

ACADEMIC CURRICULA

POST GRADUATE DEGREE PROGRAMMES

1-Year Master of Science (Physics) (NEP based Flexible Credit System)

**Syllabi for 1-Year Master of Science (Physics) Programme
Core and Elective Courses**

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA
(Deemed to be university)**

Mesra, Ranchi, Jharkhand, 835215, India

University Vision

To become a globally recognized academic institution in consonance with the social, economic and ecological environment, striving continuously for excellence in education, research and technological service to the national needs.

University Mission

- To educate students at Undergraduate, Postgraduate, Doctoral and Post Doctoral levels to perform challenging engineering and managerial jobs in industry
- To provide excellent research and development facilities to take up Ph.D. programmes and research projects
- To develop effective teaching and learning skills and state-of-the-art research potential of the faculty
- To build national capabilities in technology, education and research in emerging areas
- To provide excellent technological services to satisfy the requirements of the industry and overall academic needs of society

Department Vision

To become internationally recognized centre of excellence in academics and research in the area of Physics and related interdisciplinary fields.

Department Mission

- To impart high quality science education in a multidisciplinary vibrant academic ambience, nurture young talent and prepare them to take up challenges in diverse areas of science and technology
- To inculcate professional ethics, integrity and appreciation for diversity in students and incumbents.
- To provide environment for collaborative cutting-edge research leading to innovations, while maintaining focus on social responsibilities.
- To create performers to take up initiatives, leading to creation of new knowledge.
- Strive towards achieving satisfaction of all stakeholders.

Program Educational Objectives (PEOs)

1. To impart high quality education in Physical Sciences
2. To prepare students for taking up challenges as globally competitive physicist & researchers in diverse areas of theoretical and experimental physics
3. To make students technically and analytically skilled
4. To provide opportunity of pursuing cutting-edge research as project work.
5. To give exposure to a vibrant academic ambience
6. To create a sense of academic and social ethics among the students.
7. To prepare them to take up higher studies of interdisciplinary nature.

Program Outcomes (POs)

1. The students will obtain good knowledge in Physical sciences. They will be trained to compete for national level tests like UGC-CSIR NET, JEST, GATE etc., successfully.
2. They will be prepared to take up challenges as globally competitive physicists & researchers in diverse areas of theoretical and experimental Physics.
3. They will be technically and analytically skilled to pursue their further studies.
4. They will have a sense of academic and social ethics.
5. They will be capable of taking up higher studies of interdisciplinary nature.
6. They will be able to recognize the need for continuous learning and develop throughout their professional career.

COURSE STRUCTURE

FIRST SEMESTER						
Course Category	Course code	Course Name	L	T	P	Credit
Major	PH24501	Advanced Nuclear and Particle Physics	3	0	0	3
	PH24503	Laser Physics and Applications	4	0	0	4
	PH24504	Laser and Spectroscopy Lab	0	0	3	1.5
	PH24505	Condensed Matter Physics	3	0	0	3
	PH24506	Condensed Matter Physics Lab	0	0	3	1.5
OE/MOOC	OE/MOOC					3
Program Elective		PE (Annexure)				4
Total Credits in First Semester						20
SECOND SEMESTER						
Course Category	Course code	Course Name	L	T	P	Credit
	PH24550	Project*				20
Total Credits in Second Semester						20
Total Credits for 1-Year M.Sc. Physics						40

* Student maybe allowed (based on their performance in first semester (SGPA > 8.0) and mandatory clearance of first semester courses) to take project in premier education institutes and R&D organizations.

MOOC course from Swayam portal

ANNEXURE

ANNEXURE (Program Elective)			
S. No.	Course Code	Course Name	Credits
GROUP-A (Theoretical Physics)			
1	PH24411	NUMERICAL METHODS FOR PHYSICISTS	4
2	PH24413	ADVANCED MATHEMATICAL METHODS	4
3	PH24415	NONLINEAR DYNAMICS AND CHAOS	4
GROUP-B (Condensed Matter Physics)			
4	PH24417	THEORY OF SOLIDS	4
5	PH24419	FUNCTIONAL MATERIALS	4
6	PH24421	NONCONVENTIONAL ENERGY MATERIALS	4
GROUP-C (Photonics)			
7	PH24423	FIBER AND INTEGRATED OPTICS	4
8	PH24425	PHOTONIC AND OPTOELECTRONIC DEVICES	4
9	PH24427	QUANTUM & NONLINEAR OPTICS	4
GROUP-D (Electronics & Instrumentation)			
10	PH24429	INSTRUMENTATION AND CONTROL	4
11	PH24431	MICROPROCESSOR AND MICROCONTROLLER APPLICATIONS	4
12	PH24433	PHYSICS OF SOLID-STATE DEVICES	4
GROUP-E (Plasma Physics)			
13	PH24435	INTRODUCTION TO PLASMA PHYSICS	4
14	PH24437	THEORY OF PLASMAS	4
GROUP-F (Biophysics)			
15	PH24439	INTRODUCTION OF BIOPHYSICS AND BIOMATERIALS	4
16	PH24441	QUANTITATIVE BIOLOGY	4

Teaching and Learning Scheme

As per the new **National Credit Framework**, an account of 30 hours of learning is equivalent to 01 credit. It comprises of Classroom instructions (CI), Lab instructions (LI), Team work + Self Learning (TW + SL) in hours per semester. The division of the components mentioned will be as per the following teaching and learning scheme.

Sl. No.	Total credits	Classroom Instructions (CI) in hours per semester		Lab Instructions (LI) in hours per semester	Team work (TW) and Self Learning (SL) (TW + SL) in hours per semester	Total no. of Hours per semester
		Lectures	Tutorials			
1	04 (Four) Theory	42	14	0	64	120
2	03 (Three) Theory	28	14	0	48	90
3	03 (Three) Theory	42	0	0	48	90
4	02 (Two) Theory	28	0	0	32	60
5	02 (Two) Lab	0	0	56	4	60
6	1.5 (One and Half) Lab	0	0	42	3	45
7	01 (One) Lab	0	0	28	2	30
8	02 (Two) Project	0	0	0	60	60
9	03 (Three) Project	0	0	0	90	90
10	04 (Four) Project	0	0	0	180	180
11	03 (Three) Vocational	14	0	56	20	90

Legend:

- CI Classroom instruction (includes different instructional/ implementation strategies i.e. Lecture (L), Tutorial (T), case method, Demonstrations, video demonstration, problem-based learning etc. to deliver theoretical concepts)
- LI Laboratory Instructions (includes experiments/practical performance, problem-based experiences in laboratory, workshop, field or other locations using different instructional/ implementation strategies)
- TW Team Work (includes assignments, seminar, micro projects, industrial visits any other student activities, etc.)
- SL Self Learning, MOOCs, spoken tutorials, online educational resources etc. (if provided in curriculum structures)

COURSE INFORMATION

Course code	PH24501
Course title	Advanced Nuclear and Particle Physics
Pre-requisite(s)	Nuclear and Particle Physics
Co-requisite	
Credits	C: 3 L: 3 T: 0 P: 0 SL:
Class schedule per week	3
Class	1-Year M.Sc. (Physics)
Semester / Level	I / V
Branch	Physics
Name of Teacher	Dr. R. K. Dewanjee

Course Objectives <i>This course aims to enables the students:</i>	
Sl No.	Objectives
1	To acquire knowledge of basic Nuclear Models and their theoretical description.
2	To acquire knowledge of the Two-nucleon problem and the basic concepts of nuclear force.
3	To acquire knowledge about the nucleus by the study of scattering of two nucleons.
4	To have a good understanding of interaction of nuclear radiation with matter.
5	To have a good understanding of elementary particles and Standard Model of particle Physics.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	have knowledge about the various basic models of atomic nucleus.
CO2	have a good understanding of the two-nucleon problem and the nature of nuclear force.
CO3	learn about the method and analysis of Nuclear Scattering processes.
CO4	have a clear understanding of the theory of nuclear radiation-matter interaction.
CO5	understand the nature, interactions etc.. of the elementary particles and the basics of standard model of particle physics

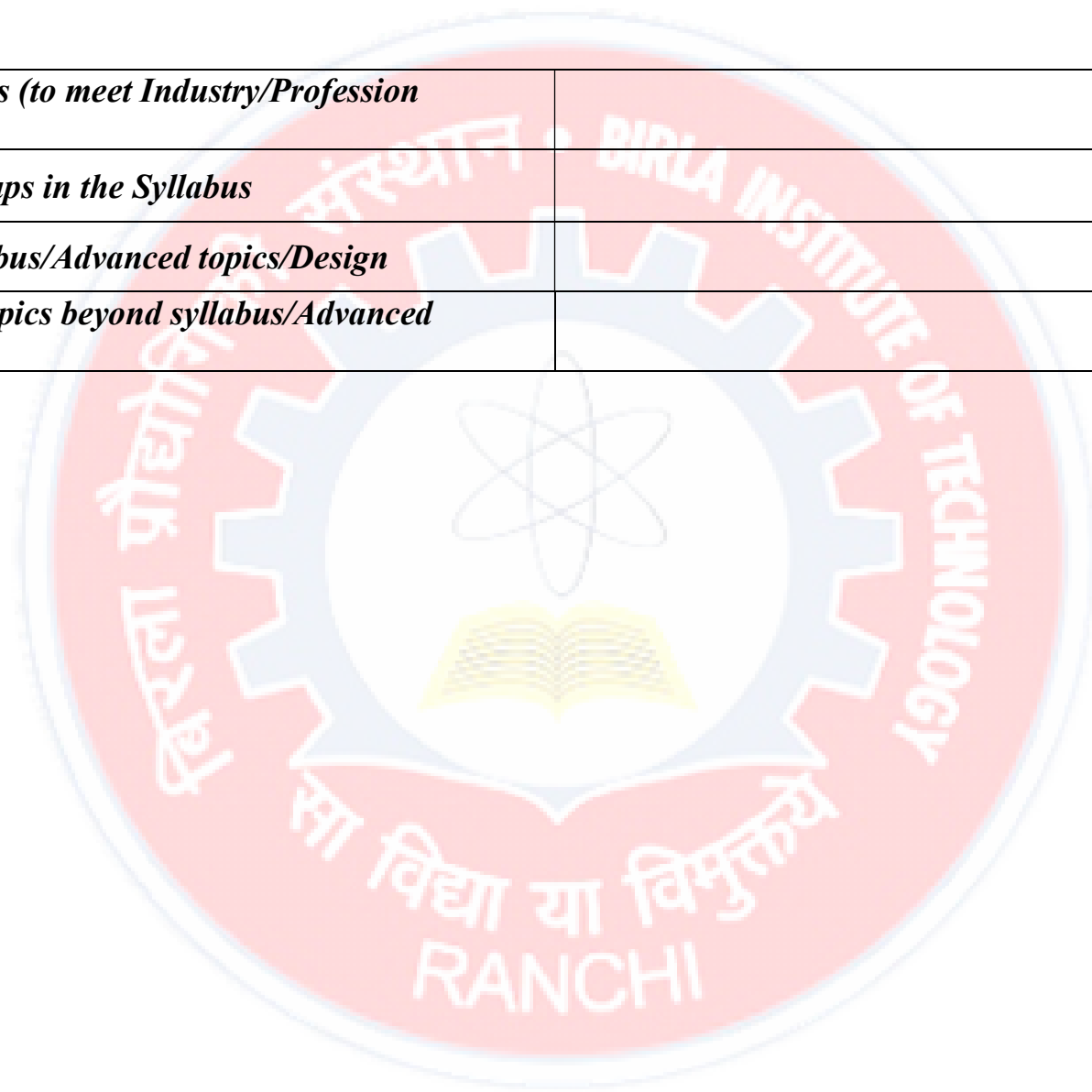
Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1	Nuclear Models	Nuclear Models: Recap of Liquid Drop Model and Semi-empirical mass formula, Shell model.	6
2	Deuteron problem and the nature of nuclear force	Two nucleon problem: Deuteron and its ground state, nature of nuclear forces, spin dependence of nuclear force.	8
3	Nucleon scattering	Scattering: Elastic and Reaction, Scattering Cross section: differential and total, Nucleon-Nucleon scattering: neutron-proton, proton-proton and neutron-neutron scattering at low energies.	8
4	Radiation-Matter Interaction	Interaction of radiation with matter, Interaction of charged particles with matter, stopping power of heavy charged particles, energy loss of electrons, absorption of gamma rays, photoelectric effect, Compton effect and pair production.	10
5	Basics of Particle Physics and Introduction to the Standard Model	Classification of elementary particles, Baryon octate and meson octate, Quark model, Intermediate vector Boson, Strong, Electro-Magnetic and Weak interactions, standard model, lepton classification and quark classification.	8

Learning Resources

Text Books	Reference Books
1. Introductory Nuclear Physics- Kenneth S-Krane. 2. Introduction to Elementary Particles: David Griffiths	1. Nuclear Theory-Roy and Nigam 2. Nuclear Physics: D. Halliday 3. Elements of Nuclear Physics: Pandya and Yadav 4. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo 5. An introduction to Nuclear Physics: Y. Jana

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	M	L	H	M
CO2	H	H	M	L	H	M
CO3	H	H	M	L	H	M
CO4	H	H	M	L	H	M
CO5	H	H	M	L	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. K. Dewanjee

COURSE INFORMATION

Course code	PH24503
Course title	Laser Physics and Applications
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / V
Branch	Physics
Name of Teacher	Dr. R. K. Sinha

Course Objectives <i>This course aims to enables the students:</i>	
Sl No.	Objectives
1	To identify conditions for lasing phenomenon and properties of the laser.
2	To discuss stable, unstable resonators and cavity modes.
3	To compare continuous and pulsed lasers.
4	To classify different types of lasers with respect to design and working principles
5	To illustrate various applications of laser e.g. holographic non-destructive testing.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	evaluate conditions for lasing phenomenon and properties of the laser.
CO2	calculate cavity modes of a given cavity and identify the given resonator is stable or unstable one.
CO3	evaluate Q-switching and the mode-locked lasing phenomenon.
CO4	appraise different type of lasers with respect to design and working principles.
CO5	assess applications of a laser for measurement of distance, holography and medical surgeries etc.

