical and non-vertical transition; Optical processes in amorphous materials**;** Measurement of absorption and luminescence spectra.
6. **Junction Theory:** Mathematical derivation of contact potential and space charge in p-n junction; Built-in voltage; Physical mechanisms of breakdown in p-n junction; Schottky barrier and Ohmic contacts; Metal-Semiconductor junction; Semiconductor heterojunction; I-V and C-V relationships.

Books recommended:

Ziman, JM	Principles of the Theory of Solids
Clark, H	Solid State Physics: an Introduction to Its Theory
Kittel, C	Quantum Theory of Solids
Ashcroft, NW and Mermin, ND	Solid State Physics
McKelveym, JPM	Solid State and Semiconductor Physics
Bhattacharya, P	Semiconductor Optoelectronic Devices (2nd edn)
Mario, PT- edited	Crystalline Semiconducting Materials and Devices
Fraser, DA	The Physics of Semiconductor Devices

PH503 ELECTRONIC COMMUNICATIONS *(~75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Communications Fundamentals:** Communications model; Frequency allocations; Types of signals; Analogue and Digital data transmissions; Transmission impairments; Noises: Types and measurements of noises.

2. **Modulation and Demodulation:** Principles; Modulations: Amplitude, Frequency, Phase, Pulse modulations; Demodulations: FM discrimination, Demodulation of PM waves.
3. **Digital Communications**: Transmission modes: Asynchronous and Synchronous; Data transmission circuits; Digital codes; Matched filter; Digital carrier system; Differential Phase Shift Keying (DPSK); Baseband & Broadband communications: Channels, ISDN; Multiplexing: FDM, TDM and STDM.
4. **Transmission Media and Antennas:** Guided transmission media: Open-wire, Coaxial, Optical fibers; Wireless transmission media: Radio and Microwave; Antennas: VHF, UHF and Microwave antennas.
5. **Optical and Satellite Communications:** Optical communication: Principles, Transmission and losses, Dispersion, Light sources and Photodetectors; Satellite communications: Orbits and inclinations, Types of satellites, Satellite construction, Satellite links.
6. **Modern Communication Systems:** Television Fundamentals: Beam scanning, Blanking and sync pulses; TV system: Transmitter and Receiver; Mobile cellular telephony: Concept of cellular technology, Operations of cellular systems; Cellular systems: GSM and CDMA; Radar: Types and uses, Radar Range, Pulse and CW Radars; Navigation: Global positioning system (GPS), Air traffic control: ILS and GCA.
7. **Computer Networking and Internet:** Computer networking: Categories, Types and Topologies; Internetworking; The Internet; World Wide Web (WWW).

Books recommended:

Frenzel, LE	Communication Electronics: Principles & Applications
Stallings, W	Data and Computer Communications
Roddy, D and Coolen, J	Electronic Communications
Roden, SR	Digital and Data Communications
Singh, A	Principles of Communication Engineering
Martin, J	Communication Satellite System
Chellis, J, Perkins, C and Streb, M	MCSE: Networking Essentials
Tanenbaum, AS	Computer Networks
Pfaffenberger, B	Mastering Internet World Wide Web

PH504 ADVANCED MEDICAL PHYSICS *(~75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Medical Internal Radiation Dosimetry (MIRD):** Internal radiation dosimetry; Radiation dose: quantities and units; Calculation of radiation dose: absorbed fraction method; Cumulated activity $\bar{A}$; Equilibrium absorbed dose constant Δ; Absorbed fraction ϕ and the dose reciprocity theorem; Mean dose per cumulated activity.
2. **Cancer Biology and Treatment:** What is cancer; Mutation of cells; Genes involved in cancer development; Tumor formation; Risk factors; Metastasis; Overview of methods of treatment; Radiation therapy-Teletherapy, Brachytherapy, Systemic radiation therapy; How radiation cures cancer; Fascination of radiation therapy.
3. **Clinical Radiation Generators:** Kilo-voltage units; Linac: X-ray and electron beam, Target and flattening filter, Beam collimation and monitoring, Gantry; Multileaf collimator (MLC); Co-60 unit: Source housing; Beam collimation and penumbra.
4. **Dose Distribution and Scatter Analysis:** Phantoms; Depth dose distribution; Percentage depth dose; Tissue-air ratio; Backscatter factor; Scatter-air ratio; Dose calculation parameters; Collimator scatter factor; Phantom scatter factor; Tissue-Phantom and Tissue-Maximum ratios; Properties of TMR; Scatter-Phantom and Scatter-Maximum ratios; Practical applications.
5. **Isodose Distribution:** Isodose chart; Measurement of isodose curves; Parameters of isodose curves; Wedge filters; Combination of radiation fields; Isocentric techniques; Wedge field technique; Tumor dose specification.
6. **Patient Data, Corrections and Setup:** Acquisition of patient data; Treatment simulation; Treatment verification; Corrections for contour irregularities; Corrections for tissue inhomogeneities; Tissue compensation; Patient positioning.
7. **Modern Radiation Therapy:** Introduction to 3-D conformal radiation therapy (3-D CRT); Intensity-modulated radiation therapy (IMRT);

