Minor Courses of PHYSICS for Engineering Major

DEPARTMENT OF PHYSICS

Amaravati 522502, Andhra Pradesh

INDIA

CURRICULUM AND SYLLABI

CURRICULUM

Department of **Physics** offers **Minor Degree in Physics** to the students of B. Tech program subjected to fulfilment of the following minimum credits criterion.

S. No.	Course Code	Course Name	Semester Selection	L-T-P-C	Credit	Comments
1	PHY 213M	Quantum Mechanics	Even	3-1-0-4	4	Mandatory
2	PHY 303M	Solid-state Physics	Odd	3-0-2-4	4	Mandatory
3	PHY 311M	Statistical Physics	Even	3-1-0-4	4	Mandatory
4	PHY 304M	Advanced Optics	Odd	3-0-2-4	4	Any one
	PHY 706M	Nanotechnology in Energy Conversion and Storage	Open	3-1-0-4	4	
	PHY 319M	Nano Device Physics	Open	3-1-0-4	4	
	PHY 702M	Introduction to Photonics	Open	3-1-0-4	4	
5	PHY 201M	Waves, Oscillations, and Optics	Odd	3-0-2-4	4	Any one
	PHY 301M	Atomic and Molecular Physics	Odd	3-0-2-4	4	
	PHY 709M	Quantum Computation	Open	3-1-0-4	4	

<u>Guidelines and recommendations</u>:

1. If you are a student from 2017 batch you are required to finish twelve (12) credits in total to procure this minor degree.
2. This means, you have to choose three out of the five listed courses.
3. Given that you are in 3rd year right now, you are left with 3 more semesters to finish these courses.
4. Note that you should have satisfied prerequisites for each of these courses.
5. If you are a student from 2018 batch onwards, you are required to finish twenty (20) credits in total to procure this minor degree.

PHY 213M	QUANTUM MECHANICS	L	T	P	C
		3	1	0	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	-- Academic Council Meeting -- , 2018				

PURPOSE	The purpose of this course is to introduce the origin of quantum mechanics, Schrodinger's wave equations and their physical significances and applications							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
1.	Understand why "quantum mechanics"							
2.	Know the concept Schrodinger's wave equation							
3.	Solve different problems using Schrodinger's wave equation							
4.	Know various operators in quantum mechanics							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I - Black body Radiation	**9**			
1.	Detection of thermal radiation	1	C		1-5
2.	Emissive power of different bodies	1	C		1-5
3.	Absorptive power of different bodies	1	C		1-5
4.	Prevost's theory	1	C		1-5
5.	Black body radiation	1	C		1-5
6.	Kirchhoff's law	1	C		1-5
7.	Pressure of radiation	1	C		1-5
8.	Stefan-Boltzmann law and its experimental verification	1	C-D		1-5
9.	Nernst heat theorem	1	D		1-5
	UNIT II – Origin of Quantum Mechanics	**9**			

10.	Historical Background - Review of Black body radiation, Review of photoelectric effects	1	C		1-5
11.	Wave particle duality	1	C		1-5
12.	Matter waves, De Broglie hypothesis	1	C		1-5
13.	Davisson and Germer experiment	1	I		1-5
14.	Concept of wave packet	1	C		1-5
15.	Phase velocity, group velocity and relation between them	1	C		1-5
16.	Heisenberg's uncertainty principle with thought experiment	1	C		1-5
17.	Electron diffraction experiment	1	I		1-5
18.	Different forms of uncertainty	1	C		1-5
	UNIT III - The Schrodinger equation	**9**			
19.	Wave function and its physical interpretation	1	C		1-5
20.	Schrodinger time independent equation (Steady state equation)	1	C		1-5
21.	Properties of a wave function	1	C		1-5
22.	Probability current density	1	C		1-5
23.	Equation of continuity and its physical significance	1	C		1-5
24.	Definition of an operator in Quantum mechanics	1	C		1-5
25.	Eigen function and Eigen values	1	C-D		1-5
26.	Expectation value	1	C-D		1-5
27.	Ehrenfest's theorem	1	D		1-5
	UNIT IV: Applications of Schrodinger Steady state equation	**9**			
28.	Free particle, Particle in infinitely deep potential well (one – dimensional)	1	C		1-5
29.	Particle in a three-dimensional rigid box	1	D		1-5
30.	Step potential, potential barrier (Qualitative discussion)	1	D		1-5
31.	Barrier penetration and tunnelling effect	1	D		1-5
32.	Harmonic oscillator (one-dimension)	1	D		1-5