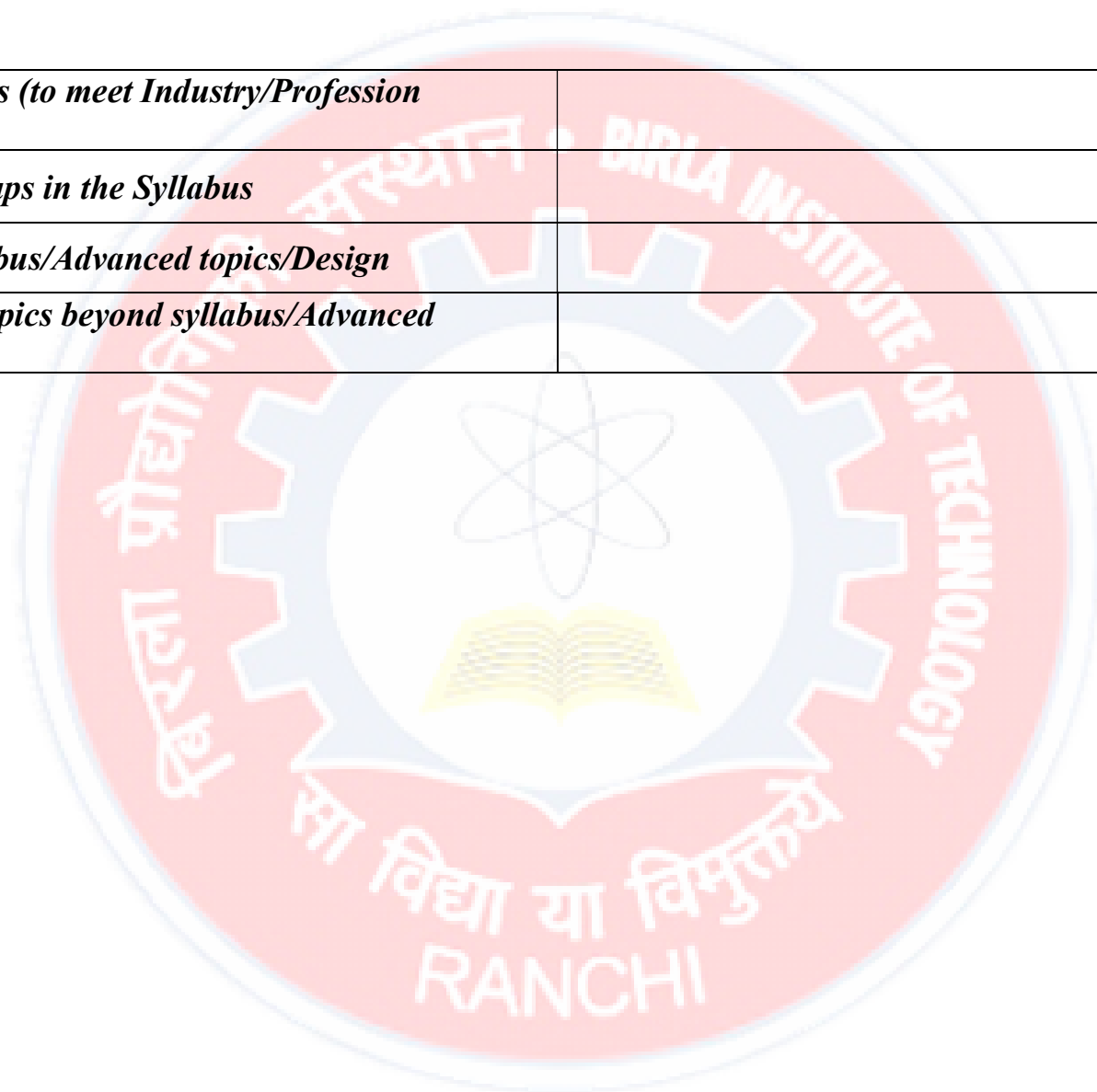
Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1		Interaction of radiation with atoms and ions: Spontaneous and Stimulated emissions, Stimulated absorption. Population inversion, gain oscillation, gain saturation, threshold, rate equation, 3 and 4 level systems, laser line shape, output power. Properties of laser: coherence, monochromaticity, divergence.	14
2		Theory of resonator. Stable and unstable resonator, Optical cavities, Cavity modes, longitudinal and transverse modes of the cavity.	08
3		Pumping processes: Incoherent optical pumping, laser pumping, electrical pumping, Continuous wave, Pulsed, Q- switched and Mode locked lasers.	09
4		Different types of lasers, design (in brief) and functioning of different lasers - Ruby laser, Nd: YAG laser, He-Ne laser, CO ₂ laser, Argon ion laser, Dye laser, Excimer laser. Free electron laser.	09
5		Spatial frequency filtering and holography, Laser in communication, Laser cutting, welding, drilling and surface treatment, Laser in isotope separation, Laser interferometry	10

Learning Resources

Text Books	Reference Books
1. K. Thyagarajan, Ajoy Ghatak, Lasers: Fundamentals and Applications, Second edition, Springer (2010) 2. O. Svelto; Principles of Lasers, Springer (2004) 3. Laser Fundamentals: William T. Silfvast, Cambridge University Press (1998)	1. K. Shimoda, Introduction to laser Physics, Springer Verlag, Berlin (1984) 2. Laser Electronics: J. T. Verdeyen, 3rdEd, Prentice Hall (1994). 3. Laser Applications in Surface Science and Technology; H. G. Rubahn; John Wiley & Sons (1999). 4. Optical Methods in Engineering Metrology: Ed D. C. Williams; Chapman & Hall

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	L	H
CO2	H	H	H	H	M	H
CO3	H	H	H	M	L	M
CO4	H	L	H	H	L	M
CO5	M	H	H	H	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. K. Sinha

COURSE INFORMATION

Course code	PH24504
Course title	Laser and Spectroscopy Lab
Pre-requisite(s)	Laser Physics & Molecular Spectroscopy
Co-requisite	Laser Physics and Applications
Credits	C: 1.5 L: 0 T: 0 P: 3 SL:
Class schedule per week	3
Class	1-Year M.Sc. (Physics)
Semester / Level	I / V
Branch	Physics
Name of Teacher	Dr. R. K. Sinha

Course Objectives <i>This course aims to provide students with:</i>	
Sl No.	Objectives
1	To learn about laser, its characteristics and alignment
2	To understand and analyze the effect of electric and magnetic fields on light through a medium
3	To make the interferometry setups and utilize them for laser wavelength measurements and refractive index measurement of transparent materials
4	To understand vibrational and rotational spectra of polyatomic molecules
5	To understand electronic spectra of molecules

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Ability to handle the low power laser and outline its characteristics
CO2	Explain and analyze the effect of electric and magnetic fields on light through a medium
CO3	Construct interferometry experiments and evaluate their applications
CO4	Ability to conduct vibrational spectroscopy experiments
CO5	Ability to conduct electronic spectroscopy experiments and analyse it.

Syllabus

List of Experiments (10-11 experiments to be conducted from the list of experiments)

1. To find out the beam shape and beam divergence of He-Ne laser beam
2. To obtain Finesse and free spectral range (FSR) of an etalon using Fabry-Perot interferometer
3. To obtain the refractive index of a glass plate using Michelson interferometer
4. To Find the speed of acoustic wave in a given liquid using Acousto-optic effect
5. To obtain Verdet constant of SF10 glass using Red (650nm) and green (532 nm) laser sources
6. To obtain half-wave voltage of LiNbO₃ crystal using linear electro-optic (Pockel) effect
7. To find out the Bohr Magneton of Cadmium source using Zeeman effect
8. To record and analyse absorption and fluorescence spectrum of Rhodamine 6G dye
9. To record and analyse vibrational spectrum of Iodine molecules
10. To analyze the rotational spectrum of acetylene and calculate rotational constant
11. To record Raman spectrum of Acetaminophen (paracetamol) and analyse it.
12. To generate elliptical and circular polarization states from an unpolarized light and make polar plot of the obtained result
13. To obtain the wavelength of Sodium source using Michelson interferometer
14. (i) To verify the Malus law using a diode laser and a set of polarizers (ii) To calculate the Brewster angle of a glass plate and obtain p-polarized light from an unpolarized light
15. To find the numerical Aperture of an optical fiber
16. To find out bending loss in an optical fiber
17. To determine the Kerr constant of the liquid (Nitrobenzene)

<i>Learning Resources</i>	
<i>Text Books</i>	<i>Reference Books</i>
	Lab Manuals

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		60%				
	Semester End Examination		40%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	Lab Journal		30%				
	Quiz		10%				
	Viva		20%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	✓
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	L	H
CO2	H	H	H	H	M	H
CO3	H	H	H	M	L	M
CO4	H	L	H	H	L	M
CO5	M	H	H	H	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD6
CO2	CD1, CD3, CD6
CO3	CD1, CD3, CD6
CO4	CD1, CD3, CD6
CO5	CD1, CD3, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. K. Sinha

COURSE INFORMATION

Course code	PH24505
Course title	Condensed Matter Physics
Pre-requisite(s)	Quantum Mechanics
Co-requisite	
Credits	C: 3 L: 3 T: 0 P: 0 SL:
Class schedule per week	3
Class	1-Year M.Sc. (Physics)
Semester / Level	I / V
Branch	Physics
Name of Teacher	Dr. S. Keshri, Dr. S. K. Mukherjee

Course Objectives <i>This course aims to enables the students:</i>	
Sl No.	Objectives
1	To relate crystal structure to symmetry, recognize the correspondence between real and reciprocal space.
2	To acquire knowledge of the behaviour of electrons in solids based on classical and quantum theories
3	To become familiar with the different types of magnetism and magnetism based phenomenon.
4	To develop an understanding of the dielectric properties and ordering of dipoles in ferroelectrics.
5	To get familiarized with the different parameters associated with superconductivity and the theory of superconductivity.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	correlate the X-ray diffraction pattern for a given crystal structure based on the corresponding reciprocal lattice.
CO2	explain how the predicted electronic properties of solids differ in the classical free electron theory, quantum free electron theory and the nearly free electron model.
CO3	explain various magnetic phenomena and describe the different types of magnetic ordering based on the exchange interaction.
CO4	differentiate between ferroelectric, anti-ferroelectric, piezoelectric and pyroelectric materials.
CO5	differentiate between type-I and type-II superconductors and their theories.

Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1	CRYSTAL DIFFRACTION AND RECIPROCAL LATTICE	Revision of concepts, crystal structure, Bravais Lattice, lattice translation vector, unit cells, Wigner Seitz cells, symmetry operations and elements, simple crystal structures, Miller indices, lattice planes, Braggs' law, Reciprocal lattice to SC, BCC, FCC, Laue's equation and Bragg's law in terms of reciprocal lattice vector, Laue's method, powder crystal diffraction, rotating crystal method, scattered wave amplitude, Fourier analysis of the basis, structure factor of lattices (sc, bcc, fcc), atomic form factor.	12
2	ENERGY BAND THEORY	Classical free electron theory, wave mechanical treatment of electron in 1D and 3D well, Wiedemann-Franz law, quantum theory of thermal conductivity, failure of free electron theory, density of states, Fermi-Dirac statistics, effect of temperature on Fermi distribution function, electrons in a periodic potential, Bloch's theorem, Kronig Penney Model, construction of Brillouin zone, reduced zone scheme, concept of energy band, energy band structure of conductors, semiconductors and insulators.	10
3	MAGNETISM	Magnetic Susceptibility, diamagnetism, paramagnetism, the ground state of an ion and Hund's rules, adiabatic demagnetization, crystal fields, orbital quenching, Jahn-Teller effect, nuclear magnetic resonance, electron spin resonance, Mossbauer spectroscopy, magnetic dipolar interaction, exchange interaction, ferromagnetism, antiferromagnetism, ferrimagnetism, spin glasses	10
4	DIELECTRICS AND FERROELECTRICS	Macroscopic Maxwell equation of electrostatics, theory of local field, theory of polarizability, dielectric constant, Claussius-Mosotti relation, optical properties of ionic crystals, dielectric breakdown, dielectric losses, ferroelectric, anti-ferroelectric, piezoelectric, pyroelectric, frequency dependence of dielectric properties, classification of ferroelectric crystal, ferroelectric phase transitions, relax or ferroelectrics.	09

5	SUPERCONDUCTIVITY	Basic properties of superconductors, phenomenological thermodynamic treatment, London equation, penetration depth, superconducting transitions, order parameter, Ginzburg-Landau theory, Cooper pair, electron-phonon interaction, BCS theory, coherence length, flux quantization, Josephson junction, high T _c superconductors, mixed state.	09
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Learning Resources	
Text Books	Reference Books
1. Introduction to Solid State Physics 8 th Edition, Charles Kittel, John Wiley and Sons, 2005. 2. Solid State Physics, Neil W. Ashcroft, N. David Mermin, Saunders College Publishing, 1976.	1. Condensed Matter Physics 2 nd Edition, Michael. P Marder, John Wiley and Sons, 2010. 2. Magnetism in Condensed Matter, Oxford Master Series in Condensed Matter Physics 4, Stephen Blundell, Oxford University Press, 2001.

Gaps in the Syllabus (to meet Industry/Profession requirements)	
Pos met through Gaps in the Syllabus	
Topics beyond syllabus/Advanced topics/Design	
Pos met through Topics beyond syllabus/Advanced topics/Design	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	NO	M	M
CO2	H	H	H	NO	M	M
CO3	H	H	H	NO	M	M
CO4	H	M	M	NO	H	M
CO5	H	H	H	NO	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. S. Keshri, Dr. S. K. Mukherjee

COURSE INFORMATION

Course code	PH24506
Course title	Condensed Matter Physics Lab
Pre-requisite(s)	
Co-requisite	Condensed Matter Physics
Credits	C: 1.5 L: 0 T: 0 P: 3 SL:
Class schedule per week	3
Class	1-Year M.Sc. (Physics)
Semester / Level	I / V
Branch	Physics
Name of Teacher	Dr. S. Keshri, Dr. S. K. Mukherjee

Course Objectives <i>This course aims to provide students with:</i>	
Sl No.	Objectives
1	Practical understanding of advanced materials characterization techniques.
2	Hands-on skills in experimental data acquisition and analysis, including measurements of permeability, permittivity, semiconductor resistance, magnetic susceptibility, and temperature-dependent properties.
3	Proficiency in scientific software tools for analyzing experimental data and modeling crystal structures.
4	Training in material synthesis and characterization.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Perform and interpret advanced laboratory experiments involving frequency-, temperature-, electrical-, dielectric-, and magnetic-property measurements of materials.
CO2	Analyze and interpret XRD and FESEM data to obtain information about crystal structure, phase composition, crystallographic parameters, and microstructural characteristics.
CO3	Use appropriate computational and visualization tools for materials characterization, data analysis, and crystal-structure visualization.
CO4	Synthesize ceramic materials and correlate processing, structure, and physical properties.