Image-Guided radiation therapy (IGRT), Stereotactic radiotherapy; Proton beam therapy.

8. **Brachytherapy:** Radioactive sources; Calibration of brachytherapy sources; Calculation of dose distribution; Systems of implant dosimetry; Computer dosimetry; Implantation techniques; Remote afterloading units; High dose rate brachytherapy.

Books recommended:

Waston, EE	MIRD primer
Khan, FM & Gibbons, JP	The Physics of Radiation Therapy (5th Ed)
Mayles, P, Nahum, A and Rosenwald, JC	Handbook of Radiotherapy Physics, Theory and Practice
Podgorsak, EB	Radiation Oncology Physics -A Handbook for Teachers and Students
Levitt, SH, Purdy, JA and Perez, CA	Technical Basis of Radiation Therapy
Godden, TJ	Physical Aspects of Brachytherapy
Johns, HE and Cunningham, JR	The Physics of Radiology (4th Edition)
Sorenson, JA and Phelps, ME	Physics In Nuclear Medicine (2nd Edition)
Dyson, NA	An Introduction to Nuclear Physics with Applications in Medicine and Biology

PH505 MATERIALS SCIENCE *(~75 lectures)*

Full Marks: ***100*** *(Examination 80, Tutorial/Terminal 15, and Attendance 5)*
(5 questions to be answered) *Examination duration:* ***4*** *hours*

1. **Microstructure Examination (brief review):** Experimental methods for the physical examination of materials; Metallurgical microscope; Microscopy of surfaces; TEM (Transmission Electron Microscopy); SEM (Scanning Electron Microscopy); STM (Scanning Tunneling Microscopy) and AFM (Atomic Force Microscopy); Thermal analysis – DTA, TGA, DSC (Differential Thermal Analysis, Thermogravimetric Analysis, Differential Scanning Calorimeter).
2. **Solidification:** Homogeneous and heterogeneous nucleations; Theory of liquid-solid phase transformation; Crystal growth technique; Sintering of materials; Glassy phase; Experimental facts regarding glass transition; V-T diagram; Non-equilibrium and thermodynamic views of glass transition; Free volume theory.

3. **Equilibrium Phase Diagrams:** Solid solution of two-component system; Simple eutectic diagram; Hume-Rothery electron compounds; Order-disorder phase transformation; Long-range and short-range order theories.
4. **Diffusion:** Fick's laws for isothermal diffusion; Atomic mechanisms of diffusion; Hydrogen diffusion; Thermodynamics of diffusion of Pd-H system; Effect of lattice defects.
5. **Engineering Alloys:** Ferrous and non-ferrous alloys; Production of steel; The iron-carbon phase diagram; The structure and classification of plain carbon steel; Heat treatment of steel; Alloy, Steel, Stainless steel; Cast-iron and malleable iron; Tool steels.
6. **Optoelectronic Materials and Devices:** Optical materials for LED, LASER and Photo detectors and their preparation and characterization; Physical processes in these materials; Graphene.
7. **Composite Materials:** Fibers for reinforced plastic; Composite materials; Formation of composites; Open-mold and closed-mold process of preparation; Metal matrix and ceramic-matrix composites; Elastic properties of composites; Strength and toughness of fiber reinforced composites.
8. **Corrosion:** Definition, Electrochemical considerations; Electrode potentials and EMF series; Nernst equations; Polarization; Evan's diagram; Forms of corrosion; Corrosion rate; Mechanism of oxidation; Corrosion prevention methods; Corrosion testing; Quasi-crystals.