33.	Correspondence principle	1	C		1-5
34.	Hydrogen atom: Qualitative discussion on the radial and angular parts of the bound state energy	1	D		1-5
35.	Energy state functions	1	C		1-5
36.	Quantum numbers $\boldsymbol{n}$, $\boldsymbol{l}$, $\boldsymbol{m_l}$, $\boldsymbol{m_s}$ – Degeneracy	1	D-I		1-5
	UNIT V: Operators in Quantum Mechanics	**9**			
37.	Position, Momentum operator	1	C		1-5
38.	Angular momentum operator	1	C		1-5
39.	Total energy operator (Hamiltonian)	1	C		1-5
40.	Commutator brackets- Simultaneous Eigen functions	1	C		1-5
41.	Commutator algebra	1	C		1-5
42.	Commutator brackets using position	1	C		1-5
43.	Momentum and angular momentum operator	1	C		1-5
44.	Raising and lowering angular momentum operator	1	C		1-5
45.	Concept of parity, parity operator and its Eigen values	1	C		1-5
	Total contact hours	**45**			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, R. Eisberg and R. Resnik 2ed Edison, 2006, Wiley
2	Introduction to Quantum Mechanics, D. Griffiths 2 edition, 2004, Pearson
3	A Textbook of Quantum Mechanics K Venkatesan, P M Mathews 2nd Edition, 2010, Mcgraw Higher Ed.
4	Concepts of Modern physics, Arthur Besier, S. Rai Choudhury, Shobhit Mahajan, 7th Edition, 2015, Mcgraw Higher Ed
5	Quantum Mechanics: Theory and Applications, Ajoy Ghatak, S. Lokanathan, 1st Edition, 2004, Mc. Millan.

Assessment:

Course nature			Theory			
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
					End semester examination Weightage :	**50%**

PHY 303M	**Solid State Physics**		**L**	**T**	**P**	**C**
			3	**0**	**2**	**4**
Co-requisite:	NIL					
Prerequisite:	NIL					
Data Book / Codes/Standards	NIL					
Course Category	CORE	Solid State Physics				
Course designed by	Department of Physics					
Approval	-- Academic Council Meeting -- , 2018					

PURPOSE	The purpose of this course is to introduce students about the crystal structure and crystal system, free electron theory of metal, band theory, electrical and thermal conductivity.

	LEARNING OBJECTIVES	**STUDENT OUTCOMES**						
	At the end of the course, student will be able to							
1.	To understand the basic knowledge on crystal structures and crystal systems							
2.	To acquire the knowledge of bonding in solids							
3.	To acquire knowledge on lattice vibrations, thermal properties and electric conductivity of solids							
4.	To comprehend the concepts of dielectric properties of solids and superconductivity							

Session	**Description of Topic**	**Contact hours**	**C-D-I-O**	**IOs**	**Reference**
	UNIT I - Crystallography	**9**			