Syllabus

List of experiments:

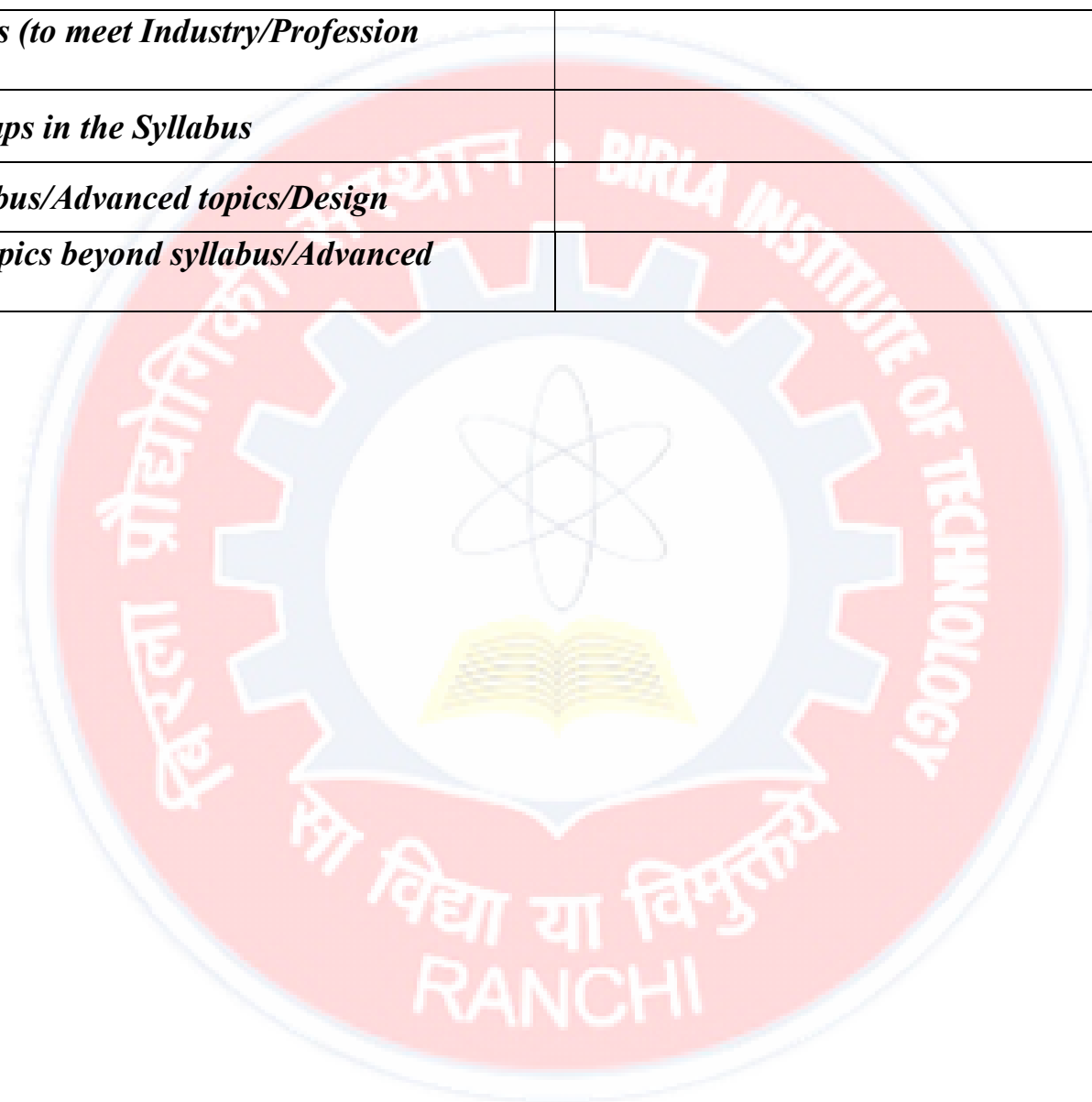
1. To study the permeability of a ferrite substance as a function of frequency. (Take at least 20 data)
2. To study the relative permittivity of a dielectric material as a function of temperature. (Take at least 20 data).
3. Analysis of XRD data using JCPDS software.
4. Analysis of FESEM data using ImageJ software to calculate density function.
5. Analysis of XRD data using CheckCell software.
6. Measurement of resistance of a semiconductor as a function of temperature.
7. Measurement of susceptibility using lock in amplifier.
8. Synthesis of a ceramic sample using a programmable furnace.
9. Analysis of XRD data using FullProf software.
10. Design of crystal structure using VESTA software.

Learning Resources

Text Books

Reference Books

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		60%				
	Semester End Examination		40%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	Lab Journal		30%				
	Quiz		10%				
	Viva		20%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	✓
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	NO	M	M
CO2	H	H	H	NO	M	M
CO3	H	H	H	NO	M	M
CO4	H	M	M	NO	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD3, CD6, CD7
CO2	CD1, CD3, CD6, CD7
CO3	CD1, CD3, CD6, CD7
CO4	CD1, CD3, CD6, CD7
CO5	CD1, CD3, CD6, CD7

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. S. Keshri, Dr. S. K. Mukherjee

COURSE INFORMATION

Course code	PH24411
Course title	Numerical Methods for Physicists
Pre-requisite(s)	Mathematical Physics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. Ray

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	To learn about optimization techniques
2	To understand the concepts of functional approximations
3	To know about algebraic eigenvalue problems
4	To gain knowledge on integral equations
5	To gain familiarity with the numerical solutions of partial differential equations

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Perform optimization via coding.
CO2	Construct computer programs on functional approximations.
CO3	Solve eigenvalue problems numerically.
CO4	Deal with integral equations.
CO5	Numerically solve partial differential equations.

Syllabus

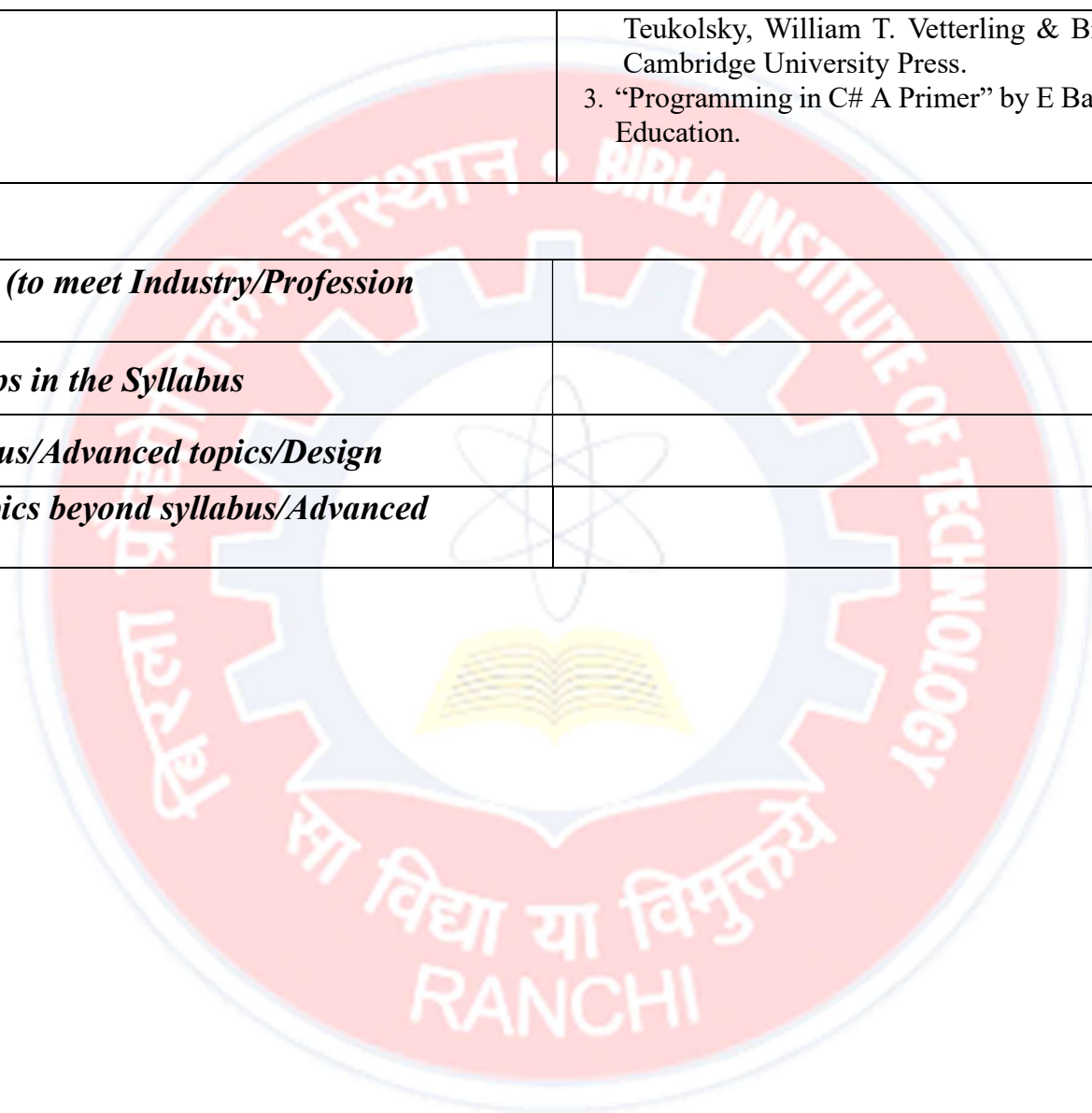
Module No.	Module name	Detailed Contents	No. of Lecture
1	Optimization	Golden Section Search, Brent's Method, Methods Using Derivative, Minimization in Several Dimensions, Quasi-Newton Methods, Direction Set Methods, Linear Programming	10
2	Functional Approximations	Choice of Norm and Model, Linear Least Squares, Nonlinear Least Squares, Discrete Fourier Transform, Fast Fourier Transform (FFT), FFT in Two or More Dimensions, Functional Approximations	10
3	Algebraic Eigenvalue Problems	Introduction, Power Method, Inverse Iteration, Eigenvalue Problem for a Real Symmetric Matrix, QL Algorithm for a Symmetric Tridiagonal Matrix, Algebraic Eigenvalue Problem	10
4	Integral Equations	Introduction, Fredholm Equations of the Second Kind, Expansion Methods, Eigenvalue Problem, Fredholm Equations of the First Kind, Volterra Equations of the Second Kind, Volterra Equations of the First Kind.	10
5	Partial Differential Equations	Wave Equation in Two Dimensions, General Hyperbolic Equations, Elliptic Equations, Successive Over-Relaxation Method, Alternating Direction Method, Fourier Transform Method, Finite Element Methods, Algorithms for Vector and Parallel Computers	10

Learning Resources

Text Books	Reference Books
	1. "Numerical methods for Scientists and Engineers" by H. M. Antia, Springer Science and Business Media. 2. "Numerical Recipes in C" by William H. Press, Saul A.

	Teukolsky, William T. Vetterling & Brian P. Flannery, Cambridge University Press. 3. “Programming in C# A Primer” by E Balagurusamy, McGraw Hill Education.
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	H	H	NO	H	L
CO2	M	H	H	NO	H	L
CO3	M	H	M	NO	M	L
CO4	L	H	L	NO	M	L
CO5	M	H	H	NO	H	L

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. Ray

COURSE INFORMATION

Course code	PH24413
Course title	Advanced mathematical methods
Pre-requisite(s)	Mathematical Physics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. Ray and Dr. S. Ghosh

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	learn path integral formalism.
2	learn representation theory of groups.
3	learn representation theory of groups.
4	learn basics of topology
5	learn one of the most powerful tools of theoretical physics that is renormalization methods and group.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Apply learn path integral formalism.
CO2	Apply representation theory of groups to solve physical problems.
CO3	Understand and apply the language to approach physics problems.
CO4	Understand topological features of physical systems.
CO5	Apply RG methods to solve physical problems especially regarding critical phenomena.

Syllabus

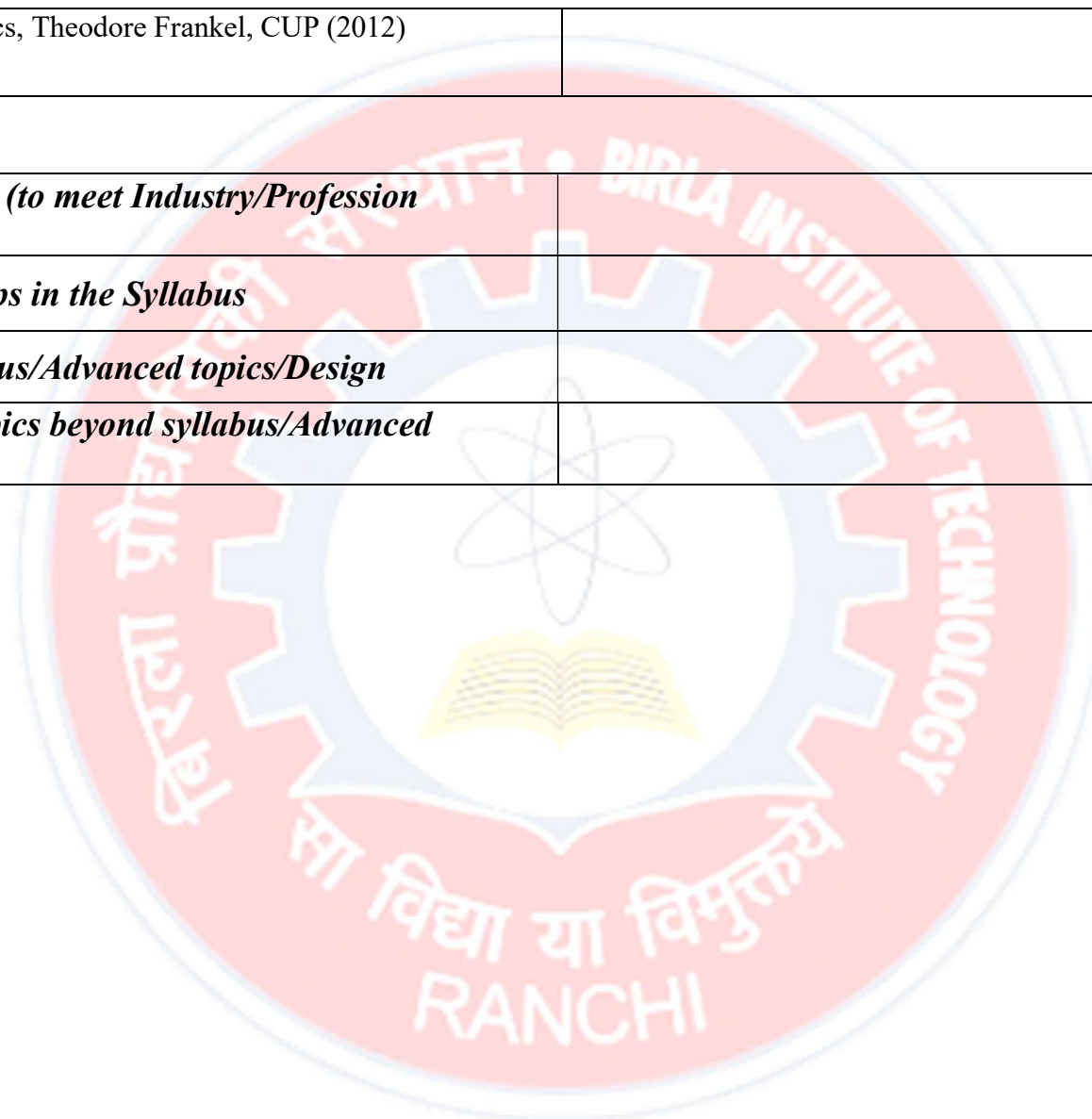
<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1		Path integral formalism: Feynman path integral, in real time, in phase space, Euclidian PI, Tunneling, Spontaneous symmetry breaking, Coherent state PI for spins, bosons and fermions, Grassman variables, Generating functions.	10
2		Representation of finite groups, Unitary matrices, Character table, Reducible and irreducible representations, Symmetries of regular geometrical objects, Countably infinite groups, Lie groups, Rotation, Translation, Unitary groups, Young-Tableaux, Casimir invariant, Applications.	10
3		Differential geometry: Manifolds, vector fields, Tangent bundle Tensors, Exterior algebra, Exterior forms, differentiation, Integration, Stokes theorem, Maxwell's equation, Lie derivative.	10
4		Elements of Topology, Continuity of functions, Topological spaces, Homotopy theory, Homology, Betti numbers, Torsion.	10
5		Renormalisation group: introduction, RG by decimation, Stable and unstable fixed points, Wilson strategy, Critical phenomena, Landau theory, Widom scaling, Kadanoff's block spins, Wilson's RG program, The Beta function, RG of non-relativistic fermions.	10

