## 1.1.3 & 1.2.1

## Supporting Documents- Department of Physical Sciences

Syllabus of Courses Highlighting the Focus on Employability/ Entrepreneurship/ Skill Development



## IK Gujral Punjab Technical University, Kapurthala Department of Physical Sciences

Ref No.: IKGPTU/PS/981

Date: 1204018

Annexue 1.1.2 51.2.2 8 (1°)

Subject: Proceedings of the Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) meeting held on 27.03.2018.

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 27.03.2018 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala. The agenda of the meeting was discussed in detail and recommendations were made on point. The proceedings of the meetings were recorded in the minutes of the meeting as enclosed as an Annexure-A.

In the meeting, the syllabus of the Engineering Physics for B. Tech. 1<sup>st</sup> Year and M.Sc.(Physics) was approved for adoption from 2018-19 which is enclosed as an Annexure-B and Annexure-C.

Submitted for necessary action.

Convener- BoS Dr. Hitesh Sharma

Chairman, Board of Studies Head, Physical Sciences.

Convene Dr. Neetika

## I.K. Gujral Punjab Technical University, Kapurthala Department of Physical Sciences

#### **Minutes of Meeting**

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 27.03.2018 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala.

The following were present in the meeting:

- 1. Dr. Amit Sarin (Chairperson)
- 2. Dr. Ravi Kumar, Member
- 3. Dr Rakesh Dogra, Member
- 4. Dr. Arvind Kumar, Member
- 5. Dr. Ranjan Kumar, Member
- 6. Dr. Kanchan L. Singh, Member
- 7. Dr. Hitesh Sharma, Member
- 8. Dr. Maninder Kaur, Member
- 9. Dr. Y S Brar, Chairperson(EE) as Special invitee
- 10. Dr. Rajiv Chauhan, Chairperson (Civil Eng) as Special invitee
- 11. Dr. Vikas Chawla, Chairperson(ME) as Special invitee

12. Dr. A S Bhuttar, Chairperson(ECE) as Special invitee

- 13. Dr. Varinderjit Singh (Special invitee)
- 14. Dr. Neetika (Special invitee)
- 15. Ms.Jaskaranpreet M.Sc.(2nd Year)-Student representative

16. Mr.Nikhil M.Sc.(1st Year)-Student representative

The following members could not attend the meeting:

- 1. Dr. Davinder Mehta, Member
- 2. Dr. R. K. Bedi, Member
- 3. Dr. Harpreet Kaur Grewal, Member
- 4. Dr. B D Gupta, Member
- 5. Dr. Rajiv Malhotra, Member
- 6. Dr. P. Arumugam, Member
- 7. S. Navdeepak Sandhu, Member
- 8. Dr. Harkirat Singh, (Special invitee)
- 9. Dr. Monika Sachdeva, (Special invitee)

The Board of Studies discussed on all the agenda points and following recommendations were made:

Agenda item 1: To consider the revision of Engineering Physics course in B.Tech-1<sup>st</sup> Year (for all Engineering Branches ) as per model syllabus of AICTE:

All BoS members discussed in detail the new model syllabi proposed for Engineering Physics by AICTE for adoption. All members agreed with the recommendations of AICTE which has proposed to offer branch specific Engineering Physics subjects to B.Tech-1<sup>st</sup> Year Students and decided to implement same in IKG Punjab Technical University. The Engineering branches for which AICTE has not proposed any theory and Lab subject, the new course subjects prepared by combining the different modules proposed by the AICTE, were approved. All engineering specializations which are being offered at present by the IKG Punjab Technical University have been categorized in seven (07) groups. Accordingly, seven (07) theory and seven (07) practical papers as mentioned below were recommended for adoption in IKGPTU from 2018-19.

S.No.	Groups	Related Branches	Course codes	Course title	Credits
1	1 Civil Engineering 1. Civil Engineering	1. Civil Engineering	BTPH101	Mechanics of solids	4
		2. Construction Engineering &	BTPH111	Mechanics of solids	1.5

Head Department of Physical Sciences LK. Gujral Punjab Technical Wiversity Main Campus

-		Management		Lab	
	2 Electrical Engineering	1. Electrical Engineering	BTPHIC	2 Optics and Modern Physics	-
		2. Automation & Robotics	BTPHII		+ 1.
		3. Electrical & Electronics		Physics Lab	
		Engineering			
		4. Electronics & Electrical Engineering			
		5. Electrical Engineering & Indust Control	Tial		
		6. Instrumentation & Control Engineering			
1.1	Mechanical	1. Mechanical Engineering	BTPH103	Electromagnetism	4
	Engineering	2. Marine Engineering	BTPH113	Durante	
		3. Production Engineering		-	
		4. Industrial Engineering	-		
		5.Tool Engineering		- 10 State 1 1 1 1 1 1	
			- Contract		
	19-2018-3	6. Automobile Engineering			
		7. Aerospace Engineering			
		8. Aeronautical Engineering			
	B.Tech (Mechanical Engineering)-2nd Year	1. Mechanical Engineering	BTPH201	Optics and Waves	4
4	Computer Science Engineering		BTPH104	Semi-Conductor Physics	4
		2.Computer Science Engineering	BTPH114	Semi-Conductor	1.5
	1	3.Information technology	+	Physics Lab	
_		4.3D Animation Engineering	-		
5	Electronics and communication Engineering	1. Electronics & Communication Engineering	BTPH105	Introduction to Semiconductor Physics	4
		2. Electronics & Computer Engineering	BTPH115	Semi-Conductor Physics Lab	1.5
		3. Electronics & Instrumentation Engineering			
		4. Electronics & Telecomm			
		Engineering	-		
		5. Electronics Engineering			
Constanting of	Coemical Sciences	1. Chemical Engineering	BTPH106	Optics and Electromagnetism	4
and the second se		2. Petrochem & Petroleum Refinery Engineering	BTPH116	Optics and Electromagnetism Lab	1.5
		3. Textile Engineering			
State of the second second		4. Food Technology			
-	Bio Technology	1. Bio-Technology	BTPH107	Introduction to	4
	Bio Technology 1. Bio-Technology		STERIO/	Introduction to Physics:	
Concession of the local division of the loca				Biotechnology	

BOS members also approved one course on Optics and Waves for B.Tech-Mechanical Engineering (2<sup>nd</sup> Year) as recommended by AICTE. The copy of approved syllabus for different branches is attached as Annexure A.

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Agenda item 2: To consider the revision of Course outcomes of M.Sc. (Physics) as per NAAC requirements

All BoS members discussed the educational objectives of the M.Sc.(Physics) course and with vision of the Department of Physical Sciences. After incorporating suggestions, BOS members approved the Vision, Mission, Program Educational objectives (PEO), Program outcome (PO), Program specific outcomes and Course outcomes(CO) of course subjects for M.Sc. (Physics) w.e.f. 2018-19. The copy of the revised scheme and syllabus with PO and COs is enclosed as Annexure B.

Agenda item 3: To consider the Revision in Course Scheme and Syllabus of M. Tech. (Nanotechnology)

The scheme and syllabus for M. Tech. (Nanotechnology) could not discussed in the meeting and shall be considered in the next BOS meeting.

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Dr. Amit Sarin Chairperson- BoS, Physical Sciences

Dean Academics

Head Department of Physical Sciences I.K. Gujral Punjab Technical Universi Main Campus

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# **M.Sc.** Physics

# Course Structure and Syllabus (Based on Choice Based Credit System) 2018 onwards



Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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#### ZZZ

## IK Gujral Punjab Technical University

#### VISION

To be an institution of excellence in the domain of higher technical education that serves as the fountainhead for nurturing the future leaders of technology and techno- innovation responsible for the techno-economic, social, cultural and environmental prosperity of the people of the State of Punjab, the Nation and the World

#### MISSION

- To provide seamless education through the pioneering use of technology, in partnership with industry and society with a view to promote research, discovery and entrepreneurship and
- To prepare its students to be responsible citizens of the world and the leaders of technology and techno-innovation of the 21st Century by developing in them the desirable knowledge, skill and attitudes base for the world of work and by instilling in them a culture for seamlessness in all facets of life.

#### **OBJECTIVES**

- To offer globally-relevant, industry-linked, research-focused, technologyenabled seamless education at the graduate, postgraduate and research levels in various areas of engineering & technology and applied sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global technological needs, is motivated to give its best and is committed to the growth of the Nation;
- To foster the creation of new and relevant technologies and to transfer them to industry for effective utilization;
- To participate in the planning and solving of engineering and managerial problems of relevance to global industry and to society at large by conducting basic and applied research in the areas of technologies;
- To develop and conduct continuing education programmes for practicing engineers and managers with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core competence of the University;,

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- To develop strong collaborative and cooperative links with private and public sector industries and government user departments through various avenues such as undertaking of consultancy projects, conducting of collaborative applied research projects, manpower development programmes in cutting-edge areas of technology, etc;
- To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;
- To provide leadership in laboratory planning and in the development of instructional resource material in the conventional as well as in the audio- visual, the video and computer-based modes;
- To develop programmes for faculty growth and development both for its own faculty as well as for the faculty of other engineering and technology institutions;
- To anticipate the global technological needs and to plan and prepare to cater to them;
- To interact and participate with the community/society at large with a view to inculcate in them a feel for scientific and technological thought and endeavour; and
- To actively participate in the technological development of the State of Punjab through the undertaking of community development programmes including training and education programmes catering to the needs of the unorganized sector as well as that of the economically and socially weaker sections of society.

## ACADEMIC PHILOSOPHY

The philosophy of the education to be imparted at the University is to awaken the "deepest potential" of its students as holistic human beings by nurturing qualities of selfconfidence, courage, integrity, maturity, versatility of mind as well as a capacity to face the challenges of tomorrow so as to enable them to serve humanity and its highest values in the best possible way.

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## DEPARTMENT OF PHYSICAL SCIENCES

#### VISION

To be a knowledge nerve centre in Physical Sciences, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life

#### MISSION

- 1. To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Physical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
- 2. To develop and conduct continuing education programmes for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
- 3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit.

Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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## M.Sc. (Physics) Program

#### Duration: 2 Years (Semester System)

This M.Sc. (Physics) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on one-year research project as an integral part of their M.Sc. programme. The programme also provide adequate exposure to the students for pursuing higher education in the field of technology (M. Tech.), Physics (M.Phil./Ph.D.) and other job opportunities in academia and industry.

#### **Eligibility:**

Pass B.Sc. with 50% marks having Physics as one of the subject. A relaxation of 5% is given in case of candidates belonging to SC/ST category.

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**PROGRAM EDUCATIONAL OBJECTIVES:** The Program Educational Objectives are the knowledge skills and attitudes which the students have at the time of post-graduation. At the end of the program, the student will be able to:

PEO1	Apply the scientific knowledge of Physics, Mathematics, Chemistry, and Physics specialization for deeper understanding of the nature.
PEO2	Identify, formulate, research literature, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PEO3	Design solutions for advanced scientific problems and design system components or processes.
PEO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PEO5	Create, select, and apply appropriate techniques, resources, and modern scientific and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PEO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.
PEO7	Communicate effectively on complex Scientific activities with the Scientific/engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PEO8	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

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PROGRAM OUTCOMES: At the end of the program, the student will be able to:

PO1	Apply principles of basic science concepts in understanding, analysis and prediction of physical systems.
PO2	To introduce interdisciplinary subjects/concepts/ideas for interdisciplinary
PO3	application of Physics concepts. To introduce advanced ideas and techniques required in emergent area of Physics.
Des.	
PO4	To develop human resource with specialization in theoretical and experimental techniques required for career in academia and industry.
PO5	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

Understand and apply principles of physics for understanding the scientific
phenomenon in classical domain.
Understand and apply mathematical techniques for describing and deeper understanding of physical systems.
Understand and apply statistical methods for describing the classical and quantum particles in various physical systems and processes.
Understand and apply inter-disciplinary concepts and computational skills for
understanding and describing the natural phenomenon.
Understand and apply principles of Quantum mechanics for understanding the
physical systems in quantum realm.
Provide exposure in various specialization of Physics (Solid State Physics/Nuclear
Physics/Particle Physics).
Provide exposure to advanced experimental/theoretical methods for measurement,
observation, and fundamental understanding of physical phenomenon/systems.
Engage in research and life-long learning to adapt to changing environment.

### SEMESTER FIRST

Course Code Course	1 itle	10110-0	Load Marks			Total	Credit	
		All	ocat	ion	Distri	bution	Marks	S
		L	T	P	Internal	External		

	TOTAL	15	5	12	250	400	650	26
MSPH417-18	Computational Physics Lab-I	-	-	6	50	25	75	3
MSPH416-18	Electronics Lab	-	-	6	50	25	75	3
MSPH415-18	Computational Physics	3	1		30	70	100	4
MSPH414-18	Electronics	3	1	-	30	70	100	4
MSPH413-18	Quantum Mechanics-I	3	1		30	70	100	4
MSPH412-18	Classical Mechanics	3	1	-	30	70	100	4
MSPH411-18	Mathematical Physics-I	3	1	-	30	70	100	4

SEMESTER SECOND

Course Code	Course Title		Load		and the second se	rks bution	Total Marks	Credits
		L	T	P	Internal	External		0
MSPH421-18	Mathematical Physics-II	3	1	-	30	70	100	4
MSPH422-18	Statistical Mechanics	3	1	-	30	70	100	4
MSPH423-18	Quantum Mechanics-II	3	1	-	30	70	100	4
MSPH424-18	Classical Electrodynamics	3	1	-	30	70	100	4
MSPH425-18	Atomic and Molecular Physics	3	1	-	30	70	100	4
MSPH426-18	Atomic, Nuclear, and Particle Physics Lab	-	-	6	50	25	75	3
MSPH427-18	Computational Physics Lab-II	-	-	6	50	25	75	3
	TOTAL	15	5	12	250	400	650	26

L: Lectures T: Tutorial P: Practical

#### SEMESTER THIRD

Course Code	Course Title		Load locat		Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External	2.53	
MSPH531-18	Condensed Matter Physics	3	1	-	30	70	100	4
MSPH532-18	Nuclear Physics	3	1	-	30	70/	100	4

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	<i>I</i>	K.	Gujral	Punjab	Technical	University,	Kapurthala
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MSPH533-18	Particle Physics	3	1	-	30	70	100	4
MSPH534-18 MSPH535-18 MSPH536-18	Elective Subject-I	3	1	-	. 30	70	100	4
MSPH537-18 MSPH538-18 MSPH539-18	Elective Subject-II	3	1	-	30	70	100	4
MSPH540-18	Condensed Matter Physics Lab	-	-	6	50	25	75	3
	TOTAL	15	5	6	200	375	575	23

### SEMESTER FOURTH

Course Code	Course Title		LoadMarksAllocationDistribution		Total Marks	Credits		
	anto en la Re	L	Т	P	Internal	External		
MSPH541-18 MSPH542-18 MSPH543-18	Elective Subject-III	3	1	-	30	70	100	4
MSPH544-18 MSPH545-18	Elective Subject-IV	3	1	-2.	30	70	100	4
MSPH546-18	M.Sc. Research Project		12		Satisfact	ory/Unsati	sfactory	12
	TOTAL	6	14	67	60	140	200	20

## TOTAL NUMBER OF CREDITS = 95

## LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

## Elective Subject-I

5. No.	Name of the Subject			Code
1	Fibre optics and non-linear optics	I ST		MSPH534-18
2	Plasma Physics			MSPH535-18
3	Nonlinear Dynamics		The last	MSPH536-18

## **Elective Subject -II**

1	Radiation Physics	MSPH537-18
2	Structures, Spectra and Properties of Biomolecules	MSPH538-18
3	Science of Renewable source of Energy	MSPH539-18

#### **Elective-III**

S.No.	Name of the Subject	Code
1	Physics of Nanomaterials	MSPH541-18
2	Experimental techniques in Nuclear and Particle Physics	MSPH542-18
3	Superconductivity and Low Temperature Physics	MSPH543-18

#### **Elective-IV**

1	Advanced Condensed Matter Physics	MSPH544-18
2	Advanced Particle Physics	MSPH545-18

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Theory			
S. No.	Evaluation criteria	Weightage in Marks	Remarks
1.	Mid term/sessional Tests	20	Internal evaluation (30 Marks)
2	Attendance	5	MSTs, Quizzes, assignments, attendance, etc. constitute internal
3	Assignments	5	evaluation. Best of two mid semester test will be considered for evaluation
4	End semester examination	70	External evaluation (70 Marks) Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous institutions. For other colleges examination will be conducted at the university level.
5	Total	100	Marks may be rounded off to nearest integer.
ractica	ıl		11 11
1	Daily evaluation of practical record/Viva Voice	30	Internal evaluation (50 Marks)
2	Attendance	5	
3	Seminar/Presentation	15	si.
	Final Practical Performance + Viva Voice	25	External evaluation (25 Marks)
5	Total	75	Marks may be rounded off to nearest integer.

## **Examination and Evaluation**

MSPH411-18

MATHEMATICAL PHYSICS-I

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L-3, T-1, P-0 Head Penetino Penetino Head Penetino Penetino

#### **Pre-requisite:** None

**Course Objectives:** The objective of the course on **Mathematical Physics-I** is to equip the M.Sc. students with the mathematical techniques that he/she needs for understanding theoretical treatment in different courses taught in this class and for developing a strong background if he/she chooses to pursue research in physics as a career.

ourse O	atcomes: At the end of the course, the student will be able to
CO1	Understand the use of complex variables for solving definite integral.
CO2	Understand and use the Delta and Gamma functions for describing physical systems
CO3	Solve partial differential equations using boundary value problems.
CO4	Understand special functions to solve the physics problems.
CO5	Use statistical methods to analysis the experimental data.

#### Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	2
CO3	3	3	3	3	3	3	3	2
CO4	3	3	3	3	2	3	3	2
CO5	3	3	3	3	2	2	2	1

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#### **Detailed Syllabus:**

- 1. **Complex Variables**: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation. *(Lectures 10)*
- Delta and Gamma Functions: Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function. (Lectures 7)
- Differential Equations: Partial differential equations of theoretical physics, boundary value, problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution. (Lectures 8)
- 4. Special Functions: Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynomials, Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.

(Lectures 10)

5. Elementary Statistics: Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution. (Lectures 5)

#### Text Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2012.

#### **Reference Books:**

- 1. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
- 2. Mathematical Physics: A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi), 1986.
- 3. Mathematical Methods in the Physical Sciences M.L. Boas (Wiley, New York) 3rd edition, 2007.
- 4. Special Functions: E.D. Rainville (MacMillan, New York), 1960.
- 5. Mathematical Methods for Physics and Engineering: K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.

MSPH412-18

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CLASSICAL MECHANICS

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**4** Credits

Main Campus

L-3, T-1, P-0

Pre-req	uisite:	None
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**Course Objectives:** The aim and objective of the course on **Classical Mechanics** is to train the students of M.Sc. students in the Lagrangian and Hamiltonian formalisms so that they can use these in the modern branches of physics such as Quantum Mechanics, Quantum Field Theory, Condensed Matter Physics, Astrophysics, etc.

Course Outcomes:	At the end of	the course, the stuc	lent will be able to

C01	Understand the necessity of Action, Lagrangian, and Hamiltonian formalism.					
CO2	Describe the motion of a mechanical system using Lagrange-Hamilton formalism.					
CO3	Use d'Alambert principle and calculus of variations to derive the Lagrange equations of motion.					
CO4	Understand essential features of a classical problem (like motion under central force, periodic motions), use them to set up and solve the appropriate physics problems.					
CO5	Understand the theory of rigid body motion which is important in several areas of physics e.g., molecular spectra, acoustics, vibrations of atoms in solids, coupled mechanical oscillators, electrical circuits, etc					

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	1	2	2	3
CO2	3	3	3	3	2	2	2	3
CO3	3	3	3	3	2	2	2	3
CO4	3	3	3	3	2	2	2	3
CO5	3	3	3	3	1	2	1	3

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#### **Detailed Syllabus:**

1. Lagrangian Formulation: Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation.

#### (Lectures 7)

2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.

(Lectures 7)

3. Hamilton's Equations: Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action.

(Lectures 7)

- 4. Canonical Transformation and Hamilton-Jacobi Theory: Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. (Lectures 10)
- 5. Rigid Body Motion: Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. (Lectures 10)

#### **Text Books:**

- 1. Classical Mechanics by H. Goldstein (Narosa), 2001.
- 2. Mechanics by L.D. Landau & E.M. Lifschz (Pergamon), 1976.

#### **Reference Books:**

- 1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi), 3<sup>rd</sup> ed 2002.
- 2. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi), 1988.
- 3. Classical Mechanics- J. W. Muller- Kirsten (World Scientific) 2008.
- 4. Advanced Classical & Quantum Dynamics by W. Dittrich, W. And M Reuter, M. (Springer) 1992.
- 5. Classical mechanics by T.W.B. Kibble and Frank H. Berkshire (Imperial College Press) 2004.
- 6. Mathematical Methods of Classical Mechanics by V. I. Arnold, (Springer) 1978.

MSPH413-18	Quantum Mechanics-I	L-3, T-1, P-0	4 Credits
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		and sources and	ent to membraged

Pre-requisite: basic knowledge of wave mechanical quantum mechanics

**Course Objectives:** The aim and objective of the course on **Quantum Mechanics-I** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the techniques of vector spaces, angular momentum, perturbation theory, and scattering theory so that they can use these in various branches of physics as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

C01	Unde	erstand the r	need for qu	antum mec	hanical for	nalism and	basic princ	ciples.		
CO2	notat	eciate the ions, eigen nanics.								
CO3	Concentration of the	er understar m of partic	a sublimation of the second second	e mathemat	tical founda	ations of ar	ıgular mon	entum of a		
		Applications of various approximation methods in solving the Schrodinger								
CO4	Appl		f various	approximat	tion metho	ds in sol	ving the S	Schrodinge		
CO4 CO5	equa									
	equa Appl	tion.	rbation theo	ory to scatte	ering matrix	and partia	l wave anal			
	equa Appl	tion. y the pertu	rbation theo	ory to scatte	ering matrix	and partia	l wave anal			

CO1	2	3	3	3	3	3	2	2	
CO2	2	3	3	3	3	3	2	1	
CO3	1	3	3	3	3	3	2	3	
CO4	-	3	3	3	3	3	3	3	
C05	-	3	3	3	3	3	1	2	
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Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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#### **Detailed Syllabus:**

- Linear Vector Space and Matrix Mechanics: Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg, Schroedinger and Interaction representations, Exchange operator and identical particles, Density Matrix and Mixed Ensemble. (Lectures 12)
- Angular Momentum: Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. (Lectures 7)
- 3. Stationary State Approximate Methods: Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. (Lectures 7)
- 4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light.

(Lectures 7)

4 Credits

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5. Scattering Theory: Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles. (Lectures 7)

#### **Text Books:**

- 1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
- 2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

#### **Reference Books:**

- 1. Quantum Mechanics: M.P. Khanna, (Har Anand, New Delhi), 2006.
- 2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
- 3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
- 4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.
- 5. Quantum Physics: Concepts and Applcations: Nouredine Zettili (Wiley, New York), 2nd ed. 2009.

L-3, T-1, P-0

#### MSPH414-18 | Electronics

				Ligita di Lis				
Pre-requisite:	Basic k	nowledge	about elect	ronics				
Course Object students of M.S of semiconduct analog circuits of physics as per Course Outcourse	Sc. class tor phy and intr er their	s to the for vsics, basi roduction requireme	mal structu c circuit a to digital el nt.	re of the sunalysis, fine function of the sunalysis, fine function of the sum	bject and t st-order no o that they	o equip the onlinear cir can use the	m with the rcuits, OPA	knowledge MP based
CO1	Und	erstand v	vorking o		t Semico	nductor d	evices (Co cations.	onstruction.
CO2	1	rn about th hyristors.	e construct	tion and wo	orking of T	nyristors ar	nd various a	opplications
CO3	Und	lerstand Ar	nalog and I	Digital Instr	uments and	their appli	ications.	
CO4	Enal	ble them fo	or using Bo	olean algel	ora and Kai	naugh map	os.	
C05	Intro	oduce then	n to the Sec	quential and	I Integrated	circuits.		
	Mappi	ng of cour	se outcom	es with the	program	specific ou	tcomes	
	PS O1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3	2	2	2	3	1	3	3
CO2	2	2	1	1 1 1 1 1 1 1	1	1	3	2
CO3	-	1	1	1	-	2	3	3
CO4	-	3	-	-	-	-	3	2
			1.1.1					

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#### **Detailed Syllabus:**

 Semiconductor Devices and applications: Direct and indirect semiconductors, Drift and diffusion of carriers, Photoconductors, Semiconductor junctions, Metal-semiconductor junctions - Ohmic and rectifying contacts, Zener diode, Schottky diode, Switching diodes, Tunnel diode, Light emitting diodes, Photodiodes, Solar cell, Liquid crystal displays.

#### (Lectures 7)

100

- UJTs and Thyristors: Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics-Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors- as a Pulse Generator, Bistable Multivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. (Lectures 10)
- 3. Analog and Digital Instruments: OPAMP and its applications, Time Base; 555 Timer, Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System.

(Lectures 8)

- 4. Digital circuits: Boolean algebra, de Morgans theorem, Karnaugh maps. (Lectures 5)
- 5. Sequential circuits: Flip-Flops RS, JK, D, COcked, preset and clear operation, race around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit. Shift registers, Asynchronous and Synchronous counters, Counter design and applications.

(Lectures8)

6. Integrated Circuits as Digital System Building Blocks: Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM: Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM Elements Bipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter.

#### **Text Books:**

(Lectures 8)

- 1. Text Book of Electronics: S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
- 2. Digital Principles and Applications: A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.

#### **Reference Books:**

- 1. Electronics Principles and Applications: A.B. Bhattacharya, New Central Book Agency P.Ltd., Kolkata, 2007.
- 2. Integrated Electronics Analog and Digital Circuits and Systems: J. Millman, C.C Halkins and C. Parikh, 2<sup>nd</sup> Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

MSPH415-18	Computational Physics	L-3, T-1, P-0	4 Credits
Scheme & Syllabu	s (M.Sc. Physics) Batch 2018 & Onward	Is and the second s	Page 19 of 71

#### **Pre-requisite:** None

**Course Objectives:** The aim and objective of the course on **Computational Physics** is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using any high level language such as Fortran, C++, etc., so that they can use these in solving simple physics problems.

CO1		oply basics oblems.	knowledge	e of comp	outational j	physics in	solving t	he physic
CO2	Pı	ogramme wi	th the C++	or any othe	r high leve	l language.		
CO3	U	Use various numerical methods in solving physics problems.						
CO4		nalyze the ou	tcome of th	ne algorithn	n/program 1	using graph	ic plots.	
C05								
	A	pply physics	knowledge	in understa	anding inter	disciplinar	y problem/	concepts.
	-	pply physics pping of cour	-		-		-	concepts.
	-		-		-		-	PSO8
C01	Maj	oping of cour	rse outcom	es with the	e program	specific ou	tcomes	
CO1 CO2	Maj PSO1	PSO2	rse outcom	es with the	PSO5	specific ou PSO6	tcomes PSO7	PSO8

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Course Outcomes: At the end of the course, the student will be able to

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**CO4** 

**CO5** 

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3

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3

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#### **Detailed Syllabus:**

- 1. Introduction to Computational Physics: Need and advantages of high level language in physics, programming in a suitable high level language (Matlab/Mathematica/Scilab/Octave), input/output, interactive input, loading and saving data, loops branches and control flow, Matrices and Vectors, Matrix and array operations, Graphic tools: Gnuplots, Origin, Sigmaplot, Visual Molecular Dynamics, Mathematica, etc. (Lectures 12)
- Programming with C++: Introduction to the Concept of Object Oriented Programming; Advantages of C++ over conventional programming languages; Introduction to Classes, Objects; C++ programming syntax for Input/Output, Operators, Loops, Decisions, simple and inline functions, arrays, strings, pointers; some basic ideas about memory management in C+. (Lectures 15)
- 3. Numerical methods: Computer algorithms, interpolations-cubic spline fitting, Numerical differentiation Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, Random number generators, Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, eigenvalue problems, Monte Carlo simulations.

(Lectures15)

#### **Text Books:**

- 1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
- 2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.

#### **Reference Books:**

- 1. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
- 2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
- 3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

MSPH416-18	Electronics Lab	L-3, T-1, P-0	4 Credits
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		Decarin	ient of Physical Sciences of Punjab Technical Univers

#### **Pre-requisite:** None

**Course Objectives:** The aim and objective of the laboratory on **Electronics Lab** is to expose the students of M.Sc. class to experimental techniques in electronics so that they can verify some of the things read in theory here or in earlier classes and develop confidence to handle sophisticated equipment.

Course Outc	omes: At the end of the course, the student will
CO1	Acquire hands on experience of handling and building electronics circuits.

	and building encourse of hundring and building electronics encours.
CO2	Be familiar with the various components such as resistors, capacitor, inductor, IC chips and how to use these components in circuits.
CO3	Be able to understand the construction, working principles and V-I characteristics of various devices such as PN junction diodes, UJT, TRIAC etc.
CO4	Capable of using components of digital electronics for various applications.
CO5	Able to design and perform scientific experiments as well as accurately record and analyze the results of experiments.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	2	1	2	2	3	3
CO2	1	2	2	1	-	2	2	3
CO3	1	3	3	1	2	3	3	2
CO4	-	3	-	2	1	3	3	2
CO5	2	2	3	3	2	3	3	3

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#### **Detailed Syllabus:**

Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. Study the forward and reverse characteristics of a Semiconctor/Zener diode.
- 2. Construction of adder, subtracter, differentiator and integrator circuits using the given OP-Amp.
- 3. Study the static and drain characteristics of a JFET.
- 4. Construction of an Astable multivibrator circuit using transistor.
- 5. Construction of a single FET amplifier with common source configuration.
- 6. To study the operation of Analog to Digital convertor.
- 7. To study the operation of Digital to Analog convertor.
- 8. Construction of a low-pass filter circuit and study its output performance.
- 9. Construction of a high-pass filter circuit and study its output performance.
- 10. To verify the Dmorgan's law using Logic Gates circuit.
- 11. To study the Characteristics of Tunnel Diode.
- 12. To study Amplitude Modulation.
- 13. To study Frequency Modulation.
- 14. To study the Characteristics of SCR.
- 15. To study the Characteristics of MOSFET.
- 16. To study the Characteristics of UJT.
- 17. To study the Characteristics of TRIAC.
- 18. To verify the different Logic and Arithmetic operations on ALU system.
- 19. To study the operation of Encoders and Decoders.
- 20. To study the operation of Left and right shift registers.
- 21. To study the operation of Counters, Ring counters.
- 22. To determine the thermal coefficient of a thermistor.
- 23. To study the operation of an Integrated Circuit Timer.

#### **Text Books:**

- 1. Text Book of Electronics: S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
- 2. Digital Principles and Applications: A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.

#### **Reference Books:**

- 1. Electronics Principles and Applications: A.B. Bhattacharya, New Central Book Agency P.Ltd., Kolkata, 2007.
- 2. Integrated Electronics Analog and Digital Circuits and Systems: J. Millman, C.C Halkins and C. Parikh, 2<sup>nd</sup>Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

ASSAULT RE		Hord No.
MSPH417-18	Computational Physics Lab-I	L-3, T-1, Part dien 4 Credits
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Pre-requisite: No	one	

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**Course Objectives:** The aim and objective of the course on **Computational Physics Lab-I** is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using  $C^{++}$  language so that they can use these in solving simple problems pertaining to physics.

CO1		pply basics oblems.	knowledge	of comput	ational Phy	ysics in so	lving vario	us physica		
CO2	P	rogramme wi	th the C++	or any othe	er high leve	l language.		0		
CO3 Use various numerical methods in describing/solving physics problems.							s.			
CO4	S	Solve problem, critical thinking and analytical reasoning as applied to scientific problems.								
C05		xplore new chnology.	areas of r	esearch in	physics a	nd allied	fields of s	cience an		
	IVIA	oping of cou	ise outcom	es with the	e program	specific ou	icomes			
	PSOI	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
C01	PSO1	PSO2 2	PSO3	PSO4	PSO5 2	PSO6 3	PSO7 3	PSO8 3		
Na sa sa			PSO3 1 -	-						
CO1 CO2 CO3	3	2	1	-		3	3			
CO2	3	2	1	1	2	3 2	3	3		

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#### **Detailed Syllabus:**

Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. To find the standard deviation, mean, variance, moments etc. of at least 25 entries.
- 2. To choose a set of 10 values and find the least squared fitted curve.
- 3. Find y for a given x by fitting a set of values with the help of cubic spline fitting technique.
- 4. To find the Roots of an Algebraic Equation by Bisection method and secant method
- 5. To find the Roots of an Algebraic Equation by Newton-Raphson Method.
- 6. To find the Roots of Linear Equations by Gauss Elimination Method.
- 7. To find the Roots of Linear Equations by Gauss-Seidal Iterative Method.
- 8. Find first order derivative at given x for a set of values with the help of Lagrange interpolation.
- 9. To perform numerical integration of a function by Trapezoidal Rule.
- 10. To perform numerical integration of a function by Simpson's Rule.
- 11. To perform numerical integration of a function by Weddle's rule.
- 12. To solve a Differential Equation by Euler's method and Modified Euler's Method.
- 13. To solve a Differential Equation by Runge Kutta method.
- 14. To find the determinant of a matrix and its eigenvalues and eigenvectors.
- 15. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.

#### **Text Books:**

- 1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
- 2. A first course in Computational Physics: P.L. DeVries (Wiley) 2nd edition, 2011.

#### **Reference Books:**

- 1. Computer Applications in Physics: S. Chandra (Narosa) 2nd edition, 2005.
- 2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
- 3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

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MSPH421	l-18	Mathem	atical Physi	cs-II	L-3, T	-1, P-0	4 C1	edits
Pre-requis	ite: No	ne	1		4 48 51 -			
the M.Sc. theoretical	Studen treatm	s: The aim and the with the ent in differ the chooses to	mathematic ent courses	al technio taught in	ques that n this clas	he/she nee s and for	ds for un	derstanding
Course Ou	itcome	At the end	of the course	, the stude	nt will able	to		States .
CO1 Understand the aplications of group theory in problems.						the branch	nes of Phys	ics
CO2	τ	Jse Fourier se	ries and tran	sformation	ns as an aid	for analyz	ing experin	nental data.
CO3	ι	Jse integral tr	ansform to se	olve mathe	ematical pro	oblems of i	nterest in P	hysics.
CO4	F	ormulate and oordinate trai	express a ph nsforms.	nysical law	in terms o	f tensors ar	nd simplify	it by use o
C05	Ι	Develop math	ematical skil	ls to solve	quantitativ	e problems	in physics	
	Ma	pping of cou	rse outcome	es with the	e program	specific ou	tcomes	
	PSO	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	1	3	1	3	3	1	2	3
CO2	1	3	2	2. 100	2	2	2	3
CO3	1	3	2	2	2	2	2	3
CO4	1	3	2	3	2	-	2	3
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#### **Detailed Syllabus:**

- Group Theory: What is a group? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3). (Lectures 10)
- 2. Tensors: Introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Noncartesian tensors, metric tensor, Covariant differentiation.

(Lectures 7)

- 3. Fourier Series and Integral Transforms: Fourier series, Dirichlet conditions, General properties, Advantages and applications, Gibbs phenomenon, Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation. Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation. *(Lectures 15)*
- 4. Integral Equations: Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory, Green's functions in one dimension. *(Lectures 10)*

#### **Text Books:**

- 1. Group Theory for Physicists: A.W. Joshi (Wiley Eastern, New Delhi) 2011.
- 2. Mathematical Methods for Physicists: G. Arfken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2012.

#### **Reference Books:**

- 1. Matrices and Tensors in Physics: A.W. Joshi (Wiley Eastern, New Delhi) 2005.
- 2. Numerical Mathematical Analysis: J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.
- 3. A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
- 4. Mathematical Physics: P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
- 5. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India, New Delhi) 2006.

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	Mecha ics–II			en: San horen	li (1.) Selici (***	a state	in second		
Pre-requ	isite: Pre	liminary cou	rse of Quant	um Mechai	nics				
introduce technique	the M.S s of Rel	es: The aim c. students to ativistic quar anches of ph	o the formal ntum mecha	structure on structure on structure of the structure of t	of the subje uantum fie	ect and to e	quip him/h	er with the	
Course C	Outcome	: At the end	of the cours	e, the stude	nt will be a	ble to	10 A.		
CO	CO1 Understand relativistic effects in quantum mechanics and need for quantum theory.						ntum field		
		Demonstrate the Lorentz covariant form of Lagrangian and Hamiltonian for scalar, vector fields, electromagnetic fields and their second quantisation.							
		Understand the symmetries and the implications of Noether's Theorem in conserved currents and charges.							
CO4 Understand th			ne interaction picture, S-matrix, and Wick's Theorem.						
CO		Explain the origin of Feynman diagrams and apply the Feynman rules to derive the amplitudes for elementary processes in QED.							
	Ma	pping of co	urse outcom	es with the	e program	specific ou	tcomes	Anne - Art	
	PSO	I PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
C01	1	1	2	2	2	2	2	3	
CO2	1	2	2	2	2	2	3	1	
CO3	1	2	3	3	2	1	2	2	
C04	1	3	3	3	2	1	2	3	
C05	1	2	1	3	2	2	3	3	

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I. K. Gujral Punjab Technical University, Kapurthala

#### **Detailed Syllabus:**

1. **Relativistic Quantum Mechanics-I:** Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation.

(Lectures 10)

2. **Relativistic Quantum Mechanics-II:** Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.

#### (Lectures 10)

- Quantum Field Theory: Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem, Quantization of real scalar field, complex scalar field, Dirac field and electromagnetic field, Covariant perturbation theory, Wick's theorem, Scattering matrix. (Lectures 10)
- 4. **Feynman diagrams**: Feynman rules, Feynman diagrams and their applications, Yukawa field theory, calculations of scattering cross-sections, decay rates with examples, Quantum Electrodynamics, calculations of matrix elements for first order and second order.

(Lectures 12)

#### **Text Books:**

- 1. Relativistic quantum Mechanics, J D Bjorken and S D Drell, (Tata McGraw Hill, New Delhi) 2013.
- A first book of Quantum Field Theory, A. Lahiri & P. Pal, (Narosa Publishers, New Delhi), 2<sup>nd</sup> ed. 2005.
- 3. Introduction to Quantum Field Theory, M. Peskin & D.V. Schroeder. (Levant Books).

#### **Reference Books:**

- 1. Quantum Field Theory in a nutshell: A Zee (University Press), 2013.Lecture on Quantum Field Theory, A. Das (World Scientific), 2008.
- 2. Text Book of Quantum Mechanics-P.M. Mathews & K. Venkatesan (Tata McGraw Hill, New Delhi), 2004.
- 3. Quantum Field Theory: H. Mandl and G. Shaw (Wiley, New York), 2010.
- 4. Advance Quantum Mechanics: J.J. Sakurai (Addison- Weslay, Reading), 2004.

MSPH424-18	Classical Electro	dynamics	1-3	T-1, P-0	4 Credits
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				Departino	nt of Physical Science Printab Technical University
				Head	AY I

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#### Pre-requisite: None

**Course Objectives:** The **Classical Electrodynamics** course covers Electrostatics and Magnetostatics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; EM waves in bounded media, waveguides, Radiation from time varying sources.

<b>Course Outcomes</b>	: At the end	of the course,	the student will	be able to
------------------------	--------------	----------------	------------------	------------

CO1	Understand and apply the laws of electromagnetism and Maxwell's equations in different forms and different media.					
CO2	Solve the electric and magnetic fields problems for different configurations.					
CO3	Provide solution to real life plane wave problems for various boundary conditions.					
CO4	Calculate reflection and transmission of waves at plane interface.					
CO5	Analyze propagation of electromagnetic waves through different waveguides.					

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3	3	1	2	1	2	1	2
CO2	3	3	1	2	2	2	2	2
CO3	3	3	1	3	2	1	2	2
CO4	3	3	2	3	2	2	1	2
CO5	3	3	1	3	2	2	2	2

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#### **Detailed Syllabus:**

- 1. Electrostatics: Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor).
  - (Lectures 10)

10

2. **Magnetostatics:** The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor)

#### (Lectures 8)

- 3. **Boundary value problems:** Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems. *(Lectures 8)*
- 4. Time varying fields and Maxwell equations: Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum.

#### (Lectures 8)

5. Electromagnetic Waves: wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide. (Lectures 10)

#### **Text Books:**

- 1. Classical Electrodynamics: S.P. Puri (Narosa Publishing House) 2011.
- 2. Classical Electrodynamics: J.D. Jackson, (New Age, New Delhi) 2009.
- 3. Introduction to Electrodynamics: D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2012.

#### **Reference Books:**

- 1. Classical Electromagnetic Radiation: J.B. Marion and M.A. Heald(Saunders College Publishing House) 3rd edition, 1995.
- 2. Electromagnetic Fields, Ronald K. Wangsness (John Wiley and Sons) 2nd edition, 1986.
- 3. Electromagnetic Field Theory Fundamentals: Bhag Singh Guru and H.R. Hiziroglu

MSPH424-18	Atomic and Molecular Physics	L-3, T-1, P-0	4 Credits
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	arten Street prospy Ru	
Pre-requisite: None	States Specificeory we	

**Course Objectives:** The aim and objective of the course on **Atomic and Molecular Physics** for the students of M.Sc. Physics is to equip them with the knowledge of Atomic, Rotational, Vibrational, Raman, and Electronic spectra.

<b>Course Outcomes:</b> At the end of the course, the student will be	e able to	
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CO1	Understand basic elements of atomic and molecular spectroscopy
CO2	Understand classical/Quantum description of electronic, vibrational and rotational spectra
CO3	Correlate spectroscopic information of known and unknown molecules with their physical description
CO4	Understand and use Raman Spectroscopy for analysis of molecules

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	2	3	2	2	3
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	2	3	3	3	3
CO5	3	3	3	2	3	3	3	3

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# **Detailed Syllabus:**

- Electronic Spectroscopy of Atoms: Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non-equivalent electrons –X-ray photoelectron spectroscopy. (Lectures 8)
- Electronic Spectroscopy of Molecules: Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition - molecular orbital theory – the spectrum of molecular hydrogen – change of shape on excitation – chemical analysis by electronic spectroscopy – reemission of energy – fundamentals of UV photoelectron spectroscopy. (Lectures 9)
- Microwave and Raman Spectroscopy: Rotation of molecules and their spectra diatomic molecules intensity of line spectra the effect of isotropic substitution non-rigid rotator and their spectra polyatomic molecules (linear and symmetric top molecules) Classical theory of Raman effect pure rotational Raman spectra (linear and symmetric top molecules). (Lectures 8)
- 4. Infra-red and Raman Spectroscopy: The energy of diatomic molecules Simple Harmonic Oscillator –the Anharmonic oscillator the diatomic vibrating rotator vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation the vibrations of polyatomic molecules –influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) Raman activity of vibrations vibrational Raman spectra vibrations of Spherical top molecules.