Books recommended:

Owen, FD	Topics in Metallurgical Thermodynamics
Heyer, RH	Engineering Physical Metallurgy
Compbell, JS	Principles of Manufacturing Material & Processes
Verron, J	Introduction of Engineering Materials
Hench, LL and Gould, RW	Characterization of Ceramics
McMillan, PW	Glass-Ceramics
Smith, NF	Principles of Material Science and Engineering
Pascoe, KJ	Intro. to the Properties of Engineering Materials
Haasen, P	Physical Metallurgy
Callister Jr, WD	Mater. Science and Engineering- an Introduction
Fontana, Mars G	Corrosion Engineering
Uhlig, HH, Revie, R	Corrosion and Corrosion Control
Bhattacharya, P	Semiconductor Optoelectronic Devices (2nd edn).
Norman, HM, Robert, AS and Mario, PT- edited	Amorphous Solids and the Liquid State

Butcher, PN and Norman, HM
Mario, PT-edited Crystalline Semiconducting Materials and Devices

PH506 SUPERCONDUCTIVITY *(~ 75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Phenomenological Theory:** London model; Thermodynamics of the superconducting state; Ginzburg-Landau (G-L) theory of phase transition: G-L free energy; G-L equation and its applications; Penetration depth; Coherence length; Type-I and type-II superconductors; Critical fields.
2. **Microscopic BCS Theory:** BCS Theory: Cooper pairs; BCS ground state; Excitations in the BCS model; Energy gap equation; Critical temperature; Isotope effect; Specific heat and coherence effects; BCS theory and G-L theory.
3. **Vortex Behaviour and Critical Current:** Mixed states; Interaction between vortices; The Abrikosov lattice; Flux dynamics: Flux flow; Flux glass; Flux creep; Magnetic hysteresis (M-H) loop; The Bean Model; Pinning of vortices.
4. **High-T_c Superconductors:** Introduction to high-T_c superconductors: Cuprate, Organic, Diboride and Fe-based superconductors; Cuprates: Structure, Physical properties, Anisotropy, Electronic and Magnetic phase diagrams; Diborides: Structure and Physical properties; Applications of high-T_c superconductors.
5. **Heavy Fermion Systems:** Heavy fermion superconductors: Structure and physical properties of heavy fermion systems; Magnetically mediated pairing; Electronic phase diagram of heavy fermion superconductors.
6. **Josephson Effect:** The tunnel effect: Metal-Insulator-Superconductor (MIS); Superconductor-Insulator-Superconductor (SIS) junctions; dc and ac Josephson effects; Josephson effect and Ginzburg-Landau equation; Josephson Junction in a circuit: The Resistance-Capacitance-Shunted Junction (RCSJ) model; Pendulum analog; Weak links: The Aslamazov-Larkin scenario; SQUIDS and their applications.

7. **Fluctuation Effects in Superconductors:** TDGL equation, Paraconductivity and Fluctuation diamagnetism, Fluctuation heat capacity.

Books recommended:

Waldram, JR	Superconductivity of Metals and Cuprates
Cyrot, M and Pavuna, D	Intro. to Superconducting and High-T_c Materials
Poole, CP, Farah, HA, Creswick, RJ and Prozorov, R	Superconductivity (2nd Edition)
Ketterson, JB and Song, SN	Superconductivity
Burns, G	High Temperature Superconductivity (an Intro.)
Tinkham, M	Introduction to Superconductivity

PH507 PHYSICS OF ENVIRONMENT *(~75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **The Essentials of Environmental Physics:** The environment; The impact of environment upon human and vice versa; Global temperature; Greenhouse effect; The Energy Balance: A zero dimensional greenhouse model; Radiative forcing; Global warming; Green house effect enhancement; Elements of weather and climate; Climate variations; Climate models.
2. **Mass and Energy Transfer:** Materials balance: Conservative and non-conservative systems; Pollutants; Step function response.
3. **Air Pollution:** General consideration; Comparison of polluted and unpolluted air; Types of air pollutants- formation and sources; Effects of air pollutants on plants and human body; Acceptable limits of air pollutants; Control of air pollutants.
4. **Water Pollution:** Water pollutants; Surface water quality: Rivers and streams, Effects of oxygen demanding waste in rivers, Ground water; Arsenic in drinking water: Source, Effects, Measurements, Prevention and control, Arsenic pollution in Bangladesh; Water purification process: in natural systems, physical process, chemical process, Bio-chemical process.