Learning Resources

<i>Text Books</i>	<i>Reference Books</i>
1. A physicist's introduction to algebraic structure, Palash B. Pal, CUP (2019) 2. Quantum field theory and condensed matter, R. Shankar, CUP (2017)	1. https://ncatlab.org/nlab/show/HomePage

3. The geometry of physics, Theodore Frankel, CUP (2012)	
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	NO	L	M
CO2	H	H	H	NO	M	M
CO3	H	H	H	NO	M	M
CO4	M	H	H	NO	L	H
CO5	M	H	H	NO	M	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. Ray and Dr. S. Ghosh

COURSE INFORMATION

Course code	PH24415
Course title	Nonlinear Dynamics and Chaos
Pre-requisite(s)	Classical Dynamics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. M. Priya

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	Train students to calculate fixed points and do stability analysis of various systems motivated from physics/biology.
2	Give a clear concept of bifurcation and some examples of the phenomenon.
3	Teach them to plot limit cycles of various differential equations on computer using C language.
4	Teach properties of limit cycles taking examples from physics.
5	Train students to solve problems on chaos.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Model physical or biological systems computationally and obtain their fixed points, saddle points, attractors, etc.
CO2	Compute the evolution of phase space as various parameters are changed.
CO3	Visualize limit cycles of various nonlinear systems graphically.
CO4	Solve problems related to oscillators, viz., relaxation oscillators, weakly nonlinear oscillators, etc.
CO5	Solve simple models of chaotic systems.

Syllabus

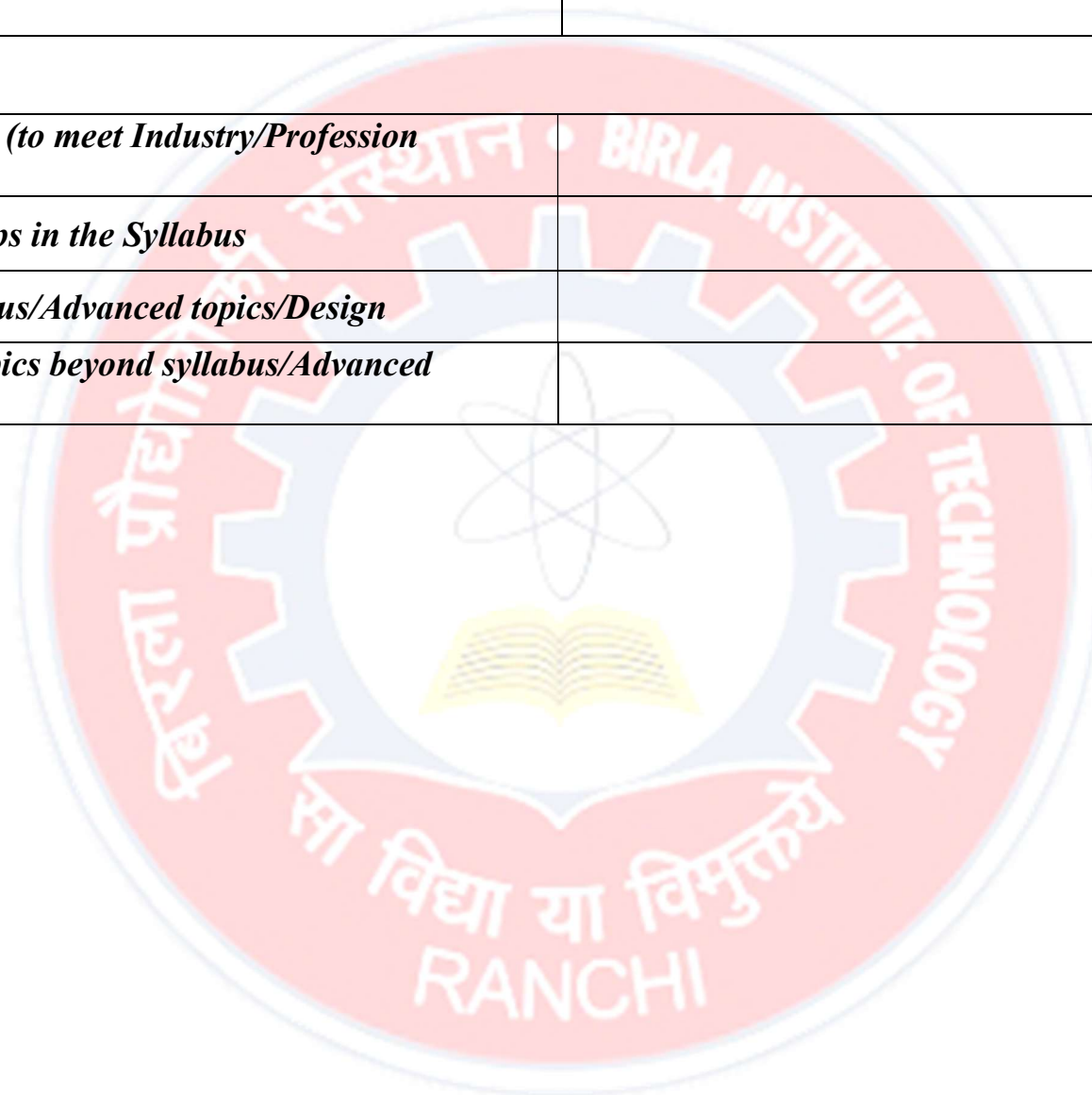
Module No.	Module name	Detailed Contents	No. of Lecture
1	Flows on the Line & Circle	Fixed Points and Stability, Population Growth, Linear Stability Analysis, Existence and Uniqueness, Impossibility of Oscillations, Potentials, Solving Equations on the Computer, Uniform Oscillator, Nonuniform Oscillator, Overdamped Pendulum, Fireflies, Superconducting Josephson Junctions.	12
2	Bifurcations	Saddle-Node Bifurcation, Transcritical Bifurcation, Laser Threshold, Pitchfork Bifurcation, Overdamped Bead on a Rotating Hoop, Imperfect Bifurcations and Catastrophes, Insect Outbreak.	09
3	Phase Plane	Phase Portraits, Existence, Uniqueness, and Topological Consequences, Fixed Points and Linearization, Rabbits versus Sheep, Conservative Systems, Reversible Systems, Pendulum, Index Theory.	10
4	Limit Cycles	Ruling Out Closed Orbits, Poincare-Bendixson Theorem, Lienard Systems, Relaxation Oscillators, Weakly Nonlinear Oscillators.	09
5	Chaos	Logistic Map: Numerics and Analysis, Liapunov Exponent, Lorenz equation and its properties, chaos on a strange attractor, Lorenz map.	10

Learning Resources

Text Books	Reference Books
1. Nonlinear dynamics and Chaos: with applications to physics, biology, chemistry, and engineering by Steven H. Strogatz, CRC Press. 2. Stability and Complexity in Model Ecosystems by Robert M May, Princeton University Press.	

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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	L	H	L	M	L
CO2	L	L	H	L	M	L
CO3	L	L	M	L	L	L
CO4	L	L	H	L	M	L
CO5	H	M	H	L	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. M. Priya

COURSE INFORMATION

Course code	PH24417
Course title	Theory of Solids
Pre-requisite(s)	Condensed Matter Physics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. Ray

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	To understand the quantum free electron theory, Fermi-Dirac statistics, and electronic transport properties.
2	To understand the band theory of solids and single-particle dynamics in a periodic potential.
3	To explore phenomenological and quantum mechanical models of macroscopic magnetic ordering.
4	To apply the Landau paradigm of phase transitions to magnetic and ferroelectric systems.
5	To analyze the frequency-dependent dielectric, optical, and coupled responses of materials.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Calculate the thermodynamic and specific heat properties of an electron gas using Fermi-Dirac statistics.
CO2	Solve for band structures and carrier effective masses using periodic potential frameworks like the Kronig-Penney model.
CO3	Analyze microscopic exchange mechanisms, spin-wave excitations, and localized moment phenomena in metals.
CO4	Apply the Landau free energy expansion to characterize first- and second-order phase transitions and domain energetics.
CO5	Model complex dielectric dispersion, optical transitions, ferroelectric hysteresis, and cross-coupling behaviors.

Syllabus

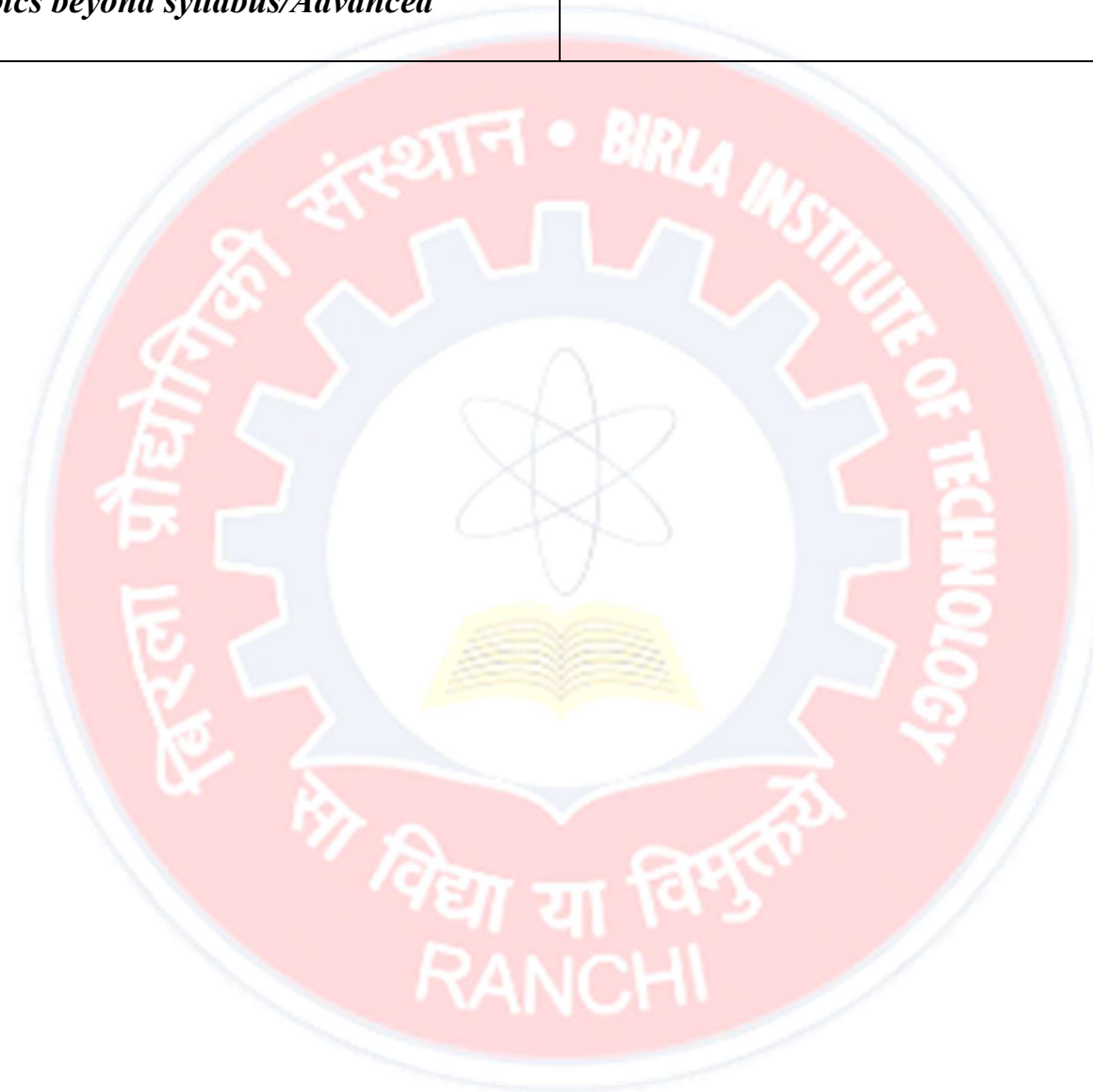
Module No.	Module name	Detailed Contents	No. of Lecture
1	Sommerfeld Theory and electron statistics	Drude model and limitations of classical theory (overview), Sommerfeld model and quantum mechanical treatment of electron in a 1D and 3D infinite potential wells, Density of states, Fermi-Dirac statistics, Fermi distribution function and its temperature dependence, Fermi energy, Fermi temperature, Specific heat of electrons, Failures of the free electron model.	10
2	Periodic Potential and Energy Band Theory	Review of crystal structures, unit cell, and reciprocal lattice, General properties of electrons in a periodic potential, Bloch theorem, Kronig Penny model, Concept of energy band, Brillouin zone in 1D and 2D: extended, reduced, and periodic zone schemes, Classification of materials as metals, semimetals and insulators, Density of states, van Hove singularities, Semiclassical motion of electrons in a periodic potential: velocity, effective mass tensor, and the physical concept of holes.	08
3	Quantum Magnetism	Magnetic susceptibility, Ferromagnets, Magnetic hysteresis: remanance and coercivity, Classification of magnets (dia-, para-, antiferro-, ferri-magnets, spin glasses), Magnetic interactions, Exchange interactions, Direct and super-exchange mechanisms, Double exchange, Introduction to complex magnetic orders (spiral/helical orders) and geometric frustration, Ising model and Heisenberg Hamiltonian, Localized vs. itinerant behaviour, Basics of the RKKY exchange mechanism and the origin of the Kondo resistance minimum. Elementary ideas of spin wave excitations (magnons). and spin liquids (discussion).	12
4	Landau Theory of Phase Transitions	Introduction to the Landau paradigm; concept of an order parameter in ferromagnets, Landau Free Energy Expansion: energy minimization and distinction between First and Second-order magnetic transitions Ferromagnetic Phase Transitions: Analytical derivation of the Curie-Weiss law from the Landau free energy. Microscopic energy trade-offs (quantum exchange energy vs. classical magnetic dipole energy); Domain wall formation.	10

5	Optical & Dielectric properties of solids	Complex dielectric function, Kramer 's-Kronig relation, Mechanical analogue of relaxation, Debye relation, Cole-cole plots, Interband and intraband transitions, Optical resonances, Linear oscillator model for electronic polarization. Ferroelectricity, Hysteresis loop, Recoverable energy, Landau theory applied to ferroelectrics, Definitions of Piezo- and pyroelectric, Basic idea of Magneto-electric coupling.	10
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<i>Learning Resources</i>	
<i>Text Books</i>	<i>Reference Books</i>
1. Introduction to Solid State Physics 8th Edition, Charles Kittel, John Wiley and Sons, 2005. 2. Solid State Physics, Neil W. Ashcroft, N. David Mermin, Saunders College Publishing, 1976. 3. Magnetism in Condensed Matter, Stephen Blundell, Oxford Master Series, Oxford University Press, 1st edition.	1. Optical properties of Solids: Anthony Mark Fox, Oxford Master Series in Physics, Oxford University Press (2001). 2. Magnetism in Condensed Matter, Oxford Master Series in Condensed Matter Physics 4, Stephen Blundell, Oxford University Press (2001). 3. Condensed Matter Physics, Michael. P Marder, John Wiley and Sons, 2nd Edition, 2010. 4. Statistical Mechanics for Chemistry and Materials Science, Biman Bagchi, CRC Press, 1st Edition. 5. A Landau Primer for Ferroelectrics, P. Chandra and P.B. Littlewood, arXiv:cond-mat/0609347v1 (2024).