(Lectures 8)

Page 35 o

 Spin Resonance Spectroscopy Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin-lattice relaxation - NMR chemical shift coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. (Lectures 8)

# **Text Books:**

- 1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
- 2. Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain.

# **Reference Books:**

- 1. Physical method for Chemists (Second Edition) by Russell S. Drago (Saunders College Publishing).
- 2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1934.
- 3. Spectroscopy Vol. I, II & III: Walker & Straughen
- 4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1962.
- 5. Spectra of diatomic molecules: Herzberg-New York, 1944.

MSPH426-	18		clear, and Par ysics Lab	rticle	L-3, T	-1, P-0	4 Cr	edits
Pre-requisit	e: None			s and a second		(asher)	20121-1	
expose the st	tudents n verify	of M.Sc. stu v some of t	and objective idents to exper he results obta	imental	techniques	in atomic	and nuclear	physics s
Course Out	comes:	At the end o	of the course, th	ne stude	nt will be a	ble to		
CO1 Acquire hands on experience of using particle detectors such as GM counter Scintillation counter.							counter an	
CO2	har	ndle oscillos	cope for visual	lisation	of various i	input and o	utput signa	ls.
CO3	Un	derstand the	basic of nucle	ear safel	y managem	nent.		
CO4		Perform scientific experiments as well as accurately record and analy results of nuclear experiments.						analyze th
C05	Sol	lve applied r	uclear probler	ns with	critical thir	nking and a	nalytical re	asoning.
	Map	ping of cour	rse outcomes v	with the	e program	specific ou	tcomes	
	PSO1	PSO2	PSO3 1	PSO4	PSO5	PSO6	PSO7	PSO8
C01	1	2	1	2	1	3	3	3
CO2	1	1	1 :	3	1	3	1	3
CO3	1	1	1	3	1	3	1	2
CO4	1	3	3	3	1	3	3	3
CO5	1	3	3 3	3	1	3	3	3
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# **Detailed Syllabus:**

Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot interferometer.
- 2. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
- 3. Determination of Lande's factor of DPPH using Electron-spin resonance (E.S.R.) spectrometer.
- 4. Determination of ionization Potential of Lithium.
- 5. Analysis of pulse height of gamma ray spectra.
- 6. To study the characteristics of G.M. tube.
- 7. To verify the inverse square law using GM counter.
- 8. To determine the dead time of G.M. counter.
- 9. To study absorption of beta particles is matter using GM counter.
- 10. To study Gaussian distribution using G.M. counter.
- 11. To estimate the efficiency of GM detector for Gamma and Beta source.
- 12. Determination of Planck's constant using Photocell and interference filters.
- 13. Verification of Inverse square law using Photocell.
- 14. To study Gaussian distribution using scintillation counter.
- 15. To study absorption of gamma radiation by scintillation counter.
- 16. To estimate the efficiency of Scintillator counter.

# **Text Books:**

- 1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
- 2. Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.

### **Reference Books:**

- 1. Physical method for Chemists (Second Edition) by Russell S. Drago (Saunders College Publishing).
- 2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1934.
- 3. Spectroscopy Vol. I, II & III: Walker & Straughen
- 4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1962.
- 5. Spectra of diatomic molecules: Herzberg-New York, 1944.

MSPH427-18	Computational Physics Lab-II	L-3, T-1, P-0	4 Credits
Pre-requisite: N	one		
students of M.Sc	ves: The aim and objective of the lab of . class in understanding numerical met e for simulation of results for differen	hods, the usage of hig	h level language such

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Course O	utcome	s: At the end	of the course	e, the stude	nt will be a	ble to		
C01		Understand an ohysics proble		sics know	ledge of m	umerical m	ethods in	solving th
CO2		Write programme with the C++ or any other high level language.						
CO3		Learn use of graphical methods in data analysis and solving physics problems						roblems.
CO4		Solve physical problem, enabling development of critical thinking and analytic reasoning.						d analytica
C05								
	1	explore applic research in ph apping of cou	ysics and all	lied fields.				and applie
	1	research in ph apping of cou	ysics and all	lied fields.				and applie
C01	M	research in ph apping of cou	ysics and all rse outcom	lied fields. es with the	e program	specific ou	tcomes	
C01 C02	M	apping of cou	ysics and all rse outcom PSO3	es with the PSO4	PSO5	specific ou PSO6	tcomes PSO7	PSO8
Constrained	PSO 1	research in phapping of courses of the second secon	ysics and all rse outcom PSO3 1	PSO4	PSO5 3	specific ou PSO6 1	tcomes PSO7 3	PSO8
CO2	PSO 1 2	Performance     1   PSO2     2     2     2	vsics and all rse outcom PSO3 1 1	PSO4 3 3	PSO5 3 3	specific ou PSO6 1 2	tcomes PSO7 3 3 3	PSO8 3 3

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Detail	ed	Svl	lab	us:
	-	Pre . 7 . 10.		

- 1. Write a program to study graphically the EM oscillations in a LCR circuit (use Runge-Kutta Method). Show the variation of (i) Charge vs Time and (ii) Current vs Time.
- 2. Study graphically the motion of falling spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
- 3. Study graphically the path of a projectile with and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
- 4. Study the motion of an artificial satellite.
- 5. Study the motion of (a) 1-D harmonic oscillator (without and with damping effects).(b) two coupled harmonic oscillators. Draw graphs showing the relations: i) Velocity vs Time, ii) Acceleration vs Time iii) Position vs Time, also compare the numerical and analytical results.
- 6. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
- 7. Study the motion of a charged particle in: (a) Uniform electric field, (b) Uniform Magnetic field, (c) in combined uniform electric and magnetic fields. Draw graphs in each case.
- 8. Use Monte Carlo techniques to simulate phenomenon of (i) Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus. (ii) to determine solid angle in a given geometry. (iii) simulate attenuation of gamma rays/neutron in an absorber and (iv) solve multiple integrals and compare results with Simpson's method.
- 9. To study phase trajectory of a Chaotic Pendulum.
- 10. To study convection in fluids using Lorenz system.

# **Text Books:**

- 1. Numerical Recipes in C++ The Art of Scientific Computing, William H. Press, Saul, A.Teukolsky, William T. Vetterling, and Brian P. Flannery, (Cambridge), 2nd ed. 2002.
- 2. A First Course in Computational Physics: P.L. DeVries (John Wiley) 2000.

#### **Reference Books:**

- 1. An introduction to Computational Physics: Tao Pang (Cambridge), 2nd ed. 2006.
- 2. Computer Applications in Physics: S. Chandra (Narosa), 2006.
- 3. Computational Physics: R.C. Verma, P.K.Ahluwalia and K.C. Sharma (New Age), 2005.
- 4. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill), 5th ed. 2011.

MSPH531-18	Condensed Matter Physics	L-3, T-1, P-0	ACredits
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# Pre-requisite: None

**Course Objectives:** The aim and objective of the course on **Condensed Matter Physics** is to expose the students of M.Sc. class to the topics like elastic constants, lattice vibrations, dielectric properties, energy band theory and transport theory so that they are equipped with the techniques used in investigating these aspects of the matter in condensed phase.

C01	l	Inderstand bas	sic element	s of crystal	structure o	f condensed	d matter.	
CO2		Understand accurate description of lattice dynamics and thermal prope crystalline solids.						roperties
CO3	τ	Understand origin of energy bands in solids with focus on semiconductors.						tors.
CO4	E	Describe and understand basics of transport properties across solids.						
C05	Γ	escribe and u	nderstand 1	nagnetic ar	nd dielectric	behavior o	of solids.	
				CO WILLI LIN	program	specific ou	LCOINCS	
	PSO		PSO3	PSO4	PSO5	specific ou PSO6	PSO7	PSO8
CO1	PSO1							PSO8
		PSO2	PSO3	PSO4	PSO5		PSO7	
CO2	3	PSO2 3	PSO3	PSO4 3	PSO5	PSO6	PSO7 3	2
CO1 CO2 CO3 CO4	3	PSO2 3 3	PSO3 3 3	PSO4 3 3	PSO5 2 3	PSO6 1 3	PSO7 3 3	2 3

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# **Detailed Syllabus:**

1. Crystal binding and Elastic constants: Binding in solids; Cohesive energy, Crystals of Inert gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals.

(Lectures 6)

111

- Lattice Dynamics and Thermal Properties: Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states, Debye T3 model; Einstein Model; anharmonic crystal interactions; thermal conductivity expansion. (Lectures 9)
- 3. Energy Band Theory: Electrons in a periodic potential: Bloch theorem, Nearly free electron model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices.

(Lectures 9)

4. **Transport Theory:** Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance.

(Lectures 8)

5. **Dielectrics and Ferro Electrics:** Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition.

(Lectures 8)

#### **Text Books:**

1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.

2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

# **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1972
- 2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
- 3. Liquid Crystals: S. Chandrasekhar (Cambridge University), 2nd ed. 1992.

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Pre-requisite: None		
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**Course Objectives:** The aim and objective of the course on **Nuclear Physics** is to familiarize the students of M.Sc. class to the basic aspects of Nuclear Physics like static properties of nuclei, radioactive decays, nuclear forces, nuclear models, and nuclear reactions so that they are equipped with the techniques used in studying these things.

CO1		Understand str types of nuclea			of nuclei, ra	adioactive o	lecay, and c	lifferent
CO2		Understand Qu	antum beha	vior of ato	ms in exter	mal electric	and magne	etic field
CO3 Compare vario			ous nuclear r	nodels and	properties	of the nucl	eus.	221
CO4		Understand ab	out nuclear	forces and	their deper	idence on v	arious para	meters.
C05		Describe vario	us types of i	nuclear rea	ctions and	their prope	rties.	
				oc with the	DO MO OTHO PRO	CTS 0.01970.017	to o see o o	
	PSO	apping of countries of countrie	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1								PSO8
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	
CO2	PSO 1	1 PSO2 2	PSO3 3	PSO4 3	PSO5 3	PSO6 3	PSO7 3	3
CO1 CO2 CO3 CO4	PSO 1 1	1 PSO2 2 3	PSO3 3	PSO4 3 3	PSO5 3 3	PSO6 3 3	PSO7 3 3	3

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# **Detailed Syllabus:**

- Nuclear Models: Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective modelnuclear vibrations spectra and rotational spectra. (Lectures 8)
- 2. Static properties of nucleus: Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfine structure, effect of external magnetic field. (Lectures 5)
- 3. Nuclear decay: Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Neutrino, detection of neutrinos, Multipolarity of gamma transitions, internal conversion process, transition rates. (Lectures 10)
- 4. Nuclear forces: Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, n-p scattering at low energies, spin-dependence of n-p scattering, p-p scattering, exchange forces & single and triplet potentials, meson theory of nuclear forces. (Lectures 10)
- 5. Nuclear reactions: Nuclear reactions and cross-sections, Resonance, Breit-Wigner dispersion formula for 1=0 and higher values, compound nucleus, Direct reactions, Transfer reactions.

# (Lectures 7)

#### **Text Books:**

- 1. Nuclear Physics: Irving Kaplan (Narosa), 2002.
- 2. Theory of Nuclear Structure: R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.

# **Reference Books:**

- 1. Basic Ideas and Concepts in Nuclear Physics : K. Hyde (Institute of Physics) 2004.
- 2. Nuclear physics: Experimental and Theoretical, H.S. Hans (New Academic Science) 2<sup>nd</sup> ed (2011).
- 3. Nuclear Physics and its applications by John Lile
- 4. Nuclear Physics by V. Devnathan

		LK. Gujal Pulja
MSPH533-18	Particle Physics	L-3, T-1, P-0 4 Credits

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# Pre-requisite: course on Quantum mechanics and Quantum field Theory

The aim and objective of the course on **Particle Physics** is to introduce the M.Sc. students to the invariance principles and conservation laws, hadron-hadron interactions, relativistic kinematics, static quark model of hadrons and weak interactions so that they grasp the basics of fundamental particles in proper perspective.

C01		verview of perview of pervices.		ctrum, thei	r interactio	on and maj	or historica	and late
CO2	1	arious invaria	iance principles and symmetry properties in particle physics.					
CO3	E	Basic rules of Feynman diagrams and the quark model for hadrons.						
CO4		Properties of neutrons and protons in terms of a simple non- model.					e nonreltiv	vistic quar
C05	V	eak interaction	on between	quarks and	how that t	his is respo	nsible for f	decay.
	Ma	oping of cou	rse outcom	es with the	e program	specific ou	tcomes	
	Ma PSO1	PSO2	PSO3	PSO4	e program PSO5	specific ou PSO6	tcomes PSO7	PSO8
C01								PSO8
C01 C02	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	20-
Constanting and the	PSO1 2	PSO2 2	PSO3 2	PSO4 3	PSO5 3	PSO6	PSO7 2	3
CO2	PSO1 2 2	PSO2 2 2	PSO3 2 2	PSO4 3 3	PSO5 3 3	PSO6 1 1	PSO7 2 2	3

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# **Detailed Syllabus:**

1. Introduction: Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units.

(Lectures 7)

Elective Subject -

- Invariance Principles and Conservation Laws: Invariance in classical mechanics and quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem. (Lectures 7)
- Hadron-Hadron Interactions: Cross section and decay rates, Pion spin, Isospin, Two nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy. (Lectures 7)
- Relativistic Kinematics and Phase Space: Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, recursion relation, effective mass, dalitz, K-3 p-decay, t-θ puzzle, dalitz plots for dissimilar particles, Breit-Wigner resonance formula, Mandelstem variables. (Lectures 7)
- 5. Static Quark Model of Hadrons: The Baryon decuplet, quark spin and color, baryon octer, quark-antiquark combination. (Lectures 7)
- 6. Weak Interactions: Classification of weak interactions, Fermi theory, Parity non conservation in β-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K- decay and its experimental determination.

(Lectures 7)

#### **Text Books:**

1.

- 1. Introduction to High Energy Physics : D.H. Perkins (Cambridge University Press), 42000.
- 2. Gauge Theory of Elementary Particle Physics, T.P Cheng & L.F. Li (Oxford).
- 3. An Introductory Course of Particle Physics, Palash Pal (CRC Press).

#### **Reference Books:**

- 1. Elementary Particles : I.S. Hughes (Cambridge University Press), 3<sup>rd</sup>ed. 1991.
- 2. Introduction to Quarks and Partons : F.E. CLose (Academic Press, London), 1979.
- 3. Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.
- 4. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).
- 5. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
- 6. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).

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MSPH53	4-18	Fibre Optics	and Non-lin	near optics	L-3, T	-1, P-0	4 C1	edits
Pre-requi	site: N	one	40					
and Nonli	inear (	ves: Course C Optics is to ex- bres and their t	pose the M	I.Sc. student	d objectiv ts to the b	e of the co basics of th	ourse on <b>F</b> e challengi	ibre Optics ng research
Course O	utcom	es: At the end	of the cours	e, the studer	it will be a	ible to		149.40
CO1		Understand th	e structure o	of optical fib	er and des	cribe prope	erties of opt	tical fibers.
CO2		Understand ar	Sector and the sector of the s					
CO3		Understand th	e principles	of fiber opti	ics commu	inication in	different n	nedia
<b>CO</b> 4	1000	Analyze the el	ectro-optic	and acousto	-optic effe	cts in fiber	5	
C05		Understand no	on-linear eff	ects in optic	al fibers.			
	M	apping of cou	rse outcom	es with the	program	specific ou	tcomes	- we
	PSC	01 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
<b>CO1</b>	-	2	-	2	-	1	2	3
CO2	-	2	-	2	-	-	1	3
CO3	-	1	-	2		-	1	3
CO4	-	2	2	2	-	-	1	3
				100 3				

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# **Detailed Syllabus:**

- Optical fibre and its properties: Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. (Lectures 7)
- Fiber fabrication and cable design: Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. (Lectures 5)
- 3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations. *(Lectures 10)*
- 4. Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.

(Lectures 10)

5. Non-linear optics/processes: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities. *(Lectures 8)* 

#### **Text Books:**

1. The Elements of Fibre Optics: S.L. Wymer and Meardon (Regents/Prentice Hall), 1993.

### **Reference Books:**

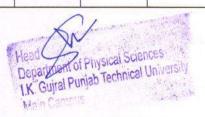
- 1. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press), 1996.
- 2. Optical Electronics: Gathak & Thyagarajan (Cambridge Univ. Press), 1989.
- 3. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press), 1991.



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MSPH535-	-18	Plas	ma Physic	S	L-3, T	-1, P-0	4 Cr	redits
Pre-requisi	te: Cours	e on Electro	odynamics	zna stali	- Teli			
Course Ob M.Sc. stude	jectives: ents to the	The aim a basics of t	nd objectiv he challeng	ve of the c ging researc	course on <b>1</b> ch field Plas	Plasma Ph sma physic	<b>ysics</b> is to s.	expose the
Course Out	tcomes: A	t the end o	of the cours	e, the stude	ent will be a	ble to		
C01		lerstand the lasma.	e origin of	plasma, co	nditions of	plasma fo	rmation and	d properties
CO2					ticle appro ent plasma		approach a.	and kinetion
CO3		ssify propa non-magne			and electric	romagnetic	waves in	magnetized
CO4					ena such as n-magnetiz		esistivity, di	iffusion and
C05	ther						o be in yze the stab	
	Mapp	ing of cour	rse outcom	es with the	e program	specific ou	itcomes	
-	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3	-	2	c	3	3	1	-
CO2	3	3	3	3	3	3	1	-
CO3	3	3	3	3	3	3	2	-
CO4	3	3	3	3	3	3	1	1
C05	3	3	3	3	3	3	2	1
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# **Detailed Syllabus:**

- 1. Introduction: Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge. (Lectures 8)
- 2. Plasma diagnostics: Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts. (Lectures 5)
- 3. Single particle orbit theory: Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves.

#### (Lectures 8)

- 4. Fluid description of plasmas: distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations. dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves, Magnetosonic waves. (Lectures 10)
- 5. Stability of fluid plasma: The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle. microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties. (Lectures 7)

# **Text Books:**

1. Introduction to Plasma Physics, F.F. Chen

# **Reference Books:**

- 1. Principles of Plasma Physics, Krall and Trievelpice
- 2. Introduction to Plasma Theory, D.R. Nicholson
- 3. The Plasma State, J.L. Shohet
- 4. Introduction to Plasma Physics, M. Uman
- 5. Principles of Plasma Diagnostic, I.H. Hutchinson



Elective Subject -I Page 49 of 71

MSPH536	5-18	Nonlin	ear Dynan	nics	L-3, T-	-1, P-0	4 Cr	edits
Pre-requis	ite: None		22.1	ad Cramps	n Futter			
	students w	The aim an ith the basic						
Course Ou	itcomes: /	At the end o	f the cours	e, the stude	nt will be a	ble to		
C01	Und cha	lerstand bas os.	sic knowled	lge of nonli	inear dynan	nics and ph	enomenolo	gy of
CO2	App	oly the tools	of dynami	ical system	s theory in	context to r	nodels.	
CO3		rn skills by hods.	solving pro	oblems on s	solving non	linear prob	lems using	numerical
<b>CO4</b>	Unc	lerstand Ha	milton app	roach for d	escribing va	arious phys	ical system	
<b>CO</b> 5	Qua	ntify classi	cal chaos a	nd Quantur	n chaos.			
	Mapp	ing of cour	se outcom	es with the	e program	specific ou	tcomes	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	2	3	3	3	3	2	3	1
CO2	-	3	3	3	3	2	3	1
CO3	1	3	3	3	3	1	3	1
<b>CO4</b>	3	3	3	3	3	1	3	2
CO5	3	3	3	3	3	2	3	2

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# **Detailed Syllabus:**

- Phenomenology of Chaos: Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos. (Lectures 8)
- Dynamics in State Space: State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence. (Lectures 10)
- 3. Hamiltonian System: Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity.

(Lectures 8)

4. Quantifying Chaos: Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism.

(Lectures 7)

5. Quantum Chaos: Quantum Mechanical analogies of chaotic behaviour, Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics.

(Lectures 7)

# **Text Books:**

1. Chaos and Non Linear Dynamics: R.C. Hilborn (Oxford Univ. Press), 2001.

### **Reference Books:**

- 1. Chaos in Dynamical Systems: E. Ott (Cambridge Univ. Press), 2002.
- 2. Applied Nonlinear Dynamics: A.H. Nayfeh and B. Balachandran (Wiley), 1995.
- 3. Chaos in Classical and Quantum Mechanics: M.C. Gutzwiller (Springer-Verlag), 1990.

**Elective Subject -II** 

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MSPH537	7-18	Radi	ation Physi		L-3, T-	-1, P-0	4 Cr	edits
Pre-requis	site: No	me		nis lejųs da metro circar	A COLORADO			1.1.1
students of that they u	f M.Sc. indersta	es: The aim a class to the re nd the details nuclear physic	latively adv of the unde	anced topic rlying aspe	s Radiation	Physics a	nd nuclear	reactions so
Course Or	utcome	s: At the end of	of the course	e, the stude	nt will be a	ble to		
CO1		Understand va charged particl			raction of	electroma	gnetic rad	iations and
CO2		Distinguish va	rious types	of radiation	s based on	their intera	action with	matter.
CO3	1	Learn and und	erstand abo	ut different	detectors a	nd their us	e for spectr	oscopy.
CO4		Use different a and electron sp				PIXE, neut	tron activat	ion analysis
	M	apping of cou	rse outcom	es with the	e program	specific ou	tcomes	
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	3	1	3	3	3	3	3
CO2	1	3	1	2	2	3	3	3
CO3	1	1	1	3	3	3	3	3
CO4	1	1	1	3	3	3	3	3
C05	1	1	1	1	2	1	1	2

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# **Detailed Syllabus:**

1. Interaction of electromagnetic radiations with Matter: Different photon interaction processes viz. photoelectric effect, Compton scattering and pair production. Minor interaction processes, Energy and Z dependence of partial photon interaction processes. Attenuation coefficients, Broad and narrow beam geometries. Multiple scattering.

(Lectures 8)

2. Interaction of charged particles with Matter: Elastic and inelastic collisions with electrons and atomic nucleus. Energy loss of heavy charged particles. Range-energy relationships, Straggling. Radiative collisions of electrons with atomic nucleus.

(Lectures 8)

3. Nuclear Detectors and Spectroscopy: General characteristics of detectors, Gas filled detectors, Organic and inorganic scintillation detectors, Semi-conductor detectors [Si(Li), Ge(Li) HPGe]. Room temperature detectors, Gamma ray spectrometers. Gamma ray spectrometery with NaI(Tl) scintillation and semiconductor detectors.

(Lectures 8)

(Lectures 8)

- 4. Nuclear spectrometry and applications: Analysis of nuclear spectrometric data, Measurements of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, Measurement of g-factors and hyperfine fields. (Lectures 8)
- 5. Analytical Techniques: Principle, instrumentation and spectrum analysis of XRF, PIXE and neutron activation analysis (NAA) techniques. Theory, instrumentation and applications of electron spin resonance spectroscopy (ESR). Experimental techniques and applications of Mossbauer effect, Rutherford backscattering. Applications of elemental analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.

#### **Text Books:**

- 1. The Atomic Nucleus: R.D. Evans, Tata Mc Graw Hill, New Delhi.
- 2. Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy, New Age, International, New Delhi.

#### **Reference Books:**

- 1. Radiation Detection and Measurements: G. F. Knoll, Wiley & Sons, New Delhi.
- 2. Introductory Nuclear Physics: K. S. Krane, Wiley & Sons, New Delhi.
- 3. An Introduction to X-ray Spectrometry: Ron Jenkin, Wiley.
- 4. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo, Narosa Publishing House, New Delhi.
- 5. Introduction to experimental Nuclear Physics: R.M. Singru, Wiley & Sons, New Delhi.

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**Guiral Puniab Technical University** 

MSPH538-	18 5	Structures, Sp of B	4 Cr	edits				
Pre-requisit	te: No	ne						
of Biomole	cules	es: The aim an is to familiar ynamics of Str	ize the M.S	c. students	with the	basics of	the recently	
Course Out	tcomes	s: At the end o	of the course	, the studer	t will be a	ble to		
<b>CO1</b>	I	Describe vario	us structural	and chemi	cal bondin	g aspects o	f Biomolec	ules.
CO2		Jnderstand st Biomolecules.	tructure and	d theoretic	al techni	ques and	their app	lication t
CO3		Jnderstand us Biomolecules.	e of various	spectrosco	pic techni	ques and t	heir applica	ation to th
CO4	τ	Jnderstand the	e structure-F	unction rela	ationship a	nd modelir	ng of biomo	lecules.
CO5	(	Dutline and co	rrelate for p	roviding so	lution to ir	terdiscipli	nary proble	m.
	Ma	pping of cou	rse outcome	es with the	program	specific ou	tcomes	
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	2	3	2
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	2	3	2

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# **Detailed Syllabus:**

- Structure Aspects of Biomolecule: Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides. (Lectures 10)
- Theoretical Techniques and Their Application to Biomolecules: Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses. (Lectures 10)
- Spectroscopic Techniques and their Application to Biomolecules: Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids. (Lectures 10)
- 4. Structure-Function Relationship and Modeling: Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model. (Lectures 10)

# Text Books:

1. Srinivasan & Pattabhi: Structure Aspects of Biomolecules.

# **Reference Books:**

- 1. Govil & Hosur: Conformations of Biological Molecules
- 2. Price: Basic Molecular Biology
- 3. Pullman: Quantum Mechanics of Molecular Conformations
- 4. Lehninger: Biochemistry
- 5. Mehler&Cordes: Biological Chemistry
- 6. Smith and Hanawait: molecular Photobiology, Inactivation and Recovery

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Elective Subject - II

MSPH539-18	Science of Renewable source of	L-3, T-1, P-0	4 Credits
Sector States	Energy server a the product	their services.	
Pre-requisite: N	one	1002	

**Course Objectives:** The aim and objective of the course on **Science of renewable Energy Sources** is to expose the M.Sc. students to the basics of the alternative energy sources like solar energy, hydrogen energy, etc..

Course Outcomes: At the end of the course, the student will be able to

CO1	Know the energy demand of world and India.
CO2	Understand traditional and alternative form of energy.
CO3	Understand concept of solar energy radiation, making of solar cell and its types
CO4	Identify hydrogen as energy source, its storage and transportation methods.
CO5	Compare wind energy, wave energy and ocean thermal energy conversion.

Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	-	3	-	3	1	2	2	3
CO2	-	2	-	3	1	2	2	3
CO3	-	3	- 11	3	2	1	3	3
CO4	( e ) ( )	3		3	2	1	3	3
C05	-	3	-	3	1	1	3	3

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# **Detailed Syllabus:**

- 1. Introduction: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*
- 2. Solar Energy: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, interrelationship between absorption coefficients and band gap recombination of carriers. Types of solar cells, p-n junction solar cell, Transport equation, current density, open circuit voltage and short circuit current, description and principle of working of single crystal, polycrystalline and amorphous silicon solar cells, conversion efficiency. Elementary ideas of Tandem solar cells, solid-liquid junction solar cells and semiconductor-electrolyte junction solar cells. Principles of photo electrochemical solar cells. Applications.
- 3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells, hydride batteries.

(Lectures 10)

4. Other sources: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC. (Lectures 8)

#### Text Books:

1. Solar Energy: S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.

# **Reference Books:**

- 1. Solar Cell Devices: Fonash (Academic Press, New York), 2010.
- 2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: Fahrenbruch and Bube (Springer, Berlin), 1983.
- 3. Photoelectrochemical Solar Cells : Chandra (New Age, New Delhi).



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	-18 C	ondensed N	Aatter Physi	cs Lab	L-3, T-	1, P-0	4 Cro	edits
Pre-requisi	ite: None			<del>tre C</del>				
to train the physics so	students that the	of M.Sc. y can inve	d objective o class to adva estigate vario lyze the data.	nnced exposed	perimental	techniques	in conder	ised matte
Course Ou	tcomes: A	At the end o	f the course,	the stude	nt will be al	ole to		
CO1	Mea	asure condu	ctivity, resist	ivity and	thermo-dyr	namical pro	operties of s	olids.
CO2	Mea	asure magne	etic propertie	s and ma	gnetic behav	vior of mag	gnetic mate	rials.
CO3		cribe the la tions.	ittice dynami	cs of sim	ple lattice	structures	in terms of	dispersion
CO4		200 A	rry out scier		eriments as	s well as	accurately	record and
	ana	lyze the res	ults of experi	ments.				
C05		-	with critical		and analytic	al reasonii	ng.	
CO5	Sol	ve problem		thinking	1986		(220)	
CO5	Sol	ve problem	with critical	thinking	1986		(220)	PSO8
C05	Sol <sup>a</sup> Mapp	ve problem	with critical	thinking : with the	program s	specific ou	tcomes	PSO8 3
	Solv Mapp PSO1	ve problem ing of cour PSO2	with critical	thinking a with the PSO4	program s	pecific ou PSO6	tcomes	Peripersesses and
C01	Solv Mapp PSO1 3	ve problem ing of cour PSO2 3	with critical	thinking a with the PSO4	PSO5	PSO6	tcomes PSO7 2	3
C01 C02	Solv Mapp PSO1 3 3	ve problem ing of cour PSO2 3 3	with critical reserve outcomes	thinking a with the PSO4 3 3	PSO5 3 3	PSO6 2 3	tcomes PSO7 2 2 2	3

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# **Detailed Syllabus:**

Note: Students are expected to perform atleast ten experiments out of following list.

- 1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
- 2. Verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
- 3. To determine charge carrier density and Hall coefficient by Hall effect.
- 4. To determine magnetic susceptibility of material using Quink 's tube method.
- 5. To determine energy gap and resistivity of the semiconductor using four probe method.
- 6. To study the B-H loop characteristics.
- 7. To determine dielectric constant of a material with Microwave set up.
- 8. To measure the Curie temperature of a given PZT sample.
- 9. To measure the velocity of ultrasonic wave in liquids.

10. To study dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.

11. To study the properties of crystals using X-Ray Apparatus.

### **Text Books:**

- 1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
- 2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

# **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1972
- 2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
- 3. Liquid Crystals: S. Chandrasekhar (Cambridge University), 2nd ed. 1992.

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# **Elective Subject -III**

MSPH541-18	Physics of Nanomaterials	L-3, T-1, P-0	4 Credits
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Pre-requisite: Condensed matter physics

**Course Objectives:** The aim and objective of the course on **Physics of Nano-materials** is to familiarize the students of M.Sc. to the various aspects related to preparation, characterization and study of different properties of the nanomaterials so that they can pursue this emerging research field as career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Demonstrate techniques of microscopy for investigations on the nanometer and atomic scales
CO2	Acquire knowledge of basic approaches to synthesize inorganic colloidal nanoparticles and their self-assembly in solution and surfaces
CO3	Understand and describe the use of unique optical properties of nanoscale metallic structures for analytical and biological applications
CO4	Understand the physical and chemical properties of carbon nanotubes and nanostructured mesoporous materials.
CO5	the structure-property relationships in nanomaterials as well as the concepts, not applicable at larger length scales.

# Mapping of course outcomes with the program specific outcomes

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	-	3	3	3	3	3	3	3
CO2	2	3	3	3	3	3	3	3
CO3	2	3	3	3	3	3	3	3
CO4	- 3.4	3	3	3	3	3	3	3
C05	-	3	3	3	3	3	3	3

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# **Detailed Syllabus:**

- Introductory Aspects: Free electron theory and its features, Idea of band structure—metals, insulators and semiconductors. Density of state in one, two and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. (Lectures 8)
- 2. **Preparation of Nanomaterials:** Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling.

(Lectures 8)

- 3. General Characterization Techniques: Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. (Lectures 8)
- 4. Quantum Dots: Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. (Lectures 8)
- 5. Other Nanomaterials: Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors. (Lectures 8)

# **Text Books:**

- 1. Nanotechnology-Molecularly Designed Materials: G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
- 2. Nanotechnology Molecular Speculations on Global Abundance: B.C. Crandall (MIT Press), 1996.

### **Reference Books:**

- 1. Quantum Dot Heterostructures: D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley), 1998.
- 2. Nanoparticles and Nanostructured Films-Preparation, Characterization and Application: J.H.Fendler (Wiley), 1998.
- 3. Nanofabrication and Bio-system: H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.
- 4. Physics of Semiconductor Nanostructures: K.P. Jain (Narosa), 1997.
- 5. Physics of Low-Dimension Semiconductors: J.H. Davies (Cambridge Univ. Press) 1998.
- 6. Advances in Solid State Physics (Vo.41): B. Kramer (Ed.) (Springer), 2001.

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Elective Subject -III

			ental Technic and Particle	-	L-3, T-	1, P-0	4 Cr	edits
Pre-requis	ite: Co	urse on Nuc	lear and Parti	cle Physics	ne utitus			
Nuclear an	id Par	ticle Physic	n and object s is to expose thods used in	the student	ts of M.Sc.	students to	o experimen	ntal aspect
Course Ou	tcome	s: At the end	d of the course	e, the stude	nt will be a	ble to		
C01		Understand radiations w	various experi ith matter.	mental tech	nniques for	describing	interaction	of
CO2		Use various	statistical met	hods for ex	perimental	data.	and the second	
CO3		Knowledge applications	about the d	lifferent ty	pes of the	e radiatior	detectors	and the
<b>CO4</b>		Introduced t	o neutron phy	sics, metho	ds to detect	tor slow an	d fast neutr	ons.
CO5		A CALL AND A CALL OF THE OWNER	ith the basic k ratories across	West Design of the state of the state		perimental	methods u	sed in the
	M	apping of co	ourse outcom	es with the	program	specific ou	tcomes	
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	1	2	3	3	3	3
CO2	1	3	3	2	1	3	3	3
CO3	1	1	1	3	1	3	3	3
	-	3	1	3	3	3	3	3
CO4	1	3	1			1000		2

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# **Detailed Syllabus:**

- Detection of radiations: Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. (Lectures 8)
- 2. Detectors: Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectrum from detector, Cherenkov detector. Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, semiconductor detectors in X- and gamma-ray spectroscopy, Pulse height spectrum, Compton-suppressed, Semiconductor detectors for charged particle spectroscopy and particle identification. General background and detector shielding.

(Lectures 15)

- 3. Neutron Physics: Interaction of neutrons with matter, Neutron detectors, Detection of fast and slow neutrons-nuclear reactions for neutron detection. *(Lectures 6)*
- 4. Experimental methods: Large gamma and charge particle detector arrays, heavy-ion reaction analysers, production of radioactive ion beams. Detector systems for high energy experiments: Collider physics (brief account), Particle Accelerators (brief account), Modern Hybrid experiments- CMS and ALICE. (Lectures 8)

### **Text Books:**

1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

tick Phone

# **Reference Books:**

- 1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
- 2. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
- 3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

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Elective Subject -III

MSPH543-18	Superconductivity and Low	L-3, T-1, P-0	4 Credits
	Temperature Physics	20] -482	
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		and a second	

Pre-requisite: Condensed Matter Physics

**Course Objectives:** The objective of the course on Superconductivity and Low Temperature Physics is to build fundamental as well as advanced understanding in the field of superconductivity. Students will not only learn theoretical aspects but also acquainted with latest trends in the experimental techniques as well. Low temperature is one of the most versatile and important tool to explore rich physics of superconductivity. With latest technology the lowest achievable temperature now is close to few  $\mu$ K. Students will also be introduced to the theoretical background of low temperature techniques as well as the high-Tc superconductors.

Course Outcomes: At the end of the course, the student will be able to

<b>CO1</b>	The	Theoretical understanding of the concept of superconductivity.							
CO2 Correlate observed experimental properties of superconductivity.							uctors with	origin o	
CO3 Describe appropriate theoretical model for superconductors.						for desc	ribing beł	navior o	
CO4		Provide exposure to High Tc class of superconductors and theoretical understanding of low temperature techniques.							
<b>CO5</b> Provide exposure about the experimental techniques for measuperconductivity.							asurement o	of	
	sup	erconductiv	ny.						
		oing of cour	9.15	es with the	e program	specific ou	tcomes	i an	
			9.15	es with the PSO4	e program PSO5	specific ou PSO6	tcomes PSO7	PSO8	
C01	Mapp	ing of cour	rse outcom	_	an at has			PSO8	
	Mapp PSO1	PSO2	rse outcom PSO3	PSO4	PSO5	PSO6	PSO7	PSO8 1 1	
CO2	Mapp PSO1 1	PSO2	PSO3 3	PSO4 3	PSO5	PSO6	PSO7	1	
CO1 CO2 CO3 CO4	Mapp PSO1 1 2	PSO2 3 3	PSO3 3 3	PSO4 3 3	PSO5 3 3	PSO6 3 3	PSO7 3 3	1	

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# **Detailed Syllabus:**

- 1. Superconductivity: Introduction, Thermodynamics, The London Equations, penetration depth, Superconductors in magnetic field, Ginzberg-Landau Theory, Type I and II superconductors, BCS theory, second quantization, Cooper Pairing, energy gap Tunnelling, Josephson effects and SIS tunneling. (Lectures 10)
- 2. **Preparation and measurement techniques:** Single crystal growth: Optical image furnace, seeded melt growth, Thin film deposition: Pulsed laser deposition, sputtering, Resistivity measurements, magnetic measurements, Point contact spectroscopy, scanning tunneling microscopy and spectroscopy. (Lectures 10)
- 3. Cryogenics: Thermal and electrical properties of different materials at low temperatures, Cooling methods above 1K, Joule-Thompson, Gifford-McMohan, Evaporation cooling, Liquefication of Helium, Cooling methods below 1K, dilution refrigeration, adiabatic demagnetisation. (Lectures 10)
- 4. Introduction to high-Tc superconductors: Discovery of high-Tc superconductors, Mechanisms of superconductivity in high-Tc superconductors, Introduction to high-Tc superconducting compound like YBCO, Synthesis, Structure and properties, Electronics and applications. (Lectures 10)

# **Text Books:**

1. Introduction to superconductivity: Michael Tinkham, Courier Corporation, 2004.

# **Reference Books:**

- 1. Introduction to superconductivity: A.C. Rose-Innes and E.H. Rhoderick, Pergamon Press, 2004.
- 2. Experimental techniques in low temperature physics: G.K. White and P.J. Meeson, Oxford Univ. Press, 2002.
- 3. Experimental low temperature physics: A. Kent, MacMillan Press, 1993.
- 4. The theory of superconductivity in high-TC Cuprates: P.W. Anderson, Princeton Series Publications.

Elective Subject -IV Page 65 of 71

MSPH544-18	Advanced Condensed Matter	L-3, T-1, P-0	4 Credits
	Physics	2110.07	
	delectricated	171	

Pre-requisite: course on Condensed Matter Physics

**Course Objectives:** The objective of the course on **Advanced Condensed Matter Physics** is to familiarize the M.Sc. students with relatively advanced topics like optical properties, magnetism, superconductivity, magnetic resonance techniques and disordered solids so that they are confident to use the relevant techniques in their later career.

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and describe Optical properties of solids
CO2	Understand and describe magnetic properties of solids
CO3	Understand use of NMR methods for describing solids
CO4	Understand and explain the behavior of superconductors
C05	Understand the effect of defects and deformation on the behavior of solids

Mapping of course outcomes with the program specific outcomes

-	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	3	2	3
CO2	1	3	3	3	3	3	2	3
CO3	1	3	3	3	3	3	3	3
CO4	1	3	3	3	3	3	2	1
C05	2	3	3	3	3	3	3	3

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# **Detailed Syllabus:**

- Optical Properties: Macroscopic theory; Reflectance and Transmittance of a slab; generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect in crystals; interband transitions. (Lectures 10)
- 2. **Magnetism:** Dia and para-magnetism in materials; Langevin theory of diamagnetism, quantum theory of diamagnetism and paramagnetism, Exchange interaction. Heisenberg Hamiltonian; Hubbard model; mean field theory; Ferro-, ferri- and antiferromagnetism; Magnons: spin waves, thermal excitation of magnons; Bloch T3/2 law. (Lectures 10)
- Nuclear Magnetic Resonance in Solids: Origin of NMR in solids- equations of motion, line width, motional narrowing, Knight shift. (Lectures 10)
- 4. **Superconductivity:** Experimental Survey; Basic phenomenology; Vortex state of a Type II superconductors; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Tunneling Experiments; High Tc superconductors; Ginzburg-Landau theory; Greens functions at zero temperature; Applications of Greens functions to superconductivity. (Lectures 10)
- 5. **Disordered Solids:** Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, Glasses, Amorphous semiconductors and Ferromagnets, Heat capacity and Thermal conductivity of amorphous solids; Quasicrystals. (Lectures 10)

# **Text Books:**

- 1. Introduction to Solid State Physics: C. Kittel (Wiley, New York) 2005.
- 2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

# **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1972.
- 2. Solid State Physics: H. Ibach and H. Luth (Springer, Berlin), 3rd. ed. 2002.
- 3. A Quantum Approach to Solids: P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.
- 4. Intermediate Quantum Theory of Solids: A.O.E. Animalu (East-West Press, New Delhi), 1991.
- 5. Solid State Physics : Ashcroft and Mermin (Reinhert & Winston, Berlin), 1976.

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MSPH545-18	<b>Advanced Particle Physics</b>	L-3, T-1, P-0	4 Credits
	ndes in adam	n file and	and an and a second
Pre-requisite: Kr	owledge of particle physics		
students of M.Sc.	es: The objective of the course on A class to the relatively advanced topic	s related to symmetry	y breaking in quantum

students of M.Sc. class to the relatively advanced topics related to symmetry breaking in quantum field theory, standard model of particle physics, QCD and quark model, and various unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

Course Outcomes: At the end of the course, the student will have understanding of

C05	Physics beyond the Standard Model Physics.							
CO4	Asymptotic freedom and infrared slavery of the running coupling constant in non-abelian gauge theory of strong interactions -QCD.							
CO3	The problem of divergencies in quantum field theories and the renormalisation methods.							
CO2	Need for standard model of particle physics and its limitations and the propertie of QCD.							
CO1	Various global and local gauge symmetries of system, invariance of action symmetry breaking, and Higgs mechanism.							