5. **Noise Pollution and Control:** Sources of Noise pollution; Noise intensity; Human perception and noise criteria; Effect of noise on people; Factors affecting threshold shift; Noise pollution control.
6. **Mechanism of Pollutants Transport:** Diffusion and its application in practical purposes; Flow in rivers: One dimensional approach, the influence of turbulence, a continuous point emission; Ground water flow: Vertical flow in the unsaturated zone, Conservation of mass, Stationary flow, Vertical flow.
7. **Nuclear Waste and the Environment:** Power plant emissions: Radioactive gases and effluents; Radioactive waste, High-level waste; Impact of reactor accidents on the environment; Radioactive waste management; Decommissioning.

Books recommended:

Masters, GM	Introduction to Environment Engineering and Science
Boecker, E and van Grondelle, R	Environmental Physics
Manahan, SE	Environmental Science & Technology
Stoker, HS and Scott, SLS	Environmental Chemistry
Monteith, JL and Unsworth, M	Principles of Environmental Physics
Peavy, HS and Rowe, DR	Environmental Engineering
Nevers, ND	Air Pollution Control Engineering
Bhatia, HS	A Textbook on Environmental Pollution and Control
Revenscroft, P, Brammer, H and Richards, K	Arsenic Pollution
Botkin, DB and Keller, EA	Environmental Science: Earth as a Living Planet
McGuffie, K and Henderson-Sellers, A	*A* Climate Modelling Primer

PH508 CRYSTALLOGRAPHY & SPECTROSCOPY *(~75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)

(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Symmetry Elements:** Point groups; uniaxial point groups; sub- and super- group of the point groups and space groups; their formation, general equivalent points, plane groups and their uses.
2. **Fourier Transform:** Fourier series; Diffraction and Fourier transform; Convolution; Diffraction by a periodic distribution; Electron density equation.
3. **Factors Affecting X-ray Intensities:** Diffraction from a rotating crystal; Absorption of X- rays; Absorption correction; Temperature factor; Lorentz and polarization factors.
4. **Determination of Crystal Structure:** Patterson function; Sharpened Patterson function; Harker line and section; Heavy atom method; Inequality relationship; Least Square Refinement; Fourier Refinement.
5. **Infrared Spectroscopy:** Introduction to IR spectroscopy; Energy of diatomic molecule; Simple harmonic oscillator; Anharmonic oscillator; Molecular vibration; IR spectrum; Scanning of IR spectrum; Sampling Technique; Qualitative and quantitative interpretation of the IR spectra.
6. **Nuclear Magnetic Resonance Spectroscopy:** Nuclei in a magnetic field; Larmor precession; Bloch equation; Free induction decay; Nuclear interaction: Chemical shifts; Dipolar interaction; Quadrupolar interaction; Relaxation process: Spin-Spin and Spin-lattice relaxation time; Magic angle spinning (MAS); A basic NMR Spectrometer; Interpretation of NMR spectra.
7. **Neutron Scattering Theory and Application:** Basic properties of neutrons; Advantages of using neutron as an experimental probe; Basics of neutron diffraction; Neutron scattering – elastic and inelastic scattering; Small angle neutron scattering; Scattering by magnons and determination of magnetic order; Scattering by phonons – relevance to structure of materials and lattice dynamics.