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	

<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	
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Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	NO	NO	M
CO2	H	H	H	NO	L	M
CO3	H	H	H	NO	M	H
CO4	M	H	H	NO	L	M
CO5	M	H	H	NO	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. Ray

COURSE INFORMATION

Course code	PH24419
Course title	Functional Materials
Pre-requisite(s)	Solid State Physics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. Ray, Dr. R. Sharma and Dr. A. Roy

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	understand the foundational concepts of phase equilibria, microstructural evolution, and processing-property relationships in metals, alloys, ceramics, and polymers.
2	explore the engineering principles, chemical classifications, and industrial applications of composite architectures and conducting polymers.
3	acquire knowledge of advanced functional systems like smart materials, metamaterials, and optoelectronic devices.
4	comprehend the effects of quantum confinement and reduced dimensionality on the fundamental physical properties of nanostructured materials
5	study contemporary liquid and vapor-phase synthesis techniques, with a specific focus on the processing, structures, and applications of carbon nanotubes and thin-film coatings.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Interpret phase diagrams and microstructural transformation behaviors to predict the physical and mechanical properties of alloys and ceramics.
CO2	Differentiate the structural configurations and processing methodologies of polymers and composites tailored for specific technical applications.
CO3	Explain the physical phenomena underlying advanced functional configurations, including shape memory effects, piezo-electricity, and photovoltaic operations.
CO4	Apply core physics frameworks to analyze quantum size effects in low-dimensional nanostructures like quantum dots, wires, and wells.
CO5	Evaluate and select appropriate state-of-the-art material synthesis routes (such as CVD, MBE, or Sol-Gel) for advanced thin-film engineering and carbon nanotube processing.



Syllabus

<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1	Metals and Alloys	Introduction to Metals and alloys, Phase rules Fe-C phase diagram, Steels, cold, hot working of metals, recovery, recrystallization and grain growth, Structure, properties.	08
2	Ceramics and Polymers	Introduction to ceramics, polymers and composites, Processing and applications of ceramics. Classification of polymers, polymerization, structure, properties, additives, products, processing and applications. Quasicrystals, Conducting Polymers; Properties and applications composites.	12
3	Advanced Materials	Smart materials, ferroelectric, piezoelectric, biomaterials (some basic information), superalloys, aerospace materials, shape memory alloys, optoelectronic materials, Materials for photodiode, light emitting diode (LED), Photovoltaic/Solar cell and meta materials.	10
4	Nanostructured Materials	Nanomaterials classification (Gleiter's Classification)–property changes done to size effects, Quantum dot, wire and well, synthesis of nanomaterials, ball milling.	08
5	Experimental techniques	Liquid state processing -Sol-gel process, Vapour state processing –CVD, MBE, Aerosol processing, fullerene and tubules, formation and characterization of fullerenes and tubules, single wall and multiwall carbon tubules, electronic properties of tubules, applications: optical lithography, MOCVD, super hard coating.	12

Learning Resources

<i>Text Books</i>	<i>Reference Books</i>
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1. Structure and properties of engineering materials, fifth edition, Henkel and Pense, McGraw Hill, 2002. 2. Biomaterials Science, An Introduction to Materials in Medicine, Edited by B.D. Ratner, A.S. Hoffman, F.J. Sckoen, and J.E.L Emons, Academic Press, second edition, 2004. 3. Materials Science and Engineering, An Introduction, William D. Callister Jr and David G. Rethwisch, Eighth Edition, John Wiley & Sons Inc.	
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	M	NO	L	NO
CO2	H	M	M	NO	M	M
CO3	M	H	M	NO	H	M
CO4	M	H	L	NO	M	M
CO5	M	H	H	L	M	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. Sharma, Dr. R. Ray and Dr. A. Roy

COURSE INFORMATION

Course code	PH24421
Course title	Nonconventional Energy Materials
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. Sharma

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	To define the current scenario of the conventional sources of energy and importance of sustainable energy sources.
2	To explain the basic of PN Junction solar cell.
3	To define the solar cell characterization.
4	To illustrate the various solar cell technologies.
5	To explain the other nonconventional energy sources

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Explain the current status of conventional sources of energy and list the various sustainable energy sources.
CO2	Define various properties of the semiconducting materials, formation of PN junction and generation of photo-voltage and photo-current of PN Junction solar cell.
CO3	Demonstrate the measurement of solar cell parameters and solar cell design for high I_{sc} , design for high V_{oc} , design for high FF.
CO4	Explain the fabrication of wafer based solar cells, thin film solar cell, organic solar cells, dye-sensitized solar cell, GaAs solar cells, Thermo-photovoltaics and multijunction solar cells.
CO5	Discuss the concepts of wind energy, bio energy, tidal power, fuel cells, and solar thermal.

Syllabus

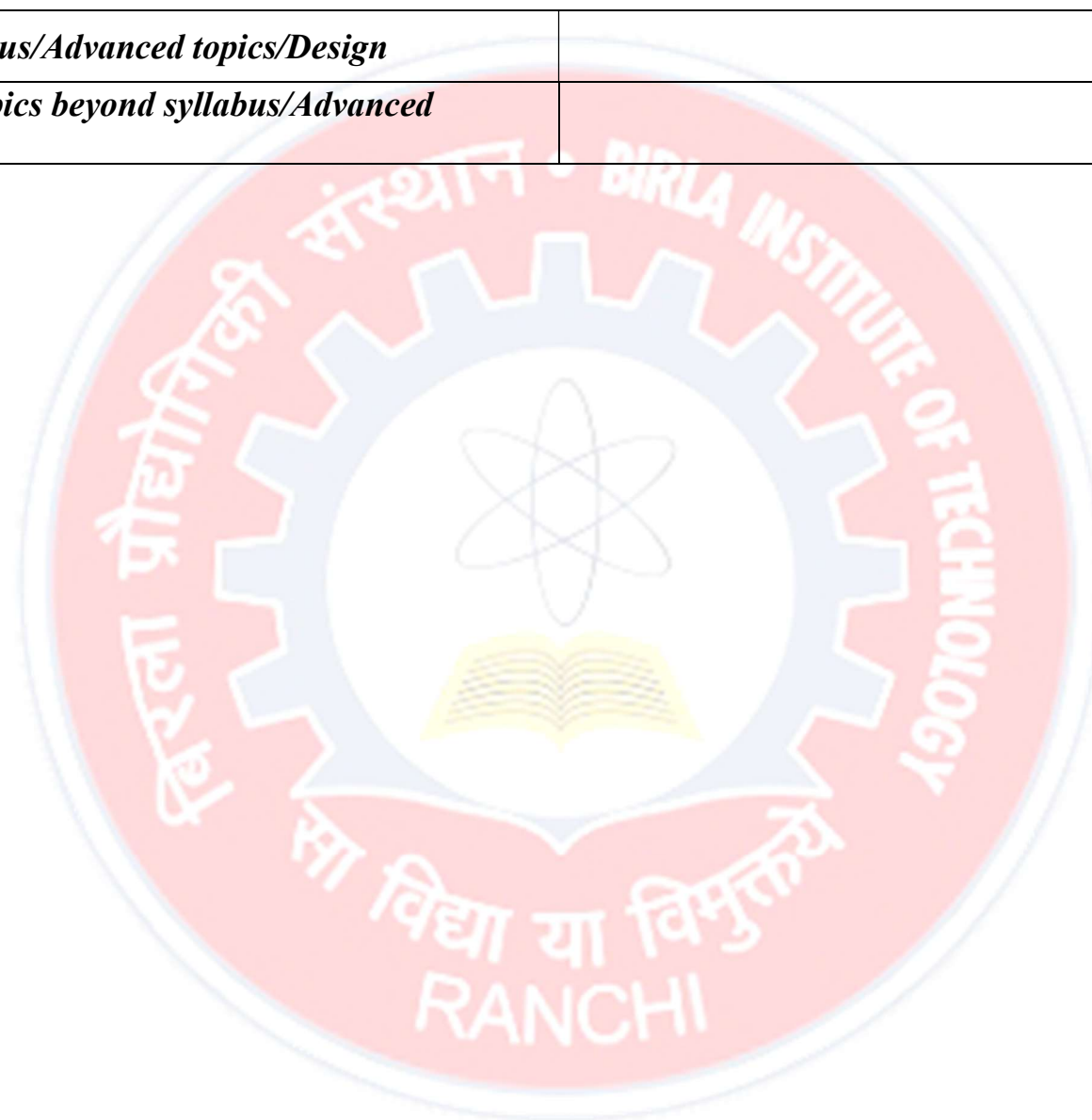
<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1		Energy sources and their availability, conventional sources of energy: Fossil fuel, Hydraulic energy, nuclear energy: nuclear fission, nuclear fusion, Environmental impact of conventional sources of energy, Need for sustainable energy sources, Nonconventional energy sources, Current status of renewable energy sources.	5
2		Structure of solar cell materials, direct and indirect band gap semiconductor, carrier concentration and distribution, drift and diffusion current densities, P-N Junction: space charge region, energy band diagram, carrier movements and current densities, carrier concentration profile; P-N junction in non-equilibrium condition, I-V Relation, P-N Junction under Illumination, Generation of photovoltage, Light generated current, I-V equation of solar cells.	10
3		Solar Cell Characteristics and Cell parameters: short circuit current, open circuit voltage, fill factor, efficiency; losses in solar cells, Solar Cell Design: design for high I_{sc} , design for high V_{oc} , design for high FF; Solar spectrum at the Earth's surface, solar simulator: I-V measurement, quantum efficiency measurement, minority carrier lifetime and diffusion length measurement.	10
4		Wafer-based Si solar cell fabrication: saw damage removal and surface texturing, P-N Junction formation, ARC and surface passivation, metal contacts—pattern defining and deposition. High efficiency solar cells, Thin Film Solar Cell Technologies: advantages of thin film technologies, thin films solar cell structures, thin film crystalline, microcrystalline, polycrystalline, and amorphous Si solar cells. Emerging solar cell technologies: working principle of organic solar cells, material properties and structure of organic solar cells; Dye-sensitized Solar Cell: working principle, materials and their properties; GaAs solar cells, Thermo-photovoltaics, multijunction solar cells.	15

5		Other nonconventional Energy Sources: Wind Energy: Classification of windmills, advantages and disadvantage of wind energy; Bio Energy: Biogas and its compositions, process of bio gas, generation – wet process, dry process, utilization and benefits of biogas technology. Tidal Power: Introduction, classification of tidal power plants, factors affecting the suitability of the site for tidal power plant, advantages and disadvantages of tidal power plants. Fuel Cells: Introduction, working of fuel cell, types of fuel cells, advantages of fuel cell technology. Solar Thermal: Solar collectors, solar cookers, solar water heater.	10
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Learning Resources	
Text Books	Reference Books
1. Solar cells: Operating principles, technology and system applications by Martin A Green, Prentice Hall Inc, Englewood Cliffs, NJ, USA, 1981. 2. Semiconductor for solar cells, H J Moller, Artech House Inc, MA, USA, 1993. 3. Solis state electronic device, Ben G Streetman, Prentice Hall of India Pvt Ltd., New Delhi 1995. 4. Direct energy conversion, M.A. Kettani, Addison Wesley Reading, 1970.	1. Handbook of Batteries and fuel cells, Linden, Mc Graw Hill, 1984.

Gaps in the Syllabus (to meet Industry/Profession requirements)	
Pos met through Gaps in the Syllabus	

<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	L	M	L	L	H
CO2	M	M	M	NO	L	L
CO3	M	H	H	NO	H	M
CO4	L	H	H	NO	H	H
CO5	L	M	H	NO	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. Sharma

COURSE INFORMATION

Course code	PH24423
Course title	Fiber and Integrated Optics
Pre-requisite(s)	Waves and Optics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. K. Sinha

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	To understand the light propagation phenomenon through fiber optic cable
2	To understand various loss mechanism of signal while travelling through an optical fiber.
3	To understand the basic working principle of waveguides and its design parameters.
4	To identify waveguides for applications in fiber optics communication systems
5	To understand the principle of working of fiber based sensors for various application purposes.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	illustrate the principle of fiber optics communications.
CO2	distinguish between various loss mechanism in fiber optics communication system.
CO3	utilize the idea of waveguide for different application purpose.
CO4	categorize different waveguides for the utilization in optics communication system
CO5	interpret different fiber sensors and their respective application and can recommend this technique for other new application.