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	3	3	3	3	3	3	3
CO2	3	2	1	3	3	3	3	3
CO3	2	3	2	3	3	3	3	3
CO4	2	2	3	2	3	3	3	3
CO5	1	3	3	2	3	3	3	3
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# **Detailed Syllabus:**

- 1. Symmetries and Symmetry Breaking in QFT: Continuous groups: Lorentz group SO(1,3) and its representations, Dirac, Weyl and Majorana fermions, Unitary groups and Orthogonal groups and their representations, Discrete symmetries: Parity, Charge Conjugation and Time reversal Invariance, CP, CPT. (Lectures 8)
- Global and Local invariances of the Action: Approximate symmetries, Noethers theorem, Spontaneous breaking of symmetry and Goldstone theorem, Higgs mechanism, Abelian and Non-Abelian gauge fields, Lagrangian and gauge invariant coupling to matter fields. (Lectures 8)
- 3. Standard Model of Particle Physics: SU(3) x SU(2) x U(1) gauge theory, Coupling to Higgs and Matter fields of 3 generations, Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix, Low energy Electroweak effective theory and Decoupling, Elementary electroweak scattering processes. (Lectures 8)
- 4. QCD and quark model: Asymptotic freedom and Infrared slavery, confinement hypothesis, Approximate flavor symmetries of the QCD lagrangian, Classification of hadrons by flavor symmetry: SU(2) and SU(3) multiplets of Mesons and Baryons, Chiral symmetry and chiral symmetry breaking, Sigma model, Parton model and Deep inelastic scattering structure functions. (Lectures 8)
- 5. Beyond The Standard Model: Neutrino mass and neutrino oscillations, Models of Neutrino mass, Left Right symmetric models, Pati-Salam, SU(5) and SO(10) Grand Unification, Unification of gauge and Yukawa couplings via RG flows, Supersymmetry and Supersymmetric Unification, Exotic processes and their phenomenology, Higgs Physics, Collider Physics, Dark matter, Baryon asymmetry generation, Leptogenesis.

(Lectures 8)

#### **Text Books:**

- 1. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
- 2. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

### **Reference Books:**

- 1. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
- 2. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).
- 3. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).



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	-18	Research	Project w	ork	L-0, T-1	2, P-0	12 Cr	edits		
Pre-requisi	te: Knowl	ledge of spe	cific branc	h of physic	s					
preliminario	es and me t the oppo	The aim of ethodology rtunity to p t.	of researc	h in Theo	retical Phy	sics and I	Experimenta	al Physics		
		t the end of	f the course	, the studer	nt will be al	ble to				
CO1	<b>CO1</b> Explain the significance and value of problem in physics, both scientifically a in the wider community.									
CO2		Design and carry out scientific experiments as well as accurately record th results of experiments.								
CO3	Critically analyse and evaluate experimental strategies, and decide which is mappropriate for answering specific questions.									
CO4	CO4 Research and communicate scientific knowledge in the context of a topic re to condensed matter physics/Nuclear/High Energy Physics, in oral, written a electronic formats to both scientists and the public at large.									
CO5 Explore new areas of research in physics and allied field technology.							fields of s	cience an		
	tech	nology.								
		inology.	se outcom	es with the	program	specific ou	tcomes			
			PSO3	es with the	program	specific ou PSO6	tcomes PSO7	PSO8		
C01	Mapp	ing of cour								
C01 C02	Mapp PSO1	ing of cour	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
	Mapp PSO1 3	PSO2	PSO3 3	PSO4 3	PSO5 3	PSO6 3	PSO7 3	PSO8 3		
CO2	Mapp PSO1 3 3	PSO2 3 2	PSO3 3 3	PSO4 3 3	PSO5 3 3	PSO6 3 3	PSO7 3 3	PSO8 3 3		

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#### Guidelines for the Project:

The aim of project work in M.Sc. 4th semesters is to expose the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.. Project work can be in Experimental or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per course guidelines.

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#### IK Gujral Punjab Technical University, Kapurthala Department of Physical Sciences

Ref No.: IKGPTU/PS/ 104 5

Date: 27:04.2018

#### Subject: Proceedings of the Board of Studies (BoS). Physical Sciences (Naterial Science Flance and Technology) meeting held on 23.04.2018

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 23.04.2018 in the Department of Physical Sciences. I K Gujral Punjab Technical University, Kapurthala. The agenda of the meeting was discussed in detail and recommendations were made on point. The proceedings of the meetings were recorded in the form of minutes of meeting. (Attacharten: Studies 2.

In the meeting, all members approved the Program Educational objectives (PEO), Program outcome (PO). Program specific butcomes and Course outcomes(CO) of course subjects and scheme and course syllabus for M.Tech. (Nano Science and Technology), enclosed here as Annexure A. Also, the syllabus, course objective (CO) and program objective. (PO) of M.So, (Physics) 2016 Batch and Engineering Physics for B. Tech. 1<sup>st</sup> Yester 211 were a proved for adoption which are enclosed as Annexure-B and Annexu. = C.

Submitted for necessary activity

Rige Converter - BoS

Dr. Hitesh Sharma

Chaimán, Board of Studies Head, Physical Sciences.

Convener- BoS Dr. Neetika

Department of Physical Sciences I.K. Gujral Punjab Technical Universit Main Car

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## I.K. Gujral Punjab Technical University, Kapurthala Department of Physical Sciences

#### Minutes of Meeting

A meeting of members of Board of Studies (BoS). Physical Sciences (Material Science/Nano Science and Technology) was held on 23.04.2018 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala.

The following were present in the meeting:

- 1. Dr. Amit Sarin (Chairperson)
- 2. Dr. Kanchan L. Singh, Member
- 3. Dr. Hitesh Sharma, Member
- 4. Dr. Maninder Kaur, Member
- 5. Dr. A. S. Bhuttar, (Chairperson, ECE, IKGPTU main campus) as Special invitee
- 6. Dr. Gazal Sharma (Food Science, IKGPTU main campus) as Special invitee
- 7. Dr. Jagmeet Bawa (IKGPTU main campus) as Special invitee
- 8. Dr Priyanka Mahajan (IKGPTU main campus) as Special invitee
- 9. Dr. Gaurav Bhragava (Chemistry, IKGPTU main campus) as Special invitee
- 10. Dr. Chander Parkash (Chemistry, IKGPTU main campus) as Special invitee
- 11. Dr. Varinderjit Singh, Member (Special Invitee)
- 12. Dr. Harkirat Singh, Member (Special invitee)
- 13. Dr. Neetika Sharma, Member (Special invitee)
- 14. S. Navdeepak Sandhu, Member

The following members could not attend the meeting:

- 1. Dr. Davinder Mehta, Member
- 2. Dr. Ravi Kumar, Member
- 3. Dr. Rakesh Dogra, Member
- 4. Dr. Arvind Kumar, Member
- 5. Dr. Ranjan Kumar, Member
- 6. Dr. R. K. Bedi, Member
- 7. Dr. Harpreet Kaur Grewal, Member
- 8. Dr. B D Gupta, Member
- 9. Dr. Rajiv Malhotra, Member
- 10. Dr. P. Arumugam, Member

The Board of Studies discussed on all the agenda points and following recommendations were made:

Agenda item 1 To consider the Revision of scheme and syllabus for M.Tech. (Nano Science



implemented in the revised M.Tech. (Nano Science and Technology). All members approved the Program Educational objectives (PEO). Program outcome (PO), Program specific outcomes and Course outcomes(CO) of course subjects for M.Tech. (Nano Science and Technology). The scheme and course syllabus of all core and elective subjects were also approved. The copy of the approved scheme and syllabus with PO and COs is enclosed as **Annexure A**.

Agenda item 2: To approve the program objectives and course outcomes of M.Sc. (Physics) 2016 batch and Engineering Physics (Batch-2011) as per NAAC requirements

All BoS members approved the educational objectives of the old M.Sc.(Physics) 2016 batch and Engineering Physics (Batch-2011) as per NAAC requirements. The copy of the revised scheme and syllabus with PO and COs of M.Sc.(Physics) 2016 batch is enclosed as **Annexure B** and Engineering Physics (Batch-2011) as **Annexure C**.

Dr Amit Sarin

Chairperson- BoS, Physical Sciences

Dean Academics

Physical Sciences Punjab Technical University

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zzz Annexure-B

# **M.Sc.** Physics

## Course Structure and Syllabus (Based on Choice Based Credit System) 2016-17

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#### DEPARTMENT OF PHYSICAL SCIENCES

#### VISION

To be a knowledge nerve centre in Physical Sciences, Pure and Applied Research and industry requirements for creating sustainable infrastructure and enhancing quality of life

#### MISSION

- To offer globally-relevant, industry-linked, research-focused, technology-enabled seamless education at the graduate, postgraduate and research levels in various areas of Physical sciences keeping in mind that the manpower so spawned is excellent in quality, is relevant to the global scientific and technological needs, is motivated to give its best and is committed to the growth of the Nation;
- To develop and conduct continuing education programmes for Science graduates with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core specialization of the University;
- 3. To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;

nt of Physical Science

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#### M.Sc. (Physics) Program

#### Duration: 2 Years (Semester System)

This M.Sc. (Physics) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on one-year research project as an integral part of their M.Sc. programme. The programme also provide adequate exposure to the students for pursuing higher education in the field of technology (M. Tech.), Physics (M.Phil./Ph.D.) and other job opportunities in academia and industry.

#### **Eligibility:**

Pass B.Sc. with 50% marks having Physics as one of the subject. A relaxation of 5% is given in case of candidates belonging to SC/ST category.

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**PROGRAM EDUCATIONAL OBJECTIVES:** The Program Educational Objectives are the knowledge skills and attitudes which the students have at the time of post-graduation. At the end of the program, the student will be able to:

PEO1	Apply the scientific knowledge of Physics, Mathematics, Chemistry, and Physics specialization for deeper understanding of the nature.
PEO2	Identify, formulate, research literature, and analyze advanced scientific problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PEO3	Design solutions for advanced scientific problems and design system components or processes.
PEO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PEO5	Create, select, and apply appropriate techniques, resources, and modern scientific and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PEO6	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional scientific practice.
PEO7	Communicate effectively on complex Scientific activities with the Scientific/engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PEO8	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of scientific and technological change.

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**PROGRAM OUTCOMES:** At the end of the program, the student will be able to:

PO1	Apply principles of basic science concepts in understanding, analysis and prediction of physical systems.
PO2	To introduce interdisciplinary subjects/concepts/ideas for interdisciplinary application of Physics concepts.
PO3	To introduce advanced ideas and techniques required in emergent area of Physics.
PO4	To develop human resource with specialization in theoretical and experimental techniques required for career in academia and industry.
PO5	Engage in lifelong learning and adapt to changing professional and societal needs.

PROGRAM SPECIFIC OUTCOMES: At the end of the program, the student will be able to:

PSO1	Understand and apply principles of physics for understanding the scientific phenomenon in classical domain.
PSO2	Understand and apply mathematical techniques for describing and deeper understanding of physical systems.
PSO3	Understand and apply statistical methods for describing the classical and quantum particles in various physical systems and processes.
PSO4	Understand and apply inter-disciplinary concepts and computational skills for understanding and describing the natural phenomenon.
PSO5	Understand and apply principles of Quantum mechanics for understanding the physical systems in quantum realm.
PSO6	Provide exposure in various specialization of Physics (Solid State Physics/Nuclear Physics/Particle Physics).
PSO7	Provide exposure to advanced experimental/theoretical methods for measurement, observation, and fundamental understanding of physical phenomenon/systems.
PSO8	Engage in research and life-long learning to adapt to changing environment.

#### SEMESTER FIRST

Course	Course Title		Load		Marks		Marks Distribution		Total	Credits
Code		All	locat	ion	Marks	vsical Sciences				
		L	T	P	Internal	External	Guiral Punja	Jechnical Uhiv		

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	TOTAL	15	5	3	175	400	575	23
PHS416	Physics Lab-I		-	3	25	50	75	3
PHS415	Atomic and Molecular Physics	3	1		30	70	100	4
PHS414	Statistical Mechanics	3	1	-	30	70	100	4
PHS413	Quantum Mechanics-I	3	1	-	30	70	100	4
PHS412	Classical Mechanics	3	1	-	30	70	100	4
PHS411	Mathematical Physics-I	3	1	101	30	70	100	4

#### SEMESTER SECOND

Course Code	Course Title	Load Allocation				urks bution	Total Marks	Credits
		L	T	P	Internal	External		
PHS421	Mathematical Physics-II	3	1		30	70	100	4
PHS422	Nuclear Physics	3	1	-	30	70	100	4
PHS423	Quantum Mechanics-II	3	1	-	30	70	100	4
PHS424	Computational Physics	3	1	-	30	70	100	4
PHS425	Condensed matter Physics-I	3	1	-	30	70	100	4
PHS426	Physics Lab-II	-	-	3	25	50	75	3
PHS427	Computational Lab	-	-	3	25	50	75	3
	TOTAL	15	5	6	200	450	650	26

L: Lectures T: Tutorial P: Practical



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#### SEMESTER THIRD

Course Code	Course Title		Loac locat		Marks D	istribution	Total Marks	Credits
		L	T	P	Internal	External		
PHS531	Condensed Matter Physics-II	3	1	-	30	70	100	4
PHS532	Classical Electrodynamics	3	1	34	30	70	100	4
PHS533	Particle Physics	3	1	-	30	70	100	4
PHS534	Electronics	3	1	-	30	70	100	4
PHS535 PHS536 PHS537 PHS538	Elective Subject-I	3	1	-	30	70	100	4
PHS539	Seminar	-	-	-	Satisfact	ory/Unsatis	factory	2
PHS540	Physics Lab-III	-	1.0	3	25	50	75	3
	TOTAL	15	5	3	175	400	575	23

#### SEMESTER FOURTH

Course Code	Course Title	Load Allocation			Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
PHS541 PHS542	Elective Subject-II	3	1	-	30	70	100	4
PHS543 PHS544	Elective Subject-III	3	1	-	30	70	100	4
PHS545	M.Sc. Research Project		12		Satisfact	ory/Unsati	isfactory	12
TOTAL		15	5	3	60	140	200	20

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#### **Elective Subjects:**

S.No.	Name of the Subject	Code
1	Fibre optics and non-linear optics	PHS535
2	Plasma Physics	PHS536
3	Nonlinear Dynamics	PHS537
4	Structures, Spectra and Properties of Biomolecules	PHS538
5	Experimental techniques in Nuclear and Particle Physics	PHS541
6	Physics of Nanomaterials	PHS542
7	Environmental Physics	PHS543
8	Science of Renewable source of Energy	PHS544

#### **Examination and Evaluation**

S. No. Remarks Weightage Mid term/sessional Tests 25% Best of two mid semester test will be 1. considered for evaluation. 2 Attendance/Seminar/ 5% Assignments 3 End semester 70% Conduct and checking of the answer sheets examination will at the Department level in case of University teaching Department or Autonomous institutions. For other colleges examination will be conducted at the university level. 4 Total 100% Marks may be rounded off to nearest integer. Practical 50% 1 Daily evaluation of Internal evaluation practical record/Viva Voice/Attendance etc. **Final Practical** 2 50% External evaluation Performance + Viva Voice 3 **Total** 100% Marks may be rounded off to nearest integer.

**PHS411** 

MATHEMATICAL PHYSICS-I

ICS-I L-3, T-1, P-0

4 Credits Page & of 64 epartment of Physical Sciences University Guital Puniab Technical University

Pre-requis	site: None							a not su				
students w in differen	<b>bjectives:</b> The set of the set o	ematical t ght in this	echniques t s class and	hat he/she	needs for u	nderstandir	g theoretic	al treatmer				
Course O	utcomes: At	the end o	f the course	e, the stude	nt will be a	ble to						
CO1		Formulate and express a physical law in terms of tensors and simplify it by use of coordinate transforms.										
CO2	Understar	nd the use	of complex	x variables	for solving	definite int	egral.					
CO3	Solve par	tial differe	ential equat	tions using	boundary v	alue proble	ms.					
CO4	Understar	nd the inte	gral equati	ons to solve	e the physic	s problems		-A-				
CO5	Use statis	tical meth	ods to anal	ysis the exp	perimental	data.		11194				
	Mappin	ng of cou	rse outcom	es with the	e program	specific ou	tcomes					
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8				
C01	3	3	3	3	3	3	3	3				
CO2	3	3	3	3	3	3	3	2				
CO3	3	3	3	3	3	3	3	2				
CO4	3	3	3	3	2	3	3	2				
C05	3	3	3	3	2	2	2	1				

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Scheme & Syllabus (M.Sc. Physics) Batch 2016 & Onwards

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#### **Detailed Syllabus:**

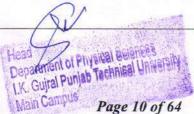
- 1. Vector fields and Tensors: Scalar and Vector fields, Scalar and Vector products: Curl, Divergent and Introduction to tensors and definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Non-Cartesian tensors, metric tensor, Covariant differentiation.
- 2. **Complex Variables**: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation.
- 3. **Differential Equations:** Partial differential equations of theoretical physics, boundary value problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution.
- 4. Integral Equations: Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory. Green's functions in one dimension.
- 5. Numerical Techniques: Roots of functions, Interpolation, Extrapolation, Differentiation, integration by trapezoid and Simpson's rule, RungeKutta method and finite difference method.
- 6. Elementary Statistics: Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution

#### **Text Books:**

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2012.

#### **Reference Books:**

- 1. Mathematical Physics : P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
- 2. Mathematical Physics : A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi), 1986.
- 3. Mathematical Methods in the Physical Sciences M.L. Boas (Wiley, New York) 3rd edition, 2007.
- 4. Special Functions : E.D. Rainville (MacMillan, New York), 1960.
- 5. Mathematical Methods for Physics and Engineering: K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.



PHS412		CLASSIC	AL MECH	IANICS	L	-3, T-1, P-0	4	Credits		
Pre-requis	site: None					ne 'r r		9 11		
students of in the mod	M.Sc. stue ern branch	dents in the	Lagrangian cs such as (	n and Hami	ltonian for	<b>assical Me</b> malisms so Juantum Fie	that they ca	an use these		
Course Or	utcomes: A	At the end o	f the course	e, the stude	nt will be a	ble to				
C01	Underst	and the nec	essity of A	ction, Lagra	angian, and	Hamiltonia	in formalis	m.		
CO2	Describ	e the motio	n of a mech	nanical system	em using L	agrange-Ha	milton for	nalism.		
CO3	Use d'Alambert principle and calculus of variations to derive the Lagrange equations of motion.									
CO4						(like motic ppropriate p				
C05	physics		cular speci	tra, acousti	cs, vibratio	is importations of ator				
	Марр	oing of cou	rse outcom	es with the	program	specific ou	tcomes			
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
C01	3	3	3	3	1	2	2	3		
CO2	3	3	3	3 at 35 sid	2	2	2	3		
CO3	3	3	3	3	2	2	2	3		
004	3	3	3	3 Calls 34	2	2	2	3		
CO4										

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#### **Detailed Syllabus:**

1. Lagrangian Formulation: Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation.

#### (Lectures 7)

2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.

#### (Lectures 7)

3. **Hamilton's Equations:** Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action.

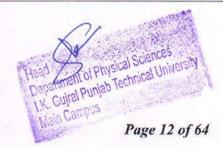
#### (Lectures 7)

- 4. Canonical Transformation and Hamilton-Jacobi Theory: Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. (Lectures 10)
- 5. Rigid Body Motion: Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. (Lectures 10)

TUTORIALS: Relevant problems given at the end of each chapter in different books.

#### Text Books:

- 1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi), 3<sup>rd</sup> ed 2002.
- 2. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi), 1988.



	Qua	antum Mec	hanics-I		L-3	, T-1, P-0	40	redits
Pre-requi	site: wave	mechanics,						
the studer techniques	ts of M.S. of vector	c. class to spaces, ang	the formal gular mome	of the course structure o ntum, pertur ysics as per	f the sub bation the	ject and to cory, and so	equip the	m with th
Course O	utcomes:	At the end o	f the course	e, the student	will be a	ble to		
C01	Und	lerstand the	need for qu	antum mech	anical for	malism and	basic prine	ciples.
CO2	nota			e and imploblems, gene				
CO3		er understar em of partic		e mathematio	cal found	ations of ar	ngular mon	nentum of
CO4		lications o ation.	f various	approximatio	on metho	ods in solv	ving the S	Schrodinge
			rhation theo	ry to scatter	ing matrix	and partia	l wave anal	
CO5	App	ly the pertu	ballon meo		1951			ysis.
CO5			and the	es with the j	orogram	specific ou	tcomes	lysis.
CO5			and the	es with the j	program PSO5	specific ou PSO6	tcomes	PSO8
C05 C01	Марј	ping of cou	rse outcom	i deni	N.C.			
	Mapj PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	Mapj PSO1 2	PSO2 3	PSO3 3	PSO4 <sub>cen</sub> 3 in a	PSO5 3	PSO6 3	PSO7	PSO8
CO1 CO2	Mapj PSO1 2 2	PSO2 3 3	PSO3 3 3	PSO4.ccm 3 in a 3 2	PSO5 3 3	PSO6 3 3	PSO7 2 2	PSO8 2 1

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#### **Detailed Syllabus:**

- Linear Vector Space and Matrix Mechanics: Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg, Schroedinger and Interaction representations, Exchange operator and identical particles, Density Matrix and Mixed Ensemble. (Lectures 12)
- Angular Momentum: Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. (Lectures 7)
- 3. Stationary State Approximate Methods: Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. *(Lectures 7)*
- 4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light.

(Lectures 7)

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5. Scattering Theory: Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of / identical particles. (Lectures 7)

#### **Text Books:**

- 1. A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
- 2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

#### **Reference Books:**

- 1. Quantum Mechanics: M.P. Khanna, (Har Anand, New Delhi), 2006.
- 2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
- 3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
- 4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.

	Sta	tistical Me	chanics		L-3, T	-1, P-0	4 Cr	edits		
Pre-requis	site: None				C Signal -					
M.Sc. stud	lent with th	ne techniqu	es of Ense	of the cour mble theory bulk in tern	so that he	e/she can u	se these to	understand		
Course O	utcomes: A	At the end o	f the cours	e, the studer	nt will be a	ble to				
C01		lerstand Ec ems of part		state and	thermody	namic pote	entials for	elementary		
CO2	Lea	rn Modern	aspects of a	equilibrium	and non-ed	quilibrium	statistical P	hysics.		
CO3		cribe the fe		examples	of Maxwel	ll-Boltzmar	nn, Bose-E	instein, and		
		Work with various models of phase transitions and thermo-dyna fluctuations.								
CO4			various me	odels of j	phase trai	nsitions a	nd thermo	o-dynamica		
CO4 CO5	fluc	tuations.		odels of j es in quantu			nd thermo	o-dynamica		
	fluc Des	tuations. cribe physic	cal quantiti		ım systems	3.		o-dynamica		
	fluc Des	tuations. cribe physic	cal quantiti	es in quantu	ım systems	3.		o-dynamica		
	fluc Des Mapp	tuations. cribe physic ing of cour	cal quantiti se outcom	es in quantu es with the	im systems program	3. specific ou	tcomes			
CO5	fluc Des Mapp PSO1	tuations. cribe physic ing of cour PSO2	cal quantiti rse outcom PSO3	es in quantu es with the PSO4	im systems program PSO5	specific ou PSO6	tcomes PSO7	PSO8		
C05	fluc Des Mapp PSO1 3	tuations. cribe physic ing of cour PSO2 3	cal quantiti rse outcom PSO3	es in quantu es with the PSO4	program PSO5 2	s. specific ou PSO6 3	PSO7	PSO8 3		
CO5 CO1 CO2	fluc Des Mapp PSO1 3 1	tuations. cribe physio ing of cour PSO2 3 -	cal quantiti rse outcom PSO3 1 -	es in quantu es with the PSO4 1 -	PSO5	s. specific ou PSO6 3 -	rtcomes PSO7 3 2	PSO8 3 1		

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#### **Detailed Syllabus:**

- 1. The Statistical Basis of Thermodynamics: The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution. (Lectures 8)
- 2. Ensemble Theory: Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations. *(Lectures 8)*
- 3. Quantum Statistics of Ideal Systems: Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism.

(Lectures 10)

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- 4. Elements of Phase Transitions: Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation. *(Lectures 4)*
- 5. Fluctuations: Thermodynamic fluctuations, random walk and Brownian motion, introduction to nonequilibrium processes, diffusion equation. (Lectures 3)

TUTORIALS: Relevant problems given in the end of each chapter in the text book.

#### **Text Books :**

1. Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 3rd edition, 2011.

#### **Reference Books :**

- 1. Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi), 1987.
- 2. Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 2nd edition, 2011.
- 3. Elementary Statistical Physics: C. Kittel (Wiley, New York), 2004.
- 4. Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.

PHS41	5	Atomic and	Molecular	Physics	L-3, T-	-1, P-0	4 Cr	edits
Pre-requi	site: Nor	ne						
the studer	nts of M	s: The aim and I.Sc. Physics and Electro	is to equi	ip them w				
Course O	utcomes	: At the end c	of the course	e, the stude	nt will be a	ble to		
C01	U	nderstand bas	sic elements	s of atomic	and molect	ular spectro	oscopy	
CO2		nderstand contational spec		antum de	scription	of electro	nic, vibra	tional an
CO3		orrelate spect hysical descri	2 m 2	formation (	of known a	nd unknow	n molecule	s with thei
CO4	U	nderstand and	d use Rama	n Spectroso	copy for an	alysis of m	olecules	2
C05		nderstand Sp nalysis	in Resonand	ce Spectros	copy with	focus on N	MR for mo	lecular
	Ma	pping of cou	rse outcom	es with the	e program	specific ou	tcomes	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3	3	3	2	3	2	2	3
CO2	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3
CO4	3	3	3	2	3	3	3	3
	3	3	3	2	3	3	3	3

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#### **Detailed Syllabus:**

- Electronic Spectroscopy of Atoms: Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non-equivalent electrons –X-ray photoelectron spectroscopy. (Lectures 8)
- Electronic Spectroscopy of Molecules: Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition - molecular orbital theory – the spectrum of molecular hydrogen – change of shape on excitation – chemical analysis by electronic spectroscopy – reemission of energy – fundamentals of UV photoelectron spectroscopy. (Lectures 9)
- Microwave and Raman Spectroscopy: Rotation of molecules and their spectra diatomic molecules intensity of line spectra the effect of isotropic substitution non-rigid rotator and their spectra polyatomic molecules (linear and symmetric top molecules) Classical theory of Raman effect pure rotational Raman spectra (linear and symmetric top molecules). (Lectures 8)
- 4. Infra-red and Raman Spectroscopy: The energy of diatomic molecules Simple Harmonic Oscillator the Anharmonic oscillator the diatomic vibrating rotator vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation the vibrations of polyatomic molecules –influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) Raman activity of vibrations vibrational Raman spectra vibrations of Spherical top molecules.

(Lectures 8)

4 Credits

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 Spin Resonance Spectroscopy Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin-lattice relaxation - NMR chemical shift coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. (Lectures 8)

#### **Text Books:**

1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).

#### **Reference Books:**

1. Physical method for Chemists (Second Edition) by Russell S. Drago (Saunders College Publishing).

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- 2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1934.
- 3. Spectroscopy Vol. I, II & III: Walker & Straughen
- 4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1962.
- 5. Spectra of diatomic molecules: Herzberg-New York, 1944.
- 6. Molecular spectroscopy: Jeanne L. McHale

PHS416 Physics Lab- I

Pre-requi	site: ]	None			1.4		14		
students o	f M.S d in	Sc. class	to expe	nd objectiv rimental set n earlier cla	ups in elec	tronics so	that they o	an verify s	some of th
Course O	utcon	nes: At	the end o	of the course	, the studer	nt will			
CO1		Acqui	re hands	on experien	ce of handl	ing and bu	ilding elec	tronics circ	uits.
CO2				th the variou to use these				capacitor, i	nductor, I
CO3		Be abl	le to und	erstand the o ces such as	construction	n, working	principles		aracteristic
CO4		Capab	le of usin	ng compone	nts of digita	al electron	ics for varie	ous applica	tions.
C05				and perfor results of e			ents as wel	ll as accura	ately recor
	ľ	Mappin	g of cour	rse outcomo	es with the	program	specific ou	tcomes	<u></u>
	PS	01	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1		2	2	1 1 1 1 1 1 1 1	2	2	3	3
CO2	1		2	2	1	-	2	2	3
CO3	1		3	3	1 1 10000	2	3	3	2
CO4	-		3		2	1	3	3	2
0.04									

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#### List of experiments:

- 1. Study the forward and reverse characteristics of a Zener diode.
- 2. Construction of adder, subtracter, differentiator and itergrator circuits using the given OP-Amp.
- 3. Study the static and drain characteristics of a JFET
- 4. Construction of an Astable multivibrator circuit using transistor
- 5. Construction of a single FET amplifier with common source configuration
- 6. Construction of an A/D converter circuit and study its performance
- 7. Construction of an D/A converter circuit and study its performance
- 8. Construction of a low-pass filter circuit and study its output performance
- 9. Construction of a high-pass filter circuit and study its output performance
- 10. Electron Spin Resonance Spectrometer Experiment
- 11. Four Probe Method- Determination of resistivity of semiconductor at different temperature
- 12. To study pulse amplitude, Pulse width and Pulse position modulation
- 13. To study the frequency response of an operational amplifier
- 14. To study the characteristics of multivibrators- bistable, Astable, monostable
- 15. To find the wavelength of sodium light using Michelson interferometer.

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PHS421		Mathen	atical Phys	sics-II	L-3, T	-1, P-0	4 Cr	edits
Pre-requi	site: No	one				2012.1		
the M.Sc. theoretical	Stude treatn	es: The aim a nts with the nent in differ she chooses to	mathemati	cal technic s taught in	ques that 1 this clas	he/she nee s and for	ds for un	derstanding
Course O	utcome	es: At the end	of the cours	e, the stude	nt will able	to		
C01		Apply of grou	p theory in	all the bran	ches of Phy	vsics.		
CO2		Use Fourier se	eries and tra	nsformation	ns as an aid	for analyz	ing experin	nental data.
CO3		Use integral tr	ansform to	solve mathe	ematical pro	oblems of i	nterest in P	hysics.
CO4		Understand th Physics.	e applicatio	ns of Delta	and gamm	a functions	s in all the	branches o
C05		Develop math	ematical ski	lls to solve	quantitativ	e problems	in physics.	
	M	apping of cou	rse outcom	es with the	program	specific ou	tcomes	
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	1	3	1	3	3	1	2	3
CO2	1	3	2	2	2	2	2	3
CO3 1		3	2	2	2	2	2	3
CO3								-
CO3 CO4	1	3	2	3	2	-	2	3

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#### **Detailed syllabus:**

- 1. **Group Theory :**What is a group ? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3).
- 2. Delta and Gamma Functions :Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function.
- 3. Special Functions :Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions : generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynominals. Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.
- 4. Fourier Series and Integral Transforms : Fourier series, Dirichlet conditions. General properties. Advantages and applications, Gibbs phenomenon. Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation. Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation.

#### **Text Books :**

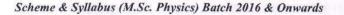
1. Group Theory for Physicists : A.W. Joshi (Wiley Eastern, New Delhi) 2011.

2. Mathematical Methods for Physicists : G. Arfken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2012.

#### **Reference Books :**

1. Matrices and Tensors in Physics : A.W. Joshi (Wiley Eastern, New Delhi) 2005.

- 2. Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.
- 3. A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
- 4. Mathematical Physics : P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
- 5. Introduction to Mathematical Physics : C. Harper (Prentice Hall of India, New Delhi) 2006.



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PHS42	2	Nuc	lear Physic	cs	L-3, T	-1, <b>P-0</b>	4 Ci	edits
Pre-requi	site: None							-
students o radioactive	f M.Sc. c e decays, 1	The aim ar lass to the nuclear force used in stud	basic aspected es, nuclear	cts of Nucl models, an	lear Physic	s like stati	c propertie	s of nucle
Course O	utcomes:	At the end o	of the cours	e, the stude	ent will be a	ble to		
C01		derstand str es of nuclea			of nuclei, ra	idioactive o	lecay, and c	lifferent
CO2	Un	derstand Qu	antum beh	avior of ato	oms in exter	nal electric	and magne	etic fields.
CO3	Co	mpare vario	us nuclear	models and	nodels and properties of the nucleus.			
CO4	Un	Understand about nuclear forces and their depe		their depen	idence on v	arious para	meters.	
C05	Des	scribe vario	us types of	nuclear rea	ctions and	their prope	rties.	
i pina te ting:	Марј	oing of cour	rse outcom	es with the	e program	specific ou	tcomes	
( decar	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	3	3	3	3	3	3
CO2	1	3	1	3	3	3	3	3
CO3	1	3	1	3	3	3	3	3
CO4	1	3	1,00100	3	3	3	3	3
CO5	1	3	2	3	2	3	3	3

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#### **Detailed Syllabus:**

- 1. Nuclear Models: Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective model-nuclear vibrations spectra and rotational spectra. (Lectures 8)
- 2. Static properties of nucleus: Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfinestructure, effect of external magnetic field, Nuclear magnetic resonance. (Lectures 5)
- 3. Nuclear decay: Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Double beta decay, Neutrino, detection of neutrinos, measurement of the neutrino helicity. Multipolarity of gamma transitions, internal conversion process, transition rates. (Lectures 6)
- 4. Nuclear forces: Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, n-p scattering at low energies, partial wave analysis, scattering length, spin-dependence of n-p scattering, effective-range theory, coherent and incoherent scattering, central and tensor forces, p-p scattering, exchange forces & single and triplet potentials, meson theory of nuclear forces. (Lectures 8)
- 5. Neutron physics: Neutron production, slowing down power and moderating ratio, neutron detection. (Lectures 3)
- 6. Nuclear reactions: Nuclear reactions and cross-sections, Resonance, Breit–Wigner dispersion formula for l=0 and higher values, compound nucleus, Coulomb excitation, nuclear kinematics and radioactive nuclear beams. (Lectures 4)

#### **Text Books :**

1. Nuclear Physics : Irving Kaplan (Narosa), 2002.

2. Theory of Nuclear Structure : R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.

#### **Reference Books :**

1.Basic Ideas and Concepts in Nuclear Physics : K. Hyde (Institute of Physics) 2004. 2.Nuclear physics: Experimental and Theoretical, H.S. Hans (New Academic Science) 2nded

(2011).

- 3. Nuclear Physics and its applications by John Liley
- 4. Nuclear Physics V. Devnathan

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PHS423	Quantum Mechanics-II	L-3, T-1, P-0	4 Credits		

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Pre-roomi	sito.	Prolim	inory oor	se of Quanti	Im Mash-	ina			
rre-requi	site.	rienn	imary cour	se or Quanti	Im Mechan	iles			
introduce techniques	the N s of I	A.Sc. s Relativ	students to vistic quant	and objecti the formal tum mechan sics as per h	structure onics and Qu	f the subje antum fie	ect and to a	equip him/l	ner with th
Course O	utcor	nes: A	t the end o	of the course	, the studer	nt will be a	ble to		
C01		Und theo		ativistic effe	ects in quan	tum mech	anics and n	leed for qua	ntum field
CO2 Demonstrate the Lorentz covariant form of Lagrangian and Hamiltonian scalar, vector fields, electromagnetic fields and their second quantisation.									
CO3				symmetries ents and cha		plications	of Noethe	r's Theoren	1 in
CO4		Und	erstand the	interaction	picture, S-1	natrix, and	d Wick's Th	neorem.	
C05				gin of Feynr for element				nman rules	to derive
	1	Mappi	ing of cour	se outcome	s with the	program	specific ou	tcomes	
	PS	01	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1		1	2	2	2	2	2	3
CO2	1		2	2	2	2	2	3	1
CO3	1		2	3	3	2	1	2	2
CO4	1		3	3	3 - 1 1	2	1	2	3
CO5	1		2	1	3	2	2	3	3

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#### **Detailed Syllabus:**

1. Relativistic Quantum Mechanics-I: Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation.

#### (Lectures 12)

2. **Relativistic Quantum Mechanics-II:** Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.

#### (Lectures 10)

3. **Quantum Field Theory:** Resume of Lagrangian and Hamiltonian formalism of a classical field, Quantization of real scalar field, complex scalar field, Dirac field and e.m. field, Covariant perturbation theory, Wick's theorem, Scattering matrix.

Feynman diagrams: Feynman diagrams and their applications, Wick's theorem, Scattering matrix, QED.

(Lectures 8)

#### **Text Books:**

- 1. Text Book of Quantum Mechanics -P.M. Mathews & K. Venkatesan-Tata McGraw Hill 2010
- 2. Quantum Mechanics G Aruldhas Prentice Hall of India 2006
- 3. Introduction to Quantum Mechanics David J.Griffiths Pearson Prentice Hall, 2005
- 4. Quantum Mechanics A Devanathan Narosa Publishing-New Delhi
- 5. Quantum Mechanics L.I Schiff McGraw Hill 1968
- 6. Quantum Mechanics A.K. Ghatak and S. Loganathan-McMillan India
- 7. Principles of Quantum Mechanics R.Shankar, Springer 2005
- 8. Quantum Mechanics Satya Prakash- KatharNathRamnath Meerut

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MSPH 4	24 Cor	nputationa	l Physics		L-3, T-	-1, P-0	4 Cr	edits
Pre-requis	site: None							
familiarize programmi	the of ing using a	M.Sc. stuc	lents with /el language	ive of the the numer e such as Fo	ical meth	nods used	in compu	itation and
Course O	atcomes: 2	At the end o	f the course	, the studen	t will be a	ble to		
C01	and the second se	bly basics blems.	knowledge	of compu	itational j	ohysics in	solving t	he physic
CO2	Pro	gramme wi	th the C++ o	or any other	high leve	l language.		
CO3	Use	various nu	merical met	hods in solv	ing physi	cs problem	s.	
CO4	Ana	alyze the ou	tcome of th	e algorithm/	program ı	ising graph	nic plots.	
C05	Apj	oly physics	knowledge	in understar	iding inter	disciplinar	y problem/	concepts.
	Марр	oing of cour	rse outcom	es with the j		specific ou	tcomes	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3	3	115	1.000	2	3	3	3
CO2	1	-			dih//=		2	1
CO3	3	3	2	2	2	2	3	3
CO4	2	3	2	1	2	1	2	3
CO5	2	3	3	2	3	2	3	3

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#### **Detailed Syllabus:**

**1.Introduction to high level language:** Need and advantages of high level language in physics, programming in a suitable high level language (Matlab/Mathematica/Scilab/ Octave), input/output, interactive input, loading and saving data, loops branches and control flow. Matrices and Vectors, Matrix and array operations, eigenvalues and eigen vectors. *(Lectures 12)* 

2.Sub programs: Advantages of modular programming, built-in functions, scripts, functions, sharing of variables between modules. (Lectures 8)

**3.Graphics:** 2D plots, style options, axis control, overlay plots, subplot, histogram, 3D plots, mesh and surface plots, contour plots. *(Lectures 8)* 

**4.Numerical computation:** Computer programs for: solving linear system of simultaneous equations, nonlinear algebraic equation, roots of polynomials, curve fitting, polynomial curve fitting, least square curve fitting, interpolation, data analysis and statistics, numerical integration, Monte-Carlo simulation, ordinary differential equation, first order and second order ODEs, event location. *(Lectures 15)* 

#### 5. List of experiments:

- 1.Black body radiation (computation and graphical representation)
- 2.Reflection and transmission of an electromagnetic wave
- 3. Statistical distributions at different temperatures
- 4.Binding energy curve for nuclei using liquid drop model
- 5.Eigen-value problem: 1-D square potential well
- 6. Eigen-values and wave-functions of a simple harmonic oscillator
- 7.Monte-Carlo simulation
- 8.Linear/Projectile motion (simulation and solutions)

#### **Text Books:**

- 1. Pratap R, "Getting started with MATLAB 7", Oxford Univ. Press, 2006
- 2. Gilat A, "Matlab: An introduction with applications", Wiley, 2008
- 3. Eaton J W, Batchman D and Hauberg S "GNU Octave Manual Version 3", Network Theory Ltd.2008
- Campbell S, Chancelier J P and Nikoukhah R, "Modeling and simulation in Scilab", Springer 2005
- 5. "Mathematica Information Center ('MathSource')": <u>http://library.wolfram.com/infocenter/</u>2009
- 6. Gerald C F and Wheatley P O, "Applied Numerical Analysis", 7th Ed, Addison Wesley, 2003

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PHS42	5	Conden	sed Matter P	hysics-I	L-3, T-	-1, P-0	4 Cr	edits	
Pre-requis	site: N	one						al Sta	
expose the properties,	stude	nts of M.Sc. y band theor	n and objectiv class to the t ry and transpo pects of the m	opics like o ort theory so	elastic cons that they	tants, lattic are equipp	e vibration	s, dielectrie	
Course O	utcom	es: At the er	d of the cours	e, the stude	nt will be a	ble to			
CO1		Understand	basic element	s of crystal	structure o	f condense	d matter.		
CO2		Understand crystalline s	accurate deso solids.	cription of	lattice dyn	amics and	thermal p	roperties o	
CO3		Understand	origin of ener	gy bands in	solids with	focus on s	semiconduc	tors.	
CO4	1997	Describe an	d understand l	oasics of tra	insport prop	perties acro	ss solids.	olids.	
C05		Describe an	d understand	magnetic ar	d dielectric	behavior	of solids.		
	M	lapping of c	ourse outcom	es with the	e program	specific ou	tcomes		
	PSC	D1 PSO	2 PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
C01	3	3	3	3 3 3	. 2	1	3	2	
CO2	3	3	3	3	3	3	3	3	
CO3	3	3	3	3	3	3	3	3	
<b>CO4</b> 3		3	3	3	3	3	3	3	
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#### **Detailed Syllabus:**

#### 1.Elastic constants :

Binding in solids; Stress components, stiffness constant, elastic constants, elastic waves in crystals.

#### 2.Lattice Dynamics and Thermal Properties :

Rigorous treatment of lattice vibrations, normal modes; Density of states, thermodynamic properties of crystal, anharmonic effects, thermal expansion.

#### **3.Energy Band Theory:**

Electrons in a periodic potential: Bloch theorem, Nearly free electron model; tight binding method; Semiconductor Crystals, Band theory of pure and doped semiconductors; elementary idea of semiconductor superlattices.

#### 4. Transport Theory:

Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance.

#### **5.Dielectric Properties of Materials:**

Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity.

#### **6.Liquid Crystals :**

Thermotropic liquid crystals, Lyotropic liquid crystals, long range order and order parameter, Various phases of liquid crystals, Effects of electric and magnetic field and applications, Physics of liquid crystal devices.

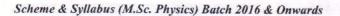
TUTORIALS :Relevant problems given in the books listed below.