Books recommended:

Abragam, A	Introduction to Nuclear Magnetic Resonance
Azaroff, L	Elementary X-ray Crystallography
Buerger, MJ	X-ray Crystallography
Carlson, TA	Photoelectron and Auger Spectroscopy
Harris, RK	Nuclear Magnetic Resonance Spectroscopy
Stout, GH and Jensen, LH	Practical Structure Determination
Woolfson, MM	X-ray Crystallography
Stranghan, BP and Walker, S	Spectroscopy

Sharma, BK	Spectroscopy
Akitt, JW	NMR and Chemistry
Bacon, GE	Neutron Diffraction
Willis, BTM and Carlile, CJ	Experimental Neutron Scattering
Squires, GL	Introduction Theory of Thermal Neutron Scattering

PH509 PARTICLE PHYSICS AND COSMOLOGY *(~75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **a) Relativistic Kinematics:** Lorentz transformations and covariance; Four-vector notation.
2. **b) Groups and their Representations:** Introductory group theory; Lie groups and algebra; Irreducible representations; SU(2); SU(3); Young's tableaux.
3. **Feynman Diagram Techniques:** Fermi's golden rule for lifetimes and Cross-sections; Feynman rules for a toy scalar theory; Cross-sections and Lifetimes, Tree level and Higher order diagrams.
4. **QED:** Dirac γ-matrices; Trace theorems; Feynman rules for QED; Calculation of cross-sections and lifetimes; Introduction to renormalisation.
5. **QCD:** QCD Feynman rules; Quark-antiquark and quark-quark interaction QCD; Confinement and asymptotic freedom; Perturbative and non-perturbative QCD.
6. **Weak Interaction and Electroweak Unification:** Feynman rules for the weak interaction; Charged and neutral weak currents; Cabibbo angle; CKM matrix; Electroweak unification.
7. **Introduction to Lagrangians for Gauge Theories and Physics beyond the Standard Model (BSM):** Gauge Theories: Lagrangians for Scalar, Spinor and Vector particles; Derivation of Feynman rules; Global and Local gauge invariance; Spontaneous symmetry breaking; Higgs mechanism; BSM: GUTs, Neutrino masses and oscillation; Ideas of Supersymmetry and String Theory; LHC physics.
8. **Cosmology:** Expansion of the universe; Hubble's law; Big bang; Friedman equation; Hubble constant; Cosmological Models, Density

parameter Ω_0; Deceleration parameter; Cosmological constant; Dark matter and its candidates; Dark energy; Cosmic microwave background; Inflation; Large scale structure.

Books recommended:

Griffiths, D	Introduction to Elementary Particles
Halzen, F and Martin, AD	Quarks and Leptons
Perkins, DH	High Energy Physics
Georgi, H	Lie Algebras in Particle Physics
Longair, MS	High Energy Astrophysics
Collins, PDB, Martin, AD & Squires, FJ	Particle Physics and Cosmology
Rolnick, WB	The Fundamental Particles and their Interactions
Kane, G	Modern Elementary Particle Physics
Aitchison, IJR and Hey, AJG	Gauge Theories in Particle Physics
Bettini, A	An Introduction to Elementary Particle Physics
Mann, R	An Introduction to Particle Physics and the Standard Model
Liddle, A	Introduction to Modern Cosmology
Ryden, B	Introduction to Cosmology
Dodelson, S	Modern Cosmology

PH510 ADVANCED REACTOR PHYSICS *(~ 75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)

(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Nuclear Reactors and Nuclear Power:** Components of nuclear reactors; Non-nuclear components of nuclear power plants; Power reactors and Nuclear steam supply systems; PWR, Organic-cooled reactors; Gas-cooled thermal reactors; Heavy-water reactor; Breeder reactors: LMFBR; MSBR.
2. **Nuclear Reactor Theory:** One-group reactor equation for different reactor shapes; Two-group critical equations; Calculations of critical size; Reflected reactors.
3. **Heat Removal:** General thermodynamic considerations; Heat generation in reactors; Heat flow by conduction; Heat transfer to

coolants; Boiling heat transfer; Reactor coolants and associated phenomena.

4. **Reactor Materials:** Structural materials; Moderator and reflector materials; Radiation effects on materials; Corrosion and chemical reactions in coolant circuit materials.
5. **Time Dependent Reactor:** Reactor Kinetics**;** Control rods and chemical shim, Temperature effects on reactivity, Fission production poisoning, Core properties during lifetime.
6. **Reactor Shielding and Safety:** Principles of reactor shielding; Different types of shielding systems and materials; Attenuation of fast neutrons and gamma rays; Principles of Nuclear power plant safety; Reactor accidents and risk analysis.