Syllabus

<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1		Principle of light propagation in fibers, step-index and graded index fibers; single mode, multimode and W-profile fibers. Ray optics representation, meridional and skew rays. Numerical aperture and acceptance angle.	05
2		Dispersion, combined effects of material and other dispersions - RMS pulse widths and frequency response, birefringence. Attenuation in optical fibers. Material dispersion and waveguide dispersion in single-mode fibers, Inter and intramodal dispersion in graded-index fibers.	10
3		Theory of optical waveguides, planar, rectangular, symmetric and asymmetric waveguides, channel and strip loaded waveguides. Anisotropic and segmented waveguides. Step-index and graded index waveguides.	10
4		Wave guide couplers, transverse couplers, grating couplers, tapered couplers, prism couplers, fiber to waveguide couplers. Multilayer planar waveguide couplers, dual channel directional couplers, Butt coupled ridge waveguides, Branching waveguide couplers. Directional couplers, optical switch; phase and amplitude modulators, filters, etc.	12
5		Fiber optics sensors, intensity modulation, phase modulation sensors, fiber Bragg grating sensors. Measurement of current, pressure, strain, temperature, refractive index, liquid level etc. Different fiber fabrication methods- chemical vapor deposition method, axial vapor deposition, plasma enhanced modified CVD.	13

Learning Resources

<i>Text Books</i>	<i>Reference Books</i>
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	1. Introduction to Fiber Optics: A.K. Ghatak and K. Thayagarajan, Cambridge University press. 2. Integrated Optics: Theory and Technology; R. G. Hunsperger; Springer (2002) 3. Optical Fiber Sensors, John Dakin and Brian Culshaw, Arctech House Inc. 4. Essentials of optoelectronics, Alan Rogers, 1st Ed., Chapman & Hall. 5. Semiconductor Optoelectronics Devices, P. Bhattacharya, PHI. 6. Optoelectronics and Photonics, principles and practices S. O. Kasap, Prentice Hall
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	H	NO	L	H
CO2	M	H	M	NO	M	H
CO3	M	H	H	L	L	M
CO4	M	M	H	L	M	M
CO5	M	M	M	L	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. K. Sinha

COURSE INFORMATION

Course code	PH24425
Course title	Photonics and Optoelectronic Devices
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. Dilip K. Singh

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	explain the properties of optoelectronic material and optical processes in semiconductor.
2	understand underlying principle & working of liquid crystal displays, optical modulator, and switches.
3	understand principle & working of light sources and photodetectors.
4	know the working of optical nonlinear devices and understand its significance for optical computing.
5	acquire the knowledge of the function and working of photonic switches and interconnects

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	identify suitable optoelectronic materials and explain optical phenomena occurring in semiconductor
CO2	recognize parameters for optimizing the performance of liquid crystal displays, optical modulator, and switches & solve related numerical problems.
CO3	identify the parameters for optimizing the performance of light sources and detectors.
CO4	define the role of different nonlinear optical devices in optical computing.
CO5	select appropriate photonic switch and interconnect for different operations under different working condition.

Syllabus

<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1	Optical processes in semiconductors	Electron-hole pair formation and recombination, Direct and indirect bandgap semiconductors, structural property of crystalline, polycrystalline, amorphous materials, optoelectronic materials, Liquid crystals, compound semiconductors, absorption in semiconductors, Stark effects in quantum well structures, Absorption and emission spectra, excitonic effects.	10
2	Displays, optical modulators, and switches	Liquid crystal cells (principle), Passive and Active matrix liquid crystal displays, Electro-optic modulator, Magneto-optic modulator, Acousto-optic modulator. Electro-absorption modulators, Mach-Zehnder Electrorefraction (Electro-optic) modulators, optical switches.	08
3	Optical sources and detectors	Light emitting diodes, surface- and edge- emitting configuration. Injection laser diodes, gain and index guided lasers, PIN and avalanche photodiodes, Photoconductors, Phototransistors, noise in photodetector. Solar cells (spectral response, conversion efficiency), Charge-coupled devices, Characteristics and applications.	12
4	Optical computing	Digital optical computing: Nonlinear devices, optical bistable devices, SEED devices, Optical phase conjugate devices, integrated devices, spatial light modulators (SLM), Optical Memory: Holographic data storage.	10
5	Photonic switching and interconnects	Kerr gates, Nonlinear Directional couplers, Nonlinear optical loop mirror (NOLM), Soliton logic gates, Free-space optical interconnects, wave-guide interconnects, holographic inteconnections.	10

Learning Resources

<i>Text Books</i>	<i>Reference Books</i>
	1. Essentials of optoelectronics, Alan Rogers, 1st Ed., Chapman & Hall. 2. Introduction to Fiber Optics, Ghatak & Thyagarajan, Cambridge University press. 3. Optoelectronics: An Introduction to Materials and Devices, Jasprit Singh, The McGraw-Hill Companies. 4. Semiconductor Optoelectronics Devices, P. Bhattacharya, PHI. 5. Optoelectronics and Photonics, principles and practices S. O. Kasap, Prentice Hall 6. Photonic switching and Interconnects; Abdellatif Marrakchi, Marcel Dekker, Inc. 7. Optical Computing, an Introduction, Mohammad A. Karim and Abdul A. S Awwal, John Wiley & Sons Inc

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	H	H	L	M	H
CO2	L	H	H	L	M	H
CO3	L	H	H	L	M	H
CO4	L	H	H	L	M	H
CO5	L	H	H	L	M	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. Dilip K. Singh

COURSE INFORMATION

Course code	PH24427
Course title	Quantum and Nonlinear Optics
Pre-requisite(s)	Basic optics and electrodynamics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. K. Sinha

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	To identify the phenomenon of the nonlinear optical interaction of light with matter
2	To examine higher harmonic generations, two-photon absorption and stimulated scattering phenomenon
3	To formulate nonlinear optics in two-level approximations
4	To analyze intensity dependent phenomenon
5	To identify nonlinear optical phenomenon for applications in optical devices

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	judge non-linear optical phenomenon
CO2	apply knowledge of nonlinear optical phenomena in higher harmonic generations, two-photo absorption and stimulated scattering phenomenon
CO3	solve nonlinear optical interaction problem in two-level system
CO4	evaluate intensity dependent material properties like refractive indices and self-focusing
CO5	design non-linear optical devices

Syllabus

<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1		Nonlinear Optical Phenomena: Introduction to nonlinear optics, description of nonlinear optical interaction, phenomenological theory of nonlinearity, nonlinear optical susceptibilities. Sum and difference frequency generation, second harmonic generation, coupled wave equation.	10
2		Manley-Rowe relations, phase matching of SHG, quasi phase matching, electric field induced SHG (EIFISH), optical parametric amplification, third harmonic generation, two-photon absorption. Stimulated Raman scattering and stimulated Brillouin scattering.	10
3		Two level atoms: nonlinear optics in two level approximations, density matrix equation, closed and open two-level atoms, steady state response in monochromatic field, Rabi oscillations, dressed atomic state, optical wave mixing in two level systems, photon echo, self-induced transparency, optical nutation, free induction decay.	10
4		Intensity dependent phenomena: intensity dependent refractive index, self-focusing, self-phase modulation, spectral broadening, optical continuum generation by short optical pulse. Optical phase conjugation, application of OPC in signal processing. Self-induced transparency, spatial and temporal solitons, solitons in Kerr media, photorefractive and quadratic solitons, Soliton pulses, optical vortices. Pulse compression.	12
5		Nonlinear guided wave optical devices: nonlinear planar waveguide, nonlinear channel waveguide, nonlinear directional coupler, nonlinear mode sorter, nonlinear Mach-Zehnder interferometer and logic gate, Nonlinear loop mirror.	8

Learning Resources

<i>Text Books</i>	<i>Reference Books</i>
1. Fundamentals of Nonlinear Optics; P. E. Powers, CRC Press Francis and Taylor (2011) 2. Principles of Nonlinear Optics; Y. R. Shen 3. Nonlinear Optics: Robert Boyd, Academic press	1. Physics of Nonlinear Optics: Guang- Sheng –He and So ng-Hao Lin; World Scientific. 2. Two Level Resonances in Atoms; Allen and J.H. Emberly, John Wiley.

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	H	L	H
CO2	H	H	H	H	M	H
CO3	H	H	H	M	L	M
CO4	H	M	H	H	L	M
CO5	M	H	H	H	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. K. Sinha

COURSE INFORMATION

Course code	PH24429
Course title	Instrumentation and Control
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. D. K. Singh

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	Course on <i>Instrumentation and control</i> intends to impart knowledge of measurement, data acquisition and control for experiments.
2	The first module of the course addresses basics of measurements like range, resolution, reproducibility, accuracy and precision.
3	Module-2 of the course introduces various types of sensors and their working to record changes in the different physical parameters.
4	The techniques of signal conditioning and noise reductions for acquired data are subject of Module- 3.
5	Last two units covers working and theory of different types of correction and regulating elements used in control systems.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Learners would develop understanding of various experimental parameters of measurements like range, resolution, reproducibility and precision.
CO2	Through this course, students would develop an insight into fundamentals of sensors/transducers, data acquisition and processing, noise minimization and control systems for automation.
CO3	This course is expected to enable students to design and understand hardware used for developing equipment for data acquisition, data conditioning and control.
CO4	Course would enable students to grasp understanding of instrumentation for automation of various physical process monitoring and control.

Syllabus

<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1	Measurement basics	Range, resolution, linearity, hysteresis, reproducibility and drift, calibration, accuracy and precision.	05
2	Sensors	Sensor Systems, characteristics, Instrument Selection, Measurement Issues and Criteria, Acceleration, Shock and Vibration Sensors, Interfacing and Designs, Capacitive and Inductive Displacement Sensors, Magnetic Field Sensors, Flow and Level Sensors, Load Sensors, Strain gauges, Humidity Sensors, Accelerometers, Photosensors, Thermal Infrared Detectors, Contact and Non-contact Position sensors, Motion Sensors, Piezoresistive and Piezoelectric Pressure Sensors, Sensors for Mechanical Shock, Temperature Sensors (contact and non-contact)	10
3	Signal conditioning	Types of signal conditioning, Amplification, Isolation, Filtering, Linearization, Classes of signal conditioning, Sensor Signal Conditioning, Conditioning Bridge Circuits, D/A and A/D converters for signal conditioning, Signal Conditioning for high impedance sensors Grounded and floating signal sources, single-ended and differential measurement, measuring grounded signal sources, ground loops, signal circuit isolation, measuring ungrounded signal sources, system isolation techniques, errors, noise and interference in measurements, types of noise, noise minimization techniques	15
4	Actuators	Correction and regulating elements used in control systems, pneumatic, hydraulic and electric correction elements.	04
5	Control System	Open loop and closed loop (feedback) systems and stability analysis of these systems, Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of linear time invariant (LTI) control systems and frequency response. Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots. Control system compensators: elements of lead and lag compensation, elements of	16

		Proportional- Integral-Derivative (PID) control. State variable representation and solution of state equation of LTI control systems.	
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<i>Learning Resources</i>	
<i>Text Books</i>	<i>Reference Books</i>
1. Electronic Instrumentation -H. S. Kalsi, Tata McGraw-Hill Education, 2010 2. Electronic Instrumentation -W. Bolton 3. Instrumentation: Electrical and Electronic Measurements and Instrumentation -A. K. Sawhney 4. Modern Electronic Instrumentation & Measurement Techniques -Helfrick & Cooper	

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	H	H	L	H	H
CO2	L	H	H	L	H	H
CO3	L	H	H	L	H	H
CO4	L	H	H	L	H	H
CO5	L	H	H	L	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. D. K. Singh

COURSE INFORMATION

Course code	PH24431
Course title	Microprocessor and Microcontroller Applications
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. D. K. Singh

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	The first module introduces architecture of 8085 and 8086 Microprocessor.
2	The module-2 is compilation of information about I/O communication Interface.
3	Microcontrollers (8051), its architecture and working is subject of module-3
4	The 4 th module contains Real time control sequences and programming of 8051-microcontroller.
5	The AVR RISC microcontroller architecture is covered in module-5.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	The course intends to impart knowledge of Microprocessors and microcontrollers to enable learners gain the knowledge of basics of Modern computation.
CO2	Knowledge of 8085/8086 architecture would make learners rich about working and design of microprocessors and microcontrollers.
CO3	The course also includes information about microcontrollers, real time control of 8051 and AVR RISC microcontroller architecture. This would enable learners to understand fundamentals of microcontrollers and implement it to design / use microcontroller for new environments.
CO4	Students will be trained to work in the IOT environment.
CO5	Learners will be capable of system level integration of devices

Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1	8086 Architecture	Introduction to 8085 Microprocessor, 8086 Architecture-Functional diagram. Register Organization, Memory Segmentation. Programming Mode. Memory addresses. Physical memory organization. Architecture of 8086, signal descriptions of 8086-common function signals. Minimum and Maximum mode signals. Timing diagrams. Interrupts of 8086. Instruction Set and Assembly Language Programming of 8086: Instruction formats, addressing modes, instruction set, assembler directives, macros, simple programs involving logical, branch and call instructions, sorting, evaluating arithmetic expressions, string manipulations.	15
2	I/O and Communication Interface	8255 PPI various modes of operation and interfacing to 8086. Interfacing keyboard, display, stepper motor interfacing, D/A and A/D converter. Memory interfacing to 8086, Interrupt structure of 8086, Vector interrupt table, Interrupt service routine, Introduction to DOS and BIOS interrupts, Interfacing Interrupt Controller 8259 DMA Controller 8257 to 8086. Communication interface: Serial communication standards, Serial data transfer schemes. 8251 USART architecture and interfacing, RS-232, IEEE-4-88, Prototyping and trouble shooting.	15
3	Introduction to Microcontrollers	Overview of 8051 microcontroller. Architecture. I/O Ports. Memory organization, addressing modes and instruction set of 8051, simple programs.	06
4	8051 Real Time Control	Interrupts, timer/ Counter and serial communication, programming Timer Interrupts, programming external hardware interrupts, programming the serial communication interrupts, programming 8051 timers and counters.	07
5	The AVR RISC microcontroller architecture:	Introduction, AVR Family architecture, Register File, The ALU. Memory access and Instruction execution. I/O memory. EEPROM. I/O ports. Timers. UART. Interrupt Structure.	07

<i>Learning Resources</i>	
<i>Text Books</i>	<i>Reference Books</i>
1 D. V. Hall. Microprocessors and Interfacing, TMGH. 2 nd edition 2006. 2 Kenneth. J. Ayala. The 8051 microcontroller, 3rd edition, Cengage learning, 2010	1 Advanced Microprocessors and Peripherals -A. K. Ray and K.M. Bhurchandani, TMH, 2nd edition 2006. 2 The 8051 Microcontrollers, Architecture and programming and Applications -K. Uma Rao, Andhe Pallavi, Pearson, 2009. 3 Microcomputer System 8086/8088 Family Architecture. Programming and Design -By Liu and GA Gibson, PHI, 2nd Ed., 4 Microcontrollers and application, Ajay. V. Deshmukh, TMGH. 2005

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	H	H	L	H	H
CO2	M	H	H	L	H	H
CO3	M	H	H	L	H	H
CO4	M	H	H	L	H	H
CO5	M	H	H	L	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. D. K. Singh

COURSE INFORMATION

Course code	PH24433
Course title	Physics of Solid-State Devices
Pre-requisite(s)	Solid State Physics, Elements of Modern Physics
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. D. K. Singh

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	identify semiconductor properties important for understanding and calculating device characteristics.
2	know the basic device building blocks that serves as the foundation of the physics of semiconductor devices.
3	learn the transistor family, its operation and distinction between the field-effect transistors and potential- effect transistors (bipolar junction transistors).
4	apply the theory of junctions and conduction processes to microwave and power devices.
5	learn the fabrication process, importance of thin film technology in realizing modern devices.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	understand the characteristics, operation, and limitations of semiconductor devices.
CO2	understand the operation of MOSFET - most-important device for advanced integrated circuits, and important component in microprocessors and memories.
CO3	understand different types of transistors, their operational principles, and applications.
CO4	understand existing devices, so that their studies of electronic circuits and systems will be meaningful.
CO5	develop the understanding with which they can later learn about any future development in devices and applications.