#### **Text Books:**

- 1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
- 2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

#### **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1972
- 2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
- 3. Liquid Crystals: S. Chandrasekhar (Cambridge University), 2nd ed. 1992.



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PHS42	6	Phy	sics Lab-II		L-3, T	-1, P-0	4 Cr	edits
Pre-requis	site: Noi	ne			- Carlos			
M.Sc. stuc	lents to	s: The aim a experimental obtained in t	techniques	in atomic	and nuclea	r physics s	so that they	can verify
Course O	utcomes	: At the end o	of the course	, the stude	nt will be a	ble to		
C01		cquire hands Scintillation		ice of usin	g particle d	letectors su	ch as GM	counter and
CO2	h	andle oscillos	scope for vis	ualisation	of various i	input and o	utput signa	ls.
CO3	U	nderstand the	e basic of nu	clear safel	y managem	nent.		
CO4		erform scien esults of nucle			well as ac	curately re	cord and a	analyze th
CO5		olve applied 1	-		critical thir	nking and a	nalytical re	asoning.
	Ma	pping of cou	rse outcome	es with the	e program	specific ou	tcomes	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	1	2	1	2	1	3	3	3
CO2	1	1	1	3	1	3	1	3
<b>CO3</b> 1		1	1	3	1	3	1	2
<b>CO</b> 4	1	3	3	3	-1	3	3	3
CO5	1	3	3	3	1	3	3	3

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#### **Detailed Syllabus:**

## Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot interferometer.
- 2. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
- 3. Determination of Lande's factor of DPPH using Electron-spin resonance (E.S.R.) spectrometer
- 4. Determination of ionization Potential of Lithium
- 5. Analysis of pulse height of gamma ray spectra
- 6. To study the characteristics of G.M. counter
- 7. To determine the dead time of G.M. counter
- 8. To study absorption of beta particles is matter
- 9. To study Gaussian distribution using G.M. counter
- 10. Source strength of a beta source using G.M counter
- 11. Determination of Planck's constant using Photocell and interference filters.
- 12. Recording and calibrating a gamma ray spectrum by scintillation counter
- 13. Detecting gamma radiation with a scintillation counter
- 14. To study absorption of gamma radiation by scintillation counter
- 15. Identifying and determining the activity of weakly radioactive samples

#### **Text Books:**

- 1. Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
- 2. Physics of Atoms and Molecules by B. H. Bransden and C. J. Joachain.

#### **Reference Books:**

- 1. Physical method for Chemists (Second Edition) by Russell S. Drago (Saunders College Publishing).
- 2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1934.
- 3. Spectroscopy Vol. I, II & III: Walker & Straughen
- 4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1962.
- 5. Spectra of diatomic molecules: Herzberg-New York, 1944.

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	7	Compu	itational I	ab	L-3, T	-1, P-0	4 Cr	edits			
Pre-requis	site: Non	9									
students of as C++ lar	f M.Sc. cl nguage fo	The aim an ass in unders r simulation at they are v	tanding nu of results	merical me for differen	thods, the unit physics p	usage of hip problems a	gh level lan nd graphic	guage such analysis o			
Course O	atcomes:	At the end of	f the cours	e, the stude	nt will be a	ble to					
CO1 Understand and apply basics knowledge of numerical methods in solving physics problems.											
CO2	W	Write programme with the C++ or any other high level language.									
CO3	Le	Learn use of graphical methods in data analysis and solving physics problems									
CO4		Solve physical problem, enabling development of critical thinking and analy reasoning.									
CO5		plore applica earch in phys		West of the second second second	physics in	frontier are	eas of pure	and applied			
	Map	ping of cour	se outcom	es with the	e program	specific ou	tcomes				
	PSO1										
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8			
C01	PSO1 1	PSO2 2	PSO3	PSO4 3	PSO5	PSO6	PSO7 3	PSO8 3			
C01 C02		- Contraction of a second	Constant of the local division of the local		Carry Carry						
	1	2	1	3	3	1	3	3			
CO2	1 2	2	1	3	3	1 2	3	3			

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#### **Detailed Syllabus:**

- 1. Black body radiation (computation and graphical representation)
- 2. Reflection and transmission of an electromagnetic wave
- 3. Statistical distributions at different temperatures
- 4. Binding energy curve for nuclei using liquid drop model
- 5. Eigen-value problem: 1-D square potential well
- 6. Eigen-values and wave-functions of a simple harmonic oscillator
- 7. Monte-Carlo simulation
- 8. Linear/Projectile motion (simulation and solutions)

## **Text Books:**

- 1. Pratap R, "Getting started with MATLAB 7", Oxford Univ. Press, 2006
- 2. Gilat A, "Matlab: An introduction with applications", Wiley, 2008
- 3. Eaton J W, Batchman D and Hauberg S "GNU Octave Manual Version 3", Network Theory Ltd.2008
- 4. Campbell S, Chancelier J P and Nikoukhah R, "Modeling and simulation in Scilab", Springer 2005
- 5. "Mathematica Information Center ('MathSource')": <u>http://library.wolfram.com/infocenter/</u>2009
- 6. Gerald C F and Wheatley P O, "Applied Numerical Analysis", 7th Ed, Addison Wesley, 2003

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I. K. Gujral Punjab Technical University, Kapurthala

PHS53	1	C	ondensed	Matter Ph	ysics-II	L-3, T	-1, P-0	4 Cr	redits		
Pre-requis	site: 1	None									
expose the properties,	stud ener	ents of gy bar	f M.Sc. cl nd theory a	ass to the t	opics like e rt theory so	elastic cons that they	tants, lattic are equipp	e vibration	hysics is to s, dielectric techniques		
Course O	utcon	nes: A	t the end o	f the course	e, the stude	nt will be a	ble to				
C01											
CO2		Understand and describe magnetic properties of solids									
CO3	CO3 Understand use of NMR methods for describing solids										
CO4	CO4 Understand and explain the behavior of superconductors										
CO5 Understand the effect of defects and deformation on the behavior of solids									lida		
COS									Jilus		
	r	viappi	ng of cour	se outcom	es with the	program	specific ou	tcomes			
	PS	01	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
CO1	3		3	3	3	2	1	3	2		
CO2	3		3	3	3	3	3	3	3		
CO3	3		3	3	3	3	3	3	3		
CO4	3		3	3	3	3	3	3	3		
					2			1			

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## **Detailed Syllabus:**

- 1. **Optical Properties** :Macroscopic theory generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect; interband transitions. *(Lectures 8)*
- Magnetism:Dia- and para-magnetism in materials, Pauli paramagnetism, Exchange interaction. Heisenberg Hamiltonian mean field theory; Ferro-, ferri-and antiferromagnetism; spin waves, Bloch T3/2 law. (Lectures 8)
- 3. Principles of Magnetic Resonance: ESR and NMR equations of motion, line width, motional narrowing, Knight shift. (Lectures 8)
- 4. **Superconductivity** :Experimental Survey; Basic phenomenology; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Vortex state of a Type II superconductors; Tunneling Experiments; High Tc superconductors. *(Lectures 8)*
- Disordered Solids : Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, glasses, amorphous semiconductors and ferromagnets, heat capacity and thermal conductivity of amorphous solids, nanostructures short expose; Quasicrystals. (Lectures 8)

#### **Text Books:**

- 1. Introduction to Solid State Physics : C. Kittel (Wiley, New York) 2005.
- 2. Quantum Theory of Solids : C. Kittel (Wiley, New York) 1987.

#### **Reference Books:**

- 1. Principles of the Theory of Solids : J. Ziman (Cambridge University Press) 1972.
- 2. Solid State Physics : H. Ibach and H. Luth (Springer, Berlin), 3rd. ed. 2002.
- 3. A Quantum Approach to Solids : P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.
- 4. Intermediate Quantum Theory of Solids : A.O.E. Animalu (East-West Press, New Delhi), 1991.
- 5. Solid State Physics : Ashcroft and Mermin (Reinhert & Winston, Berlin), 1976.



PHS532	Classical Electrodynamics	L-3, T-1, P-0	4 Credits
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#### **Pre-requisite:** None **Course Objectives:** The Classical Electrodynamics course covers Electrostatics and Magnetostatics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; EM waves in bounded media, waveguides, Radiation from time varying sources. Course Outcomes: At the end of the course, the student will be able to **CO1** Understand and apply the laws of electromagnetism and Maxwell's equations in different forms and different media. CO2 Solve the electric and magnetic fields problems for different configurations. CO3 Provide solution to real life plane wave problems for various boundary conditions. **CO4** Calculate reflection and transmission of waves at plane interface. CO5 Analyze propagation of electromagnetic waves through different waveguides. Mapping of course outcomes with the program specific outcomes PSO1 PSO<sub>2</sub> PSO3 PSO4 PSO5 PSO6 PSO8 PSO7 **CO1** 3 3 1 2 1 2 1 2 CO<sub>2</sub> 3 3 1 2 2 2 2 2

3

3

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**CO3** 

**CO4** 

**CO5** 

3

3

3

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#### **Detailed Syllabus:**

- 1. Electrostatics: Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor). (Lectures 10)
- 2. **Magnetostatics:** The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor)

#### (Lectures 8)

- 3. **Boundary value problems:** Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems. *(Lectures 8)*
- 4. Time varying fields and Maxwell equations: Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum.

#### (Lectures 8)

- 5. Electromagnetic Waves: wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide, Waves in rarefied plasma (ionosphere) and cold magneto-plasma, Frequency dispersive characteristics of dielectrics, conductors and plasmas. *(Lectures 8)*
- 6. Radiation from Localized Time varying sources: Solution of the inhomogeneous wave equation in the absence of boundaries, Fields and radiation of a localized oscillating source, electric dipole and electric quadrupole fields, center fed antenna. (Lectures 4)

#### **Text Books:**

- 1. Classical Electrodynamics: S.P. Puri (Narosa Publishing House) 2011.
- 2. Classical Electrodynamics: J.D. Jackson, (New Age, New Delhi) 2009.
- 3. Introduction to Electrodynamics: D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2012.

#### **Reference Books:**

- 1. Classical Electromagnetic Radiation: J.B. Marion and M.A. Heald(Saunders College Publishing House) 3rd edition, 1995.
- 2. Electromagnetic Fields, Ronald K. Wangsness (John Wiley and Sons) 2nd edition, 1986, no.
- 3. Electromagnetic Field Theory Fundamentals: Bhag Singh Guru and H.R. Hizkoglu

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PHS53	13	Pa	rticle Physic	es	L-3, T	-1, P-0	4 Cr	edits	
Pre-requi	site: co	urse on Quan	tum mechan	ics and Qua	antum field	Theory			
invariance static quar	princip k mode	ctive of the co les and conse l of hadrons a r perspective.	ervation laws	, hadron-ha	adron intera	actions, rela	ativistic kin	ematics,	
Course O	utcome	s: At the end	of the cours	e, the stude	nt will be a	ble to unde	erstand	2.4	
CO1 Overview of particle spectrum, their interaction and major historical and la developments.									
CO2		Various invar	iance princip	les and syr	nmetry pro	perties in p	article phys	ics.	
CO3		Basic rules of Feynman diagrams and the quark model for hadrons.							
CO4 Properties of neutrons and protons in terms of a simple nonreltivis model.							vistic quai		
CO5		Weak interact	tion between	quarks and	l how that t	his is respo	nsible for f	decay.	
adia di Ci	M	apping of cou	urse outcom	es with the	e program	specific ou	tcomes		
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8	
CO1	2	2	2 cased	3	3	1	2	3	
CO2	2	2	2	3	3	1	2	3	
CO3	2	2	1	3	3	1	2	3	
	1	1	1	3	3	2	3	3	
CO4				AL	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				

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#### **Detailed Syllabus:**

1. Introduction: Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units.

(Lectures 7)

- 2. Invariance Principles and Conservation Laws: Invariance in classical mechanics and quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem. (Lectures 7)
- Hadron-Hadron Interactions: Cross section and decay rates, Pion spin, Isospin, Two nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy. (Lectures 7)
- Relativistic Kinematics and Phase Space: Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, recursion relation, effective mass, dalitz, K-3 p-decay, t-θ puzzle, dalitz plots for dissimilar particles, Breit-Wigner resonance formula, Mandelstem variables. (Lectures 7)
- 5. Static Quark Model of Hadrons: The Baryon decuplet, quark spin and color, baryon octer, quark-antiquark combination. (Lectures 7)
- 6. Weak Interactions: Classification of weak interactions, Fermi theory, Parity non conservation in β-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K- decay and its experimental determination.

(Lectures 7)

#### **Text Books:**

1.

1. Introduction to High Energy Physics : D.H. Perkins (Cambridge University Press), 42000.

#### **Reference Books:**

- 1. Elementary Particles : I.S. Hughes (Cambridge University Press), 3rded. 1991.
- 2. Introduction to Quarks and Partons : F.E. COse (Academic Press, London), 1979.
- 3. Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.

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Head Anthent of Physical Sciences
Departal Punjau I.K. Gujral Punjau Main Campus

PHS534 Electronics

L-3, T-1, P-0

4 Credits

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## Pre-requisite: Basic knowledge about electronics

**Course Objectives:** The aim and objective of the course on **Electronics** is to introduce the students of M.Sc. class to the formal structure of the subject and to equip them with the knowledge of semiconductor physics, basic circuit analysis, first-order nonlinear circuits, OPAMP based analog circuits and introduction to digital electronics so that they can use these in various branches of physics as per their requirement.

Course Outcomes: At the end of the course, the student will be able to

Learn about the construction and working of Thyristors and various applications of Thyristors.
Thynstois.
Understand Analog and Digital Instruments and their applications.
Enable them for using Boolean algebra and Karnaugh maps.
Introduce them to the Sequential and Integrated circuits.

	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	3	2	2	2	3	1	3	3
CO2	2	2	1	1	1	1	3	2
CO3	-	1	1	1	-	2	3	3
CO4	-	3		<u> </u>	-		3	2
CO5	-	2	2	2	1	3	3	1

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#### **Detailed Syllabus:**

- Analog and Digital Instruments: Introduction-Basic Emitter Follower Voltmeter; FET Input Voltmeter; Voltage Follower Voltmeter; Amplifier Type OP AMP Voltmeter; Voltage to Current Converter; Current Measurement with Analog Electronic Instrument; Time Base; Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System; Digital LCR Measurements. (Lectures 8)
- 2. UJTs and Thyristors: Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors-As a Pulse Generator, BistableMultivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. (Lectures 10)
- Digital Integrated Circuits: 7400 TTL; TTL Parameters; TTL-MOSFET's; CMOS FET's;Three State TTL Devices; External drive for TTL Loads; TTL Driving External Loads; 74C00 CMOS; CMOS Characteristics; TTL to CMOS Interface; CMOS to TTL interface; Current Tracers. (Lectures 7)
- 4. Integrated Circuits as Analog System Building Blocks: Electronic Analog Computation; Active Filters: Butterworth Filter-Practical Realization-High Pass Filter-Band Pass Filter-Band Reject Filter; Delay Equalizer; Switched Capacitor Filters; Comparators; Sample and Hold Circuits; Waveform Generators: Square Wave Generator Pulse Generator-Triangle wave Generator-Sawtooth Generator; Regenerative Comparator: Schmitt Trigger.
- 5. Integrated Circuits as Digital System Building Blocks: Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM:Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM ElementsBipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter. (Lectures 8)

## **Text Books:**

- 1. Text Book of Electronics: S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
- 2. Digital Principles and Applications: A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.

## **Reference Books:**

- 1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
- 2. Integrated Electronics Analog and Digital Circuits and Systems: J. Millman, C.C Halkins and C. Parikh, 2<sup>nd</sup> Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

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PHS53	5	Fibre Optics	and Non-li	near optics	L-3, T	-1, P-0	4 Cr	edits		
Pre-requis	site: No	one					and the second sec			
and Nonli	near C	es: Course C Optics is to express and their u	pose the M	I.Sc. student						
Course Oi	itcome	s: At the end	of the cours	e, the studer	nt will be a	ble to				
CO1 Understand the structure of optical fiber and describe properties of optical fiber										
CO2	1	Understand and compare the various processes of fibers fabrication								
CO3	1	Understand the principles of fiber optics communication in different media								
CO4		Analyze the electro-optic and acousto-optic effects in fibers								
C05	1	Understand no	n-linear eff	ects in optic	al fibers.					
	M	apping of cou	rse outcom	es with the	program	specific ou	tcomes			
	PSO	1 PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8		
C01	-	2	a tol.i	2	-	1	2	3		
CO2	-	2	<b>1</b>	2			1	3		
CO3	-	1		2	T M		1	3		
CO4	-	2	at inareli	2	25.28	-	1	3		

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## **Detailed Syllabus:**

- Optical fibre and its properties: Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. (Lectures 7)
- Fiber fabrication and cable design: Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. (Lectures 5)
- 3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations. *(Lectures 10)*
- 4. Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.

(Lectures 10)

5. Non-linear optics/processes: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities. *(Lectures 8)* 

#### **Text Books:**

1. The Elements of Fibre Optics: S.L. Wymer and Meardon (Regents/Prentice Hall), 1993.

#### **Reference Books:**

- 1. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press), 1996.
- 2. Optical Electronics: Gathak & Thyagarajan (Cambridge Univ. Press), 1989.
- 3. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge/University Press), 1991.

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Elective Subject -I

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PHS53	16	Plasma Physics L-3, T-1, P-0 4									
Pre-requi	site: Cours	e on Electr	odynamics								
Course O M.Sc. stu	bjectives: dents to the	The aim a e basics of t	and objecti the challeng	ve of the or ging researc	course on 1 ch field Pla	<b>Plasma Ph</b> sma physic	<b>ysics</b> is to s.	expose the			
Course O	utcomes:	At the end o	of the cours	e, the stude	ent will be a	ible to	illing				
C01		Understand the origin of plasma, conditions of plasma formation and properties of plasma.									
CO2	Dis stat	Distinguish between the single particle approach, fluid approach and kinetic statistical approach to describe different plasma phenomena.									
C03		Classify propagation of electrostatic and electromagnetic waves in magnetized plasmas									
C04		cribe the b bility for bo						iffusion and			
C05											
1	Mapp	ing of cour	rse outcom	es with the	e program	specific ou	tcomes				
1111	PSO1		PSO3	PSO4	PSO5	PSO6	PSO7	PSO8			
C01	3	-	2	2	3	3	1	-			
CO2	3	3	3	3	3	3	1	-			
					a set of the set of th						

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**CO4** 

CO5

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## **Detailed Syllabus:**

- 1. Introduction: Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge. (Lectures 8)
- 2. Plasma diagnostics: Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts. (Lectures 5)
- 3. Single particle orbit theory: Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves.

#### (Lectures 8)

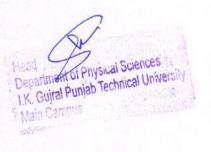
- 4. Fluid description of plasmas: distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations. dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves, Magnetosonic waves. (Lectures 10)
- 5. Stability of fluid plasma: The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle. microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties. (Lectures 7)

#### **Text Books:**

1. Introduction to Plasma Physics, F.F. Chen

#### **Reference Books:**

- 1. Principles of Plasma Physics, Krall and Trievelpice
- 2. Introduction to Plasma Theory, D.R. Nicholson
- 3. The Plasma State, J.L. Shohet
- 4. Introduction to Plasma Physics, M. Uman
- 5. Principles of Plasma Diagnostic, I.H. Hutchinson



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PHS53	37	Nonlin	lear Dynar	nics	L-3, T	-1, P-0	4 Ci	redits				
Pre-requi	site: None		-									
the M.Sc.	<b>bjectives:</b> students w an systems	The aim an ith the basi	nd objective cs of the re	e of the cou cently eme	rse on <b>Non</b> rging resea	l <b>inear Dyr</b> rch field of	amics is to dynamics	o familiariz of nonline:				
Course O	utcomes:	At the end o	of the cours	e, the stude	ent will be a	ble to						
C01		Understand basic knowledge of nonlinear dynamics and phenomenology of chaos										
CO2	App	Apply the tools of dynamical systems theory in context to models										
CO3	Lea	Learn skills by solving problems on solving nonlinear problems using numerica methods.										
CO4	Und	Understand Hamilton approach for describing various physical system										
CO5	Qua	ntify classi	cal chaos a	nd Quantur	n chaos							
	Марр	ing of cour	rse outcom	es with the	e program	specific ou	tcomes					
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8				
CO1	2	3	3	3	3	2	3	1				
CO2	-	3	3	3	3	2	3	1				
CO3	1	3	3	3	3	1	3	1				
<b>CO</b> 4	3	3	3	3	3	1	3	2				
CO5	3	3	3	3	3	2	3	2				

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## **Detailed Syllabus:**

- Phenomenology of Chaos: Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos. (Lectures 8)
- Dynamics in State Space: State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence. (Lectures 10)
- 3. **Hamiltonian System**: Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity.

(Lectures 8)

4. Quantifying Chaos: Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism.

(Lectures 7)

5. Quantum Chaos: Quantum Mechanical analogies of chaotic behaviour, Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics.

(Lectures 7)

#### **Text Books:**

1. Chaos and Non Linear Dynamics: R.C. Hilborn (Oxford Univ. Press), 2001.

#### **Reference Books:**

- 1. Chaos in Dynamical Systems: E. Ott (Cambridge Univ. Press), 2002.
- 2. Applied Nonlinear Dynamics: A.H. Nayfeh and B. Balachandran (Wiley), 1995.
- 3. Chaos in Classical and Quantum Mechanics: M.C. Gutzwiller (Springer-Verlag), 1990.

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Elective Subject -I

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PHS53	· · · · · · · · · · · · · · · · · · ·			pectra and l iomolecules		L-3, 7	Г-1, Р-0	4 Cı	redits
Pre-requi	site:	None							
of Biomo	lecule	es is to	familiar	nd objective ize the M.S ructures, Spo	c. students	with the	basics of	the recentl	y emergin
Course O	utcor	nes: At	the end c	of the course	, the studer	nt will be a	ible to		
C01		Descr	ibe vario	us structural	and chemi	cal bondir	ng aspects o	of Biomoleo	cules.
CO2	CO2 Understand structure and theoretical techniques and their application Biomolecules.								
CO3 Understand use of various spectroscopic techniques and their application t Biomolecules.								ation to th	
CO4		Under	stand the	structure-F	unction rela	ationship a	and modeli	ng of biom	olecules.
C05		Outlin	e and co	rrelate for pr	roviding so	lution to in	nterdiscipli	nary proble	m
	r	Mappin	g of cour	rse outcome	es with the	program	specific ou	tcomes	
	PS	01	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	3		3	3	3	3	2	3	2
CO2	3		3	3	3	3	3	3	3
CO3	3		3	3	3	3	3	3	3
CO4	3		3	3	3	3	3	3	3
CO5	3		3	3	3	3	2	3	2

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## **Detailed Syllabus:**

- 1. Structure Aspects of Biomolecule: Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides. (Lectures10)
- 2. Theoretical Techniques and Their Application to Biomolecules: Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses. (Lectures 10)
- Spectroscopic Techniques and their Application to Biomolecules: Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids. (Lectures 10)
- 4. Structure-Function Relationship and Modeling: Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model. (Lectures 10)

#### **Text Books:**

1. Srinivasan & Pattabhi: Structure Aspects of Biomolecules.

#### **Reference Books:**

- 1. Govil & Hosur: Conformations of Biological Molecules
- 2. Price: Basic Molecular Biology
- 3. Pullman: Quantum Mechanics of Molecular Conformations
- 4. Lehninger: Biochemistry
- 5. Mehler&Cordes: Biological Chemistry
- 6. Smith and Hanawait: molecular Photobiology, Inactivation and Recovery

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PHS53	39		Seminar		L-0, 7	<b>F-2, P-0</b>	2 C	redits			
Pre-requi	site:	Knowledge of s	specific bran	ch of physi	cs						
Course Comethodolo	bjectogy of	tives: The aim f research in Th	of the ser	<b>ninar</b> is to ysics and E	o expose t xperimenta	he student l Physics.	s to prelin	unaries an			
Course O	utcor	nes: At the end	of the cours	e, the stude	ent will be a	able to		1			
CO1 Explain the significance and value of problem in physics.											
CO2		Design and carry out scientific experiments as well as accurately record the of experiments.									
CO3		Critically analyse the experimental strategies, and decide which one is most appropriate for answering specific questions.									
CO4	Communicate the scientific knowledge in the context of a topic related to Physics, in oral, written and electronic formats.										
C05		Explore new areas of research in physics and allied fields of science technology.									
	N	Mapping of cou	irse outcom	es with the	e program	specific ou	tcomes				
	PSO1 PSO2 PSO3 P		PSO4	PSO5	PSO6	PSO7	PSO8				
CO1	3	3	3	3	3	3	3	3			
CO2	3	2	3	3	3	3	3	3			
CO3	3	3	3	3	3	3	3	3			
CO4	2	3	2	3	3	3	3	3			
	2	3	3	3	3	3	3				

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## Guidelines for the seminar:

The aim of Seminar in M.Sc. 3th semesters is to expose some of the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, analysis of data, etc. related to research Project work which can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department in the start of the 3rd semester. These seminars are aimed to develop in-depth subject knowledge and skill. Besides subject expertise, they help train students in the presentation and communication skill.

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	0	Phy	sics Lab-II	α	L-3, T	-1, <b>P-0</b>	4 Ci	redits
Pre-requi	site: None							
students of they can in	t M.Sc. cla	ass to advar various rele	nced experi	ve of the d imental tecl cts and are d	iniques in	condensed	matter phy	sics so th
Course O	utcomes: A	At the end o	f the cours	e, the stude	nt will be a	ble to		57= 17.
CO1	Me	asure condu	ictivity, res	istivity and	thermo-dy	namical pro	operties of	solids.
CO2	Me	asure magn	etic propert	ties and mag	gnetic beha	vior of ma	gnetic mate	erials.
CO3	Des rela	scribe the la tions.	ittice dynai	mics of sim	ple lattice	structures	in terms of	f dispersi
CO4	Des	ign and ca lyze the res	rry out sci ults of expe	ientific exp eriments.	eriments a	s well as	accurately	record a
CO5	and the second sec		Leiss	al thinking a	and analytic	cal reasonii	ng.	
	Mann			an mith the		States and the second second second		
	wrapp	ing of cour	se outcom	es with the	program	specific ou	tcomes	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01								PSO8 3
CO1 CO2	PSO1	PSO2		PSO4	PSO5	PSO6	PSO7	and produced and
	PSO1 3	PSO2 3		PSO4 3	PSO5	PSO6 2	PSO7	3
CO2	PSO1 3 3	PSO2 3 3	PSO3	PSO4 3 3	PSO5 3 3	PSO6 2 3	PSO7 2 2	3

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## **Detailed Syllabus:**

# Note: Students are expected to perform atleast ten experiments out of following list.

- 1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
- 2. Temperature dependence of a ceramic capacitor-verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
- 3. To determine charge carrier density and Hall coefficient by Hall effect.
- 4. To determine energy gap and resistivity of the semiconductor using four probe method.
- 5. To determine magnetic susceptibility of material using Quink 's tube method.
- 6. To determine energy gap and resistivity of the semiconductor using four probe method.
- 7. To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization.
- 8. To study the series and parallel characteristics of photovoltaic cell
- 9. To study the spectral characteristics of photovoltaic cell.
- 10. To determine the g-factor using ESR spectrometer.

#### **Text Books:**

- 1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
- 2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

## **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1972
- 2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
- 3. Liquid Crystals: S. Chandrasekhar (Cambridge University), 2nd ed. 1992.

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# Elective Subject -II

PHS54	41	Experime Nuclear a	ental Techn nd Particle	iques in Physics	L-3, 7	F-1, P-0	4 C	redits
Pre-requi	site: Co	ourse on Nucl	ear and Part	icle Physic	ŝ			
Nuclear a	nd Par	ticle Physics ment and met	is to expose	e the studer	nts of M.Sc	, students t	o experime	ental aspect
Course O	utcome	s: At the end	of the cours	e, the stude	ent will be a	ible to		
C01	e	Understand va adiations wit		imental tec	hniques for	describing	; interactior	n of
CO2	τ	Jse various st	atistical me	thods for ex	cperimental	data.		-
CO3		Knowledge a pplications.	bout the c	lifferent ty	pes of th	e radiation	detectors	and the
CO4	Ι	ntroduced to	neutron phy	sics, metho	ds to detec	tor slow an	d fast neutr	ons.
C05		Equipped with various labora	the basic k tories acros	nowledge a s the world	bout the ex	perimental	methods u	sed in the
	Ma	pping of cou	rse outcom	es with the	e program	specific ou	tcomes	
	PSO	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
CO1	1	2	1	2	3	3	3	3
CO2	1	3	3	2	1	3	3	3
CO3	1	1	1	3	ī	3	3	3
CO4	1	3	1	3	3	3	3	3
				1 2				

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#### **Detailed Syllabus:**

- 1. Detection of radiations: Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectrum from detector, Cherenkov detector. Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, semiconductor detectors in X- and gamma-ray spectroscopy, Pulse height spectrum, Compton-suppressed, Semiconductor detectors for charged particle spectroscopy and particle identification. *(Lectures 18)*
- Electromagnetic and Hadron calorimeters: Motion of charged particles in magnetic field, Magnetic dipole and quadrupole lenses, beta ray spectrometer. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General background and detector shielding. (Lectures 10)
- 3. Experimental methods: Detector systems for heavy-ion reactions : Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments :Collider physics (brief account), Particle Accelerators (brief account), Secondary beams, Beam transport, Modern Hybrid experiments- CMS and ALICE. *(Lectures 15)*

#### **Text Books:**

1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

#### **Reference Books:**

- 1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
- 2. Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
- 3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.

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Elective Subject -II

PHS54	12 ]	Physics of Na	nomateria	ls	L-3, 1	-1, P-0	4 Cr	edits
Pre-requi	site: Co	ndensed mat	ter physics	S			A CONTRACTOR	
familiarize	e the stu lifferent	es: The aim a dents of M.Sc properties of	to the va	rious aspec	ts related to	preparatic	n, character	rization and
Course O	utcome	s: At the end of	of the cours	se, the stude	ent will be a	ible to		
C01	I a	Demonstrate t tomic scales	echniques	of microsco	opy for inv	estigations	on the nan	ometer and
CO2		Acquire know anoparticles a	vledge of and their se	basic app lf-assembly	roaches to in solutior	synthesiz	e inorgani ces	c colloida
CO3	L	Understand ar netallic struct	nd describe ares for ana	e the use alytical and	of unique biological	optical pr application	operties of s	nanoscal
CO4	L n	Inderstand th anostructured	e physical mesoporo	and cher us materials	nical prop	erties of c	arbon nand	otubes and
C05	tl n	he structure-protection of applicable	roperty rela at larger ler	ationships in ngth scales.	n nanomate	rials as we	I as the con	cepts,
	Ma	pping of cour	rse outcom	es with the	e program	specific ou	tcomes	
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
C01	-	3	3	3	3	3	3	3
CO2	2	3	3	3	3	3	3	3
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Scheme & Syllabus (M.Sc. Physics) Batch 2016 & Onwards

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#### **Detailed Syllabus:**

- Introductory Aspects: Free electron theory and its features, Idea of band structure—metals, insulators and semiconductors. Density of state in one, two and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. (Lectures 8)
- 2. **Preparation of Nanomaterials:** Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling.

(Lectures 8)

- 3. General Characterization Techniques: Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. (Lectures 8)
- 4. Quantum Dots: Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. *(Lectures 8)*
- 5. Other Nanomaterials: Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors. (Lectures 8)

#### **Books:**

- 1. Nanotechnology-Molecularly Designed Materials: G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
- 2. Nanotechnology Molecular Speculations on Global Abundance: B.C. Crandall (MIT Press), 1996.
- 3. Quantum Dot Heterostructures: D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley), 1998.
- 4. Nanoparticles and Nanostructured Films-Preparation, Characterization and Application: J.H.Fendler (Wiley), 1998.
- 5. Nanofabrication and Bio-system: H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.
- 6. Physics of Semiconductor Nanostructures: K.P. Jain (Narosa), 1997.
- 7. Physics of Low-Dimension Semiconductors: J.H. Davies (Cambridge Univ. Press) 1998.
- 8. Advances in Solid State Physics (Vo.41): B. Kramer (Ed.) (Springer), 2001.

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of Physical Sciences

Elective Subject -III

PHS54	3 En	vironment	al Physics		L-3, 1	-1, <b>P-0</b>	4 Ci	edits
Pre-requis	site: none							
Course Ol understand	bjectives: ling of env	The objecti voronmenta	ve of the collection of the co	ourse on Ei nd related e	nvironment effects.	al Physics	is to build f	undamenta
Course O	utcomes: A	At the end o	of the cours	e, the stude	ent will be a	ble to		
C01	Und	lerstand the	e essential c	of the envir	onmental p	hysics		
CO2	Apr	bly the sola	r and terres	trial radiati	ons to the e	arth atmos	phere syste	m.
CO3	Des	cribe the fa	ctors respo	nsible for e	envirnmenta	al pollution	and degrad	lation.
CO4		vide exposi sing.	ire to envoi	ronmental o	changes and	lunderstan	d the idea c	of remote
CO5		vide exposi nges.	ire to the st	udenst abo	ut the globa	and regio	nal environ	mental
	Марр	ing of cour	rse outcom	es with the	e program	specific ou	tcomes	
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CO1	1	3	3	3	3	3	3	1
CO2	2	3	3	3	3	3	3	1
CO3	2	3	3	3	<u> </u>	3	3	840
		3	3	3	3	3	3	-
CO4	2	5	2		n in 3		-	-

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#### **Detailed Syllabus:**

- 1. Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere, Composition of air, Greenhouse effect, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Lass of motion, hydrostatic equilibrium, General circulation of the topics, Elements of weather and climate of India. *(Lectures 10)*
- 2. Solar and Terrestrial Radiation :Physics of radiation, Interaction of light with matter, tayleigh and Mie scattering, Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.), Solar and terrestrial spectra, UV radiation, Ozone depletion problem, IR absorption energy balance of the earth atmosphere system (Lectures 8)
- 3. Environmental Pollution and degradation: Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors governing air, Water and noise pollution, Air and water quality standards, Waste disposal, Heat island effect, Land and sea breeze, Puffs and plumes, Gaseous and particulate matters, Wet and dry deposition. *(Lectures 8)*
- 4. Environmental Changes and remote sensing: Energy sources and combustion processes, Renewable sources of energy, Solar energy, Wind energy, bioenergy, hydropower, fuel cells, nuclear energy, Forestry and bioenergy. *(Lectures 7)*
- 5. Global and Regional Climate: Elements of weather and climate, Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, Viscous forces, Reynolds number, Enhanced Greenhouse Effect, Energy balance-a Zero-dimensional Greenhouse model, Global climate models. (Lectures 10)

#### **Text and Reference Books**

- 1. Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).
- 2. J. T Hougtion: The Physics of atmosphere (Cambridge University Press, 1977).
- 3. J Twidell and J Weir: Renewable energy Resources (Elbs, 1988).
- 4. Sol Wieder: An introduction t solar energy for scientists and Engineers (John Wiley, 1982)
- 5. R. N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).
- 6. G.J. Haltiner and R.T. Williams: Numerical Weather Prediction (John Wiley, 1980).

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Gujral Punjab Technical Un

Elective Subject -III

PHS54	14	Science of I	Renewable s Energy	source of	L-3, T	-1, P-0	4 Credits	
Pre-requi	site: Non	e		an alo				
Course C Sources is energy, hy	s to expos	se the M.Sc.	and objecti students to	ve of the basics	course on s of the alte	Science ernative er	of renewa	ble Energ
Course O	utcomes:	At the end of	of the course	e, the stude	nt will be a	ble to		11-10-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1
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CO2	U	nderstand tra	ditional and	alternative	form of er	nergy.		
CO3			ncept of sola	1		0748355	olar cell and	l its types.
CO4			gen as energ					
CO5			energy, way	PLUE AND A	Ta			
			rse outcome					
	PSO1	PSO2	PSO3	PSO4	PSO5	PSO6	PSO7	PSO8
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CO2	-	2	-	3	1	2	2	3
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Main Campus

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## **Detailed Syllabus:**

- 1. Introduction: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. *(Lectures 8)*
- 2. Solar Energy: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, interrelationship between absorption coefficients and band gap recombination of carriers. Types of solar cells, p-n junction solar cell, Transport equation, current density, open circuit voltage and short circuit current, description and principle of working of single crystal, polycrystalline and amorphous silicon solar cells, conversion efficiency. Elementary ideas of Tandem solar cells, solid-liquid junction solar cells and semiconductor-electrolyte junction solar cells. Principles of photo electrochemical solar cells. Applications. (Lectures 12)
- 3. Hydrogen Energy: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells, hydride batteries.

(Lectures 10)

4. Other sources: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC. *(Lectures 8)* 

#### **Text Books:**

1. Solar Energy: S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.

## **Reference Books:**

- 1. Solar Cell Devices: Fonash (Academic Press, New York), 2010.
- 2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: Fahrenbruch and Bube (Springer, Berlin), 1983.
- 3. Photoelectrochemical Solar Cells : Chandra (New Age, New Delhi).

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	45	Resea	rch Project	work	L-0, T-	-12, P-0	12 C	redits
Pre-requi	site: Ki	nowledge of s	specific bran	ch of physi	cs			
preliminar	ties and get the c	ves: The aim d methodolog opportunity to ment.	y of resear	ch in The	oretical Ph	vsics and	Experiment	tal Physics
Course O	utcome	es: At the end	of the cours	e, the stude	nt will be a	ble to		
CO1		Explain the s in the wider c	ignificance a ommunity.	and value o	f problem	in physics,	both scient	ifically and
CO2		Design and or results of exp	carry out sc eriments.	ientific exp	periments a	as well as	accurately	record the
CO3		Critically ana appropriate for				ategies, and	l decide wh	ich is most
CO4	1	Research and to condensed electronic for	matter physi	ics/Nuclear	High Ener	gy Physics	in oral, wr	
CO4	1	to condensed	matter physi mats to both	ics/Nuclear scientists a	High Ener	gy Physics. lic at large.	, in oral, wr	itten and
		to condensed electronic for Explore new	matter physi mats to both areas of r	ics/Nuclear scientists a esearch in	/High Ener nd the publ physics a	gy Physics lic at large. nd allied	, in oral, wr fields of s	itten and
		to condensed electronic for Explore new technology. apping of cou	matter physi mats to both areas of r	ics/Nuclear scientists a esearch in	/High Ener nd the publ physics a	gy Physics lic at large. nd allied	, in oral, wr fields of s	itten and
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C05	1 1 1 M: PSO 3	to condensed electronic for Explore new technology. apping of cou 1 PSO2 3	matter physi mats to both areas of re irse outcom PSO3 3	cs/Nuclear scientists a esearch in es with the PSO4 3	/High Ener nd the publ physics a program PSO5 3	gy Physics, lic at large. nd allied specific ou PSO6 3	, in oral, wr fields of s itcomes PSO7 3	itten and cience and PSO8 3
CO5 CO1 CO2	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	to condensed electronic for Explore new technology. apping of cou 1 PSO2 3 2	matter physimats to both areas of reserved on the second s	esearch in esearch in PSO4 3 3	High Ener nd the publ physics a program PSO5 3 3 3	gy Physics, lic at large. nd allied specific ou PSO6 3 3 3	in oral, wr fields of s itcomes PSO7 3 3 3	itten and cience and PSO8 3 3 3

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#### Guidelines for the Project:

The aim of project work in M.Sc. 4th semesters is to expose the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.. Project work can be in Experimental or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per course guidelines.

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#### Minutes of Meeting

A meeting of Board of Studies Applied Science and Material Science held on 20th Jan 2016 at 11:00 am at the office of Dean Academics, IKG Punjab Technical University.

The following members were present:

- 1. Dr. Ravi Kumar, BCET Gurdaspur, (Chairman)
- 2. Dr. N.K. Verma, Thaper University, Patiala (Member)
- 3. Dr.A.K. Tyagi, SBSCET, Ferozepur (Member)
- 4. Dr. Rakesh Dogra, BCET Gurdaspur,(Member)
- 5. Dr. Kanchan L Singh DAVIET, Jalandhar (Member)
- 6. Dr. Hitesh Sharma, Punjab Technical University (Coordinator)

The following members were not present:

- 1. Dr. R. C. Singh, GNDU, Amritsar (Member)
- 2. Dr.Ajay Kumar SBSCET, Ferozepur (Member)

# The Board took the agenda and following recommendations were made:

- The course credits of Engineering Physics are as per Choice based credit guidelines of IKG PTU, therefore no change is required. The syllabus was discussed and revised syllabus was approved, copy enclosed as Annexure-A.
- Post graduate course in Physics should be named as M.Sc. (Physics) instead of M.Sc. (Applied Physics), should be adopted uniformly for the University campus as well as for affiliated colleges
- 3. The course scheme and syllabus contents of M.Sc. (Physics) for PITK, IKG PTU campus as formulated by a committee headed by Prof KN Pathak was presented in the BOS (Physics) meeting. Committee approved the item as presented. An approved copy of the same is enclosed-Annexure-B. Committee members further appreciated the efforts of the committee headed by Prof. K.N. Pathak and decided that

same scheme and credits of M.Sc. (Physics) be implemented uniformly for all Colleges and University Campus from 2016-2017 after minor changes, copy Enclosed- Annexure-C

4. The new course scheme and credits for M.Tech (Nanotechnology) was discussed thoroughly and committee felt need for revising the contents of course. Members discussed that since the course was running only in two colleges and at present there is no admission since last two years, so it was recommended that course be renamed either as M.Tech Material Science & Nano Technology or M.Tech Material Science and Engineering (with specialization in Nanotechnology) and syllabus be formulated accordingly.

Meeting ended with the vote of thanks to the Chairman, BOS (Physics, Material Science and Nanotechnology)

Dr. Hitesh Sharma

Dr. N.K. Verma

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Dr. Rakesh Dogra

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Dr. RAV Department of Physical Sciences K. Guiral Punjab Technical Univer Main Campus

1KGPTU/AS/1342 22/10/16

Subject: Minutes of Board of Studies in Physics, Material Science and Nanotechnology on 20<sup>th</sup> Jan 2016

A meeting of Board of Physics, Material Science and Nanotechnology held on 20th Jan 2016 at 11:00 am at the office of Dean Academics, IKG Punjab Technical University.

The following members were present:

- Dr. Ravi Kumar, BCET Gurdaspur, (Chairman) 1.
- 2. Dr. A.K. Tyagi, SBSCET, Ferozpur (Member)
- 3. Dr. N.K. Verma, Thaper University (Member)
- 4. Dr. Rakesh Dogra, BCET Gurdaspur(Member)
- 5. Dr. Kanchan L Singh, DAVIET, Jalandhar (Member)
- 6. Dr. Hitesh Sharma, IKG Punjab Technical University (Coordinator)

The minutes of same are enclosed for necessary action.