Books recommended:

Stacey, WM	Nuclear Reactor Physics
Duderstadt, JJ and Hamilton, LJ	Nuclear Reactor Analysis
Garg, S et al	Nuclear Reactor Physics
Garland, WJ	www.nuceng.ca (website)
Glasstone, S and Sesonske, A	Nuclear Reactor Engineering
Liverhant, SE	Elementary Introduction to Nuclear Reactor Physics
Lamarsh, JR	Introduction to Nuclear Engineering
Murray, RL	Introduction to Nuclear Engineering
King, DG	Nuclear Power Systems
Henry, A	Nuclear Reactor Analysis

PH511 BIOMEDICAL INSTRUMENTATION AND IMAGING SYSTEM (~75 lectures)

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Fundamentals of Medical Instrumentation:** Physiological systems of human body; Cardio vascular system; Respiratory system; Nervous system; Source of biomedical signals; Basic medical instrumentation system; Microprocessor; Interfacing of analog signals to microprocessors; PC based medical instruments.
2. **Bioelectric Signals and Electrodes:** Origin of bioelectric signals; Electrocardiogram (ECG), Electroencephalogram (EEG);

Electromyogram (EMG); Recording electrodes; Metal-electrolyte interface; Skin contact impedance; Silver-silver chloride electrodes; Electrodes for: ECG, EEG, EMG; Electrical conductivity of jellies and creams.

3. **Instrumentation Amplifier and Recorders:** Principle of instrumentation amplifier; Carrier amplifier; Chopper amplifier; Biomedical signal analysis techniques; Fourier transform; Signal processing techniques; Writing processes: Ink jet recorder; Potentiometric recorder; Digital recoder, Biomedical recorders; ECG; Vector cardiograph (VCG); EEG; EMG; Biofeedback instrumentation.
4. **Patient Monitoring System:** Cardiac monitor; Cardiac monitor using digital memory; Central monitors; Measurement of: Heart rate, Pulse rate, Blood pressure, Respiration rate, Foetal monitoring instruments.
5. **Clinical Laboratory Instruments and Blood Cell Counters:** Principles of spectrophotometer; Microprocessor based spectrophotometer; Automated biochemical analysis system; Clinical flame photometer; pH measurements of blood; Blood pCO_2; Blood pO_2 ; Complete blood gas analyzer; Methods of blood cell counting; Coulter counters; Automatic recognition and differential counting at cells.
6. **Audiometer and Hearing Aids:** Basic audiometer; Sections of audiometer; Mechanical; Electrical; Evoked response audiometer system; Hearing aids; Conventional, Digital; Cochlear implants.
7. **Modern Imaging Instrumentation:** X-ray machines; Digital radiography; X-ray computed tomography (CT); Position emission tomography (PET); Nuclear medical imaging; Magnetic resonance imaging (MRI) ; Ultrasonic imaging; Thermal imaging.
8. **Therapeutic Equipments:** Cardiac pacemaker; Cardiac defibrillators; Haemodialysis machines; Lithotriptor machine; Radiotherapy equipment; Physiotherapy and electrotherapy equipment.

Books recommended:

R,S, Khandpur	Handbook of Biomedical Instrumentation
L Cromwell, F J. Weibell, E A Pfeiffer	Biomedical Instrumentation and Measuring system
B.L. Chrisfe	Introduction to Biomedical Instrumentation

PH512 QUANTUM FIELD THEORY *(~ 75 lectures)*

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)

(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

1. **Canonical Quantisation:** Real Klein-Gordon field; Complex Klein-Gordon field; Dirac (Spinor) field; Electromagnetic vector field; Choice of gauge.
2. **Perturbative Expansion, Feynman Diagrams Techniques and Path Integral Quantisation:** Perturbative (loop) expansion; Feynman diagrams; Propagators and interactions; S-matrix; Path integral formalism; Generating functional; Green's function for free and interacting fields; Examples using ϕ^4 theory; Connected and disconnected diagrams; Fermions; LSZ reduction formula; Gauge fields; Gauge invariance; QED: Photon propagator; Self-energy; Ward-Takahashi identities; Cross-sections for some elementary processes.
3. **Renormalisation:** Renormalisability of a theory; Ultraviolet and infrared divergences; Divergences in ϕ^4 theory; Dimensional regularization; Renormalisation of ϕ^4 theory; Divergences in QED; Renormalisation of QED; Renormalisation group.
4. **Symmetry Breaking:** Goldstone theorem; Pion as a Goldstone-Nambu boson; Higgs mechanism and Glashow-Salam-Weinberg model.
5. **Applications:**
   a) Non-Abelian Gauge Theories: Yang-Mills theory; Faddeev-Popov ghosts; One-loop divergences in QCD; Asymptotic freedom.
   b) Condensed Matter Physics: Superfluids; Landau-Ginzburg theory; Superconductivity; Quantum Hall fluids.