Syllabus

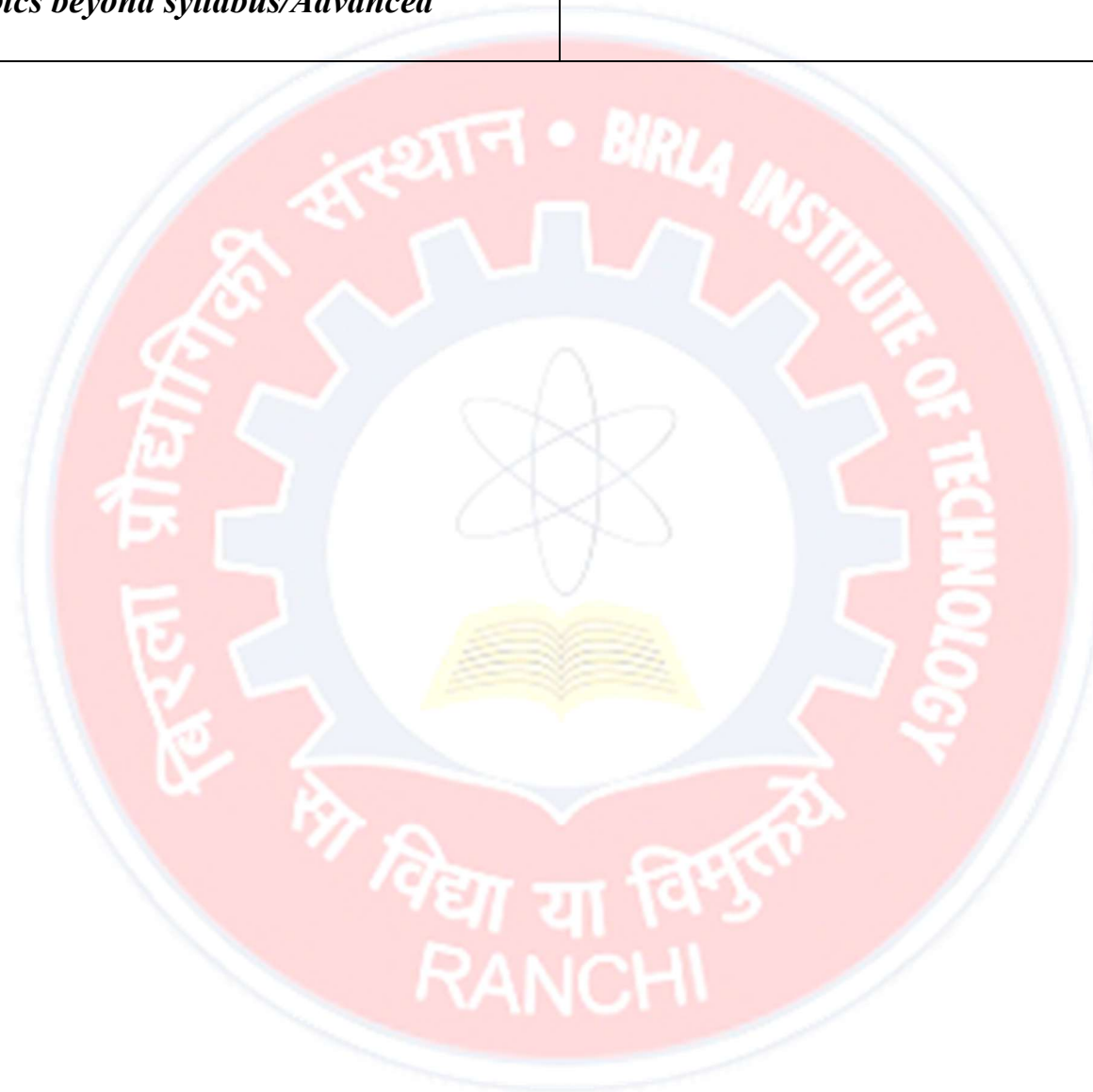
<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1		Crystal Properties and Growth of Semiconductors – semiconductor materials, crystal lattices, planes and directions, bulk crystal growth, epitaxial growth. Energy Bands and Charge Carriers in Semiconductors – bonding forces and energy bands in solids, charge carriers in semiconductors, effective mass, carrier concentration, Fermi level, space charge neutrality, drift of carriers in electric and magnetic fields. Excess Carriers in Semiconductors – optical absorption, luminescence, recombination, steady state carrier generation, quasi-Fermi level, diffusion of carriers, diffusion and drift of carriers, continuity equation.	11
2		Junctions– p-n Junction, Equilibrium Condition, Space-Charge at a Junction, Contact Potential, Qualitative Description of Current Flow, Forward and Reverse Biased Junction, Steady State Conditions, Reverse Bias Breakdown, Capacitance of a p-n Junction, Deviation from Simple Theory – Effect of Carrier Injection, Varactor Diode, Metal-Semiconduction Junction – Schottky Barriers, Ohmic Contacts, Heterojunctions.	08
3		Field Effect Transistors – Transistor Operation, Junction FET – Pinch-off and Saturation, Gate Control, Current-Voltage Characteristics, Metal-Semiconductor FET, Metal-Insulator- Semiconductor FET. Metal-Oxide-Semiconductor FET (MOSFET) – Basic Operation, Ideal MOS Capacitor, Effect of Real Surfaces, Threshold Voltage, Capacitance-Voltage Analysis, Current-Voltage Characteristics of MOS Gate Oxides, MOSFET Output and Transfer Characteristics, Mobility Models, Short Channel effect, Control of Threshold Voltage, Body Effect, Subthreshold Characteristics, MOSFET Scaling and Hot Electron Effects, Drain-Induced Barrier Lowering, Short Channel and Narrow Width Effects, Gate-Induced Drain Leakage, Advanced MOSFET	18

		Structures – Strained Si FETs, SOI MOSFETs and FinFETs. Bipolar Junction Transistor (BJT) – Fundamentals of BJT Operation, Amplification with BJT, Minority Carrier Distribution and Terminal Current, Biasing, Switching, Other Important Effects and Frequency Limitation.	
4		Fabrication of MOSFET – Materials, Bulk Crystal Growth, Doping, Epitaxy, Oxidation, Diffusion, Ion Implantation, Lithography – Optical and e-Beam, Etching processes. Integrated circuits– Introduction and Evolution, Monolithic Device Elements, Charge Transfer Devices, Memory Devices, Testing, Bonding and Packaging.	08
5		High-Frequency and High-Power Devices– Tunnel Diodes and Devices, IMPATT Diode, Transferred Electron Mechanism, Gunn Diode, Nanoelectronic Devices.	05

<i>Learning Resources</i>	
<i>Text Books</i>	<i>Reference Books</i>
1. Streetman, B.G. and Banerjee, S.K., Solid State Electronic Devices, 6th Edition, (PHI, 2005). 2. Sze, S.M. and Kwok, K.Ng., Physics of Semiconductor Devices, 3rd Edition, (Wiley-Interscience, 2006).	1. Neamen, D. A., Semiconductor Physics and Devices: Basic Principles, Third Edition, (McGraw-Hill, 2003). 2. Quinn, J. J. and Yi, K.-S., Solid State Physics: Principles and Modern Applications, 1st Edition (Springer, 2009). 3. Millman, J. and Halkias C. C., Integrated Electronics: Analog and Digital Circuits and Systems, 2nd Edition (Tata McGraw Hill, 2017).

<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	

<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	
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Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	L	H	H
CO2	H	H	H	L	H	H
CO3	H	H	H	L	H	H
CO4	H	H	H	L	H	H
CO5	H	H	H	L	H	H

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. D. K. Singh

COURSE INFORMATION

Course code	PH24435
Course title	Introduction to Plasma Physics
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. R. K. Paul, Dr. R. Kumar

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	learn the fundamental concepts of Plasma Physics.
2	learn about the charged particle motion in electric and magnetic field.
3	gain knowledge about the ionization process and diffusion.
4	learn about the basic Plasma Diagnostic Methods.
5	learn how to use plasma for various application.

Course Outcomes (COs) <i>Upon successful completion of the course, students will</i>	
CO	Course Outcomes
CO1	have an idea about the basics of Plasma (Fourth State of Matter).
CO2	be able to visualize the motion of charged particles in electric and magnetic field.
CO3	have knowledge about the ionization and diffusion of Plasma.
CO4	be able to measure the different plasma parameters.
CO5	be familiar with different applications of Plasma.

Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1		The fourth state of matter, collective behavior, charge neutrality, space and time scale, concept of plasma temperature, Classification of Plasma, Debye shielding, Debye length, plasma frequency, plasma parameters and criteria for plasma state.	10
2		Single particle dynamics, charged particle motion in electric field, magnetic field and in combined electric and magnetic field, Basics of $E \times B$ drift, Drift of guiding centre, gradient drift, curvature drift and magnetic mirror.	10
3		Ionization by collision, Townsends theory of collision ionization, The breakdown potential, Thermal ionization and excitation, concepts of diffusion, mobility and electrical conductivity, Ambipolar diffusion.	10
4		Basic plasma diagnostics, Single probe method, Double probe method, Optical emission spectroscopy (basic idea), Abel inversion.	10
5		Controlled Thermonuclear fusion, Tokamak, Laser Fusion, MHD Generator, Industrial applications of plasma.	10

Learning Resources

Text Books	Reference Books
	1. Introduction to Plasma Physics and Controlled Fusion, Francis, F. Chen, Plenum Press, 1984. 2. Fundamental of Plasma Physics, J, A. Bittencourt, Springer-Verlag New York Inc., 2004. 3. The Fourth State of Matter- Introduction to Plasma Science, S. Eliezer

	and Y. Eliezer, IoP Publishing Ltd., 2001. 4. Elementary Plasma Physics, L. A. Arzimovich, Blaisdell Publishing Company, 1965. 5. Plasmas- The Fourth State of Matter, D. A. Frank- Kamenetskii, Macmillan Press, 1972.
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	L	H	H	NO	M	M
CO2	H	M	M	NO	L	M
CO3	L	H	H	NO	H	M
CO4	L	H	H	NO	M	M
CO5	L	M	H	L	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. R. Kumar

COURSE INFORMATION

Course code	PH24437
Course title	Theory of Plasmas
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. P. K. Tiwari, Dr. R. Kumar

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	learn about the similarity of plasma with fluid.
2	learn about the diffusion and mobility of plasma.
3	learn about the resistivity and single fluid MHD equation of plasma.
4	learn about the Boltzmann and the Vlasov equation.
5	learn about the different type of discharges.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Be familiar about the method by which plasma can be treated as a fluid.
CO2	Be familiar with the diffusion and mobility process.
CO3	Be able to derive the set of single fluid MHD equation.
CO4	Be able to describe plasma with Boltzmann and Vlasov equation.
CO5	Be familiar with the different type of electrical discharges.

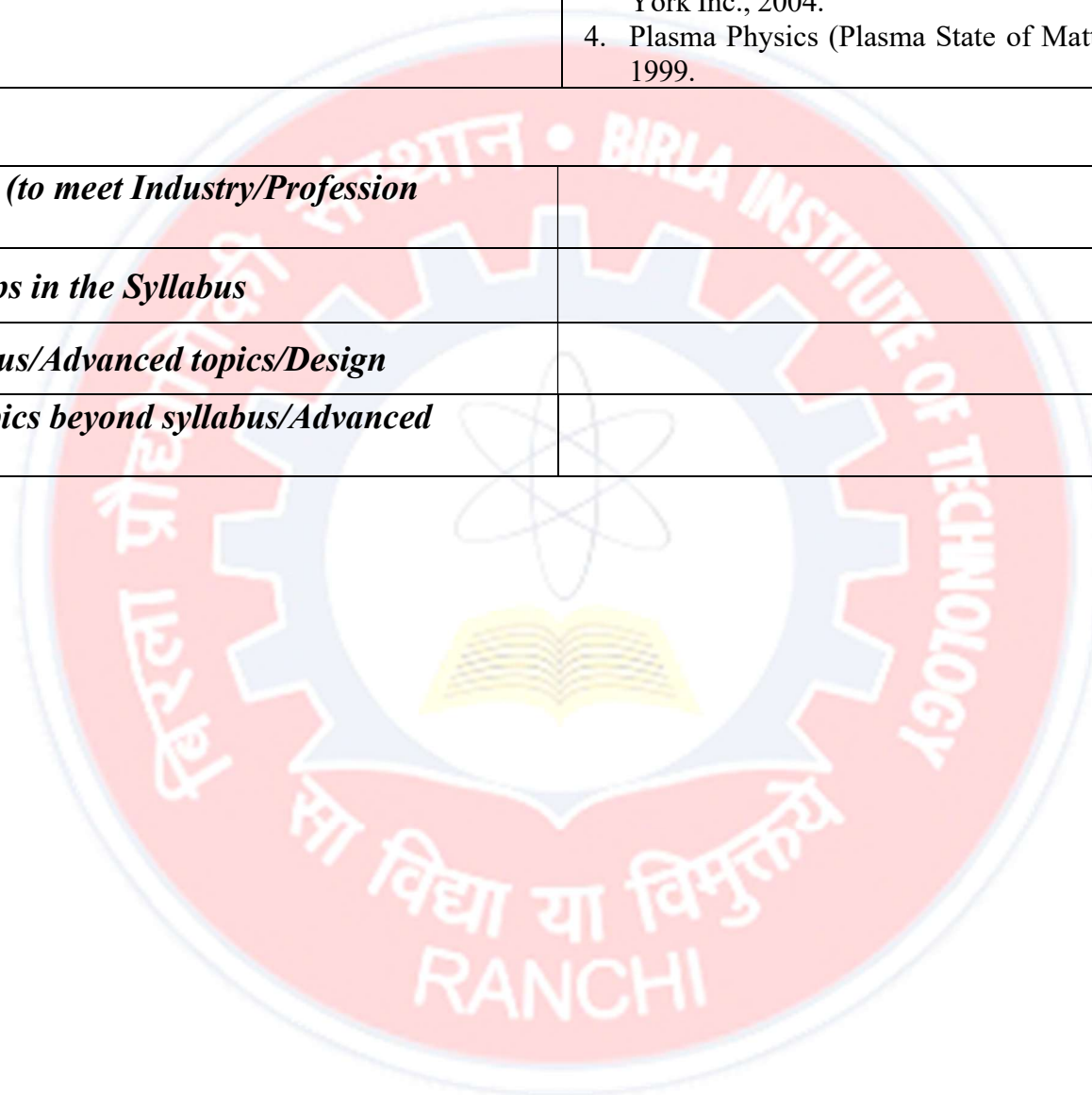
Syllabus

<i>Module No.</i>	<i>Module name</i>	<i>Detailed Contents</i>	<i>No. of Lecture</i>
1		Relation of plasma physics to ordinary electromagnetic field, Fluid equation of motion, Fluid drifts perpendicular to B, Fluids drifts parallel to B, Plasma approximation.	10
2		Diffusion and mobility in weakly ionized gases, Decay of a plasma by diffusion, steady state solution, Recombination, diffusion across a magnetic field, collision in fully ionized plasma.	10
3		Mechanics of coulomb collisions, Physical meaning of resistivity, Numerical value of resistivity, Single fluid MHD equations, Diffusion in fully ionized plasma, Bohm diffusion and Neoclassical diffusion.	10
4		Concepts of elementary kinetic theory of plasmas, The meaning of distribution function, Boltzmann and Vlasov equation.	10
5		Electrical discharges, Electrical breakdown in gases, glow discharge, Self-sustained discharges, Paschen curve, High frequency electrical discharge in gases, electrode less discharge, capacitively and inductively coupled plasmas, ECR Plasmas, Electrical arcs.	10