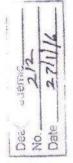
Dr. Hitesh Sharma Coordinator-BOS(Physics, Material Science and Nanotechnology)

Dr. Buta Singh Dean, Academics Incharge (Bos)

Min 27/1/16

Copy to: Dr. Hitesh to browned fleace minutes directly to the Euchary (Bus) in feature

Development of Physical Sciences I.K. Gujral Punjab Technical University Main Car



# BTPH-101 (Engineering Physics)

# Objective/s and Expected outcome:

The objective of the course is to develop a scientific temper and analytical capability in the engineering graduates through the learning of physical concepts and their application in engineering & technology. Comprehension of some basic physical concepts will enable graduates to think logically the engineering problems that would come across due to rapidly developing new technologies. The student will be able to understand the various concepts effectively; logically explain the physical concepts: apply the concept in solving the engineering problem; realize, understand and explain scientifically the new developments and breakthroughs in engineering and technology; relate the developments on Industrial front to the respective physical activity, happening or phenomenon.

#### PARTA

1. Electromagnetic Waves: Physical significance of Gradient, Divergence & Curl. Displacement current, Maxwell equations, Equation of EM waves in free space, velocity of EM waves, Poynting vector, Electromagnetic Spectrum (Basic ideas of different region).

(6)

2. Magnetic Materials & Superconductivity: Basic ideas of Dia, Para, Ferro & Ferri, Ferrites, Superconductivity, Superconductors as ideal diamagnetic materials, Signatures of Superconducting state, Meissner Effect, Type I & Type II superconductors, London equations, Introduction to BCS theory.

3. Elements of crystallography: Unit cell, Basis, Space lattice, Crystal Systems, Miller (8) Indices of Planes & Directions in cubic system, Continuous & Characteristic X-Rays, X- ray diffraction and Bragg's Law, Bragg's spectrometer, X-ray radiography.

#### PART B

4. Lasers:

Coherence, Stimulated and spontaneous emissions, Einstein coefficients, Population Inversion, Pumping Mechanisms, Components of a laser System. Three & four level laser systems; Ruby, He-Ne, CO2 and semiconductor Lasers, Introduction to Holography.

5. Fibre Optics: Introduction, Acceptance Angle, Numerical Aperture, Normalized frequency. Modes of propagation, material dispersion & pulse broadening in optical fibres, fibre connectors, splices and couplers, applications of optical fibres. (5)

6. Quantum Theory: Need and origin of quantum concept, Wave-particle duality. Matter waves. Group & Phase velocities, Uncertainty Principle, Significance & normalization of wave function. Schrodinger wave equation: time independent & dependent, Eigen functions & Eigen values, particle in a box. Quantum confinement nano physics and related applications

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mous.

## Reference Books:

- 1. Introduction to Electrodynamics by David J. Griffiths
- 2. Materials science and engineering: a first course by V. Raghvan
- 3. Optics by Ajay Ghatak
- 4. Optical Fibre Communication: Principles And Practice by Senior
- 5. Concepts of Modern Physics by Arthur Beiser

Annexure-A

(6)

#### FIRST SEMESTER

#### Contact Hours: 23 Hrs.

Code	Course Title	I want and	Load ocati		Total Marks	Credits
		L	Т	Ρ		
PHS411	Mathematical Physics-I	3	1	-	100	4
PHS412	Classical Mechanics	3	1	-	100	4
PHS413	Quantum Mechanics-I	3	1	-	100	4
PHS414	Statistical Physics	3	1	-	100	4
PHS415	Atomic and Molecular Physics	3	1	-	100	4
PHS416	Physics Lab-I		-	3	75	3
1	TOTAL	15	5	3	575	23

#### SECOND SEMESTER

#### Contact Hours: 26 Hrs.

Code	Course Title	and the second s	Load ocat		Total Marks	Credits
		L	Т	Ρ		
PHS421	Mathematical Physics-II	3	1	-	100	4
PHS422	Nuclear Physics	3	1	-	100	4
PHS423	Quantum Mechanics-II	3	1	-	100	4
PHS424	Computational Physics	3	1	-	100	4
PHS425	Condensed Matter Physics-I	3	1	-	100	4
PHS426	Physics Lab – II	-	-	3	75	3
PHS427	Computational Lab	-	-	3	75	3
	TOTAL	15	5	6	650	26

Department of Physical Sciences I.K. Gujral Punjab Technical University Main Campus

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Code	Course Title	Load	Alloc	ation	Total	Credits
-		L	Т	P	Marks	
PHS531	Condensed Matter Physics-II	3	1	-	100	4
PHS532	Classical Electrodynamics	3	1	-	100	4
PHS533	Particle Physics	3	1	-	100	4
PHS534	Electronics	3	1	-	100	4
PHS535 PHS536 PHS537 PHS538	Elective Subject-I	3	1.	-	100	4
PHS 539	Seminar	-	-	-	Satisfactory/ Unsatisfactory	2
PHS540	Physics Lab-III			3	75	3
	TOTAL	15	5	3	575	25

#### FOURTH SEMESTER

Contact Hours: 08 Hrs.

Code	Course Title	Load	Alloc	ation	Total	Credits
	Constant of the starts	L	T	P	Marks	
PHS541 PHS542	Elective Subject-II	3	1	-	100	4
PHS543 PHS544	Elective Subject-II	3	1	-	100	4
PHS545	Research Project	-	-	-	Satisfactory/ Unsatisfactory	12
	TOTAL	6	2		200	20

#### **ELECTIVE SUBJECTS:**

S.No.	Name of the Subject	Code
1	Fiber optics and non-linear optics	PHS-535
2	Plasma Physics	PHS-536
3	Nonlinear Dynamics	PHS-537
4	Structures, Spectra and Properties of Biomolecules	PHS-538
5	Experimental techniques in Nuclear Physics and particle Physics	PHS 541
6	Physics of Nanomaterials	PHS 542
7	Environmental Physics	PHS 543
8	Science of Renewable source of Energy	PHS 544
		6%
	Head Daparb I.K. Guj	ment of Physical Sciences ral Punjat Technical Universi
	Main Ca	ampus 🕜

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#### Examination and Evaluation :

S.No.		Weightage	Remarks
Theory		80%	
1.	Mid term sessional Test (I/II/III)	25 %	Best of two test will be considered for evaluation and quizzes etc constitute internal evaluation
2	Attendance /Seminars/Assignments	5 %	
3	End semester examination	70%	Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous institutions. For other colleges examination will be conducted at the university level
	Total	100%	Marks may be rounded off to nearest integer
Practica	I manual in the second second second	10 - 01 - 10 - 10 - 10 - 10 - 10 - 10 -	
1	Daily evaluation of practical record Assignment/Viva Voice/ Attendance etc	50%	Internal evaluation
2	Final Practical Performance + Viva Voice	50%	External evaluation
3	Total	100%	Marks may be rounded off to nearest integer

Department of Physical Sciences IK Gujral Punjab Technical Universit

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#### PHS411- MATHEMATICAL PHYSICS-I

Total Marks	Credits	L	Т	P
100	4	3	1	1 12

- 1. Vector fields and Tensors :Scalar and Vector fields, Scalar and Vector products: Curl, Divergent and Introduction to tensors and definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Non-Cartesian tensors, metric tensor, Covariant differentiation.
- 2. **Complex Variables** : Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals, Dispersion relation.
- 3. **Differential Equations :** Partial differential equations of theoretical physics, boundary value, problems, Neumann &Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution.
- 4. Integral Equations :Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory. Green's functions in one dimension.
- 5. **Numerical Techniques:** Roots of functions, Interpolation, Extrapolation, Differentiation, integration by trapezoid and Simpson's rule, RungeKutta method and finite difference method.
- 6. Elementary Statistics: Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution

#### Suggested Readings/Books :

- Mathematical Methods for Physicists : G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2012.
- Mathematical Physics : P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
- Mathematical Physics : A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi), 1986.
- Mathematical Methods in the Physical Sciences M.L. Boas (Wiley, New York) 3rd edition, 2007.
- Special Functions : E.D. Rainville ( MacMillan, New York), 1960.
- Mathematical Methods for Physics and Engineering :K.F.Riley, M.P.Hobson and S.J. Bence (Cambridge University Press, Cambridge) 3rd ed., 2006.



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#### PHS412 CLASSICAL MECHANICS

⊺otal larks	Credits		L	Т	
100	4	Chever and the California and	3	1	

- 1. Lagrangian Formulation: Mechanics of a system of particles; constraints of motion, generalized coordinates, D'Alembert's Principle and Lagrange's velocity dependent forces and the dissipation function, Applications of Lagrangian formulation.
- 2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.
- 3. Hamilton's Equations: Legendre Transformation, Hamilton's equations of motion, Cycliccoordinates, Hamilton's equations from variational principle, Principle of least action.
- 4. Canonical Transformation and Hamilton-Jacobi Theory: Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton-Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom.
- 5. Rigid Body Motion: Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top.

TUTORIALS : Relevant problems given at the end of each chapter in different books.

#### Suggested Readings/Books :

- Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi), 3rded 2002.
- Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, NewDelhi), 1988.

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#### PHS413 QUANTUM MECHANICS-I

Total Marks	Credits	L	Т	P
100	4	3	1	-

- Linear Vector Space and Matrix Mechanics: Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hemitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation. Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg and Schroedinger representations, Exchange operator and identical particles. Density Matrix and Mixed Ensemble.
- Angular Momentum: Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L2 and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J2 and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients.
- Stationary State Approximate Methods: Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems.
- 4. **Time Dependent Perturbation:** General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light.
- 5. Scattering Theory : Scattering Cross-section and scattering amplitude, partial wave analysis, Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles.

#### Suggested Readings/Books :

- A Text book of Quantum Mechanics, P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 2nd edition, 2004.
- Quantum Mechanics : V.K. Thankappan (New Age, New Delhi), 2004.
- Quantum Mechanics : M.P. Khanna, (HarAnand, New Delhi), 2006.
- Modern Quantum Mechanics : J.J. Sakurai (Addison Wesley, Reading), 2004.
- Quantum Mechanics : J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
- Quantum Physics : S. Gasiorowicz (Wiley, New York), 3rd ed. 2003.

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#### PHS 414 STATISTICAL PHYSICS

Total Marks	Credits	L	Т	P
100	4	3	1	-

- 1. The Statistical Basis of Thermodynamics: The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution.
- 2. Ensemble Theory: Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations.
- 3. Quantum Statistics of Ideal Systems: Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism.
- 4. Elements of Phase Transitions: Introduction, a dynamical model of phase transitions, Ising model in zeroth approximation.
- 5. Fluctuations: Thermodynamic fluctuations, random walk and Brownian motion, introduction tononequilibrium processes, diffusion equation.

TUTORIALS: Relevant problems given in the end of each chapter in the text book.

#### Suggested Readings/Books :

- Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 3<sup>rd</sup>edition, 2011.
- Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi), 1987.
- Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) 2nd edition, 2011.
- Elementary Statistical Physics: C. Kittel (Wiley, New York), 2004.
- Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.

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#### PHS415 ATOMIC AND MOLECULAR PHYSICS

Total Marks	Credits
100	4

L	Т	Ρ
3	1	-

- Electronic Spectroscopy of Atoms: Electronic wave function and atomic quantum numbers hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non equivalent electrons – basics of X-ray photoelectron spectroscopy.
- 2. Electronic Spectroscopy of Molecules Diatomic molecular spectra: Bom-Oppenheimer approximation vibrational spectra and their progressions Franck-Condon principle dissociation energy and their products –rotational fine structure of electronic-vibration transition molecular orbital theory the spectrum of molecular hydrogen change of shape on excitation chemical analysis by electronic spectroscopy reemission of energy fundamentals of UV photoelectron spectroscopy.
- Microwave and Raman Spectroscopy: Rotation of molecules and their spectra diatomic molecules intensity of line spectra – the effect of isotropic substitution – non-rigid rotator and their spectra – polyatomic molecules (linear and symmetric top molecules) – Classical theory of Raman effect - pure rotational Raman spectra (linear and symmetric top molecules).
- 4. Infra-red and Raman Spectroscopy: The energy of diatomic molecules Simple Harmonic Oscillator the Anharmonic oscillator the diatomic vibrating rotator vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation the vibrations of polyatomic molecules influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) Raman activity of vibrations vibrational Raman spectra vibrations of Spherical top molecules.
- Spin Resonance Spectroscopy Spin and magnetic field interaction Larmor precession relaxation time – spin-spin relaxation - spin–lattice relaxation - NMR chemical shift - coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR.

#### Suggested Readings/Books :

- Fundamentals of Molecular Spectroscopy by Colin N. Banwell and Elaine M. McCash (Tata McGraw - Hill Publishing Company limited)
- Physical method for Chemists (Second Edition) by Russell S. Drago (Saunders College Publishing)
- Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1934.
- Spectroscopy Vol. I, II & III: Walker & Straughen
- Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1962.
- Spectra of diatomic molecules: Herzberg-New York, 1944.



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#### PHS416-Physics Lab-I

Total Marks	Credits	ter chaitan sandispi	Т
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#### S.No. Name of the Experiment

	INTERCO O POLICIA CARLON
1	Study the forward and reverse characteristics of a Zener diode.
2	Construction of adder, subtracter, differentiator and itergrator circuits using the given OP-Amp.
3	Study the static and drain characteristics of a JFET
4	Construction of an Astablemulti-vibrator circuit using transistor
5	Construction of a single FET amplifier with common source configuration
6	Construction of an A/D converter circuit and study its performance
7	Construction of an D/A converter circuit and study its performance
8	Construction of a low-pass filter circuit and study its output performance
9	Construction of a high-pass filter circuit and study its output performance
10	Electron Spin Resonance Spectrometer Experiment
11	Four Probe Method-Determination of resistivity of semiconductor at different temperature
12	To study pulse amplitude, Pulse width and Pulse position modulation
13	To study the frequency response of an operational amplifier
15	To study the characteristics of multivibrators- bistable, Astable, monostable
16	To find the wavelength of sodium light using Michelson interferometer

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#### PHS421 MATHEMATICAL PHYSICS-II

Total Marks	Credits	L	Т	P
100	4	3	1	-

- Group Theory :What is a group ? Multiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism, Definition of representation and its properties, Reducible and irreducible representations, Schur's lemmas (only statements), characters of a representation. Example of C4v, Topological groups and Lie groups, three dimensional rotation group, special unitary groups SU(2) and SU(3).
- 2. Delta and Gamma Functions :Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function.
- 3. Special Functions :Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions : generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynominals. Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.
- 4. Fourier Series and Integral Transforms : Fourier series, Dirichlet conditions. General properties. Advantages and applications, Gibbs phenomenon. Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives; Momentum representation. Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation.

#### Suggested Readings/Books :

- Group Theory for Physicists : A.W. Joshi (Wiley Eastern, New Delhi) 2011.
- Mathematical Methods for Physicists : G. Arfken and H.J. Weber, (Academic Press, San Diego)7th edition, 2012.
- Matrices and Tensors in Physics : A.W. Joshi (Wiley Eastern, New Delhi) 2005.
- Numerical Mathematical Analysis, J.B. Scarborough (Oxford Book Co., Kolkata) 4th edition.
- A First Course in Computational Physics: P.L. Devries (Wiley, New York) 1994.
- Mathematical Physics : P.K. Chatopadhyay (Wiley Eastern, New Delhi) 2011.
- Introduction to Mathematical Physics : C. Harper (Prentice Hall of India, New Delhi) 2006.

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#### PHS422NUCLEAR PHYSICS

Total Marks	Credits	L	Т	P
100	4	3	1	-

- Nuclear Models: Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective model- nuclear vibrations spectra and rotational spectra.
- Static properties of nucleus: Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfinestructure, effect of external magnetic field, Nuclear magnetic resonance.
- 3. Nuclear decay: Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Double beta decay, Neutrino, detection of neutrinos, measurement of the neutrino helicity. Multipolarity of gamma transitions, internal conversion process, transition rates,
- 4. Nuclear forces: Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, n-p scattering at low energies, partial wave analysis, scattering length, spin-dependence of n-p scattering, effective-range theory, coherent and incoherent scattering, central and tensor forces, p-p scattering, exchange forces & single and triplet potentials, meson theory of nuclear forces.
- 5. Neutron physics: Neutron production, slowing down power and moderating ratio, neutron detection.
- Nuclear reactions: Nuclear reactions and cross-sections, Resonance, Breit-Wigner dispersion formula for I=0 and higher values, compound nucleus, Coulomb excitation, nuclear kinematics and radioactive nuclear beams.

#### Suggested Readings/Books :

- Nuclear Physics : Irving Kaplan (Narosa), 2002.
- Theory of Nuclear Structure : R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.
- Basic Ideas and Concepts in Nuclear Physics : K. Hyde (Institute of Physics) 2004.
- Nuclear physics: Experimental and Theoretical, H.S. Hans (New Academic Science) 2<sup>nd</sup>ed (2011).
- Nuclear Physics and its applications by John Liley
- Nuclear Physics V. Devnathan

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#### PHS423 QUANTUM MECHANICS -II

'otal larks	Credits	L	Т	
100	4	3	1	

- 1. **Relativistic Quantum Mechanics-I**: Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle. The non-relativistic limit of Dirac equation,
- 2. Relativistic Quantum Mechanics-II Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lambshift.
- 3. Quantum Field Theory: Resume of Lagrangian and Hamiltonian formalism of a classical field, Quantization of real scalar field, complex scalar field, Dirac field and e.m. field, Covariant perturbation theory,
- 4. Feynman diagrams: Feynman diagrams and their applications, Wick's Theorem. Scattering matrix. QED.

#### Suggested Readings/Books :

- Text Book of Quantum Mechanics -P.M. Mathews & K. Venkatesan-Tata McGraw Hill 2010
- Quantum Mechanics G Aruldhas Prentice Hall of India 2006
- Introduction to Quantum Mechanics David J.Griffiths Pearson Prentice Hall, 2005
- Quantum Mechanics A Devanathan Narosa Publishing-New Delhi
- Quantum Mechanics L.I Schiff McGraw Hill 1968
- Quantum Mechanics A.K. Ghatak and S. Loganathan-McMillan India
- Principles of Quantum Mechanics R.Shankar, Springer 2005
- Quantum Mechanics Satya Prakash- KatharNathRamnath Meerut

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#### PHS424 COMPUTATIONAL PHYSICS

Total Marks	Credits		L	Т	P
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- Introduction to high level language: Need and advantages of high level language in physics, programming in a suitable high level language (Matlab/Mathematica/Scilab/ Octave), input/output, interactive input, loading and saving data, loops branches and control flow. Matrices and Vectors, Matrix and array operations, eigenvalues and eigen vectors.
- 2. Sub programs: Advantages of modular programming, built-in functions, scripts, functions, sharing of variables between modules.
- Graphics: 2D plots, style options, axis control, overlay plots, subplot, histogram, 3D plots, mesh and surface plots, contour plots.
- 4. Numerical computation: Computer programs for: solving linear system of simultaneous equations, nonlinear algebraic equation, roots of polynomials, curve fitting, polynomial curve fitting, least square curve fitting, interpolation, data analysis and statistics, numerical integration, Monte-Carlo simulation, ordinary differential equation, first order and second order ODEs, event location.
- 5. List of Experiments
  - a) Black body radiation (computation and graphical representation)
  - b) Reflection and transmission of an electromagnetic wave
  - c) Statistical distributions at different temperatures
  - d) Binding energy curve for nuclei using liquid drop model
  - e) Eigen-value problem: 1-D square potential well
  - f) Eigen-values and wave-functions of a simple harmonic oscillator
  - g) Monte-Carlo simulation
  - h) Linear/Projectile motion (simulation and solutions)

#### Suggested Readings/Books :

- Pratap R, "Getting started with MATLAB 7", Oxford Univ. Press, 2006
- Gilat A, "Matlab: An introduction with applications", Wiley, 2008
- Eaton J W, Batchman D and Hauberg S "GNU Octave Manual Version 3", Network Theory Ltd. 2008
- Campbell S, Chancelier J P and Nikoukhah R, "Modeling and simulation in Scilab", Springer 2005
- Mathematica Information Center ('MathSource'): http://library.wolfram.com/infocenter/ 2009
- Gerald C F and Wheatley P O, "Applied Numerical Analysis", 7th Ed, Addison Wesley, 2003

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#### PHS425 CONDENSED MATTER PHYSICS-I

Total Marks	Credits	L	Т	P
100	4	3	1	-

#### 1. Elastic constants :

Binding in solids; Stress components, stiffness constant, elastic constants, elastic waves in crystals.

#### 2. Lattice Dynamics and Thermal Properties :

Rigorous treatment of lattice vibrations, normal modes; Density of states, thermodynamic properties of crystal, anharmonic effects, thermal expansion.

#### 3. Energy Band Theory:

Electrons in a periodic potential: Bloch theorem, Nearly free electron model; tight binding method; Semiconductor Crystals, Band theory of pure and doped semiconductors; elementary idea of semiconductor superlattices.

#### 4. Transport Theory:

Electronic transport from classical kinetic theory; Introduction to Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance.

#### 5. Dielectric Properties of Materials:

Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity.

#### 6. Liquid Crystals :

Thermotropic liquid crystals, Lyotropic liquid crystals, long range order and order parameter, Various phases of liquid crystals, Effects of electric and magnetic field and applications, Physics of liquid crystal devices.

#### Suggested Readings/Books :

- Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
- Quantum Theory of Solids : C. Kittel (Wiley, New York) 1987.
- Principles of the Theory of Solids : J. Ziman (Cambridge University Press) 1972
- Solid State Theory : Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
- Liquid Crystals : S. Chandrasekhar (Cambridge University), 2nd ed. 1992.

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#### PHS426-PHYSICS LAB-II

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		oi.	Plater parts			
			Name of the Experimer	IT		
	Determination of interferometer	e/m of electro	on by Normal Zeeman Ef	fect using Febry	Perot	t
	To verify the exis	tence of Bohr	's energy levels with Fra	nk-Hertz experim	ents.	
	Determination of spectrometer	Lande's factor	r of DPPH using Electror	n-spin resonance	e (E.S	5.R.)
	Determination of	ionization Pot	tential of Lithium			
5	Analysis of pulse	height of gam	nma ray spectra			
6	To study the char	racteristics of	G.M. counter			
}	To determine the	dead time of	G.M. counter			
	To study absorpt	ion of beta par	rticles is matter			
)	To study Gaussia	an distribution	using G.M. counter			
)	Source strength	of a beta sourc	ce using G.M counter			
1	Determination of	Planck's cons	stant using Photocell and	interference filte	rs.	
12	Recording and ca	alibrating a gai	mma ray spectrum by so	intillation counte	r	
3	Detecting gamma	a radiation with	h a scintillation counter			
4	To study absorpt	ion of gamma	radiation by scintillation		(	$\swarrow$
5	Identifying and de	etermining the	activity of weakly radioa	active samples	d .	ant of Physical Punjab

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#### PHS427-COMPUTATIONAL LAB

Total Marks	Credits
75	3

L	Т	P
-	-	3

#### List of Experiments

- 1. Black body radiation (computation and graphical representation)
- 2. Reflection and transmission of an electromagnetic wave
- 3. Statistical distributions at different temperatures
- 4. Binding energy curve for nuclei using liquid drop model
- 5. Eigen-value problem: 1-D square potential well
- 6. Eigen-values and wave-functions of a simple harmonic oscillator
- 7. Monte-Carlo simulation
- 8. Linear/Projectile motion (simulation and solutions)

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#### PHS531 CONDENSED MATTER PHYSICS-II

Total Marks	Credits	L	Т	P
100	4	3	1	-

- 1. Optical Properties :Macroscopic theory generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect; interband transitions.
- Magnetism :Dia- and para-magnetism in materials, Pauli paramagnetism, Exchange interaction. Heisenberg Hamiltonian – mean field theory; Ferro-, ferri- and antiferromagnetism; spin waves, Bloch T3/2 law.
- 3. Principles of Magnetic Resonance: ESR and NMR equations of motion, line width, motional narrowing, Knight shift.
- Superconductivity :Experimental Survey; Basic phenomenology; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Vortex state of a Type II superconductors; Tunneling Experiments; High Tc superconductors.
- 5. **Disordered Solids :** Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, glasses, amorphous semiconductors and ferromagnets, heat capacity and thermal conductivity of amorphous solids, nanostructures short expose; Quasicrystals.

#### Suggested Readings/Books :

- Introduction to Solid State Physics : C. Kittel (Wiley, New York) 2005.
- Quantum Theory of Solids : C. Kittel (Wiley, New York) 1987.
- Principles of the Theory of Solids : J. Ziman (Cambridge University Press) 1972.
- Solid State Physics : H. Ibach and H. Luth (Springer, Berlin), 3rd. ed. 2002.
- A Quantum Approach to Solids : P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.
- Intermediate Quantum Theory of Solids : A.O.E. Animalu (East-West Press, New Delhi), 1991.
- Solid State Physics : Ashcroft and Mermin (Reinhert& Winston, Berlin), 1976.

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#### PHS532 CLASSICAL ELECTRODYNAMICS

Total Marks	Credits	L	Т	P
100	4	3	1	-

- Electrostatics : Laplace and Poisson's equations, Electrostatic potential and energy densityof the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor).
- Magnetostatics :The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor)
- 3. **Boundary value problems**: Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems.
- 4. Time varying fields and Maxwell equations : Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum.
- 5. Electromagnetic Waves : wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide, Waves in rarefied plasma (ionosphere) and cold magneto-plasma, Frequency dispersive characteristics of dielectrics, conductors and plasmas.

#### Suggested Readings/Books :

- Classical Electrodynamics : S.P. Puri (Narosa Publishing House) 2011.
- Classical Electrodynamics : J.D. Jackson, (New Age, New Delhi) 2009.
- Introduction to Electrodynamics: D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2012.
- Classical Electromagnetic Radiation : J.B. Marion and M.A. Heald, (Saunders CollegePublishing House) 3rd edition, 1995.
- Electromagnetic Fields, Ronald K. Wangsness (John Wiley and Sons) 2nd edition, 1986.
- Electromagnetic Field Theory Fundamentals :Bhag Singh Guru and H.R. Hiziroglu

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#### PHS533 PARTICLE PHYSICS

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100	4	3	1	

- 1. Introduction : Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture,types of interactions electromagnetic, weak, strong and gravitational, units.
- Invariance Principles and Conservation Laws: Invariance in classical mechanics and in quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay. Time reversal invariance, CPT theorem.
- 3. Hadron-Hadron Interactions : Cross section and decay rates, Pion spin, Isospin, Twonucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy.
- Relativistic Kinematics and Phase Space : Introduction to relativistic kinematics, particlereactions, Lorentz invariant phase space, two-body and three-body phase space, recursion relation, effective mass, dalitz, K-3 p-decay, t-θ puzzle, dalitz plots for dissimilar particles,Breit-Wigner resonance formula, Mandelstem variables.
- 5. Static Quark Model of Hadrons : The Baryon decuplet, quark spin and color, baryon octer, quarkantiquark combination.
- Weak Interactions : Classification of weak interactions, Fermi theory, Parity nonconservationin ßdecay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in Kdecay and its experimental determination.

#### Suggested Readings/Books :

- Introduction to High Energy Physics : D.H. Perkins (Cambridge University Press).
- Elementary Particles : I.S. Hughes (Cambridge University Press), 3<sup>rd</sup>ed. 1991.
- Introduction to Quarks and Partons : F.E. Close (Academic Press, London), 1979.
- Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.

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#### PHS534 ELECTRONICS

Total Marks	Credits	L	Т	P
100	4	3	1	-

- Analog and Digital Instruments: Introduction-Basic Emitter Follower Voltmeter; FET Input Voltmeter; Voltage Follower Voltmeter; Amplifier Type OP AMP Voltmeter; Voltage to Current Converter; Current Measurement with Analog Electronic Instrument; Time Base; Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System; Digital LCR Measurements.
- 2. UJTs and Thyristors: Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics – Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices-Thyristors in Series and in Parallel; Applications of Thyristors-As a Pulse Generator, BistableMultivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT.
- Digital Integrated Circuits: 7400 TTL; TTL Parameters; TTL-MOSFET's; CMOS FET's;Three State TTL Devices; External drive for TTL Loads; TTL Driving External Loads; 74C00 CMOS; CMOS Characteristics; TTL to CMOS Interface; CMOS to TTL interface; Current Tracers.
- 4. Integrated Circuits as Analog System Building Blocks: Electronic Analog Computation; Active Filters: Butterworth Filter-Practical Realization-High Pass Filter-Band Pass Filter-Band Reject Filter; Delay Equalizer; Switched Capacitor Filters; Comparators; Sample and Hold Circuits; Waveform Generators: Square Wave Generator Pulse Generator-Triangle wave Generator-Sawtooth Generator; Regenerative Comparator: Schmitt Trigger.
- 5. Integrated Circuits as Digital System Building Blocks: Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM:Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM ElementsBipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter.

#### Suggested Readings/Books :

- Text Book of Electronics by S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
- Digital Principles and Applications by A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.
- Electronics Principles and Applications by A.B. Bhattacharya, New Central Book Agency P.Ltd., Kolkata, 2007.
- Integrated Electronics Analog and Digital Circuits and Systems by Jacob Millman, Christos C Halkins and Chetan Parikh, 2<sup>nd</sup>Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

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#### PHS-535 FIBRE OPTICS AND NON-LINEAR OPTICS

Total Marks	Credits	L	Т	P
100	4	3	1	-

- 1. **Optical fibre and its properties:** Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types.
- Fiber fabrication and cable design: Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing.
- 3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and

Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations.

- 4. Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.
- Non-linear optics/processes: Introduction, anharmonic potentials and nonlinear polarization, non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes, macroscopic and microscopic susceptibilities.

#### Suggested Readings/Books :

- The Elements of Fibre Optics: S.L.Wymer and Meardon (Regents/Prentice Hall), 1993.
- Lasers and Electro-Optics: C.C. Davis (Cambridge University Press), 1996.
- Optical Electronics :Gathak&Thyagarajan (Cambridge Univ. Press), 1989.
- The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press), 1991.

#### PHS-536 PLASMA PHYSICS

otal arks	Credits	L	Т	
00	4	3	1	1

- Introduction to the Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge.
- 2. Plasma diagnostics: Probes, energy analyzers, magnetic probes and optical diagnostics, preliminary concepts.
- 3. **Single particle orbit theory:** Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves.
- 4. Fluid description of plasmas: distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations.dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves, Magneto sonic waves.
- 5. Stability of fluid plasma: The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle.microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties.

#### Suggested Readings/Books :

- Introduction to Plasma Physics, F.F. Chen
- Principles of Plasma Physics, Krall and Trievelpice
- Introduction to Plasma Theory, D.R. Nicholson
- The Plasma State, J.L.Shohet
- Introduction to Plasma Physics, M.Uman
- Principles of Plasma Diagnostic, I.H. Hutchinson

Department of Physical Scie K. Gujral Punia Main Campus

Scheme & Syllabus (M. Sc. Phy.) Batch 2016 & Onwards

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#### **PHS-537 NONLINEAR DYNAMICS**

Total //arks	Credits	en and many spirits?	L	Т	P
100	4		3	1	-

**1. Phenomenology of Chaos** :Linear and nonlinear systems, A nonlinear electrical system, Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and sizescaling, self similarity, models and universality of chaos.

2. **Dynamics in State Space:** State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence.

3. **Hamiltonian System** : Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaosand stochasticity.

4. **Quantifying Chaos** :Time series, Lyapunov exponents. Invariant measure, Kolmogorov - Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism.

5. Quantum Chaos : Quantum Mechanical analogies of chaotic behaviour. Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics.

#### Suggested Readings/Books :

- Chaos and Non Linear Dynamics : R.C. Hilborn (Oxford Univ. Press), 2001.
- Chaos in Dynamical Systems : E. Ott (Cambridge Univ. Press), 2002.
- Applied Nonlinear Dynamics : A.H. Nayfeh and B. Balachandran (Wiley), 1995.
- Chaos in Classical and Quantum Mechanics : M.C. Gutzwiller (Springer-Verlag), 1990.

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#### PHS-538 STRUCTURES, SPECTRA AND PROPERTIES OF BIOMOLECULES

Total Marks	Credits	L	Т	P
100	4	3	1	-

- 1. Structure Aspects of Biomolecule: Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides.
- 2. Theoretical Techniques and Their Application to Biomolecules: Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses.
- Spectroscopic Techniques and their Application to Biomolecules: Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids.
- 4. Structure- Function Relationship and Modeling: Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model.

#### Suggested Readings/Books :

- Srinivasan & Pattabhi: Structure Aspects of Biomolecules.
- Govil&Hosur: Conformations of Biological Molecules
- Price: Basic Molecular Biology
- Pullman: Quantum Mechanics of Molecular Conformations
- Lehninger: Biochemistry
- Mehler&Cordes: Biological Chemistry dantation Cheoretica
- Smith and Hanawait: molecular Photobiology, Inactivation and Recovery

B Fild: Extended Sputt
 B Fild: Extended Sputt

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#### PHS539-SEMINAR

Total Marks	Credits
Satisfactory/	2
nsatisfactory	2

L	Т	Ρ
-	-	

The aim of Seminar in M.Sc. 3th semesters is to expose some of the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, analysis of data, etc. related to research Project work which can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department in the start of the 3rd semester. These seminars are aimed to develop in-depth subject knowledge and skill. Besides subject expertise, they help train students in the presentation and communication skill.

Situation of Physical Sciences Guiral Púnjab Technical Univer

#### PHS540-PHYSICS LAB-III

Total Marks	Credits
75	3

L	Т	P
-	-	3

#### S.No. Name of the Experiment

1	To study temperature dependence of conductivity of a given semiconductor crystal using four probe method
2	Temperature dependence of a ceramic capacitor-verification of curie-weiss law for the electrical susceptibility of a ferroelectric material
3	To determine charge carrier density and Hall coefficient by Hall effect
4	To determine the band gap of a semiconductor using p-n junction diode
5	To determine magnetic susceptibility of material using Quink 's tube method
6	To determine energy gap and resistivity of the semiconductor using four probe method
7	To trace hysteresis loop and calculate retentivity, coercivity and saturation magnetization
8	To determine dielectric constant of a material with Microwave set up
9	To study the series and parallel characteristics of photovoltaic cell
10	To study the spectral characteristics of photovoltaic cell
11	To determine the g-factor using ESR spectrometer

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#### PHS-541 EXPERIMENTAL TECHNIQUES IN NUCLEAR PHYSICS AND PARTICLE PHYSICS

Total Marks	Credits	L	Т	P
100	4	3	1	-

**1.Detection of radiations:** Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, description of electron and gamma ray spectrum from detector, Cherenkov detector. Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, semiconductor detectors for charged particle spectroscopy, Pulse height spectrum, Compton-suppressed, Semiconductor detectors for charged particle spectroscopy and particle identification.

2. Electromagnetic and Hadron calorimeters: Motion of charged particles in magnetic field, Magnetic dipole and quadrupole lenses, beta ray spectrometer. Detection of fast and slow neutrons - nuclear reactions for neutron detection. General background and detector shielding.

**3. Experimental methods** : Detector systems for heavy-ion reactions : Large gamma and charge particle detector arrays, multiplicity filters, electron spectrometer, heavy-ion reaction analysers, nuclear lifetime measurements (DSAM and RDM techniques), production of radioactive ion beams. Detector systems for high energy experiments :Collider physics (brief account), Particle Accelerators (brief account), Secondary beams, Beam transport, Modern Hybrid experiments- CMS and ALICE.

#### Suggested Readings/Books :

- Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
- Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
- Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.
- Detectors for particle radiation by Konrad Kleinknecht(Cambridge University Press), 1999.



#### PHS 542 PHYSICS OF NANOMATERIALS

Total Marks	Credits	L	Т	P
00	4	3	1	-

- 1. Introductory Aspects : Free electron theory and its features, Idea of band structure—metals, insulators and semiconductors. Density of state in one, two and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials.
- 2. Preparation of Nanomaterials :Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling.
- 3. General Characterization Techniques : Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy.
- Quantum Dots : Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots.
- 5. Other Nanomaterials :Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors.

TUTORIALS : Relevant problems pertaining to the topics covered in the course.

#### Suggested Readings/Books :

- Nanotechnology Molecularly Designed Materials : G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
- Nanotechnology Molecular Speculations on Global Abundance : B.C. Crandall (MIT Press), 1996.
- Quantum Dot Heterostructures: D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley), 1998.
- Nanoparticles and Nanostructured Films-Preparation, Characterization and Application :J.H.Fendler (Wiley), 1998.
- Nanofabrication and Bio-system: H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.
- Physics of Semiconductor Nanostructures: K.P. Jain (Narosa), 1997.
- Physics of Low-Dimension Semiconductors: J.H. Davies (Cambridge Univ. Press) 1998.
- Advances in Solid State Physics (Vo.41) : B. Kramer (Ed.) (Springer), 2001.

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#### PHS-543 ENVIRONMENTAL PHYSICS

Total Marks	Credits		L	Т	P
100	4	a service of sections of	3	1	-

- 1. Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere, Composition of air, Greenhouse effect, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Lass of motion, hydrostatic equilibrium, General circulation of the topics, Elements of weather and climate of India.
- Solar and Terrestrial Radiation : Physics of radiation, Interaction of light with matter, tayleigh and Mie scattering, Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.), Solar and terrestrial spectra, UV radiation, Ozone depletion problem, IR absorption energy balance of the earth atmosphere system.
- 3. Environmental Pollution and degradation: Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors governing air, Water and noise pollution, Air and water quality standards, Waste disposal, Heat island effect, Land and sea breeze, Puffs and plumes, Gaseous and particulate matters, Wet and dry deposition.
- Environmental Changes and remote sensing: Energy sources and combustion processes, Renewable sources of energy, Solar energy, Wind energy, bioenergy, hydropower, fuel cells, nuclear energy, Forestry and bioenergy.
- 5. Global and Regional Climate: Elements of weather and climate, Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, Viscous forces, Reynolds number, Enhanced Greenhouse Effect, Energy balance-a Zero-dimensional Greenhouse model, Global climate models.

#### Suggested Readings/Books :

- Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).
- J. T Hougtion: The Physics of atmosphere (Cambridge University Press, 1977).
- J Twidell and J Weir: Renewable energy Resources (Elbs, 1988).
- Sol Wieder: An introduction t solar energy for scientists and Engineers (John Wiley, 1982)
- R. N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).
- G.J. Haltiner and R.T. Williams: Numerical Weather Prediction (John Wiley, 1980).



#### PHS 544 SCIENCE OF RENEWABLE SOURCE OF ENERGY

Total Marks	Credits		т	P
100	4	3	1	-

- 1. Introduction : Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources.
- Solar Energy :Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, fundamentals of photovoltaic energy conversion. Direct and indirect transition semi-conductors, interrelationship between absorption coefficients and band gap recombination of carriers. Types of solar cells, p-n junction solar cell, Transport equation, current density, open circuit voltage and short circuit current, description and principle of working of single crystal, polycrystalline and amorphous silicon solar cells, conversion efficiency. Elementary ideas of Tandem solar cells, solid-liquid junction solar cells and semiconductor-electrolyte junction solar cells. Principles of photo electrochemical solar cells. Applications.
- Hydrogen Energy: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells, hydride batteries.
- Other sources : Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC.

#### Suggested Readings/Books :

- Solar Energy : S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.
- Solar Cell Devices : Fonash (Academic Press, New York),2010.
- Fundamentals of Solar Cells, Photovoltaic Solar Energy : Fahrenbruch and Bube (Springer, Berlin), 1983.
- Photoelectrochemical Solar Cells : Chandra (New Age, New Delhi).



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#### PHYS 545 RESEARCH PROJECT

Total Marks	Credits	L	T	F
Satisfactory/ Unsatisfactroy	12	-	-	3

The aim of project work in M.Sc. 4th semesters is to expose some of the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiment, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc. Project work can be in Experimental Physics or Theoretical Physics in the thrust as well as non-thrust research areas of the department.

A student opting for this course will be attached to one teacher of the department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc as per course guidelines.



### IK Gujral Punjab Technical University, Kapurthala Department of Physical Sciences

Ref No.: IKGPTU/PS/ 1990

Date: 15/04/2019.

Annexue 1.1.2 8 1.22 (111)

Subject: Proceedings of the Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) meeting held on 29.03.2019.

A meeting of members of Board of Studies (BoS), Physical Sciences (Material Science/Nano Science and Technology) was held on 29.03.2019 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala. The agenda of the meeting was discussed in detail and recommendations were made on point. The proceedings of the meetings were recorded in the minutes of the meeting as enclosed as an Annexure -1.

Submitted for necessary action.

Conve

Dr. Neetika

Chairman, Board of Studies Head, Physical Sciences.

Department of Pt I.K. Guiral Punjab Technical University Main Campus

### I.K. Gujral Punjab Technical University, Kapurthala Department of Physical Sciences

RefNO: 1KGPTU)PS/1989

### **Minutes of Meeting**

Dak: 15/04/2019

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A meeting of members of Board of Studies (BoS). Physical Sciences (Material Science/Nano Science and Technology) was held on 29.03.2019 in the Department of Physical Sciences, I K Gujral Punjab Technical University, Kapurthala.

## Following members of BOS and special invitees were present and actively participated in discussion:

- 1. Dr. Amit Sarin (Chairperson)
- 2. Dr. R. K. Bedi, Member
- 3. Dr Rakesh Dogra, Member
- 4. Dr. Hitesh Sharma, Member
- 5. Dr. Gaurav Bhargava, (Special invitee)
- 6. Dr. Maninder Kaur, Member
- 7. Dr. Jagmeet Bawa, (Special invitee)
- 8. Dr. Priyanka Mahajan, (Special invitee)
- 9. Dr. Sarabjit Singh Mann, (Special invitee)
- 10. Dr. Varinderjit Singh (Special invitee)
- 11. Dr. Neetika (Special invitee)
- 12. S. Navdeepak Sandhu, Member
- 13. Mr. Gurcharan Singh, M.Sc. (2nd Year)-Student representative
- 14. Mr. Nikhil M.Sc. (2<sup>nd</sup> Year)-Student representative

The following members could not attend the meeting:

- 1. Dr. Davinder Mehta, Member
- 2. Dr. Harpreet Kaur Grewal, Member
- 3. Dr. Kanchan L Singh, Member
- 4. Dr. B D Gupta, Member
- 5. Dr. Rajiv Malhotra, Member
- 6. Dr. P. Arumugam, Member
- 7. Dr. Ravi Kumar, Member
- 8. Dr. Arvind Kumar, Member
- 9. Dr. Ranjan Kumar, Member
- 10. Dr. Ashish Arora, (Special invitee)

Technical Universit

### Agenda item 1: To consider the revision of Program Educational objectives (PEO), Program outcomes (POs), Program specific outcomes (PSOs) and Course outcomes of M.Sc. (Physics) course

All BoS members discussed the Program Educational objectives (PEO), Program outcomes (POs), Program specific outcomes (PSOs) of the M.Sc. (Physics) course and with vision of the Department of Physical Sciences. After incorporating suggestions, BOS members recommended the Program Educational objectives (PEO), Program outcomes (POs), Program specific outcomes (PSOs) and Course outcomes (COs) of various subjects for M.Sc. (Physics) w.e.f. 2018-19. The copy of revised scheme and syllabus with revised PEOs, POs, PSOs, and COs is enclosed as Annexure A.