Books recommended:

Peskin, ME and Schroeder, DV	An Introduction to Quantum Field Theory
Ryder, LH	Quantum Field Theory
Zee, A	Quantum Field Theory in a Nutshell
Ramond, P	Field Theory: A Modern Primer
Weinberg, S	Quantum Theory of Fields, vols. 1 and 2
Itzhykson, C and Zuber, J	Quantum Field Theory
Kaku, M	Quantum Field Theory
Srednicki, M	Quantum Field Theory

PH513 OPTICAL FIBRE PHYSICS *(~ 75 lectures)*

Full Marks: ***100*** *(Examination 80, Tutorial/Terminal 15, and Attendance 5)*
(5 questions to be answered) *Examination duration:* ***4*** *hours*

1. **Basic Characteristics**: Ray theory; Electromagnetic theory; Single mode fibre; Multimode fibres.
2. **Transmission Characteristics:** Material absorption loss; Linear ion linear scattering loss; Band loss; Splice loss; Different types of dispersions; Polarization.
3. **Fabrication of Optical Fibre:** Liquid phase technology; Vapour phase deposition technique (OVP, VAD, MCVD and PCVD); Fluoride gas fibers.
4. **Optical Communication Systems:** Sources: Different types of LASER and their characteristics; LEDs; Detectors: Principles, PIN photodiodes; APDs; Transmitter; Fibre sensors; Optical interferometers.
5. **Optical Amplifications and Integrated Optics:** Optical amplifier; Fibre amplifier; Integrated optics principle; Planer waveguide; Integrated optical devices.
6. **Measurement Methods in Optical Fibre:** General experimental consideration; Measurement of attenuation; Refractive index profile; Numerical aperture; Pulse dispersion and bandwidth.

Books recommended:

Ghatak, A and Thyagarajan, K	Introduction to Fibre Optics
Seuior, JM	Optical Fibre Communication
Ghatak, A and Thyagarajan, ZK	Optical Electronics
Shydev, AW and Love, JD	Optical Waveguide Theory
Gowav, P	Optical Communication
Lacy, EA	Fiber Optics

PH523 PRACTICALS

Full Marks: ***100*** (*Examination 80, Tutorial/Terminal 15, and Attendance 5*)
(5 *questions to be answered*) *Examination duration:* ***4*** *hours*

List of Experiments

1. Determination of total cross-section by analyzing bubble chamber photos.
2. Measurement of the range of π-meson in liquid hydrogen.
3. Determination of the maximum energy of beta particles from its energy spectrum.
4. Measurement of the mass of π-meson from the analysis of the decay of pions and muons in hydrogen bubble chamber.
5. Analysis of nuclear interactions on a bubble chamber film using relativistic kinematics.
6. a) Determination of the thermal neutron flux using neutron activation method.
   b) Determination of the half-life of a radioisotope using 7mCi Ra-Be neutron source.
7. Studies of magnetic properties of a ferromagnetic sample using an oscilloscope.
8. Studies of conductivity and activation energy of a semiconducting sample and measurement of TCR.
9. Determination of Hall constant, Hall mobility and other related parameters of a semiconducting sample.
10. Study of the characteristics of a solar cell/panel.
11. Deconvolution of digitized NMR spectrum and hence identification and quantification of various species present in an amorphous material.
12. Identification and quantification of various chemical bonds present in a specific material by using IR Spectrum.

13. Estimation of absorption coefficient and optical band gap from absorption edge of amorphous and crystalline semiconductors.
14. Study of pulse width modulation (using 555 timer).