<i>Learning Resources</i>	
<i>Text Books</i>	<i>Reference Books</i>
	1. Gas Discharge Physics, Y. P. Raizer, Springer, 1997. 2. Introduction to Plasma Physics and Controlled Fusion, Francis, F. Chen, Plenum Press, 1984. 3. Fundamental of Plasma Physics, J. A. Bittencourt, Springer-Verlag New

	York Inc., 2004. 4. Plasma Physics (Plasma State of Matter) S. N. Sen, Pragati Prakashan, 1999.
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	



Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	M	M	NO	L	L
CO2	H	M	H	NO	L	L
CO3	H	H	H	NO	M	L
CO4	H	H	H	NO	M	L
CO5	M	M	M	NO	M	L

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
CD2	Assignments/Seminars
CD3	Laboratory experiments/teaching aids
CD4	Industrial/guest lectures
CD5	Industrial visits/in-plant training
CD6	Self- learning (SL) such as use of NPTEL material and internet
CD7	Simulation

<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
CO2	CD1, CD2, CD6
CO3	CD1, CD2, CD6
CO4	CD1, CD2, CD6
CO5	CD1, CD2, CD6

<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. P. K. Tiwari, Dr. R. Kumar

COURSE INFORMATION

Course code	PH24439
Course title	Introduction of Biophysics and Biomaterials
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. P. K. Tiwari, Dr. S. K. Sinha

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	Understanding basic Laws associated with Biophysics and Biomaterials.
2	Understand life's molecules, cellular processes, energy, interactions, and applications.
3	Understand molecular motors, nanoscale interactions, and biological nanotechnology applications.
4	Analyze biomaterial structure, properties, and interactions for diagnostics and design.
5	Design durable, bio-compatible biomaterials for implants, prosthetics, and engineering

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Optimize biomaterial design, performance, interactions, and biological system integration.
CO2	Design biomaterials that mimic, interact, and integrate with biological systems.
CO3	Enhance nanoscale biomaterial functionality, precision, energy efficiency, and molecular control.
CO4	Understand the basic principle of different techniques used to characterize the materials properties and correlate with structure.
CO5	Biomaterial characterization, imaging, and design for medical applications.

Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1	Laws of Physics and Chemistry	Laws of Physics and Chemistry, free energy, internal energy, Thermodynamics and statistical mechanics, reaction kinetics, radiation energy, Biomechanics, fluid flow, gas transport, Physics of audition and vision, Structure of solids, chemical bonding and forces, diffusion, viscosity, thermal conduction.	12
2	Introduction to Cellular-Molecular Biophysics	Prokaryotes, Eukaryotes, Nucleus, Endoplasmic Reticulum, Ribosomes, Mitochondria, Molecular components of cell, Carbohydrates, Lipids, Proteins, Nucleic acids, Heter macromolecules, Physics of Biomolecules, Bio membrane, Thermodynamics of Biosystems, Bioenergetics, Neurobiophysics.	12
3	Physics of Nano-biomachines	Particle Size, Surface Area, and Volume, Molecular machines: Linear, translatory motors, Rotary motors, thermodynamics of molecular machines, STM, AFM.	10
4	Introduction of Techniques and methods	Microscope, FESEM, FTIR, Raman Spectroscopy, UV-Visible Spectroscopy, Zeta-Potential, Optical Tweezers, CT, MRI.	8
5	Characterization of materials	Stress-strain, mechanical failure, viscoelasticity, strengthening by heat treatment, Surface properties and adhesion.	8

Learning Resources	
Text Books	Reference Books
	1. Elementary Biophysics, P. K. Srivastava, Narosa Publishing House Pvt. Ltd, Second Ed. 2015 2. Nanotechnology: Basic Calculations for Engineers and Scientists, by Louis Theodore, John Wiley & Sons, Inc., 2006

	3. Biophysics by Vasantha Pattabhi, and N. Gautham, Narosa Publishing House Pvt. Ltd, 2009. 4. Biophysics: An Introduction, by Rodney M. J. Cotterill, John Wiley & Sons, Ltd., 2004. 5. Biomaterials: An Introduction by J B. Parks and Roderic S. Lakes, Springer-Verlag New, 2007. 6. Y. Leng, “Materials Characterization: Introduction to Microscopic and Spectroscopic Methods”, Second Edition, Wiley-VCH, 2013.
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<i>Gaps in the Syllabus (to meet Industry/Profession requirements)</i>	
<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
<i>Pos met through Topics beyond syllabus/Advanced topics/Design</i>	

Course Outcome (CO) Attainment Assessment Tools and Evaluation Procedure

<i>Direct Assessment</i>	<i>Assessment Tool</i>		<i>% Contribution during CO Assessment</i>				
	Continuous Internal Assessment		50%				
	Semester End Examination		50%				
	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
	3 Quizzes of 10 marks each.		30%				
	Seminar		10%				
	Assignment(s)		10%				
	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	H	H	H	NO	H	M
CO2	H	H	H	NO	H	M
CO3	H	H	H	NO	H	M
CO4	H	M	H	NO	H	L
CO5	H	H	H	NO	H	M

<i>Course Delivery Methods</i>	
CD1	Lecture by use of boards/LCD projectors/OHP projectors
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<i>Mapping Between Course Outcomes and Course Delivery Method</i>	
Course Outcomes	Course Delivery Method
CO1	CD1, CD2, CD6
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<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
		Dr. P. K. Tiwari, Dr. S. K. Sinha

COURSE INFORMATION

Course code	PH24441
Course title	Quantitative Biology
Pre-requisite(s)	
Co-requisite	
Credits	C: 4 L: 4 T: 0 P: 0 SL:
Class schedule per week	4
Class	1-Year M.Sc. (Physics)
Semester / Level	I / IV
Branch	Physics
Name of Teacher	Dr. P. K. Tiwari, Dr. S. K. Sinha

Course Objectives <i>This course aims to enables the students to:</i>	
Sl No.	Objectives
1	Understand the basics of scientific terminologies.
2	Comprehend cell organelles and functions.
3	Explore the plasma membrane characteristics.
4	Understand cells functionalities through transport of ions.
5	Investigate the genesis of cancer.

Course Outcomes (COs) <i>Upon successful completion of the course, students will be able to</i>	
CO	Course Outcomes
CO1	Read, write and understand medical terms.
CO2	Apply organelles functions in homeostasis.
CO3	Analyze molecules transportation for drug delivery across membranes.
CO4	Create signalling techniques via devising sensing mechanisms.
CO5	Evaluate cancer genesis and its treatment methodologies.

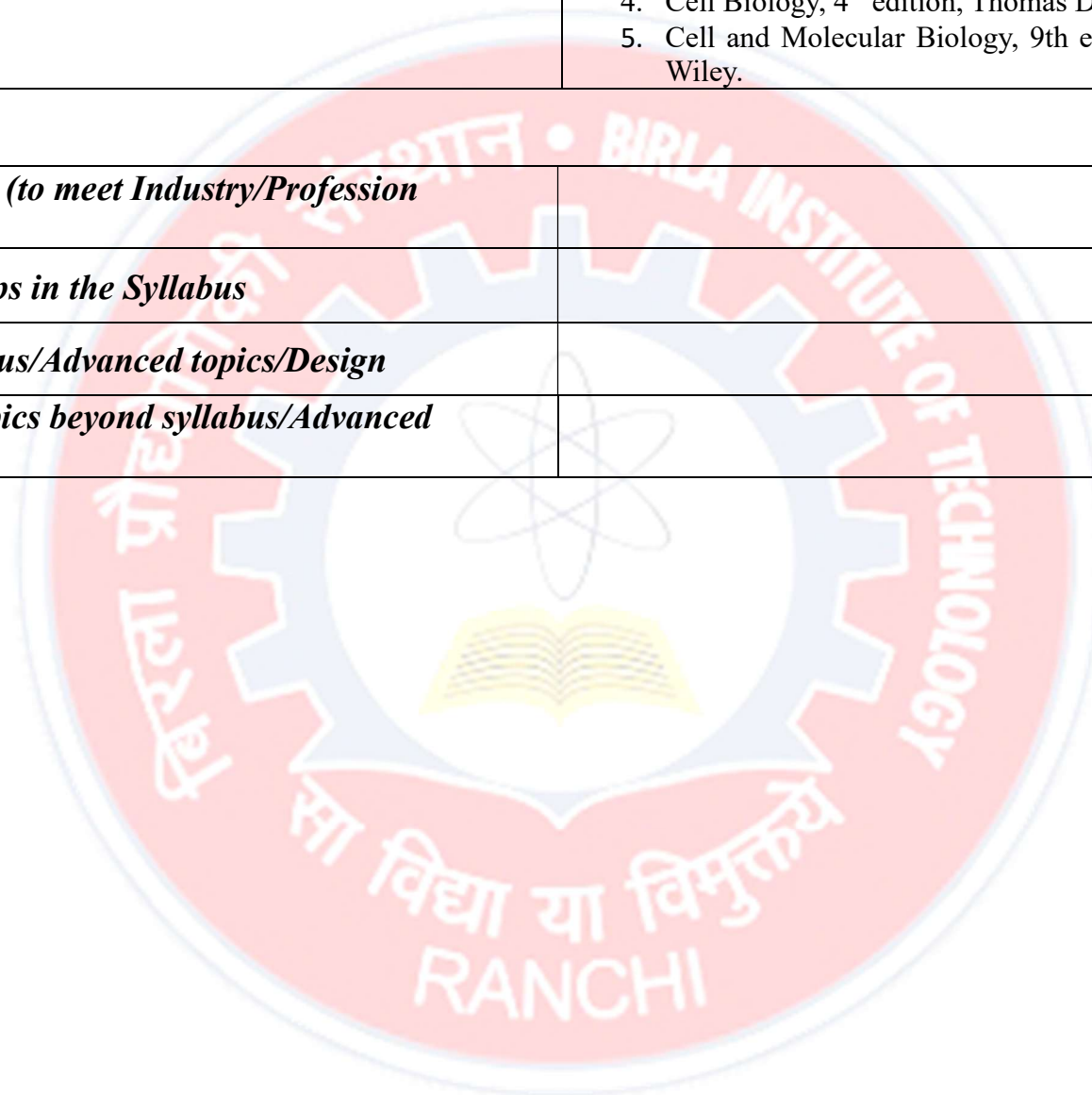
Syllabus

Module No.	Module name	Detailed Contents	No. of Lecture
1	Scientific Terminology	Origin of scientific terms in biology and Medicine, Suffix, Prefix and Root Words, Plural Rules, Usage of Greek and Latin terms in the Healthcare Domain.	8
2	Cell Introduction	Cells and Genomes, Cell Chemistry and Bioenergetics, Proteins, DNA and Chromosomes.	8
3	Cell Membrane Characteristics	The Lipid Bilayer, Membrane Proteins, Principles of Membrane Transport, Transporters and Active Membrane Transport, Channels and the Electrical Properties of Membranes.	10
4	Cell Compartmentalization and Signalling Mechanism	Cell Compartments, The Transport of Molecules between the Nucleus and the Cytosol, Intracellular Membrane Traffic, Principles of Cell signalling, Signalling in Plants.	12
5	Cell Cycle, Oncology and Therapeutics	Overview of Cell Cycle, Cell-cycle Control System, Mitosis, Cytokinesis, Meiosis, Cell Death, Cancer-genesis and Prevention, Stem cells and Tissue Renewal, Therapeutics: Electrotherapy and Hyperthermia treatment.	12

Learning Resources	
Text Books	Reference Books
	1. Medical Terminology: A Short course, 8th edition (2017), Davi-Ellan Chabner, Elsevier. 2. Molecular Biology of the Cell, 6th edition (2008), Bruce Alberts, et al., Taylor and Francis Group. 3. The Cell: A Molecular Approach, 6th edition (2013), Geoffrey M. Cooper and Robert E. Hausman, Sinauer Associates Inc.

	4. Cell Biology, 4 th edition, Thomas D. Pollard et al. (2022), Elsevier. 5. Cell and Molecular Biology, 9th edition, Gerald Karp et al. (2019), Wiley.
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<i>Pos met through Gaps in the Syllabus</i>	
<i>Topics beyond syllabus/Advanced topics/Design</i>	
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	<i>Continuous Internal Assessment</i>		<i>% Distribution</i>				
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	Seminar		10%				
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	<i>Assessment Components</i>		<i>CO1</i>	<i>CO2</i>	<i>CO3</i>	<i>CO4</i>	<i>CO5</i>
	Continuous Internal Assessment		✓	✓	✓	✓	
	Semester End Examination		✓	✓	✓	✓	✓

<i>Indirect Assessment</i>	

<i>Mapping Between Course Outcomes and Program Outcomes</i>						
CO	PO1	PO2	PO3	PO4	PO5	PO6
CO1	M	M	M	NO	H	M
CO2	H	H	H	NO	H	M
CO3	H	H	H	NO	H	M
CO4	H	H	H	NO	H	M
CO5	H	H	H	L	H	M

<i>Course Delivery Methods</i>	
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<i>Course Designers</i>		
<i>Experts from Industry</i>	<i>Experts from Higher Technical Institutions</i>	<i>Internal Experts</i>
	PE1 END	Dr. P. K. Tiwari, Dr. S. K. Sinha