## Agenda item 2: To consider the syllabus of inter disciplinary value-added course on Personality Development for Main Campus

All BoS members discussed the syllabus of inter disciplinary value-added course on Personality Development for M.Sc. Physics students. The syllabus for audit course is designed by the Dr. Priyanka Mahajan. Board members agreed that more interdisciplinary course on Human values, Management, etc., may be added in near future. The copy of finalized syllabus of Personality Development is enclosed as Annexure-B.

## Agenda item 3: To consider the study scheme and syllabus of B. Sc. (Hons) Physics for the first two semesters in the academic session 2019-2020

All BoS members discussed the study scheme of B Sc. (Hons) Physics and syllabus of 1<sup>st</sup> and 2<sup>nd</sup> semester starting from the academic session 2019-2020 in the IKGPTU Main Campus. Board members agreed that two physics core courses with their respective labs will be offered in first two semesters. Proposed study scheme and physics courses syllabus is attached here as Annexure-C. Further subject codes and open elective subjects will be discussed in the next BOS meeting.

## Agenda item 4: To consider the courses on skill and employability enhancement related.

All BoS members discussed and recommended that theory and lab courses on Mathematical Physics, Electronics, Computational, Statistical, Nuclear, Condensed matter, Renewable energies, and Dissertation are essential for the employability enhancement of M.Sc. Physics students.

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### Agenda item 5: To consider syllabus of new courses in PhD Course works

All BoS members discussed and recommended the syllabus of new courses on 1) Advanced Particle Physics and 2) Renewable Energy Resources in the Curriculum of Ph. D course work as per the specialization available in the Department of Physical Sciences. The copy of approved syllabus of Advance Particle Physics and Renewable Energy Resources is enclosed as Annexure-D.

Dr. Amit Sarin Chairperson- BoS, Physical Sciences

**Dean** Academics



Annexure-A

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# **M.Sc.** Physics

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## Course Structure and Syllabus (Based on Choice Based Credit System) 2018 onwards



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Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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# IK Gujral Punjob Technical University

### VISION

To be an institution of excellence in the dorbaln of higher technical education that serves as the fountainhead for nurturing the future center of technology and techno-innovation responsible for the techno-economic, some and the technology and technology of the people of the State of Punjab, the Nation and the World

### MISSION

- To provide seamless education through the pioneering use of technology, in partnership with industry and society with a close to offenote research, discovery and entrepreneurship and
- To prepare its students to be responsible crizens of the world and the leaders of technology and techno-innovation of the list Center why developing in them the desirable knowledge, skill and attitudes base for the second of work and by instilling in them a culture for seamlessness in all facets of hte

### OBJECTIVES

- To offer globally-relevant, industry-linked, research-focused, technology- enabled seamless education at the grounder, unstgraduate and research levels in various areas of engineering & technology and applier, sciences keeping in mind that the manpower so spawned is excellent in quanty, is relevant to the global technological needs, is motivated to give its best and is committed to are provide or the Nation;
- To foster the creation of new and relevant technologies and to transfer them to industry for effective utilization;
- To participate in the planary and a society at large by conducting and managerial problems of relevance to global industry and a society at large by conducting by sic and applied research in the areas of technologies.

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ient of Physical Sciences 14 FIC: Gujral Punjab Technical University ain Campus

- To develop and conduct continuing education programmes for practicing engineers and managers with a view to update their fundamental knowledge base and problem-solving capabilities in the various areas of core competence of the University;
- To develop strong collaborative and cooperative links with private and public sector industries and government user departments through various avenues such as undertaking of consultancy projects, conducting of collaborative applied research projects, manpower development programmes in cutting-edge areas of technology, etc;
- To develop comprehensive linkages with premier academic and research institutions within the country and abroad for mutual benefit;
- To provide leadership in laboratory planning and in the development of instructional resource material in the conventional as well as in the audio-visual, the video and computer-based modes;
- To develop programmes for faculty growth and development both for its own faculty as well as for the faculty of other engineering and technology institutions;
- · To anticipate the global technological needs and to plan and prepare to cater to them;
- To interact and participate with the community/society at large with a view to inculcate in them a feel for scientific and technological thought and endeavour; and
- To actively participate in the technological development of the State of Punjab through the undertaking of community development programmes including training and education programmes catering to the needs of the unorganized sector as well as that of the economically and socially weaker sections of society.

### ACADEMIC PHILOSOPHY

The philosophy of the education to be imparted at the University is to awaken the "deepest potential" of its students as holistic human beings by nurturing qualities of selfconfidence, courage, integrity, maturity, versatility of mind as well as a capacity to face the challenges of tomorrow so as to enable them to serve humanity and its highest values in the best possible way.

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Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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## DEPARTMENT COOPHYSICAL SCIENCES

#### 1/5105

To be a knowledge nearest entry social Sciences. Pure and Applied Research and industry requirements for creating secondable infrastructure and enhancing quality of life

#### MISSION

- To offer globally-relevant industry-linked, research-focused, technology-enabled seamless education at the graduate postgraduate and research levels in various areas of Physical sciences keeping of a that the manpower so spawned is excellent in quality, is relevant to the graduate of the indice and technological needs, is motivated to give its best and is committed to the many of the Nation:
- To develop and condition on control council on programmes for Science graduates with a view to update their control hoordedge base and problem-solving capabilities in the various of a conspectativation of the Conversity.
- To develop comprehensive linkages with premier academic and research institutions within the country and abroad for matual benefit.



Scheme & Syllabus (M.Sc. Physics) Band roll's Antoniards

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### M.Sc. (Physics) Program

### Duration: 2 Years (Semester System)

This M.Sc. (Physics) Program includes various core, electives, and other interdisciplinary courses. The diverse lab experiments allow students to understand the fundamental aspects of the subject. A choice of advanced elective courses offers a glimpse in the frontier areas of research and allow students to work on research project as an integral part of their M.Sc. program. The program also provides adequate exposure to the students for pursuing higher education in the field of technology, research and development in Physics and related areas (M.Phil./Ph.D.) and other job opportunities in academia and industry.

### Eligibility: -

Pass B.Sc. with 50% marks having Physics as one of the subject. A relaxation of 5% is given in case of candidates belonging to SC/ST category.

PROGRAM EDUCATIONAL OBJECTIVES: At the end of the program, the student will be able to:

PEO1	Apply principles of basic scientific concepts in understanding, analysis, and prediction of physical systems.
PEO2	To develop human resource with specialization in theoretical and experimental techniques required for career in academia, research and industry.
PEO3	Engage in lifelong learning and adapt to changing professional and societal needs.



Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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PROGRAM OUTCOMES: At the end of the program, the student will be able to: Apply the scientific knowledge to solve the complex physics problems. PO1 Identify, formulate, and analyze advanced scientific problems reaching substantiated PO2 conclusions using first principles of mathematics, physical, and natural sciences. Design solutions for advanced scientific problems and design system components or PO3 processes that meet the specified needs with appropriate attention to health and safety risks, applicable standard: and economic, environmental, cultural and societal consideration Use research-based knowledge and methods including design of experiments. PO<sub>4</sub> analysis and interpretation of data, and symmetries of the information to provide valid conclusions. POS Create, select, and apply up to plane communicates, resources, and modern scientific tools to complex physics problems with an understanding of the limitations. PO6 Apply reasoning informer by the contextual knowledge to assess societal, health, safety, legal and cultural issues, and the consequent responsibilities relevant to the professional selection of machine PO7 Understand the angulat of the actentific solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development. PO8 Apply ethical principles and commit to the norms of scientific practice. PO9 Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary setungs. PO10 Communicate effectively or adjustition activities with the scientific/Engineering community and with society a write, such as, being after to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. PO11 Demonstrate knew rouge and materstanding of the scientific principles and apply these to one slowing that and the same hadder in a team, to manage projects and in manufisciptinary environment PO12 Recognize the need of and a sec he preparation and abrity to ongage in independent and life-tong learning as the how as so cost of referrific and technological change.

Ten anti

PROGRAM SPECIFIC OUTCOMES At the end of the program, the student will be able to:

Understand the basis and of an an once ats of a fforent brenches of physics.
Perform and design meeting on the actas of fectronics, some nuclear, specific condensed matter and competitional physics.
Apply the concerns and the concerns of areas of benefities of the concerns of

Scheme & Syllabors (M. Sc. Physical Sector Sector)

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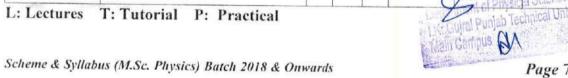
SEMES	TER	FIRST	

Course Code	Course Title		Load Allocation		Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH411-18	Mathematical Physics-I	3	1	-	30	70	100	4
MSPH412-18	Classical Mechanics	3	1	-	30	70	100	4
MSPH413-18	Quantum Mechanics-I	3	1	-	30	70	100	4
MSPH414-18	Electronics	3	1	-	30	70	100	4
MSPH415-18	Computational Physics	3	1	-	30	70	100	4
MSPH416-18	Electronics Lab	-	-	6	50	25	75	3
MSPH417-18	Computational Physics Lab-I	-	-	6	50	25	75	3
1	TOTAL	15	5	12	250	400	650	26

### SEMESTER SECOND

Course Code	Course Title		Load Allocation		Marks Distribution		Total Marks	Credits
		L	T	P	Internal	External		
MSPH421-18	Mathematical Physics-II	3	1	-	30	70	100	4
MSPH422-18	Statistical Mechanics	3	1	-	30	70	100	4
MSPH423-18	Quantum Mechanics-II	3	1	-	30	70	100	4
MSPH424-18	Classical Electrodynamics	3	1	-	30	70	100	4
MSPH425-18	Atomic and Molecular Physics	3	1	-	30	70	100	4
MSPH426-18	Atomic, Nuclear, and Particle Physics Lab	-	-	6	50	25	75	3
MSPH427-18	Computational Physics Lab-II	-	-	6	50	25	75	3
	TOTAL	15	5	12	250	400	650	26

P: Practical **I** utorial 63



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I. K. Galrat Funjah Fechnical University, Kaparthala

SEM	EST	ER	TH	RD

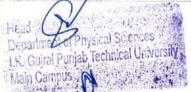
Course Code	Course Title		Loai locat		Marks D	istribution	Total Marks	Credits
		L	T	Ţ.	Internal	External		
MSPH531-18	Condensed Matter Physic	3	1	-	30	70	100	4
MSPH: 32-18	Nuclear Physics	3	1	1-	30	70	100	4
MSPH533-18	Particle Physics	3	1	-	?()	70	100	4
MSPH534-18 MSPH535-18 MSPH536-18	Elective Subject-I	3	ł	-	30	70	100	4
and the second s	Elective Subj. 1	7	4	1.	310	70	100	4
MSPH540-18	Condensed Mutter Physics Lab			6	50	75	75	3
	TOTAL	15	5	6	200	375	575	23

### SEMESTER FOURTH

Course Title	Ą			Marks D	istributicn	Total Marks	Credits
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Elective Subject-III	à	1	*	30	70	100	4
Elective Subject-iv	3	1	-	30	70	100	4
Dissertation		1.2		200	160	366.*	12
TOTAL	6	14		260	240	500	20
	Elective Subject-111 Elective Subject-14 Dissertation	Elective Subject-111 3 Elective Subject-14 3 Dissertation	Allocat       L       Elective Subject-111       3       Elective Subject-113       3       1	Allocation       L     I       Elective Subject-111     3       Elective Subject-13     1       Dissertation     12	Allocation       L     1       P     (n) error)       Elective Subject-111     3       I     -       3     1       -     30       Elective Subject-11     3       1     -       3     1       -     30       -     30       -     30       -     30       -     30       -     30       -     30	Allocation       L     I       P     Internal       Elective Subject-111     3       Image: Subject-111 <td< td=""><td>Allocation     Marks       L     I     P     Internet/External       Elective Subject-111     3     I     -     30     70     100       Elective Subject-11     3     I     -     30     70     100       Elective Subject-11     3     I     -     30     70     100       Dissertation     12     200     160     366.4</td></td<>	Allocation     Marks       L     I     P     Internet/External       Elective Subject-111     3     I     -     30     70     100       Elective Subject-11     3     I     -     30     70     100       Elective Subject-11     3     I     -     30     70     100       Dissertation     12     200     160     366.4

\*Evaluation criteria as and which adopted by IKCPTU

TOTAL NUMBER OF CREDITS = 95



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### LIST OF DEPARTMENTAL/INTERDISCIPLINARY ELECTIVES

### **Elective Subject-I**

S. No.	Name of the Subject	Code
1	Fibre optics and non-linear optics	MSPH534-18
2	Radiation Physics	MSPH535-18
3	Nonlinear Dynamics	MSPH536-18

### **Elective Subject -II**

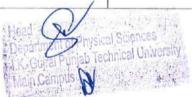
S.No.	Name of the Subject	Code
1	Plasma Physics	MSPH537-18
2	Structures, Spectra and Properties of Biomolecules	MSPH538-18
3	Science of Renewable Source of Energy	MSPH539-18

### Elective-III

S.No.	Name of the Subject	Code
1	Physics of Nanomaterials	MSPH541-18
2	Experimental Techniques in Nuclear and Particle Physics	MSPH542-18
3	Superconductivity and Low Temperature Physics	MSPH543-18

### Elective-IV -

	Name of the Subject	Code
1	Advanced Condensed Matter Physics	MSPH544-18
2	Advanced Particle Physics	MSPH545-18
3	Environment Physics	MSPH546-18



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Theory	V		
S. No.	Evaluation criteria	Weightage n Marks	Remarks
1	Mid term/sessional Tests	20	Internal evaluation (20 Marks)
2	Attendance	S	-MSTs, Quizzes, assignments, attendance, etc., constitute internal
3	Assignments	5	evaluation. Average of two mid comester test will be considered for evaluation.
4	End semester examination	70	External evaluation (70 Marks) Conduct and checking of the answer sheets will at the Department level in case of University teaching Department or Autonomous net tutions. for other colleges examination will be conducted at the University level.
5	Total	100	Marks may be rounded off to nearest
ractics	al		
1	Evaluation of practical record/ Viva Voice	30	internal evaluation (50 Marks)
2	Attendance	5	
3	Seminar/Presentation	15	
4	Final Practical Performance - Viva Voice	25	External evaluation (25 Marks)
5	Total	75	nacks may be rounded off to nearest

Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Invarus

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			Intern	al Assessment		
	Communica presenta		Re	esponse to queries	Maximum Marks	Evaluated by
Departmental Presentation	20			30	50	Committee Member: 1.Head 2.Superviso 3.One of Faculty Member
Dissertation	Plagiarism	Subject Matter	Usage of Language	Publication/Presentation in Conference	150	
	25	70	25	30		
			External	Assessment		
External Examiner			Subject Ma	tter	50	
			50			
-	Communi and Preser		Re	sponse to queries		Committee Member:
Viva Voce	20			30	50	1.Head 2.External Expert 3.Supervisor 4. Director (MC) nominee
		То	tal		300	

#### **Evaluation Process:**

- 1. The subject matter evaluation can further be defined on the basis of Title, Review of literature/Motivation, Objectives, Methodology, Results and discussions, and Conclusion.
- 2. The usage of language and the subject matter shall be evaluated by the supervisor. Out of 300 marks, 95 marks are to be evaluated by the concerned supervisor.
- 3. Total 15% Plagiarism is admissible for submission of the dissertation. For (0-5)% of plagiarism, candidate should be awarded 25 marks. For >5%-10% candidate should be awarded 15 marks and for the range of > 10% to < 15%, candidate should be awarded 5 marks.
- 4. For publication candidate should be awarded full 30 marks and for presenting the work related to dissertation, candidate should be awarded 25 marks.

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Department of Physical Sciences LKA Gural Punjab Technical University Main Campus

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### **Detailed Syllabus:**

- 1. Complex Variables: Introduction, Cauchy-Riemann conditions, Cauchy's Integral formula, Laurent expansion, singularities, calculus of residues, evaluation of definite integrals. Dispersion relation. (Lectures 10)
- Delta and Gamma Functions: Dirac delta function, Delta sequences for one dimensional function, properties of delta function, Gamma function, factorial notation and applications, Beta function. (Lectures 7)
- 3. Differential Equations: Partial differential equations of theoretical physics, boundary value, problems, Neumann & Dirichlet Boundary conditions, separation of variables, singular points, series solutions, second solution. *(Lectures 8)*
- 4. **Special Functions:** Bessel functions of first and second kind, Generating function, integral representation and recurrence relations for Bessel's functions of first kind, orthogonality. Legendre functions: generating function, recurrence relations and special properties, orthogonality, various definitions of Legendre polynomials, Associated Legendre functions: recurrence relations, parity and orthogonality, Hermite functions, Laguerre functions.

(Lectures 10)

5. Elementary Statistics: Introduction to probability theory, random variables, Binomial, Poisson and Normal distribution. (Lectures 5)

### Text Books:

1. Mathematical Methods for Physicists: G. Arfken and H.J. Weber (Academic Press, SanDiego) 7th edition, 2011.

### **Reference Books:**

- 1. Mathematical Physics: P.K. Chattopadhyay (Wiley Eastern, New Delhi), 2004.
- 2. Mathematical Physics: A.K. Ghatak, I.C. Goyal and S.J. Chua (MacMillan, India, Delhi), 1986.
- 3. Mathematical Methods in the Physical Sciences M.L. Boas (Wiley, New York) 2rd edition, 2007.
- 4. Special Functions: E.D. Rainville (MacMillan, New York), 1960.
- 5. Mathematical Methods for Physics and Engineering: K.F. Riley, M.P. Hobson and S.J. Bence (Cambridge University Press, Cambridge) 2rd ed., 2006.



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CC	2	Use d'Alambert principle and calculus of variations to derive the Lagrange equat of motion.									juation	
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CO	5	Apprecia physics mechani	e.g., m	oteento	1,154	. acous	sties, vi	hich is orations	import; of ato	ant in si ans in s	everal a olids, c	reas of oupled
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CO5

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### **Detailed Syllabus:**

1. Lagrangian Formulation: Mechanics of a system of particles; constraints of motion, generalized coordinates, d'Alembert Principle and Lagrange's velocity-dependent forces and the dissipation function, Applications of Lagrangian formulation.

### (Lectures 7)

2. **Hamilton's Principles:** Calculus of variations, Hamilton's principle, Lagrange's equation from Hamilton's principle, extension to nonholonomic systems, advantages of variational principle formulation, symmetry properties of space and time and conservation theorems.

(Lectures 7)

3. Hamilton's Equations: Legendre Transformation, Hamilton's equations of motion, Cyclic coordinates, Hamilton's equations from variational principle, Principle of least action.

(Lectures 7)

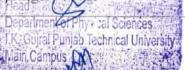
- 4. Canonical Transformation and Hamilton-Jacobi Theory: Canonical transformation and its examples, Poisson's brackets, Equations of motion, Angular momentum, Poisson's Bracket relations, infinitesimal canonical transformation, Conservation Theorems. Hamilton- Jacobi equations for principal and characteristic functions, Action-angle variables for systems with one-degree of freedom. (Lectures 10)
- 5. Rigid Body Motion: Independent co-ordinates of rigid body, orthogonal transformations, Eulerian Angles and Euler's theorem, infinitesimal rotation, Rate of change of a vector, Coriolis force, angular momentum and kinetic energy of a rigid body, the inertia tensor, principal axis transformation, Euler equations of motion, Torque free motion of rigid body, motion of a symmetrical top. (Lectures 10)

### Text Books:

- 1. Classical Mechanics: H. Goldstein, C.Poole and J.Safko (Pearson Education Asia, New Delhi). 2<sup>rd</sup> ed 2001.
- 2. Mechanics by L.D. Landau & E.M. Lifschz (Pergamon), 1976.

### **Reference Books:**

- 3. Classical Mechanics of Particles and Rigid Bodies: K.C. Gupta (Wiley Eastern, New Delhi). 1988.
- 4. Classical Mechanics- J. W. Muller- Kirsten (World Scientific) 2008.
- 5. Advanced Classical & Quantum Dynamics by W. Dittrich, W. And M Reuter, M. (Springer) 1991.
- 6. Classical mechanics by T.W.B. Kibble and Frank H. Berkshire (Imperial College, Press) 2004.
- 7. Mathematical Methods of Classical Mechanics by V. I. Arnold, (Springer) 1978.



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MSF	PH413-1	8 Qui	antum	Mechanics	.)		L-3, 1	C-1, P-0	1	4 Cred	its
Pre-	requisit	e: Basic	knowle	edge of war	e mechanic:	al quanti	im mech	anics			
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Head Department of Phy+ cal Sciences I.K. Guiral Punjab Technical University Main Campus Main Campus

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### **Detailed Syllabus:**

- Linear Vector Space and Matrix Mechanics: Vector spaces, Schwarz inequality, Orthonormal basis, Operators: Projection operator, Hermitian and Unitary operators, change of basis, Eigenvalue and Eigenvectors of operators, Dirac's bra and ket notation, commutators, Simultaneous eigenvectors, Postulates of quantum mechanics, uncertainty relation, Harmonic oscillator in matrix mechanics, Time development of states and operators, Heisenberg, Schroedinger and Interaction representations, Exchange operator and identical particles, Density Matrix and Mixed Ensemble. (Lectures 12)
- Angular Momentum: Angular part of the Schrödinger equation for a spherically symmetric potential, orbital angular momentum operator. Eigen values and eigenvectors of L<sup>2</sup> and Lz. Spin angular momentum, General angular momentum, Eigen values and eigenvectors of J<sup>2</sup> and Jz. Representation of general angular momentum operator, Addition of angular momenta, C.G. coefficients. (Lectures 7)
- Stationary State Approximate Methods: Non-Degenerate and degenerate perturbation theory and its applications, Variational method with applications to the ground states of harmonic oscillator and other sample systems. (Lectures 7)
- Time Dependent Perturbation: General expression for the probability of transition from one state to another, constant and harmonic perturbations, Fermi's golden rule and its application to radiative transition in atoms, Selection rules for emission and absorption of light.

(Lectures 7)

 Scattering Theory: Scattering Cross-section and scattering amplitude, partial wave analysis. Low energy scattering, Green's functions in scattering theory, Born approximation and its application to Yukawa potential and other simple potentials. Optical theorem, Scattering of identical particles. (Lectures 7)

### Text Books:

- A Text book of Quantum Mechanics: P.M. Mathews and K. Venkatesan (Tata McGraw Hill, New Delhi) 1nd edition, 2004.
- 2. Quantum Mechanics: V.K. Thankappan (New Age, New Delhi), 2004.

### **Reference Books:**

- 1. Quantum Mechanics: M.P. Khanna, (Har Anand, New Delhi), 2006.
- 2. Modern Quantum Mechanics: J.J. Sakurai (Addison Wesley, Reading), 2004.
- 3. Quantum Mechanics: J.L. Powell and B. Crasemann (Narosa, New Delhi), 1995.
- 4. Quantum Physics: S. Gasiorowicz (Wiley, New York), 2rd ed. 2002
- Quantum Physics: Concepts and Appleations: Nouredine Zettili (Willow New York), 2nd ed. 2009.
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Scheme & Syllabus (M.Sc. Physics 4

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### **Detailed Syllabus:**

 Semiconductor Devices and applications: Direct and indirect semiconductors, Drift and diffusion of carriers, Photoconductors, Semiconductor junctions, Metal-semiconductor junctions - Ohmic and rectifying contacts, Zener diode, Schottky diode, Switching diodes, Tunnel diode, Light emitting diodes, Photodiodes, Solar cell, Liquid crystal displays.

### (Lectures 7)

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- UJTs and Thyristors: Operational Principle of UJT: UJT Relaxation Oscillator circuit; PNPN Diode: Characteristics- As a Relaxation Oscillator-Rate Effect; SCR: V-I Characteristics-Gate Triggering Characteristics; DIAC and TRIAC; Thyristors: Basic Parameters- As Current Controllable Devices- Thyristors in Series and in Parallel; Applications of Thyristors- as a Pulse Generator, Bistable Multivibrator, Half and Full Wave Controlled Rectifier, TRIAC based AC power control, SCR based Crowbar Protection; Gate Turn-Off Thyristors; Programmable UJT. (Lectures 10)
- 3. Analog and Digital Instruments: OPAMP and its applications, Time Base; 555 Timer, Basic Digital Frequency Meter System; Reciprocal Counting Technique; Digital Voltmeter System.

- 4. Digital circuits: Boolean algebra, de Morgans theorem, Karnaugh maps. (Lectures 5)
- Sequential circuits: Flip-Flops RS, JK, D, COcked, preset and clear operation, race around conditions in JK Flip-flops, master-slave JK flip-flops, Switch contact bounce circuit. Shift registers, Asynchronous and Synchronous counters, Counter design and applications.

### (Lectures8)

6. Integrated Circuits as Digital System Building Blocks: Binary Adders: Half Adder-Parallel Operation-Full Adder-MSI Adder-Serial Operation; Decoder/Demultiplexer: BCD to Decimal Decoder-4-to-16 line Demultiplexer; Data Selector/Multiplexer:16-to-1 Multiplexer; Encoder; ROM: Code Converters-Programming the ROM-Applications; RAM:Linear Selection-Coincident Selection-Basic RAM Elements Bipolar RAM-Static and Dynamic MOS RAM; Digital to Analog Converters: Ladder Type D/A Converter-Multiplying D/A Converter; Analog to Digital Converters: Successive Approximation A/D Converter.

(Lectures 8)

### **Text Books:**

- 1. Text Book of Electronics: S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
- 2. Digital Principles and Applications: A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.

### **Reference Books:**

- 1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
- 2. Integrated Electronics Analog and Digital Circuits and Systems: J. Millman, C.C. Halkins and C. Parikh, 1<sup>nd</sup> Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.

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<sup>(</sup>Lectures 8)

MSP	H415-18	Cor	nputat	ional Ph	ysics		L	-3, T-1,	P-0	4	Credit	S
Pre-r	equisite:	Under	standin	g of grac	iume ie	el phys	nes	(*)				
famili progra in solv	arize the imming ing siraj	studer using a ple phy	nts of M ny high nica pro		idents nguag	with the such as	numeri Fortrar	cal met 1, C++,	hods us etc., so	ed in co	mputat	ion and
Cours	e Outeo	mes: A	t the er	ad of the	grausse	the stra	fent will	be able	10		50 AV 1100	
C	01	App	ly basi lems.	ies know	viedge	of con	nputatio	nal phy	sics in	solvin	g the	physics
(	02		and the second of the last term in the l	with the	6.1.1	any of	hor h.zh	level la	nguage			
0	'03	A.A		- Charle is								
C	04			outcom								
C	:05			e physica							*******	
	ala la constant a la con			of cours	and some the second second	The second			outcor	nes		
	PO1	PO2	POR	1.04	1	206	P07	PO3	PO9	PO10	PO11	PO12
CO1	3	3	2	2	2	1	1	2	3	2	3	2
CO2	3	3	3	1 1	2	1	1	1	3	2	3	2
CO3	3	3							4	2	2	2
								8		14.	-44	2
CO4	3	3	3			3	2	2	2	2	2	2

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### **Detailed Syllabus:**

- Introduction to Computational Physics: Need and advantages of high level language in physics, programming in a suitable high level language (Matlab/Mathematica/Scilab/Octave), input/output, interactive input, loading and saving data, loops branches and control flow, Matrices and Vectors, Matrix and array operations, Graphic tools: Gnuplots, Origin, Sigmaplot, Visual Molecular Dynamics, Mathematica, etc. (Lectures 11)
- Programming with C++: Introduction to the Concept of Object Oriented Programming; Advantages of C++ over conventional programming languages; Introduction to Classes, Objects; C++ programming syntax for Input/Output, Operators, Loops, Decisions, simple and inline functions, arrays, strings, pointers; some basic ideas about memory management in C+. (Lectures 15)
- 3. Numerical methods: Computer algorithms, interpolations-cubic spline fitting, Numerical differentiation Lagrange interpolation, Numerical integration by Simpson and Weddle's rules, Random number generators, Numerical solution of differential equations by Euler, predictor-corrector and Runge-Kutta methods, eigenvalue problems, Monte Carlo simulations.

(Lectures15)

### Text Books:

- 1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
- 2. A first course in Computational Physics: P.L. DeVries (Wiley) 1nd edition, 2011.

### **Reference Books:**

- 1. Computer Applications in Physics: S. Chandra (Narosa) Ind edition, 2005.
- 2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
- 3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.

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MSI	PH416-1	8 EI	ectronic	s Lab				3, 1-1	P-0		4 Credi	ts
Pre-	requisite	e: Unde	rstandir	ng of gri	aduate F	vel phy	sies exp	eriments				
the th	ints of N	1.5c. cl	ass to c	Xperma	Midda Gitt	radues	m elect	ty on El tronics s elop con	o that t	hey can	verify	some o
Cour	se Outc	omes:	At the e	nd of th	e corre	the stu	dent wi	1				
	CO1	Ace	quire ha	nds on a	Nperform	e of ha	ndling a	ind build	ing elec	tronics	circuits	
	CO2	Be	familiar	with th	e var ov	comp	onents s	uch as re				
į	CO3	Be	able to a	understa	and the c	onstruc	tion, wo	circuits. rking pr des, UJT	nciples , TRIA	and V-I C, etc.	charac	teristic
(	04	Cap	able of	using c	manne	as of qu	gitai ele	ctronics	for vari	ous app	lication	ş.
(	005	Abl	e to de:	sign on		i stier	fic exp	neriment.				
		M	apping	often	28 31.4	mei v	th the j	erogran	outcor	nes	1999 (.) y 140 (	
	PO1	PO2	PO3	PO4	pens	PO6	PO7	PO8	PO9	PO10	POIL	PO12
CO1	2	2	2			2	1	2	2	2	2	2
CO2	2	1	2	2	1.	3	!	2	2	2	2	2
CO3	1	1	2			÷	1	2	2	2	2	2
CO4	2	2	2	2	tan sana an A	3	ł	2	2	2	2	2
05	3	2	3	13			1.1	2	2	2	2	2
			1					40	4	25	4	4

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### **Detailed Syllabus:**

### Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. Study the forward and reverse characteristics of a Semiconctor/Zener diode.
- Construction of adder, subtracter, differentiator and integrator circuits using the given OP-Amp.
- 3. Study the static and drain characteristics of a JFET.
- 4. Construction of an Astable multivibrator circuit using transistor.
- 5. Construction of a single FET amplifier with common source configuration.
- 6. To study the operation of Analog to Digital convertor.
- 7. To study the operation of Digital to Analog convertor.
- 8. Construction of a low-pass filter circuit and study its output performance.
- 9. Construction of a high-pass filter circuit and study its output performance.
- 10. To verify the Dmorgan's law using Logic Gates circuit.
- 11. To study the Characteristics of Tunnel Diode.
- 12. To study Amplitude Modulation.
- 13. To study Frequency Modulation.
- 14. To study the Characteristics of SCR.
- 15. To study the Characteristics of MOSFET.
- 16. To study the Characteristics of UJT.
- 17. To study the Characteristics of TRIAC.
- 18. To verify the different Logic and Arithmetic operations on ALU system.
- 19. To study the operation of Encoders and Decoders.
- 20. To study the operation of Left and right shift registers.
- 21. To study the operation of Counters, Ring counters.
- 22. To determine the thermal coefficient of a thermistor.
- 23. To study the operation of an Integrated Circuit Timer.

### Text Books:

- 1. Text Book of Electronics: S. Chattopadhyay, New Central Book Agency P.Ltd., Kolkata, 2006.
- 2. Digital Principles and Applications: A.P. Malvino and D.P. Leach, Tata McGraw-Hill, Publishing Co., New Delhi.

### **Reference Books:**

- 1. Electronics Principles and Applications: *A.B. Bhattacharya*, New Central Book Agency P.Ltd., Kolkata, 2007.
- 2. Integrated Electronics Analog and Digital Circuits and Systems: J. Millman, C.C Halkins and C. Parikh, 1<sup>nd</sup>Edition, Tata McGraw Hill Education Private Limited, New Delhi, 2010.



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MSPH417-18	Computational Physics Lab-I	L-3, T-1, P-0	4 Credits
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Pre-requisite: Understanding of graduate icver numerical methods

**Course Objectives:** The aim and objective of the course on **Computational Physics Lab-I** is to familiarize the of M.Sc. students with the numerical methods used in computation and programming using C++ language so that they can use these in solving simple problems pertaining to physics.

Course Outcomes:	At the end e	d the course	the student will	the able to
		and the second sec		I ON OUTP IN

(	CO1	App	oly basic plems.	es know	dedge o	f comp	utations	l Physic	es in so	lving vi	arious p	hysica
(	CO2	Prop	gramme	with up	261 0	any or	her Ligh	i level la	nolisian			
(	CO3							ng/solvi.			lems	
(	004	Sol	/e probl blems.	on, odi	ist Re	king ar	id analy	tical rea	soning	as appli	ed to se	ientific
(	CO5	Ana	lyse and	Ircerod	ues the	Aperira	ental da	ita.	ne es citatoris e			and a second ballion of
a su na dana a	POI	PO2	001	L <sup>end</sup> a	7. 5.	97.76	POT	P()8	P()9	PO10	POIL	PO12
C01	3	3	2	2		1	1	2	3	2	3	2
CO1 CO2	3	3	2	2	2	1	1	2	3	2	3	
		3 3 3		1	2	1	1       1	2	3 3 i	2 2 2	3	

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CO5

1

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2

### **Detailed Syllabus:**

### Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. To find the standard deviation, mean, variance, moments etc. of at least 15 entries.
- 2. To choose a set of 10 values and find the least squared fitted curve.
- 3. Find y for a given x by fitting a set of values with the help of cubic spline fitting technique.
- 4. To find the Roots of an Algebraic Equation by Bisection method and secant method
- 5. To find the Roots of an Algebraic Equation by Newton-Raphson Method.
- 6. To find the Roots of Linear Equations by Gauss Elimination Method.
- 7. To find the Roots of Linear Equations by Gauss-Seidal Iterative Method.
- 8. Find first order derivative at given x for a set of values with the help of Lagrange interpolation.
- 9. To perform numerical integration of a function by Trapezoidal Rule.
- 10. To perform numerical integration of a function by Simpson's Rule.
- 11. To perform numerical integration of a function by Weddle's rule.
- 12. To solve a Differential Equation by Euler's method and Modified Euler's Method.
- 13. To solve a Differential Equation by Runge Kutta method.
- 14. To find the determinant of a matrix and its eigenvalues and eigenvectors.
- 15. To generate random numbers between (i) 1 and 0, (ii) 1 and 100.

### Text Books:

- 1. Numerical Mathematical Analysis, J.B. Scarborough (Oxford & IBH Book Co.) 6th ed., 1979.
- 2. A first course in Computational Physics: P.L. DeVries (Wiley) 1nd edition, 2011.

### **Reference Books:**

- 1. Computer Applications in Physics: S. Chandra (Narosa) Ind edition, 2005.
- 2. Computational Physics: R.C. Verma, P.K. Ahluwalia and K.C. Sharma (New Age) 2000.
- 3. Object Oriented Programming with C++: Balagurusamy, (Tata McGrawHill) 4th edition 2008.



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MSI	PH421-	18	Mati	rematic	ti Phys	03-11		L-3, T-1.	P-0	4	4 Credi	ts
Pre-1	requisit	e: Unde	erstand	ing of gr	aduate	level n	athem	atics	in a subsection of the			***************
the theor	M.Sc. S etical t	students reatmen	with t in di	the mat fferent	hemetic courses	taught	niques in thi	<ol> <li>Matha that he s class as a care</li> </ol>	she ne and fo	eds for	unders	tandin
Cour	se Outo	omes:	At the e	nd of the	CORLes	the stu	dent wi	II able to	and the second second			
1	CO1	Une Phy	derstand vsica.	the bas	ics and	aplicatio	ons of g	roup theo	ory in a	ll the bra	inches o	ıf
CO2 Use Fourier series and transformations as an aid for analyzing physical pr											sical pro	blems.
(	C <b>O</b> 3	Ap	oly integ	rai trans	alam 1	soive n	nathem:	itical pro	blems	of Physic	es intere	st.
(	CO4	Fer	mulate rdinate	nd et or ransforr	esca po ns.	sical h	av≓in te	rms of te	nsors a	nd simp	lify it by	use o
(	CO5	Dev	elop mi	theman	cai skill	s to solv	ve quan	litative p	oblem.	s in phys	ies.	
	-	M	apping	Q∦ co⊴r	se nase -	10113 W	ith the j	program	outco	n#8		
10 1 -	PO1	PO2	PO3	PO4	POS	PO6	PO7	PO8	PO9	PO10	POIL	PO12
COI	3	3	2	12		1	1	-	2	1	1	2
CO2	3	3	2	1		1	1	-	2	1	1	2
CO3	3	3	2	2	-	i menenen in I	i	-	2		1	2
CO4	3	3	2	2		1	l	-	2	1	1	2
CO5	3	13	2	1					2	1		

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### **Detailed Syllabus:**

- Group Theory: What is a group? Montiplication table, conjugate elements and classes, subgroups, Isomorphism and Homomorphism. Definition of representation and its properties. Reducible and irreducible representation. Schur's temmas (only statements), characters of a representation. Example of C4v. hepological groups and Lie groups, three dimensional rotation group, special unitary groups S1 (1) and SU(2). (Lectures 10)
- 2. Tensors: introduction, definitions, contraction, direct product. Quotient rule, Levi-Civita symbol, Noncartesian tensors, metric tensor, Covariant differentiation.

(Lectures 7)

- Fourier Series and Integral Trumpler as: Fourier series, Dirichlet conditions, General properties, Advantages and applications, Gibbs phenomenon, Fourier transforms, Development of the Fourier integral, Inversion theorem, Fourier transforms of derivatives: Momentum representation, Laplace transforms, Laplace transforms of derivatives, Properties of Laplace transform, Inverse Laplace transformation. (Lectures 15)
- 4. Integral Equations: Definitions and classifications, integral transforms and generating functions. Neumann series, Separable Kernels, Hilbert-Schmidt theory, Green's functions in one dimension.

#### Text Books:

- 1. Group Theory for Physicists. A. W. Joshi Wiley Eastern, New Dethi) 2011.
- Mathematical Methods for Physicists, C. Ariken and H.J. Weber, (Academic Press, San Diego) 7th edition, 2011.

### Reference Books:

- 1. Matrices and Tensors in Physics: A.V. Joshi (Wiley Eastern, New Delhi) 2005.
- 2. Numerical Mathematical Analysis: LB Scarborough (Oxford Book Co., Kolkata) 4th edition.
- 3. A First Course in Computational Physics: P. L. Devries (Wiley, New York) 1994.
- 4. Mathematical Physics: P.K. Chatomach, av (Wiley Eastern, New Delhi) 2011.
- 5. Introduction to Mathematical Physics: C. Harper (Prentice Hall of India, New Delhi) 2006.

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MSPH422-18	Statistical Mechanics	L-3, T-1, P-0	4 Credits

### Pre-requisite: Understanding of graduate level statistical mechanics

**Course Objectives:** The aim and objective of the course on **Statistical Mechanics** is to equip the M.Sc. student with the techniques of statistical ensemble theory so that he/she can use these to understand the macroscopic properties of the matter in bulk in terms of its microscopic constituents.

<b>Course Outcomes:</b>	At the end of the course,	the student will be able to
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CO1	Find the connection between Statistical Mechanics and thermodynamics
CO2	Use ensemble theory to explain the behavior of Physical systems
CO3	Explain the statistical behavior of Bose-Einstein and Fermi-Dirac systems and their applications.
CO4	Work with models of phase transitions and thermo-dynamical fluctuations.
C05	Describe physical problems using quantum statistics.

### Mapping of course outcomes with the program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POII	PO12
CO1	-	1	-	-	-	-	-	1	1	-	-0	-
CO2	3	3	3	1	3	2	1	2	2	1	1	1
CO3	3	3	3	1	2	2	1	2	2	1	1	1
CO4	3	3	3	1	2	2	1	2	2	1	1	1
CO5	3	3	3	1	2	2	1	2	2	1	1	1



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### **Detailed Syllabus:**

- The Statistical Basis of Thermodynamics: The macroscopic and microscopic states, contact between statistics and thermodynamics, classical ideal gas, Gibbs paradox and its solution. (Lectures 7)
- 2. Ensemble Theory: Phase space and Liouville's theorem, the microcanonical ensemble theory and its application to ideal gas of monatomic particles; The canonical ensemble and its thermodynamics, partition function, classical ideal gas in canonical ensemble theory, energy fluctuations, equipartition and virial theorems, a system of quantum harmonic oscillators as canonical ensemble, statistics of paramagnetism; The grand canonical ensemble and significance of statistical quantities, classical ideal gas in grand canonical ensemble theory, density and energy fluctuations. (Lectures 10)
- 3. Quantum Statistics of Ideal Systems: Quantum states and phase space, an ideal gas in quantum mechanical ensembles, statistics of occupation numbers; Ideal Bose systems: basic concepts and thermodynamic behaviour of an ideal Bose gas, Bose-Einstein condensation, discussion of gas of photons (the radiation fields) and phonons (the Debye field); Ideal Fermi systems: thermodynamic behaviour of an ideal Fermi gas, discussion of heat capacity of a free electron gas at low temperatures, Pauli paramagnetism.

(Lectures 10)

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- 4. Elements of Phase Transitions: Introduction, a dynamical model of phase transitions. Ising model in zeroth approximation. (Lectures 8)
- 5. Fluctuations: Thermodynamic fluctuations, random walk and Brownian motion, introduction to non-equilibrium processes, diffusion equation.

#### (Lectures 5)

### Text Books:

 Statistical Mechanics: R.K. Pathria and P.D. Beale (Butterworth-Heinemann, Oxford), 2<sup>rd</sup> edition, 2011.

### **Reference Books:**

- 1. Statistical Mechanics: K. Huang (Wiley Eastern, New Delhi), 1987.
- 2. Statistical Mechanics: B.K. Agarwal and M. Eisner (Wiley Eastern, New Delhi) Ind edition, 2011.
- 3. Elementary Statistical Physics: C. Kittel (Wiley, New York), 2004.
- 4. Statistical Mechanics: S.K. Sinha (Tata McGraw Hill, New Delhi), 1990.



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MSI	PH423-	18	Qua	ntum N	lechani	(s-II		L-3, T-1	, P-0		4 Credi	ts
Pre-	requisi	te: Prel	iminary	course o	f Quant	um Mec	chanics		r (#)r por der Dessis			
techn	auce the	e M.Sc of Relat	s: The a student ivistic q nches of	s to the tiantum	dormał mecha	fructur files and	e of the l Ouanti	e subject um field	and to	equin h	im/har	with th
Cour	rse Out	comes:	At the e	nd of the	e course	the sti	ident wi	ll be able	e to	1793211713 Mil		
1	C01	De	fine the d need fo	relativis n quanta	tic QM Int Ecl	is the c theory	ovarian	t formul:	tion of	quantun	n mecha	nies
CO2 Give the significance of k lein Gordon and Dirac equation and existence of antiparticles.												f
	CO3	Ap	ply the s	ymmetr	ics prin	ciples ai ges.	nd Noet	her's the	orem in	calcula	ting the	
(	CO4	De	monstrat ds.	e the sec	cond au	ntizatio	on for se	calar. Di	rac. and	electror	nagneti	2
(	CO5	Ex	plain the amplitu	origin o	C Feyna Maria	an diag	irams ar essee	nd apply	the Fey	nman ru	les to d	erive
dan dan		N	lapping	of cour	se oute	omes w	ith the	orogram	outcor	nes		ta de esta dese
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POII	PO12
CO1	2	2	2			1	1	2	2	Ì	2	2
02	2	2	3			1	2	1	2	1	2	2
03	2	2	12	1		1	1	I	 2	1	2	2
04	2	2	2		ļ	1	1	2	2	]	2	2
05	2	2	13	-		1	2	2		1	2	2

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### **Detailed Syllabus:**

1. Relativistic Quantum Mechanics-I: Klein-Gordon equation, Dirac equation and its plane wave solutions, significance of negative energy solutions, spin angular momentum of the Dirac particle, the non-relativistic limit of Dirac equation.

### (Lectures 10)

 Relativistic Quantum Mechanics-II: Electron in electromagnetic fields, spin magnetic moment, spin-orbit interaction, Dirac equation for a particle in a central field, fine structure of hydrogen atom, Lamb shift.

### (Lectures 10)

- 3. Quantum Field Theory: Resume of Lagrangian and Hamiltonian formalism of a classical field, Noether theorem, Quantization of real scalar field, complex scalar field, Dirac field and electromagnetic field, Covariant perturbation theory, Wick's theorem, Scattering matrix. (Lectures 10)
- 4. **Feynman diagrams**: Feynman rules, Feynman diagrams and their applications, Yukawa field theory, calculations of scattering cross-sections, decay rates with examples, Quantum Electrodynamics, calculations of matrix elements for first order and second order.

(Lectures 10)

#### Text Books:

- 1. Relativistic quantum Mechanics, J D Bjorken and S D Drell, (Tata McGraw Hill, New Delhi) 2012.
- A first book of Quantum Field Theory, A. Lahiri & P. Pal, (Narosa Publishers, New Delhi). 1<sup>st</sup> ed. 2005.
- 3. Introduction to Quantum Field Theory, M. Peskin & D.V. Schroeder. (Levant Books) 2015.

### **Reference Books:**

- 1. Quantum Field Theory in a Nutshell: A Zee (University Press), 2012.
- 2. Lecture on Quantum Field Theory, A. Das (World Scientific), 2008.
- 3. Text Book of Quantum Mechanics-P.M. Mathews & K. Venkatesan (Tata McGraw Hill. New Delhi), 2004.
- 4. Quantum Field Theory: H. Mandl and G. Shaw (Wiley, New York), 2010.
- 5. Advance Quantum Mechanics: J.J. Sakurai (Addison-Wesley, Reading), 2004.



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MSPH424-18	Classical Electrodynamics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of graduate so vel electricity and magnetism

Course Objectives: The Classical Electrodynamics course covers Electrostatics and Magnetostatics including Maxwell equations, and their applications to propagation of electromagnetic waves in dielectrics; End waves in bounded media, waveguides. Radiation from time varying sources.

Course Outcomes: At the end of the course the student will be able to

C01	Understand and apply the laws of electromagnetism and use Maxwell equations in different forms and different media.
CO2	Explain the dynamics of charged bodies and radiation from localized time varying electromagnetic sources.
CO3	Provide solution to real life plane wave problems for various boundary conditions for different charge configurations.
CO4	Describe the proposition of electromagnetic waves and its propagation through different med and provide contactions
C05	To develop an understanding about the waveguides, and propagation of waves through different waveguides.

### Mapping of course outcomes with the program outcomes

	POI	PO2	300	508	$b_{i+2}$	906	PO7	PO3	PC9	POID	PO11	PO12
C01	2	2	2	1	2	1	2	1	l	1	2	3
CO2	2	2	1	1	1 1. 1	1	1	I	1	3	2	3
CO3	2	2	2	12	12	2	1	i	ì	2	2	3
CO4	2	2		2	1	2	1	1	1	2	2	3
CO5	ĵ	2	1			1	1	2	2		2	3

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### **Detailed Syllabus:**

1. Electrostatics: Laplace and Poisson's equations, Electrostatic potential and energy density of the electromagnetic field, Multipole expansion of the scalar potential of a charge distribution, dipole moment, quadrupole moment, Multipole expansion of the energy of a charge distribution in an external field, Static fields in material media, Polarization vector, macroscopic equations, classification of dielectric media, Molecular polarizability and electrical susceptibility, Clausius-Mossetti relation, Models of Molecular polarizability, energy of charges in dielectric media (Maxwell stress tensor).

### (Lectures 10)

2. **Magnetostatics:** The differential equations of magnetostatics, vector potential, magnetic fields of a localized current distribution, Singularity in dipole field, Fermi-contact term, Force and torque on a localized current distribution. (Magnetic stress tensor)

#### (Lectures 8)

- Boundary value problems: Uniqueness theorem, Dirichlet and Neumann Boundary conditions, Earnshaw theorem, Green's (reciprocity) theorem, Formal solution of electrostatic boundary value problem with Green function, Method of images with examples, Magnetostatic boundary value problems. (Lectures 8)
- 4. **Time varying fields and Maxwell equations:** Faraday's law of induction, displacement current, Maxwell equations, scalar and vector potential, Gauge transformation, Lorentz and Coulomb gauges, Hertz potential, General expression for the electromagnetic fields energy, conservation of energy, Poynting Theorem, Conservation of momentum.

### (Lectures 8)

5. Electromagnetic Waves: wave equation, plane waves in free space and isotropic dielectrics, polarization, energy transmitted by a plane wave, Poynting theorem for a complex vector field, waves in conducting media, skin depth, Reflection and refraction of e.m. waves at plane interface, Fresnel's amplitude relations, Reflection and Transmission coefficients, polarization by reflection, Brewster's angle, Total internal reflection, Stoke's parameters, EM wave guides, Cavity resonators, Dielectric waveguide, optical fibre waveguide. (Lectures 10)

### **Text Books:**

- 1. Classical Electrodynamics: S.P. Puri (Narosa Publishing House) 2011.
- 2. Classical Electrodynamics: J.D. Jackson, (New Age, New Delhi) 2009.
- 3. Introduction to Electrodynamics: D.J. Griffiths (Prentice Hall India, New Delhi) 4th ed., 2011.

### **Reference Books:**

- 1. Classical Electromagnetic Radiation: J.B. Marion and M.A. Heald(Saunders College Publishing House) 2nd edition, 1995.
- 2. Electromagnetic Fields, Ronald K. Wangsness (John Wiley and Sens) Ind edition. 1986.
- 3. Electromagnetic Field Theory Fundamentals: Bhag Singh Guru and H.R. Hiziroglu

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MSF	PH425-1	18	Atomic	and Me	olecular	Physics	•	3, T-1,	P-0	4	Credi	ts
Pre-r	equisit	e: Unde	rstandir	ig of gri	icune la	vel spev	troscop	ý		n al lann na cù ann a		
the s	tudents	of M.S	The air Sc. Phy and Ele	SICS IS	to cam	f the them	course c with th	na Aiom ne know	ie and ledge	Molecu of Aton	lar Phy nic, Rot	sics for ational
Cour	se Outo	omes:	At the ei	nd of th	e course	, the stu	dent wil	l be able	to			****
	C01		ve the b atom	asic ha	swiedzie	f Dob	r's- Son	merfelc	Quant	um theo	ry of hy	/drogen
(	02		derstand lecules	classic	al/quan	lum de	scriptio:	n of ele	etronic	spectra	of atc	m and
(	03	Use	microv	vave and	d Raman	Spectro	scopy !	for analy	sis of ki	nown me	olecules	
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CO4	2	2	3	3	2	1	2	2	2	3	1	3
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### **Detailed Syllabus:**

- Electronic Spectroscopy of Atoms: Bohr-Sommerfeld model of atomic structure, Electronic wave function and atomic quantum numbers – hydrogen spectrum – orbital, spin and total angular momentum - fine structure of hydrogen atom – many electron spectrum: Lithium atom spectrum, angular momentum of many electrons – term symbols – the spectrum of helium and alkaline earths – equivalent and non-equivalent electrons –X-ray photoelectron spectroscopy. (Lectures 8)
- Electronic Spectroscopy of Molecules: Diatomic molecular spectra: Born-Oppenheimer approximation – vibrational spectra and their progressions – Franck-Condon principle – dissociation energy and their products –rotational fine structure of electronic-vibration transition - molecular orbital theory – the spectrum of molecular hydrogen – change of shape on excitation – chemical analysis by electronic spectroscopy – reemission of energy – fundamentals of UV photoelectron spectroscopy. (Lectures 9)
- Microwave and Raman Spectroscopy: Rotation of molecules and their spectra diatomic molecules intensity of line spectra the effect of isotropic substitution non-rigid rotator and their spectra polyatomic molecules (linear and symmetric top molecules) Classical theory of Raman effect pure rotational Raman spectra (linear and symmetric top molecules). (Lectures 8)
- 4. Infra-red and Raman Spectroscopy: The energy of diatomic molecules Simple Harmonic Oscillator the Anharmonic oscillator the diatomic vibrating rotator vibration-rotation spectrum of carbon monoxide –breakdown of Born-Oppenheimer approximation the vibrations of polyatomic molecules –influence of rotation on the spectra of polyatomic molecules (linear and symmetric top molecules) Raman activity of vibrations vibrational Raman spectra vibrations of Spherical top molecules.

(Lectures 8)

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 Spin Resonance Spectroscopy Spin and magnetic field interaction – Larmor precession – relaxation time – spin-spin relaxation - spin-lattice relaxation - NMR chemical shift coupling constants – coupling between nuclei – chemical analysis by NMR – NMR for nuclei other than hydrogen – ESR spectroscopy - fine structure in ESR. (Lectures 8)

### Text Books:

- 1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
- 2. Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.

### **Reference Books:**

1. Physical method for Chemists (Second Edition): Russell S. Drago (Saunders College Publishing).

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- 2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1924.
- 3. Spectroscopy Vol. I, II & III: Walker & Straughen
- 4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Will, 1961,
- 5. Spectra of diatomic molecules: Herzberg-New York, 194 Department of

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MSI	PH426-	18	Atomic		ar, and es Lab	Partich	2	L-3, T-1	P-0		4 Credi	ts
Pre-1	requisit	e: Unde	erstandi:	ig of gra	iduae k	· EPato	nic spec	troscopy	and ni	iclear pl	iysics	
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03	1	1	   1	2		3		2		2	2	2
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### **Detailed Syllabus:**

### Note: Students are expected to perform atleast 10 experiments out of following list.

- 1. Determination of e/m of electron by Normal Zeeman Effect using Febry Perot interferometer.
- 2. To verify the existence of Bohr's energy levels with Frank-Hertz experiments.
- 3. Determination of Lande's factor of DPPH using Electron-spin resonance (E.S.R.) spectrometer.
- 4. Determination of ionization Potential of Lithium.
- 5. Analysis of pulse height of gamma ray spectra.
- 6. To study the characteristics of G.M. tube.
- 7. To verify the inverse square law using GM counter.
- 8. To determine the dead time of G.M. counter.
- 9. To study absorption of beta particles is matter using GM counter.
- 10. To study Gaussian distribution using G.M. counter.
- 11. To estimate the efficiency of GM detector for Gamma and Beta source.
- 12. Determination of Planck's constant using Photocell and interference filters.
- 13. Verification of Inverse square law using Photocell.
- 14. To study Gaussian distribution using scintillation counter.
- 15. To study absorption of gamma radiation by scintillation counter.
- 16. To estimate the efficiency of Scintillator counter.

#### **Text Books:**

- 1. Fundamentals of Molecular Spectroscopy: Colin N. Banwell and Elaine M. McCash (Tata McGraw-Hill Publishing Company limited).
- 2. Physics of Atoms and Molecules: B. H. Bransden and C. J. Joachain.

#### **Reference Books:**

- 1. Physical method for Chemists (Second Edition): Russell S. Drago (Saunders College Publishing).
- 2. Introduction to Atomic Spectra: H.E. White-Auckland McGraw Hill, 1924.
- 3. Spectroscopy Vol. I, II & III: Walker & Straughen
- 4. Introduction to Molecular spectroscopy: G.M. Barrow-Tokyo McGraw Hill, 1961.
- 5. Spectra of diatomic molecules: Herzberg-New York, 1944.

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MSPH427-18	Computational Physics Lab-II	L-3, T-1, P-0	4 Credits
1			

Pre-requisite: Understanding of graduate level numerical methods and C++

**Course Objectives:** The aim and objective of the lab on Computational Physics-II is to train the students of M.Sc. class in understanding numerical methods, the usage of high level language such as C++ language for simulation of results for different physics problems and graphic analysis of physical data, so that they are well equipped in the use of computer for solving physics related problems.

C01	Understand and apply basics knowledge of numerical methods in solving the physics problems.
CO2	Write programme with the a ++ or any other high level language.
CO3	Learn use of graphical methods in data analysis and solving physics problems.
CO4	Solve physical public multing development of critical thinking and analytica reasoning.
CO5	Apply computational physics in frontier areas of pure and applied research in physics and allied field
	Mapping of course outcomes with the program outcomes
PO1	PO2 PO3 PO4 PO5 PO6 PO7 PO8 PO9 PO10 PO11 PO12

	PO1	PO2	PO3	PO4	poye	PO6	PQ7	PO8	PO9	PO10	PO11	PO12
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CO4	3	3	2	2	1	1	1	1	1	ž	1	1
C05	1	1	1	-	1	1	-	1	3	2	1	1

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## Detailed Syllabus:

- 1. Write a program to study graphically the EM oscillations in a LCR circuit (use Runge-Kutta Method). Show the variation of (i) Charge (s Time and (ii) Current vs Time.
- 2. Study graphically the motion of tailing spherical body under various effects of medium (viscous drag, buoyancy and air drag) using Euler method.
- 3. Study graphically the path of a projectile with and without air drag using FN method. Find the horizontal and maximum height in either case. Write your comments on the findings.
- 4. Study the motion of an artificial satellite.
- 5. Study the motion of (a) 1-D harmonic oscillator (without and with damping effects).(b) two coupled harmonic oscillators. Draw graphs showing the relations: i) Velocity vs Time, ii) Acceleration vs Time iii) Position vs Time, also compare the numerical and analytical results.
- 6. To obtain the energy eigenvalues of a quantum oscillator using the Runge-Kutta method.
- 7. Study the motion of a charged particle in: (a) Uniform electric field. (b) Uniform Magnetic field, (c) in combined uniform electric and magnetic fields. Draw graphs in each case.
- 8. Use Monte Carlo techniques to simulate phenomenon of (i) Nuclear Radioactivity. Do the cases in which the daughter nuclei are also unstable with half life greater/lesser than the parent nucleus. (ii) to determine solid angle in a given geometry. (iii) simulate attenuation of gamma rays/neutron in an absorber and (iv) solve multiple integrals and compare results with Simpson's method.
- 9. To study phase trajectory of a Chaotic Pendulum.
- 10. To study convection in fluids using Lorenz system

## Text Books:

- 1. Numerical Recipes in C++ The Act of Scientific Computing, William H. Press, Saul. A.Teukolsky, William T. Votterling, and innen P. Flannery, (Cambridge), Inc. ed. 2001.
- 2. A First Course in Computational Physics P.L. DeVries (John Wiley) 2000.

## **Reference** Books:

- 1. An introduction to Computational Physical Tac Pang (Cambridge), Ind ed. 2006.
- 2. Computer Applications in Physics: S. Chamara (Nerosa), 2006.
- 3. Computational Physics: R.C. Verma S. Johnwalls and K.C. Sharme (New Age), 2005.
- 4. Object Oriented Programming with Case Sulagurmanny, (Tata Mc 1). 5th ed. 2011.

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MS	PH531	-18	Con	lensed [	Matter	Physics		L-3, T-	1, P-0		4 Cred	lits
Pre	requisi	te: Uno	derstand	ing of gr	aduate 1	evel sol	id state	physics				
prop	erties, e	energy	s: The a s of M.S band the g these a	orv and	to the t	opics II	ke elasti	ic consta	ints, lati			1.1
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	CO4	To in	explain solids	the basi	c transp	ort theo	ry for u	nderstan	ding the	e transpo	ort phen	omenor
1	C <b>O</b> 5	Us pro	ing vari	ous mo of insula	odels of tors.	' molec	ular po	larizabil	ity, uno	lerstand	the di	electric
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02	2	2	2	2	2	2	2	2	2	2	2	2
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## **Detailed Syllabus:**

Crystal binding and Elastic constants: Binding in solids; Cohesive energy, Crystals of Inert 1. gases, ionic crystal, Covalent Crystals, Analysis of elastic strains: dilation, stress components; Elastic Compliance and Stiffness: elastic constants, elastic waves in cubic crystals.

(Lectures 6)

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- 2. Lattice Dynamics and Thermal Properties: Vibrations of crystal with monatomic and two atom per primitive Basis; Quantization of Elastic waves, Phonon momentum; Inelastic scattering by phonons, Phonon Heat Capacity, Planck Distribution, normal modes; Density of states, Debye T2 model; Einstein Model; anharmonic crystal interactions; thermal conductivity expansion. (Lectures 9)
- Energy Band Theory: Electrons in a periodic potential: Bloch theorem, Nearly free electron 3. model; Kronig Penney Model; Electron in a periodic potential; tight binding method; Wigner-Seitz Method Semiconductor Crystals, Band theory of pure and doped semiconductors; effective mass elementary idea of semiconductor superlattices.

(Lectures 9)

Transport Theory: Electronic transport from classical kinetic theory; Introduction to 4. Boltzmann transport equation; electrical and thermal conductivity of metals; thermoelectric effects; Hall effect and magneto resistance.

(Lectures 8)

5. Dielectrics and Ferro Electrics: Polarization mechanisms, Dielectric function from oscillator strength, Clausius-Mosotti relation; piezo, pyro- and ferro-electricity; Dipole theory of ferroelectricity; thermodynamics of ferroelectric transition.

(Lectures 8)

## Text Books:

- Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005. 1.
- Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987. 2.

## **Reference Books:**

- Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1971 1.
- Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970. 2.
- Liquid Crystals: S. Chandrasekhar (Cambridge University), Ind ed. 1991. 3.

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M	SPH532	-18		Nuclei	ir Phys	1073 1	· · · · · · · · · · · · · · · · · · ·	L-3, T-	1, P-0		4 Cree	lits
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radi	oactive	decays.	s: The a class to nuclear used in	forces	PHIC boor	sundate	cours, √uelear , and nu	on Nucl Physics iclear rea	tar Ph like str ctions	ysics is atic proj so that t	to famil perties o hey are	iarize tl of nucle equippe
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	CO4	Us		n-aucle				on probl	em to c	explain r	ature of	2
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## **Detailed Syllabus:**

- Nuclear Models: Liquid drop model, Binding energy; fission and fusion, Experimental evidence for shell effects, Shell Model, Spin-Orbit coupling, Magic numbers, Application of Shell Model like Angular momenta and parities of nuclear ground states, Collective modelnuclear vibrations spectra and rotational spectra. (Lectures 8)
- Static properties of nucleus: Nuclear radii and measurements, nuclear binding energy (review), nuclear moments and systematic, wave-mechanical properties of nuclei, hyperfine structure. (Lectures 5)
- 3. Nuclear decay: Review of barrier penetration of alpha decay & Geiger-Nuttal law. Beta decays, Fermi theory, Kurie plots and comparative half-lives, Allowed and forbidden transitions, Experimental evidence for Parity-violation in beta decay, Electron capture probabilities, Neutrino, detection of neutrinos, Multipolarity of gamma transitions, internal conversion process. (Lectures 10)
- 4. Nuclear forces: Evidence for saturation of nuclear density and binding energies (review), types of nuclear potential, Ground and excited states of deuteron, dipole and quadrupole moment of deuteron, single and triplet potentials, meson theory of nuclear forces.

(Lectures 10)

5. Nuclear reactions: Nuclear reactions and cross-sections, Resonance, Breit- Wigner dispersion formula for l=0 and higher values, compound nucleus, Direct reactions, Transfer reactions.

(Lectures 7)

## **Text Books:**

- 1. Nuclear Physics: Irving Kaplan (Narosa), 2001.
- 2. Theory of Nuclear Structure: R.R. Roy and B.P. Nigam (New Age, New Delhi) 2005.

## **Reference Books:**

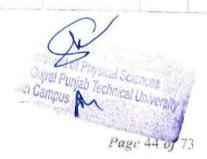
- 1. Basic Ideas and Concepts in Nuclear Physics : K. Hyde (Institute of Physics) 2004.
- 2. Nuclear physics: Experimental and Theoretical, H.S. Hans (New Academic Science) 1<sup>nd</sup> ed (2011).
- 3. Nuclear Physics and its applications: John Lile
- 4. Nuclear Physics: V. Devnathan



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MS	SPH533	-18		Partic	le Physi	03		L-3, T-	I, P-0		4 Cred	its
Pre-	-requis	ite: cou	se on Q	uantum	mechan	ics and	Quantu	m field ]	heory	1		
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(	CO5		ak inter					and how				
		M	lapping	of cour	rse oute	mes w	ith the	program	outcor	nes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POIL	PO12
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02	1	1	1	2	12	1	1	2	2	2	2	3
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## **Detailed Syllabus:**

1. Introduction: Fermions and bosons, particles and antiparticles, quarks and leptons, interactions and fields in particle physics, classical and quantum pictures, Yukawa picture, types of interactions - electromagnetic, weak, strong and gravitational, units.

Invariance Principles and Conservation Laws: Invariance in classical mechanics and quantum mechanics, Parity, Pion parity, Charge conjugation, Positronium decay, Time reversal invariance, CPT theorem. (Lectures 7)

- Hadron-Hadron Interactions: Cross section and decay rates, Pion spin, Isospin, Two nucleon system, Pion-nucleon system, Strangeness and Isospin, G-parity, Total and Elastic cross section, Particle production at high energy. (Lectures 7)
- Relativistic Kinematics and Phase Space: Introduction to relativistic kinematics, particle reactions, Lorentz invariant phase space, two-body and three-body phase space, dalitz plots, K-2p-decay, t-θ puzzle, dalitz plots for dissimilar particles, Breit-Wigner resonance formula. Mandelstem variables. (Lectures 7)
- 5. Static Quark Model of Hadrons: The Baryon decuplet, quark spin and color, baryon octer, quark-antiquark combination. (Lectures 7)
- 6. Weak Interactions: Classification of weak interactions, Fermi theory, Parity non conservation in B-decay, experimental determination of parity violation, helicity of neutrino, K-decay, CP violation in K- decay and its experimental determination.

(Lectures 7)

## Text Books:

- 1. Introduction to High Energy Physics: D.H. Perkins (Cambridge University Press), 2000.
- 2. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
- 3. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

## **Reference Books:**

- 1. Elementary Particles : I.S. Hughes (Cambridge University Press), 2<sup>rd</sup>ed. 1991.
- 2. Introduction to Quarks and Partons : F.E. CLose (Academic Press, London), 1979.
- 3. Introduction to Particle Physics : M.P. Khanna (Prentice Hall of India, New Delhi), 2004.
- 4. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).
- 5. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
- 6. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).



# Elective Subject -I

-										2016	cuve.	subje	ct -1
MS	SPH534	-18	Fi	bre Op	tics and	l Non-li	ucar of	otics	L-3, T-	1, P-0		4 Cred	its
Pre	-requis	ite: 1	Und	erstandi	ng of gr	aduate	evel op	tics	+				1997 - 1997 - 1997
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## **Detailed Syllabus:**

- 1. **Optical fibre and its properties:** Introduction, basic fibre construction, propagation of light, modes and the fibre, refractive index profile, types of fibre, dispersion, data rate and band width, attenuation, leaky modes, bending losses, cut-off wavelength, mode field diameter, other fibre types. *(Lectures 7)*
- Fiber fabrication and cable design: Fibre fabrication, mass production of fiber, comparison of the processes, fiber drawing process, coatings, cable design requirements, typical cable design, testing. (Lectures 5)
- 3. **Optics of anisotropic media:** Introduction, the dielectric tensor, stored electromagnetic energy in anisotropic media, propagation of monochromatic plane waves in anisotropic media, directions of D for a given wave vector, angular relationships between D, E, H, k and Poynting vector S, the indicatrix, uniaxial crystals, index surfaces, other surfaces related to the uniaxial indicatrix, Huygenian constructions, retardation, biaxial crystals, intensity through polarizer/waveplate/ polarizer combinations. *(Lectures 10)*
- 4. Electro-optic and acousto-otpic effects and modulation of light beams: Introduction to the electro-optic effects, linear electro-optic effect, quadratic electro-optic effects, longitudinal electro-optic modulation, transverse electro optic modulation, electro optic amplitude modulation, electro-optic phase modulation, high frequency wave guide, electro-optic modulator, strain optic tensor, calculation of LM for a logitudinal acoustic wave in isotropic medium, Raman-Nath diffraction, Raman-Nath acousto-optic modulator.

(Lectures 10)

5. Non-linear optics/processes: Introduction, anharmonic potentials and nonlinear polarization. non-linear susceptibilities and mixing coefficients, parametric and other nonlinear processes. macroscopic and microscopic susceptibilities. *(Lectures 8)* 

## Text Books:

1. The Elements of Fibre Optics: S.L. Wymer and Meardon (Regents/Prentice Hall), 1992.

## **Reference Books:**

- 1. Lasers and Electro-Optics: C.C. Davis (Cambridge University Press), 1996.
- 2. Optical Electronics: Gathak & Thyagarajan (Cambridge Univ. Press), 1989.
- 3. The Elements of Non-linear Optics: P.N. Butcher & D. Cotter (Cambridge University Press). 1991.



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## **Detailed Syllabus:**

1. Interaction of electromagnetic radiations with Matter: Different photon interaction processes viz. photoelectric effect, Compton scattering and pair production. Minor interaction processes, Energy and Z dependence of partial photon interaction processes. Attenuation coefficients, Broad and narrow beam geometries. Multiple scattering.

(Lectures 8)

2. Interaction of charged particles with Matter: Elastic and inelastic collisions with electrons and atomic nucleus. Energy loss of heavy charged particles. Range-energy relationships, Straggling. Radiative collisions of electrons with atomic nucleus.

#### (Lectures 8)

3. Nuclear Detectors and Spectroscopy: General characteristics of detectors, Gas filled detectors, Organic and inorganic scintillation detectors, Semi-conductor detectors [Si(Li), Ge(Li) HPGe]. Room temperature detectors, Gamma ray spectrometers. Gamma ray spectrometry with Nal(Tl) scintillation and semiconductor detectors.

#### (Lectures 8)

- 4. Nuclear spectrometry and applications: Analysis of nuclear spectrometric data, Measurements of nuclear energy levels, spins, parities, moments, internal conversion coefficients, Angular correlation, Perturbed angular correlation, Measurement of g-factors and hyperfine fields. (Lectures 8)
- 5. Analytical Techniques: Principle, instrumentation and spectrum analysis of XRF, PIXE and neutron activation analysis (NAA) techniques. Theory, instrumentation and applications of electron spin resonance spectroscopy (ESR). Experimental techniques and applications of Mossbauer effect, Rutherford backscattering. Applications of elemental analysis, Diagnostic nuclear medicine, Therapeutic nuclear medicine.

#### Text Books:

(Lectures 8)

- 1. The Atomic Nucleus: R.D. Evans, Tata Mc Graw Hill, New Delhi.
- 2. Nuclear Radiation Detectors: S. S. Kapoor and V. S. Ramamurthy, New Age, International, New Delhi.

#### **Reference Books:**

- 1. Radiation Detection and Measurements: G. F. Knoll, Wiley & Sons, New Delhi.
- 2. Introductory Nuclear Physics: K. S. Krane, Wiley & Sons, New Delhi.
- 3. An Introduction to X-ray Spectrometry: Ron Jenkin, Wiley.
- 4. Techniques for Nuclear and Particle Physics Experiments: W. R. Leo, Narosa Publishing House, New Delhi.
- 5. Introduction to experimental Nuclear Physics: R.M. Singru, Wiley & Sons, New Delhi.



Elective Subject -I

										LILLE	ve Subj	ect -1
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## **Detailed Syllabus:**

- Phenomenology of Chaos: Linear and nonlinear systems, A nonlinear electrical system, 1. Biological population growth model, Lorenz model; determinism, unpredictability and divergence of trajectories, Feigenbaum numbers and size scaling, self similarity, models and universality of chaos. (Lectures 8)
- 2. Dynamics in State Space: State space, autonomous and nonautonomous systems, dissipative systems, one dimensional state space, Linearization near fixed points, two dimensional state space, dissipation and divergence theorem. Limit cycles and their stability, Bifurcation theory, Heuristics, Routes to chaos. Three-dimensional dynamical systems, fixed points and limit cycles in three dimensions, Lyapunov exponents and chaos. Three dimensional iterated maps, U-sequence. (Lectures 10)
- 3. Hamiltonian System: Non-integrable systems, KAM theorem and period doubling, standard map. Applications of Hamiltonian Dynamics, chaos and stochasticity.

(Lectures 8)

Quantifying Chaos: Time series, Lyapunov exponents. Invariant measure, Kolmogorov -4. Sinai entropy. Fractal dimension, Statistical mechanics and thermodynamic formalism.

(Lectures 7)

5. Quantum Chaos: Quantum Mechanical analogies of chaotic behaviour, Distribution of energy eigenvalue spacing, chaos and semi-classical approach to quantum mechanics.

(Lectures 7)

#### Text Books:

1. Chaos and Non Linear Dynamics: R.C. Hilborn (Oxford Univ. Press), 2001.

## **Reference Books:**

- Chaos in Dynamical Systems: E. Ott (Cambridge Univ. Press), 2001. 1.
- Applied Nonlinear Dynamics: A.H. Nayfeh and B. Balachandran (Wiley), 1995. 2.
- 3. Chaos in Classical and Quantum Mechanics: M.C. Gutzwiller (Springer-Verlag), 1990.

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I. K. Gujral Punjab Technical University, Kapurthala

## Elective Subject -II

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## **Detailed Syllabus:**

- Introduction: Plasma State, elementary concepts and definitions of temperature and other parameters, occurrence and importance of plasma for various applications, Production of Plasma in the laboratory, Physics of glow discharge, electron emission, ionization, breakdown of gases, Paschen's laws and different regimes of E/p in a discharge, Townsend discharge and the evolution of discharge. (Lectures 8)
- Plasma diagnostics: Probes, energy analyzers, magnetic probes and optical diagnostics. preliminary concepts. (Lectures 5)
- 3. Single particle orbit theory: Drifts of charged particles under the effect of different combinations of electric and magnetic fields, Crossed electric and magnetic fields, Homogenous electric and magnetic fields, spatially varying electric and magnetic fields, time varying electric and magnetic fields, particle motion in large amplitude waves.

#### (Lectures 8)

- 4. Fluid description of plasmas: distribution functions and Liouville's equation, macroscopic parameters of plasma, two and one fluid equations for plasma, MHD approximations commonly used in one fluid equations and simplified one fluid and MHD equations. dielectric constant of field free plasma, plasma oscillations, space charge waves of warm plasma, dielectric constant of a cold magnetized plasma, ion- acoustic waves, Alfven waves. (Lectures 10)
- 5. Stability of fluid plasma: The equilibrium of plasma, plasma instabilities, stability analysis, two stream instability, instability of Alfven waves, plasma supported against gravity by magnetic field, energy principle. microscopic equations for my body system: Statistical equations for many body systems, Vlasov equation and its properties, drift kinetic equation and its properties. (Lectures 7)

#### Text Books:

1. Introduction to Plasma Physics, F.F. Chen

#### **Reference Books:**

- 1. Principles of Plasma Physics, Krall and Trievelpice
- 2. Introduction to Plasma Theory, D.R. Nicholson
- 3. The Plasma State, J.L. Shohet
- 4. Introduction to Plasma Physics, M. Uman
- 5. Principles of Plasma Diagnostic, I.H. Hutchinson



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I. K. Gujral Punjab Technical University, Kapurthala

Elective Subject-II

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CO3         Understand use of various spectroscopic techniques and Biomolecules.         CO4         Understand the structure-Function relationship and modeli         CO5         Outline and correlate for providing solution to interdiscipli         Mapping of course outcomes with the program outcomes         PO1         PO2         2         2         2         2         PO5</td><td>of Biomolecules       L-3, 1-1, P-0         requisite: Understanding of graduate level chemistry and physics         rese Objectives: The aim and objective of the course on Structures, Spectra iomolecules is to familiarize the M.Se. students with the basics of the record field of dynamics of Structures, Spectra and properties of Biomolecules.         rese Outcomes: At the end of the course, the student will be able to         CO1       Describe various structural and chemical bonding aspects of Biomolecules.         CO2       Understand structure and theoretical techniques and their Biomolecules.         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## **Detailed Syllabus:**

- 1. Structure Aspects of Biomolecule: Conformational Principles, Conformation and Configuration Isomers and Derivatives, Structure of Polynucleotides, Structure of Polypeptides, Primary, Secondary, Tertiary and Quaternary Structure of Proteins, Structure of Polysaccharides. (Lectures10)
- Theoretical Techniques and Their Application to Biomolecules: Hard Sphere Approximation, Ramachandran Plot, Potential Energy Surface, Outline of Molecular Mechanics Method, Brief ideas about Semi-empirical and Ab initio Quantum Theoretical Methods, Molecular Charge Distribution, Molecular Electrostatic Potential and Field and their uses. (Lectures 10)
- Spectroscopic Techniques and their Application to Biomolecules: Use of NMR in Elucidation of Molecular Structure, Absorption and Fluorescence Spectroscopy, Circular Dichroism, Laser Raman Spectroscopy, IR spectroscopy, Photoacoustic Spectroscopy, Photo-biological Aspects of Nucleic Acids. (Lectures 10)
- 4. Structure-Function Relationship and Modeling: Molecular Recognition, Hydrogen Bonding, Lipophilic Pockets on Receptors, Drugs and Their Principles of Action, Lock and Key Model and Induced fit Model. (Lectures 10)

## **Text Books:**

1. Srinivasan & Pattabhi: Structure Aspects of Biomolecules.

#### **Reference Books:**

- 1. Govil & Hosur: Conformations of Biological Molecules
- 2. Price: Basic Molecular Biology
- 3. Pullman: Quantum Mechanics of Molecular Conformations
- 4. Lehninger: Biochemistry
- 5. Mehler & Cordes: Biological Chemistry
- 6. Smith and Hanawait: molecular Photobiology, Inactivation and Recovery



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Sol	urse O urces is ergy, hyd	to ex droger	ives: The pose the r energy,	aim ar M.Sc. s etc.	nd object tudents	tive of to the b	the co	urse on the alte	Science	e of re	newable sources	e Energ like sol
			es: At the								0.01 g to 4 - 10 m + 0.11 m - 10 m	
	C01		Understa alternativ							between	n traditi	onal an
	CO2		Describe									
	CO3		Analyze r	naking o	f solar c	ell and	its types	and and	- derma	ii applici	ations.	
	CO4	i	dentify h	ydrogen	as energ	sourc	e, its sto	Tage and	Iranen			
	C05	(	'ompare i	wind are	rgy, war	an energ	ey and p	cean the	rmal en		method:	S.
			Mappin	g of cour	rse oute	omes w	ith the	Drogrop	a contest	e gy con	version	
	1.000							program	i outcol	nies		
	POI	PO	2 PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POII	DOLD
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05	2	2	-	2	1	1	2	1	1	3	1	

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Scheme & Syllabus (M.Sc. Physics) Butch 2018 & Observals

## **Detailed Syllabus:**

- 1. Introduction: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. (Lectures 8)
- Solar Energy: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, Principal of working of solar cell, Performance characteristics of solar cell. Types of solar cell, crystalline silicon solar cell, Thin film solar cell, multijunction solar cell, Elementary ideas of perovskite solar cell, dye synthesized solar cell and Tandem solar cell, PV solar cell, module, array, and panel, Applications.

#### (Lectures 11)

3. **Hydrogen Energy**: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors, use of hydrogen as fuel; use in vehicles and electric generation, fuel cells.

(Lectures 10)

4. Other sources: Nature of wind, classification and descriptions of wind machines. power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC, basic idea about biogas, biofuel, and biodiesel.

(Lectures 8)

#### **Text Books:**

1. Solar Energy: S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.

## **Reference Books:**

- 1. Solar Cell Devices: Fonash (Academic Press, New York), 2010.
- 2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: Fahrenbruch and Bube (Springer, Berlin), 1982.
- 3. Photoelectrochemical Solar Cells : Chandra (New Age, New Delhi).



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MS	PH540-1	8 0	Conden	seci Ma	tter Ph	vsies La	b	L-3, T-	I, P-0		4 Cred	its			
Pre-	requisite	: Unde	erstandi	ng of gr	aduate l	ovel soli	d state	physics	experin	ients		1 ma (11			
Courto tra physi	rse Obje ain the s ics so the isticated	ctives: tudent:	The airs of M.	m and o Sc. elas	bjective is to ac	of the lyanced	courses	on Con	densed	Matter	Physic ondense ident to	s Lab d matte handl			
Cour	rse Outco	omes:	At the e	nd of the	e cours:	the stu	dent wi	ll be abl	e to	· · · · · · · · · · · · · · · · · · ·					
	CO1	Me	asure co	nductiv	ity, resi	stivity a	nd therr	no-dyna	mical p	ropertie	s of soli	ds.			
	CO2	Me	Measure conductivity, resistivity and thermo-dynamical properties of solids. Measure magnetic properties and magnetic behavior of magnetic materials.												
(	CO3	Des	Describe the lattice dynamics of simple lattice structures in terms of dispersion relations.												
(	CO4	Des anal	Design and carry out scientific experiments as well as accurately record and analyze the results of experiments.												
(	205	Solv	e proble	en with	critical	thinking	g and ar	alytical	reasoni	ne.					
		M	apping	of cour	se outco	omes wi	th the p	orogran	outcom	nes	n y an				
	POI	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POII	PO12			
CO1	2	1	1	1	1		-	2	2	2	2	2			
02	2	1	1	1	1			2	2	2	2	2			
203	1	1	1	1	ï	-		2	2	2	2	2			
04	2	2	2	2	2	2	2	2	2	2	2	2			
05	3	3	2	2	7	2	2	2	2	2					
										4	2	2			

Gujral Punjab Technical University

Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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## **Detailed Syllabus:**

## Note: Students are expected to perform atleast ten experiments out of following list.

- 1. To study temperature dependence of conductivity of a given semiconductor crystal using four probe method.
- 2. Verification of curie-weiss law for the electrical susceptibility of a ferroelectric material.
- 3. To determine charge carrier density and Hall coefficient by Hall effect.
- 4. To determine magnetic susceptibility of material using Quink 's tube method.
- 5. To determine energy gap and resistivity of the semiconductor using four probe method.
- 6. To study the B-H loop characteristics.
- 7. To determine dielectric constant of a material with Microwave set up.
- 8. To measure the Curie temperature of a given PZT sample.
- 9. To measure the velocity of ultrasonic wave in liquids.
- 10. To study dispersion relation for Mono-atomic and Diatomic lattices using Lattice dynamic kit.
- 11. To study the properties of crystals using X-Ray Apparatus.

### **Text Books:**

- 1. Introduction to Solid State Physics: C. Kittel (Wiley, New York), 8th ed. 2005.
- 2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

## **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1971
- 2. Solid State Theory: Walter A. Harrison (Tata McGraw-Hill, New Delhi) 1970.
- 3. Liquid Crystals: S. Chandrasekhar (Cambridge University), Ind ed. 1991.



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2M

## Elective Subject -III

MSPH	MSPH541-18 Physics of Nanomaterials							L-3, T-1	, P-0	T	4 Cred	its				
Pre-re	quisite	: Con	densed	matter	physics	1	o constante aure.		*****		*********	1				
rannina.	of diffe	s stude	INS OF D	A.SC. 10	the var	LOUIS ASI	Parts ral	e on Ph ated to p can purs	mammint	and alan	on a surviver					
Course	Outco	mes:	At the e	nd of th	e course	, the sti	ident wi	II be abl	e to	a an						
CO1 Apply the knowledge on free electron theory to the band structure of insulators, and semiconductors.												metal				
CO2 Acquire knowledge of basic approaches to synthesize the inorganic nanopart											article					
CO	CO3 Describe the use of unique optical properties of nanoscale metallic structur analytical and biological applications															
CC	)4	Unc nan	derstand ostructu	the pl red mes	emical als.	properti	es of	carbon	nanotub	es an						
CC	)5	Det	ermine, cepts, n	the stru ot appric	cture-pi able at	operty larger le	relation	ships in ales.	nanom	aterials	as well	as the				
		M	apping	of cour	se ourc	omes w	ith the j	orogram	ourcoi	nes						
	POI	PO2	PO3	r'04	POS	PO6	PO7	PO8	PO9	PO10	POII	PO12				
CO1 1		2	2	3	3	1	2	1	1	2	2	3				
CO2 1		2	2	3	3	2	2	1	1	2	2	3				
203 1		2	2	3	3	2	2	1		2	2	3				
204 1		2	2	3	3	2	2	1	1	2	2	3				
05 1		2	2	2	ine en espe	2	2	1	1	2	2	3				
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## **Detailed Syllabus:**

- 1. Introductory Aspects: Free electron theory and its features, Idea of band structure metals, insulators and semiconductors. Density of state in one, two, and three dimensional bands and its variation with energy, Effect of crystal size on density of states and band gap. Examples of nanomaterials. (Lectures 8)
- 2. Preparation of Nanomaterials: Bottom up: Cluster beam evaporation, ion beam deposition, chemical bath deposition with capping techniques and Top down: Ball Milling.

(Lectures 8)

- 3. General Characterization Techniques: Determination of particle size, study of texture and microstructure, Increase in x-ray diffraction peaks of nanoparticles, shift in photo luminescence peaks, variation in Raman spectra of nanomaterials, photoemission microscopy, scanning force microscopy. (Lectures 8)
- 4. Quantum Dots: Electron confinement in infinitely deep square well, confinement in one and two-dimensional wells, idea of quantum well structure, Examples of quantum dots, spectroscopy of quantum dots. (Lectures 8)
- 5. Other Nanomaterials: Properties and applications of carbon nanotubes and nanofibres, Nanosized metal particles, Nanostructured polymers, Nanostructured films and Nano structured semiconductors. (Lectures 8)

## Text Books:

- 1. Nanotechnology-Molecularly Designed Materials: G.M. Chow & K.E. Gonsalves (American Chemical Society), 1996.
- 2. Nanotechnology Molecular Speculations on Global Abundance: B.C. Crandall (MIT Press), 1996.

## **Reference Books:**

- 1. Quantum Dot Heterostructures: D. Bimerg, M. Grundmann and N.N. Ledentsov (Wiley), 1998.
- 2. Nanoparticles and Nanostructured Films-Preparation, Characterization and Application: J.H.Fendler (Wiley), 1998.
- 3. Nanofabrication and Bio-system: H.C. Hoch, H.G. Craighead and L. Jelinski (Cambridge Univ. Press), 1996.
- 4. Physics of Semiconductor Nanostructures: K.P. Jain (Narosa), 1997.
- 5. Physics of Low-Dimension Semiconductors: J.H. Davies (Cambridge Univ. Press) 1998.
- 6. Advances in Solid State Physics (Vo.41): B. Kramer (Ed.) (Springer), 2001.



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I. K. Gujral Punjab Technical University, Kapurthala

## Elective Subject -III

										Liechv	e subje	ct -111
IVIS	SPH542	-18	Expe Nucle	rimenta ar and	d Techa Particle	iques in Physic	n s	L-3, T-	1, P-0		4 Cred	lits
Pre	-requis	ite: Co	urse on N	vuclear	Physics	and Par	ticle Ph	ysics	•	1		
ofdi	ifferent	equipr	ient and	method	s usec în	) the fiel	dents of m	urse on f M.Sc. s aclear ph	students ysics ar	imental to expe id partic	<b>Techn</b> rimenta le physi	<b>iques</b> l'aspec es.
Cou		comes	: At the a	end of th	re cours	e, the st	udent w	ill be abl	e to	1		
CO1 Understand various experimental techniques for describing radiations with matter.											ction of	
	CO2	2 Use various statistical methods for experimental data.										
	CO3	Knowledge about the different types of the radiation detectors and applications.										id thei
	CO4	In	roduced	to neut	on phys	ics, met	hods to	detector	slow a	id fast n	entrops	
	CO5	Eq	uipped v rious lab	vith the	basic kr	owledg	e about	the expe	rimenta	method	ds used	in the
	n nun <del>ssan</del> a	N	Aapping	of cou	rse oute	ines w	ith the	program	outco	nes	· · · · · · · · · · · · · · · · · · ·	
	PO1	PO2	PO3	PO4	POS	PO6	PO7	PO8	PO9	POIO	PO11	PO12
CO1	-	-	2		1	•	-	1		1	1	1
02	-	~		3	1	-	-	3	1	1	1	1
03	-	-	1	2	13		1	3	2	2	2	2
04	-	-	1	3	3	1	1	2	2			
05	-		1	3						2	2	2
				3	1	1		2	2	2.	2	2

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## **Detailed Syllabus:**

- 1. Detection of radiations: Interaction of gamma-rays, electrons, heavy charged particles, neutrons, neutrinos and other particles with matter. General properties of Radiation detectors, energy resolution, detection efficiency and dead time. Statistics and treatment of experimental data. *(Lectures 8)*
- 2. Detectors: Gas-filled detectors, Proportional counters, space charge effects, energy resolution, time characteristics of signal pulse, position-sensitive proportional counters, Multiwire proportional chambers, Drift chamber, Time projection chamber. Organic and inorganic scintillators and their characteristics, light collection and coupling to photomultiplier tubes and photodiodes, Semiconductor detectors, Ge and Si(Li) detectors, Charge production and collection processes, Pulse height spectrum, General background and detector shielding.

(Lectures 16)

3. Applications of Detectors: Description of electron and gamma ray spectrum from detector, semiconductor detectors in X- and gamma-ray spectroscopy, Compton-suppressed, Semiconductor detectors for charged particle spectroscopy and particle identification.

(Lectures 8)

4. Experimental methods: Large gamma and charge particle detector arrays, heavy-ion reaction analysers, production of radioactive ion beams. Detector systems for high energy experiments: Collider physics (brief account), Particle Accelerators (brief account), Modern Hybrid experiments- CMS. (Lectures 8)

## Text Books:

1. Techniques in Nuclear and particle Experiments by W.R. Leo (Springer), 1994.

## **Reference Books:**

- 1. Radiation detection and measurement by Glenn F. Knoll (Wiley), 2010.
- Introduction to Experimental Particle Physics by Richard Fernow (Cambridge University Press), 2001.
- 3. Detectors for particle radiation by Konrad Kleinknecht (Cambridge University Press), 1999.



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I. K. Gujral Punjab Technical University, Kapurthala

Elective Subject -III

	SPH543	1	Superco) Fempera	ture Ph	ity and l tysics	Low		L-3, T-	1, P-0		4 Cre	dits
Pre-	requisi	ite: cou	irse in Co	ondense	d Matier	Physic	s			1		
supe trend impo achie backy	rconduc ls in the ortant to evable to ground	etivity. e expension ool to emperato of low	es: The uild fur Students rimental explore ature now temperat	will no techriqu rich phy is close ture tech	ot only f nes as w /sics of e to few miques a	wen a earn the vell. Lo superce µK. St as well a	s advait coretical w tempe onductiv udents v as the hi	aspects erature i vity. Wi vill also gh-Tc su	but als s one c th lates be intro upercon	nding i so acqua of the m t techno	n the unted w ost vers ology th	field ith late atile a
*****			At the e									
	CO1		neoretica								1	
CO2 Correlate observed experimental pr superconductivity.								ies of s	upercor	ductors	with c	rigin c
(	CO3 Describe appropriate theoret superconductors.							del fo	r des	cribing	behav	ior o
(	CO4	Pro	ovide exp derstandi	oosure to ng of lo	) High T w tempe	e class trature i	of super	conduct es.	ors and	theoreti	cal	
C	05	Pro	ovide exp erconduc	osure at					s îor m	easurem	ent of	
and the second second		N	lapping	of cour	se outco	mes wi	th the p	rogram	ourcon	nes		
	POI	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POII	PO12
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03	1	2	2	2	2	2	2		2	-	3	3
	1	2	2	2	2	2	2	-	2	2	2	3
04				2		-						
04 05	1	2	2	4		- Ele	an Al	1	2	1	3	3

## **Detailed Syllabus:**

- Superconductivity: Introduction, Thermodynamics, The London Equations, penetration depth, Superconductors in magnetic field, Ginzberg-Landau Theory, Type I and II superconductors, BCS theory, second quantization, Cooper Pairing, energy gap Tunnelling, Josephson effects and SIS tunneling. (Lectures 10)
- Preparation and measurement techniques: Single crystal growth: Optical image furnace, seeded melt growth, Thin film deposition: Pulsed laser deposition, sputtering, Resistivity measurements, magnetic measurements, Point contact spectroscopy, scanning tunneling microscopy and spectroscopy. (Lectures 10)
- Cryogenics: Thermal and electrical properties of different materials at low temperatures, Cooling methods above 1K, Joule-ThomPOn, Gifford-McMohan, Evaporation cooling, Liquefication of Helium, Cooling methods below 1K, dilution refrigeration, adiabatic demagnetisation. (Lectures 10)
- 4. Introduction to high-Tc superconductors: Discovery of high-Tc superconductors, Mechanisms of superconductivity in high-Tc superconductors, Introduction to high-Tc superconducting compound like YBCO, Synthesis, Structure and properties, Electronics and applications. (Lectures 10)

#### Text Books:

1. Introduction to superconductivity: Michael Tinkham, Courier Corporation, 2004.

#### **Reference Books:**

- 1. Introduction to superconductivity: A.C. Rose-Innes and E.H. Rhoderick, Pergamon Press. 2004.
- 2. Experimental techniques in low temperature physics: G.K. White and P.J. Meeson, Oxford Univ. Press, 2001.
- 3. Experimental low temperature physics: A. Kent, MacMillan Press, 1992.
- 4. The theory of superconductivity in high-TC Cuprates: P.W. Anderson, Princeton Series Publications.



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# Elective Subject -IV

MS	PH544		Advance Physics	d Cond	ensed N	fatter		L-3, T-	1, P-0		4 Cree	lits
Pre	-requis	ite: cou	rse on C	ondense	d Matte	r Physic	¢s 👘			1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	
supe	erconduc	ctivity,	s: The o Sc. stude magneti rechniqu	c resona	nce tecl	brimes						
Cou	rse Out	comes:	At the o	end of th	e cours	e, the st	udent w	ill be ab	le to	<b>6</b>		
CO1 Comprehend and describe the Optical properties of solids macroscopic theories.												nployin
	CO2 Explain various types of mignetic phenomenon in solids, underlying physics correlation with the applications.											sics, an
CO3 Understand and realize the use of NMR methods for describing solids.												
	CO4		erpret th									
1	CO5	Fig	ure out ids									avior o
		N	Ispping	ofcour	'se oufc	mes w	ith the j	program	n outco	mes		
	POI	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
01	2	1	2	2	2	2	1	1	2	2	2	3
02	2	2	2	2	1	2	1	2	2	1	2	3
03	3	2	12	1 2	12	i - 1	2	2	2	2	1	
04	2	2	2	2	2	2	2	1				2
	3	2	2	2	1	2	2	2	2	2	2	2
05	3											

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## **Detailed Syllabus:**

 Optical Properties: Macroscopic theory; Reflectance and Transmittance of a slab; generalized susceptibility, Kramers- Kronig relations, Brillouin scattering, Raman effect in crystals; interband transitions. (Lectures 8)

2. **Magnetism:** Dia and para-magnetism in materials; Langevin theory of diamagnetism, quantum theory of diamagnetism and paramagnetism, Exchange interaction. Heisenberg Hamiltonian; Hubbard model; mean field theory; Ferro-, ferri- and antiferromagnetism; Magnons: spin waves, thermal excitation of magnons; Bloch T2/1 law. (Lectures 8)

- 3. Nuclear Magnetic Resonance in Solids: Origin of NMR in solids- equations of motion, line width, motional narrowing, Knight shift. (Lectures 8)
- 4. Superconductivity: Experimental Survey; Basic phenomenology; Vortex state of a Type II superconductors; BCS pairing mechanism and nature of BCS ground state; Flux quantization; Tunneling Experiments; High Tc superconductors; Ginzburg-Landau theory; Greens functions at zero temperature; Applications of Greens functions to superconductivity. (Lectures 8)
- 5. **Disordered Solids:** Basic concepts in point defects and dislocations; Noncrystalline solids: diffraction pattern, Glasses, Amorphous semiconductors and Ferromagnets, Heat capacity and Thermal conductivity of amorphous solids; Quasicrystals. (Lectures 8)

#### **Text Books:**

- 1. Introduction to Solid State Physics: C. Kittel (Wiley, New York) 2005.
- 2. Quantum Theory of Solids: C. Kittel (Wiley, New York) 1987.

## **Reference Books:**

- 1. Principles of the Theory of Solids: J. Ziman (Cambridge University Press) 1971.
- 2. Solid State Physics: H. Ibach and H. Luth (Springer, Berlin), 2rd. ed. 2001.
- 3. A Quantum Approach to Solids: P.L. Taylor (Prentice-Hall, Englewood Cliffs), 1970.
- 4. Intermediate Quantum Theory of Solids: A.O.E. Animalu (East-West Press, New Delhi), 1991.
- 5. Solid State Physics : Ashcroft and Mermin (Reinhert & Winston, Berlin), 1976.

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Elective Subject -IV

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MSI	PH545-	18	Adva	nced Pa	rticle P	bysics		L-3, T-1	, P-0		4 Credi	ts
Pre-	requisi	te: Kno	wledge	of partic	le physi	cs	<u> </u>					
field scher	theory, nes so t	M.Sc. cl standai	ass to the rd mode winders	e relativ	vely adv ticle ph	anced t vsics, C	opics re ICD and	nced Pa lated to i quark are well	symmet model	ry break	ting in t	juantur ificatio
Cour	rse Out	comes:	At the e	nd of th	e course	, the stu	ident wi	ll be able	e to			
CO1 Understand various global and local gauge symmetries of system, invariation, symmetry breaking, and Higgs mechanism.												ance o
CO2 Need for standard model of particle physics and its limitations and the prop of QCD.											opertie	
(	CO3	Der ren	fine the ormalise	problem tion me	of dive thods.	rgencie	s in qua	ntum fiel	d theor	ies and t	he	
(	CO4	Asy	mptotic abelian	freedor gauge	n and in theory o	trared s f strong	lavery o interact	f the rur ions -Q(	ning co CD.	oupling o	constant	in
(	CO5	Giv	en expo	sure abc	out the p	inysics b	beyond t	he Stand	lard Mo	del.		
		M	lapping	of cour	se outc	omes w	ith the j	orogram	outcor	nes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	2	2	2	2	-	2	1	2	2
CO2	2	1	1	2	2	2	2	-	2	1	2	2
03	1	2	1	2	2	2	2	-	2	3	1	2
CO4	1	1	2	1	2	2	2	-	1	2	1	2
05	1	2	2	1	2	2	2	-	2	2	3	2
	1	1	J				1 Photos					



## **Detailed Syllabus:**

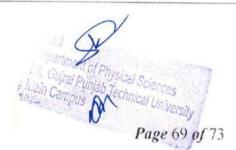
- 1. Symmetries and Symmetry Breaking in QFT: Continuous groups: Lorentz group SO(1,2) and its representations, Unitary groups and Orthogonal groups and their representations, Discrete symmetries: Parity, Charge Conjugation and Time reversal Invariance, CP, CPT. (Lectures 10)
- Global and Local invariances of the Action: Approximate symmetries, Noethers theorem, Spontaneous breaking of symmetry and Goldstone theorem, Higgs mechanism, Abelian and Non-Abelian gauge fields, Lagrangian and gauge invariant coupling to matter fields. (Lectures 10)
- 3. **Standard Model of Particle Physics:** SU(2) x SU(1) x U(1) gauge theory, Coupling to Higgs and Matter fields of 2 generations, Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix, Low energy Electroweak effective theory and Decoupling, Elementary electroweak scattering processes. (Lectures 10)
- 4. QCD and quark model: Asymptotic freedom and Infrared slavery, confinement hypothesis, Approximate flavor symmetries of the QCD lagrangian, Classification of hadrons by flavor symmetry: SU(1) and SU(2) multiplets of Mesons and Baryons, Chiral symmetry and chiral symmetry breaking, Sigma model, Parton model and Deep inelastic scattering structure functions. (Lectures 10)

#### Text Books:

- 1. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
- 2. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

#### **Reference Books:**

- 1. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
- 2. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).
- 3. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).



## **Elective Subject -IV**

MSF	PH546-1	18	Env	ironme	ntal Phy	ysics	1	3, T-1	, P-0		4 Credi	ts
Pre-r	requisit	e: Knov	vledge o	f classic	cal phys	ics						
of M	Sc phy	sics to	the reci	ent adva	ancemer	nts in th	nis field	so that	they up	cpose the nderstan nd other	d these	aspect
Cour	se Outo	comes:	At the er	nd of the	e course	, the stu	dent wil	ll be abl	e to			
(	CO1	Un	derstand	the diff	fereni ty	pes of p	ollution	that oc	cur in th	e Earth'	s enviro	nment
(	CO2	Apj	ply the l	aws of r	adiatior	to Sola	ir and Te	errestria	l Radiat	ion		
CO3 Describe the main reservoirs and exchanges in the global carbon cycle a explain the challenges involved in reducing CO2 emissions									ycle and	I		
(	CO4	App	olication	in the 1	Renewal	ble sour	ces of er	nergy				
(	05		cribe ho n the loo							fferent	scales,	rangin
		M	apping	of cour	se outc	omes w	ith the p	program	n outco	mes		
	POI	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	POII	PO1:
C01	2	2	2	2	2	2	2	2	2	1	2	3
CO2	2	1	2	2	2	2	2	2	2	2	2	2
CO3	2	2	2	2	2	2	2	2	2	1	2	2
CO4	1	2	1	2	2	2	2	2	2	2	-	3
	1	2	2	2	2	2	2	2	2	2	2	2



## **Detailed syllabus:**

- 1. Essentials of Environmental Physics: Structure and thermodynamics of the atmosphere, Composition of air, Greenhouse effect, Transport of matter, energy and momentum in nature, Stratification and stability of atmosphere, Lass of motion, hydrostatic equilibrium, General circulation of the topics, Elements of weather and climate of India.
- 2. Solar and Terrestrial Radiation: Physics of radiation, Interaction of light with matter. tayleigh and Mie scattering, Laws of radiation (Kirchoffs law, Planck's law, Beer's law, Wien's displacement law, etc.), Solar and terrestrial spectra, UV radiation, Ozone depletion problem, IR absorption energy balance of the earth atmosphere system.
- 3. Environmental Pollution and degradation: Elementary fluid dynamics, Diffusion, Turbulence and turbulent diffusion, Factors governing air, Water and noise pollution, Air and water quality standards, Waste disposal, Heat island effect, Land and sea breeze, Puffs and plumes, Gaseous and particulate matters, Wet and dry deposition.
- 4. Environmental Changes and remote sensing: Energy sources and combustion processes, Renewable sources of energy, Solar energy, Wind energy, bioenergy, hydropower, fuel cells, nuclear energy, Forestry and bioenergy.
- 5. Global and Regional Climate: Elements of weather and climate, Stability and vertical motion of air, Horizontal motion of air and water, Pressure gradient forces, Viscous forces, Reynolds number, Enhanced Greenhouse Effect, Energy balance-a Zero-dimensional Greenhouse model, Global climate models.

#### Suggested Readings/Books :

- 1. Egbert Boeker & Rienk Van Groundelle: Environmental Physics (John Wiley).
- 2. J. T Hougtion: The Physics of atmosphere (Cambridge University Press, 1977).
- 3. J Twidell and J Weir: Renewable energy Resources (Elbs, 1988).
- Sol Wieder: An introduction t solar energy for scientists and Engineers (John Wiley, 1982)
- 5. R. N. Keshavamurthy and M. Shanker Rao: The Physics of Monsoons (Allied Publishers, 1992).
- 6. G.J. Haltiner and R.T. Williams: Numerical Weather Prediction (John Wiley, 1980).

Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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MSI	PH547-	18	Dissertation L-0, T-12, P-0 12 Credit									its
Pre-	requisit	te: Knov	wledge o	of specif	fic brand	h of ph	ysics			l	10 <sup>-1</sup> -10-10-10-10-10-10-10-10-10-10-10-10-10-	1103 <b>84-1-4</b> -1-1-1-
stude Phys devel	ents to j ics. Stu lopment	orelimin idents g of a lab	aries an get the poratory	d meth opportu experir	odology inity to nent	of rese partici	arch in pate in	Theore some	tical Ph ongoing	ertation ysics an ; researc	d Expe	rimenta
Course Outcomes: At the end of the course, the student will be able to         CO1       Explain the significance and value of problem in physics, both science in the wider community.									ientific	ally and		
1	CO2 Design and carry out scientific experiments as well as accurately recorresults of experiments.										ord the	
CO3 Critically analyse and evaluate experimental strategies, and decide which appropriate for answering specific questions.									is most			
CO4 Research and communicate scientific knowledge in the context of a to condensed matter physics/Nuclear/High Energy Physics, in oral, electronic formats to both scientists and the public at large.								a topic writter	related and			
(	CO5	Exp		w area					~	fields o	of scien	ce and
		M	lapping	of cour	se outc	omes w	ith the j	program	n outco	mes		
	PO1	PO2	PO3	PO4	PO5	PO6	PC7	PO8	PO9	POIO	POII	PO12
CO1	2	2	1	3	1	2	2	2	2	3	2	3
CO2	3	3	3	2	2	2	1	2	2	2	2	2
CO3	2	2	2	2	2	2		2	2	1 2	I	3
CO4	1	1	-	1		2	2	2	2	3	1	3
05	-	2	2	1		1		2	2		2	2
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Scheme & Syllabus (M.Sc. Physics) Batch 2018 & Onwards

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## Guidelines for the Dissertation:

The aim of project work in M.Sc. 4th semesters is to expose the students to preliminaries and methodology of research and as such it may consist of review of some research papers, development of a laboratory experiments, fabrication of a device, working out some problem, participation in some ongoing research activity, analysis of data, etc.. Project work can be in Experimental Physics, Theoretical Physics, or Simulation(quantum based softwares, HPCC, etc.) based in the thrust as well as non-thrust research areas of the Department.

A student opting for this course will be attached to one teacher of the Department before the end of the 3rd semester. A report about the work done in the project (typed on both the sides of the paper and properly bound) will be submitted by a date to be announced by the Head of Department.

Assessment of the work done under the project will be carried out by a committee on the basis of effort put in the execution of the project, interest shown in learning the methodology, report prepared, grasp of the problem assigned and viva-voce/seminar, etc. as per course guidelines.

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#### Annexure-B

# Draft Syllabus of Personality Development

#### UNIT I

# Building up and enrichment of Vocabulary

Learning Derivatives, Prefixes and Suffixes; Homonyms & Homophones; Pairs/Group of words; Synonyms & Antonyms; One word substitution; Foreign words & Phrases

#### UNIT II

# Application of Business Communication

#### (a) Speaking Module

- Oral communication-Everyday Interactions, Group Discussions, Public speaking;
- Conversation Skills; Business Etiquette;
- · Presentation Skills- combating stage fright, preparing power point presentations
- Non- Verbal Communication in Oral & Power Point Presentations; Telephonic Skills;
- Preparation for job interview- practice through mock interview

## (b) Mechanics of Writing

- · Descriptive and argumentative essays,
- · Scientific & Technical Writing- writing abstracts & summaries, research papers;
- Writing business letters, emails; memos;
- Drafting Reports- training reports, project reports, varied business reports;
- Career Documents: Preparing a selling resume, covering letters, CVs, Preparing Portfolio etc.

#### Suggested Readings:

- 1. Practical English Usage. Michael Swan. OUP. 1995.
- 2. On Writing Well. William Zinsser. Harper Resource Book. 2001
- 3. Study Writing, Liz Hamp-Lyons and Ben Heasly. Cambridge University Press. 2006.
- 4. Communication Skills. Sanjay Kumar and Pushp Lata. Oxford University Press. 2011.
- 5. Exercises in Spoken English. Parts. I-III. CIEFL, Hyderabad. Oxford University Press
- English Language Skills. Aruna Koneru. McGraw Hill Education (India) hy Privatences Limited. 2015.
   Main Campus

Annexure-C

# **B.Sc. (Hons.)** Physics

# Course Structure and Syllabus (Based on Choice Based Credit System) 2019 onwards

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Scheme & Syllabus (B.Sc. Hons. Physics) Batch 2019 & Onwards

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#### SEMESTER FIRST

Course Code	Course Title	- 1	Loa oca	d tion		urks bution	Total Marks	Credits
		L	T	P	Internal	External		
BSHPXXX- 19	Optics	3	1	-	40	60	100	4
BSHPXXX- 19	Mechanics	3	1	-	40	60	100	4
BSHPXXX- 19	Mathematics-I	3	1	-	40	60	100	4
BSHPXXX- 19	Chemistry-I	3	1	-	40	60	100	4
BSHPXXX- 19	Communicative English -I	3	1	-	20	30	50	2
BSHPXXX- 19	Punjabi Compulsory-I or Mudhli Punjabi-I	2	-	-	20	30	50	2
BSHPXXX- 19	Physics Lab-I	-	-	6	50	25	75	3
BSHPXXX- 19	Chemistry Lab-I	-	-	4	30	20	50	2
	TOTAL	16	4	10	280	345	625	25

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L: Lectures T: Tutorial P: Practical

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Course Code	Course Title	A		ad ation		arks ibution	Total Marks	Credits
		L	1	r   P	Internal	External		
BSHPXXX- 19	Waves and Vibrations	3	1	-	40	60	100	4
BSHPXXX- 19	Electricity and Magnetism	3	1	-	40	60	100	4
BSHPXXX- 19	Mathematics-II	3	Anal	-	40	60	100	4
BSHPXXX- 19	Chemistry-II	3	1	-	40	60	100	4
BSHPXXX- 19	Communicative English -i1	2	-	-	20	30	50	2
BSHPXXX- 19	Punjabi Compulsory-I or Mudhli Punjabi-II	2	-	-	20	30	50	2
BSHPXXX- 19	Physics Lab-II	-		6	50	25	75	3
I9	Chemistry Lab-II	-		4	30	20	50	2
	TOTAL	16	4	10	280	345	625	25

## SEMESTER SECOND

L: Lectures T: Tutorial P: Practical

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BSHPXXX- 19	Optics	L-3, T-1, P-0	4 Credits
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Pre-requisite: Understanding of senior secondary level Physics and Mathematics

**Course Objectives:** The objective of the course is to develop basic understanding of Interference, Diffraction and Polarization among students. The Students also learn about the LASER and its applications. Students will be equipped with knowledge to measure wave length, refractive index and other related parameters, which will act as a strong background if he/she chooses to pursue research in physics as a career.

#### **Detailed Syllabus:**

#### PART-A

#### UNIT I

Interference: Definition and properties of wave front, Temporal and Spatial Coherence, Young's double slit experiment, Lloyd's single mirror and Fresnel's Biprism. Phase change on reflection: Stokes' treatment. Interference in Thin Films: parallel and wedge-shaped films, Fringes of equal inclination (Haidinger Fringes), Newton's Rings: Measurement of wavelength and refractive index. Interferometer: Michelson Interferometer-(1) Idea of form of fringes (No theory required), (2) Determination of Wavelength, (3) Wavelength Difference, (4) Refractive Index, Fabry-Perot interferometer. (12 Lectures)

#### UNIT-II

**Diffraction:** Huygens Principle, Huygens-Fresnel Diffraction theory, Fraunhofer diffraction: Single slit. Circular aperture, Rayleigh criterion of resolution, Resolving Power of a telescope, Double slit, Multiple slits, Diffraction grating, Resolving power of grating. Fresnel Diffraction: Fresnel's Assumptions, Fresnel's Half-Period Zones for Plane Wave. Explanation of Rectilinear Propagation of Light, Theory of a Zone Plate: Multiple Foci of a Zone Plate, Fresnel diffraction pattern of a straight edge and circular aperture. (11 Lectures)

#### PART-B

#### UNIT-III

Polarization: Plane polarized light, Representation of Unpolarized and Polarized light, Polarization by Reflection, Brewster's law, Malus Law, Polarization by Selective absorption by Crystals. Polarization by Scattering, Polarization by Double Refraction, Nicol Pristr, Huygen's theory of Double Refraction, Polaroid, Elliptically and Circularly polarized lights. Quarter and Half wave plates.

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#### UNIT-IV

Laser and Application: Lasers. Spontaneous emission, Stimulated absorption, Stimulated emission, Einstein coefficients, Einstein relations, Conditions for Laser actions. Population inversion, Different types of Laser Pumping mechanism: Optical Pumping, Electric Discharge and Electrical pumping, Resonators, Two, Three and Four level laser systems, Ruby laser, He-Ne gas Laser, Semiconductor laser, CO2 laser, applications of laser: Holography, Principle of Holography. Recording and Reconstruction Method. Theory of Holography as Interference between two Plane Waves. Point source holograms. (11 Lectures)

# Text and Reference Books:

1. Optics: A.K. Ghatak (Tata-McGraw Hill). 1992.

2. Fundamentals of Optics: F.A. Jenkins and H.E. White (McGraw Hill), 1981.

Department of Physical Sciences I.K. Gujral Punjab Technical University Main Campus D

BSHPXXX- 19	Mechanics	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level Physics and Mathematics

**Course Objectives:** The aim and objective of the course on Mechanics is to introduce the students to the formal structure of vector mechanics, harmonic oscillators, and mechanics of solids so that they can use these in Engineering as per their requirement. This will act as a strong background if he/she chooses to pursue higher studies in physics.

#### **Detailed Syllabus:**

#### UNIT I:

**Fundamentals of Dynamics:** Reference frames. Inertial frames; Review of Newton's Laws of Motion. Galilean transformations; Galilean invariance. Dynamics of a system of particles. Centre of Mass. Principle of conservation of momentum. Impulse. Momentum of variable-mass system: motion of rocket.

**Work and Energy:** Work and Kinetic Energy Theorem. Conservative and non-conservative forces. Potential Energy. Energy diagram. Stable and unstable equilibrium. Force as gradient of potential energy. Work done by non-conservative forces. Law of conservation of Energy. (12 Lectures)

#### UNIT-II

Non-Inertial Systems: Non-inertial frames and fictitious forces. Uniformly rotating frame. Laws of Physics in rotating coordinate systems. Centrifugal force. Coriolis force and its applications. Components of Velocity and Acceleration in Cylindrical and Spherical Coordinate Systems. Collisions: Elastic and inelastic collisions between particles. Centre of Mass and Laboratory frame of refrences. (11 Lectures)

#### UNIT-III

**Gravitation and Central Force Motion:** Law of gravitation. Gravitational potential energy. Inertial and gravitational mass. Potential and fields due to spherical shell and solid sphere. Motion of a particle under a central force field. Two-body problem and its reduction to one-body problem and its solution. The energy equation and energy diagram. Kepler's Laws. Satellite in circular orbit and applications. Geosynchronous orbits. Weightlessness. Basic idea of global positioning system (GPS). (11 Lectures)

#### **UNIT-IV:**

Special Theory of Relativity: Michelson-Morley Experiment and its outcome. Postulates of Special Theory of Relativity. Lorentz Transformations. Simultaneity and order of events. Lorentz contraction. Time dilation. Relativistic transformation of velocity, Variation of mass with velocity. Massless Particles. Mass-energy Equivalence. Relativistic Doppler effect. Min owski space time, Relativistic Kinematics. Energy-Momentum Four Vector.

(12 Lectures)

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#### Text and Reference Books:

- 1. Mechanics, Berkeley Physics, Vol.1, C.Kittel, W.Knight, et.al. 2007. Tata McGraw-Hill.
- 2. Physics, Resnick, Halliday and Walker 8/e. 2008, Wiley.
- 3. Feynman Lectures, Vol. I, R.P.Feynman, R.B.Leighton, M.Sands, 2008, Pearson Education
- 4. Introduction to Special Relativity, R. Resnick, 2005, John Wiley and Sons
- 5. University Physics. F.W Sears, M.W Zemansky, H.D Young 13/e, 1986, Addison Wesley
- 6. Physics for scientists and Engineers with Modern Phys., J.W.Jewett, R.A.Serway, 2010. Cengage Learning

7. Theoretical Mechanics, M.R. Spiegel, 2006, Tata McGraw Hill.

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BSHP121-19	Vibrations and Waves	L-3, T-1, P-0	4 Credits

Pre-requisite: Understanding of senior secondary level physics and Mathematics

**Course Objectives:** The objective of the course provides an exposure about simple harmonic motions, damped harmonic motions and forced oscillations. Students learns about the different waves, propagation of waves in various mediums and reflection/transmission of waves at the interface of mediums.

#### **Detailed Syllabus:**

#### PART-A

#### UNIT-I

Simple and Damped Harmonic Motion: Simple harmonic motion, energy of a SHO, Compound pendulum, Torsional pendulum, Electrical Oscillations, Lattice Vibrations, Transverse Vibrations of a mass on a string, Anharmonic Oscillations. Damped simple harmonic motion, Decay of free Vibrations due to damping, types of damping, Determination of damping coefficients – Logarithmic decrement, relaxation time and Q-factor. Electromagnetic damping. (12 Lectures)

#### UNIT-II

**Forced Vibrations and Resonance**: Forced mechanical and electrical oscillator, Transient and Steady State Oscillations, Displacement and velocity variation with driving force frequency, Variation of phase with frequency resonance, Power supplied to forced oscillator by the driving force. Q-factor and band width of a forced oscillator, Electrical and nuclear magnetic resonances. (1 2 lectures)

#### PART-B

#### UNIT-III

**Coupled Oscillations**: Stiffness coupled oscillators, Normal coordinates and modes of vibrations. Inductance coupling of electrical oscillators, Normal frequencies, Forced vibrations and resonance for coupled oscillators, Masses on string-coupled oscillators.

Waves in Physical Media: Types of waves, wave equation (transverse) and its solution characteristics impedance of a string, Impedance matching, Reflection and Transmission of waves at boundary, Energy of vibrating string, wave and group velocity. (12 Lectures)

#### UNIT-IV

**Electromagnetic waves:** Physical interpretation of Maxwell's equations, E.M waves and wave equation in a medium having finite permeability and permittivity but with conductivity  $\sigma = 0$ . Poynting vector, Impedance of a dielectric to EM waves, EM waves in a conducting medium and skin depth, EM wave velocity in a conductor and anomalous dispersion, Response of a conducting medium to EM waves. Reflection and transmission of EM waves at a boundary of two dielectric media for normal and oblique incidence, Reflection of EM waves from surface of a conductor at normal incidence. (12 Lectures)

#### Text and Reference Books:

1. Text Book of Vibrations and Waves: S.P. Puri (Macmillan India), 2004.

2. The Physics of Vibrations and Waves: H.J. Pain (Wiley and ELBS), 1976.

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BSHP122-19	Electricity and Magnetism	L-3, T-1, P-0	4 Credits
Pre-requisite: Basi	c knowledge of Electricity and Magne	tism at high school leve	4.
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	The objective of the course is to exponentism so that they can use these as per		formal structure of

Course Outcomes: At the end of the course, the student will be able to

CO1	Understand and describe the different concepts of electrostatics and magnetostsics
CO2	Apply the knowledge of Maxwell's equation and flow of electromagnetic waves in rea problems.
CO3	Analyze the wave propagation in different media
CO4	Compare the different types of polarization
CO5	have a solid foundation in electromagnetism fundamentals required to solve problems and also to pursue higher studies.

#### Detailed Syllabus:

#### PART-A

UNIT I Review of Vector Analysis and Electrostatics: scalar and vector product; gradient, divergence and curl and their significance; Gauss-divergence theorem and Stoke's theorem (statement only); Electrostatic field; electric flux; Gauss's law of electrostatics; Applications of Gauss law-Electric filed due to point charge, infinite line of charge, uniformly charged spherical shell and solid sphere, plane charge sheet; Electric potential as line integral of electric field, potential due to point charge and electric dipole; calculation of electric field from potential; Poisson's equation and Laplace's equation(Cartesian coordinate); Capacitance; capacitance of a spherical conductor and cylindrical capacitor, Energy per unit volume in electrostatic field, Dielectric medium, dielectric polarization and its types, Displacement vector, Boundary conditions (12 Lectures)

UNIT-II Magnetostatics: Magnetic flux; magnetic flux density; Faraday's law; magnetomotive force; Biot-Savart's law and its applications-straight conductor, circular coll, divergence and curl of magnetic field; Ampere's work law in differential form; Magnetic-vector pitcential; ampere's force law; magnetic vector potential; Energy stored in a magnetic field, boundary conditions on magnetic fields. *(10 Lectures)* 

#### PART-B

UNIT-III Maxwell's Equations and Poynting Vector: Equation of continuity for time varying fields; Inconsistency of ampere's law; concept of sinusoidal time variations (Phasor notation); Maxwell's equations with physical significance; Maxwell equations in free space, static field and in Phasor notation; Difference between displacement current and conduction current; Concept of Poynting vector; Poynting Theorem. (11 Lectures)

UNIT-IV Electromagnetic Waves: Wave equation in free space or non-conducting or lossless medium; wave equation for conducting medium; wave propagation in lossless and conducting medium (phasor form); Propagation characteristics of EM waves in free space, lossless and in conducting medium; Uniform plane waves and solution; relation between electric and magnetic fields of an electromagnetic wave; Linear, circular and elliptical polarization; depth of penetration, Reflection of waves by a perfect conductor: normal incidence and oblique incidence: Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence. (12 Lectures)

#### **Reference Books:**

- David Griffiths, Introduction to Electrodynamics, Pearson Education India Learning Private (i) Limited: 4 edition.
- Edward C Jordan and Keith G Balmain, Electromagnetic waves and radiating systems, (ii) Prentice Hall
- Kraus John D, Electromagnetics, McGraw-Hill Publisher (iii) (iv)
- W. Saslow, Electricity, magnetism and light, Academic Press

Head Department of Physical Sciences I.K. Gujral Punjab Technical University Main Campus

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PHSS906-18	<b>Advanced Particle Physics</b>	L-3, T-1, P-0	4 Credits
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Pre-requisite: Knowledge of particle physics

**Course Objectives:** The objective of the course on **Advanced Particle Physics** is to expose the students of Ph.D. to the relatively advanced topics related to symmetry breaking in quantum field theory, standard model of particle physics, QCD and quark model, and various unification schemes so that they understand these aspects properly and are well equipped to pursue a career in high energy physics.

Course Outcomes: A	the end of the course,	the student will have
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CO1	Understanding of various global and local gauge symmetries of system, invariance of action, symmetry breaking, and Higgs mechanism.
CO2	Need for standard model of particle physics and its limitations and the properties of QCD.
CO3	The problem of divergencies in quantum field theories and the renormalisation methods.
CO4	Asymptotic freedom and infrared slavery of the running coupling constant in non-abelian gauge theory of strong interactions -QCD.
CO5	Physics beyond the Standard Model Physics.

#### **Detailed Syllabus:**

- Symmetries and Symmetry Breaking in QFT: Continuous groups: Lorentz group SO(1,2) and its representations, Dirac, Weyl and Majorana fermions, Unitary groups and Orthogonal groups and their representations, Discrete symmetries: Parity, Charge Conjugation and Time reversal Invariance, CP, CPT. (Lectures 10)
- Global and Local invariances of the Action: Approximate symmetries, Noethers theorem, Spontaneous breaking of symmetry and Goldstone theorem, Higgs mechanism, Abelian and Non-Abelian gauge fields, Lagrangian and gauge invariant coupling to matter fields. (Lectures 10)
- 3. Standard Model of Particle Physics: SU(2) x SU(1) x U(1) gauge theory, Coupling to Higgs and Matter fields of 2 generations, Gauge boson and fermion mass generation via spontaneous symmetry breaking, CKM matrix, Lowgenergy Decroweak effective theory and Decoupling, Elementary electroweak scattering processes Physical Science (Lectures 10) I.K. Gujral Punish Technical University
- 4. QCD and quark model: Asymptotic freedom and Infrared slavely, confinement hypothesis, Approximate flavor symmetries of the QCD lagrangian, Classification of hadrons by flavor symmetry: SU(1) and SU(2) multiplets of Mesons and Baryons, Chiral symmetry and chiral symmetry breaking, Parton model and Deep inelastic scattering structure functions.

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(Lectures 10)

#### Text Books:

- 1. Gauge Theory of Elementary Particle Physics: T.P Cheng & L.F. Li (Oxford).
- 2. An Introductory Course of Particle Physics: Palash Pal (CRC Press).

# Reference Books:

- 1. First Book of Quantum Field Theory: A. Lahiri & P. Pal, Narosa, New Delhi.
- 2. Introduction to Quantum Field Theory: M. Peskin & D.V. Schroeder. (Levant Books).
- 3. Dynamics of the Standard Model: J.F. Donoghue (Cambridge University Press).

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(Lectures 8)

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PHS907-18	Renewable Energy Resources	L-3, T-1, P-0	4 Credits
Pre-requisite	: Understanding of semiconductor physic	ics	
expose the Ph	ctives: The aim and objective of the co .D. students to the basics of the alternati	ourse on <b>Renewable</b> ve energy sources lik	Energy Resources is to the solar energy, hydrogen
	omes: At the end of the course, the stude	ent will be able to	
energy, etc. Course Outco CO1	Understand the energy demand of alternative form of energy.		between traditional and
Course Oute	Understand the energy demand of alternative form of energy.	world & distinguish	
Course Oute CO1	Understand the energy demand of alternative form of energy. Describe the concept of solar energy	world & distinguish radiation and therma	
Course Outer CO1 CO2	Understand the energy demand of alternative form of energy.	world & distinguish radiation and therma types.	al applications.

#### **Detailed Syllabus:**

- 1. Introduction: Production and reserves of energy sources in the world and in India, need for alternatives, renewable energy sources. (Lectures 8)
- Solar Energy: Thermal applications, solar radiation outside the earth's atmosphere and at the earth's surface, Principal of working of solar cell, Performance characteristics of solar cell. Types of solar cell, crystalline silicon solar cell, Thin film solar cell, multijunction solar cell, Elementary ideas of perovskite solar cell, dye synthesized solar cell and Tandem solar cell, PV solar cell, module array, and panel, Applications. (Lectures 11)
- 3. Hydrogen Energy: Environmental considerations, solar hydrogen through photo electrolysis and photocatalytic process, physics of material characteristics for production of solar hydrogen. Storage processes, solid state hydrogen storage materials, structural and electronic properties of storage materials, new storage modes, safety factors. use of hydrogen as fuel; use in vehicles and electric generation, fuel cells. (Lectures 10)
- 4. Other sources: Nature of wind, classification and descriptions of wind machines, power coefficient, energy in the wind, wave energy, ocean thermal energy conversion (OTEC), system designs for OTEC, basic idea about biogas, biofuel, and biodiesel.

#### **Text Books:**

1. Solar Energy: S.P. Sukhatme (Tata McGraw-Hill, New Delhi), 2008.

#### **Reference Books:**

- 1. Solar Cell Devices: Fonash (Academic Press, New York), 2010.
- 2. Fundamentals of Solar Cells, Photovoltaic Solar Energy: Fahrenbruch and Bube (Springer. Berlin), 1982.
- 3. Photoelectrochemical Solar Cells : Chandra (New Age, New Delhi).