1.	Crystalline and amorphous solids, Lattice, Basis, Translational vectors, Primitive unit cell.	1	C		1,2
2.	Symmetry operations, Different types of lattices-2D and 3D (Bravais lattices)	1	C		1,2
3.	Miller indices, Inter-planer distances, SC, BCC and FCC structures, Packing fraction	1	C		1,2
4.	Crystal structures- NaCl, diamond, CsCl, ZnS,	1	C		1,2
5.	Concept of reciprocal lattice and its properties with proof. Ionic, covalent, molecular and metallic binding in crystalline solids	1	C		1,2
6.	Cohesive energies of ionic and metallic crystals.	1	C		1,2
7.	Anisotropy of physical properties of a single crystal, defects in crystal structures Crystal as a grating	1	C		1,2
8.	Bragg's law and Bragg's Diffraction condition in direct and reciprocal lattice Ewald's construction	1	C		1,2
9.	Debye Schrrerer method	1	C		1,2
	UNIT II – Lattice Vibrations and specific heat of solids	**9**			
10.	Specific heats of solids	1	C		1,2
11.	Normal mode of frequencies coupled vibrations of atoms	1	C		1,2
12.	Breakdown of classical theory	1	C		1,2
13.	Linear chain frequency distribution function	1	C		1,2
14.	Quantization of harmonic vibrations	1	C		1,2
15.	Phonons	1	C		1,2
16.	Debye theories of specific heat of solids	1	C		1,2
17.	Einstein theories of specific heats of solids	1	C		1,2
18.	Phonon vibration of diatomic linear lattice	1	C		1,2
	UNIT III - Free electron theory of metals	**9**			
19.	Free Electron model	1	C		3,4
20.	Energy levels and Density of orbital in 1D and 3D	1	C		3,4
21.	Bloch function	1	C		3,4
22.	Nearly free electron model (NFE model)	1	C		3,4
23.	Fermi energy, Application of the Fermi-Dirac distribution	1	C		3,4
24.	Specific heat due to conduction electron	1	C		3,4

25.	Para-magnetism, thermionic emission,	1	C,D		3,4
26.	Photoelectric effect of metals,	1	C,D		3,4
27.	Origin of contact potentials between metals	1	C,D		3,4
	UNIT IV: Band theory of solids, electrical and thermal conductivity	**9**			
28.	Band theory of solids	1	C		5,6
29.	Band formation	1	C		5,6
30.	Fermi-sphere, example of simple cubic lattice	1	C		5,6
31.	Idea of Brillouin zone	1	C		5,6
32.	Density of states	1	C		5,6
33.	overlapping on energy bands	1	C		5,6
34.	Effective mass of electron (with derivation)	1	C		5,6
35.	Concept of hole	1	C		5,6
36.	Distinction between metal, semiconductor and insulator	1	C		5,6
	UNIT V: Electrical and thermal conductivity in solids	**9**			
37.	Simple theories of electrical and thermal conductivity	1	C, D		5,6
38.	The Wiedemann-Franz law	1	C, D		5,6
39.	Boltzmann transport equation	1	C, D		5,6
40.	Sommerfeld theory of electrical conductivity	1	C		5,6
41.	Mean free path of electrons	1	C		5,6
42.	Temperature dependent resistivity of metals	1	C, D		5,6
43.	Temperature dependent resistivity of semiconductors, and insulators	1	C, D		5,6
44.	Hall Effect in metals	1	C, D, I		5,6
45.	Hall Effect in semiconductors	1	C, D, I, O		5,6
	Total contact hours	45			

LEARNING RESOURCES

	TEXT BOOKS
1	Elementary Solid-State Physics, M Ali Omar, Revised Edition, 2015, Pearson
2	Introduction to Solid State Physics, Charles Kittel, 8th edition, 2004, John Wiley & Sons
3	Solid State Physics Puri R.K., Babbar V.K – 1 Edition, 2010 S Chand Publication
4	Solid State Physics, S O Pillai, 18th edition 2018, New Age International
	REFERENCE BOOKS
5	Solid State Physics, Neil W. Ashcroft, N. Mermin Reprint Edition, Brooks/Cole 1976
6	Solid State Physics, A. J. Dekker, 2008, Laxmi Publication/Prentice Hall

Laboratory: Solid State Physics

PURPOSE	The purpose is to introduce the sophisticated and best experimental characterization tools to obtain the basic attributes of solids, such as, crystallinity, optical, electronic, magnetic, plasmonic, nano form of matter. Introduce to the current state-of-the art research facilities to carry research projects. Demonstrate the power of century old basic fundamental laws existence in the present technology.	
LEARNING OBJECTIVES		**STUDENT OUTCOMES**
At the end of the course, student will be able to		
1.	Measure the lattice parameter, lattice crystal structure, electronic properties, bandgap, plasmonic, carrier densities of any kind of state of matter. Which are all the fundamental and basic attributed of any matter.	
2.	Develop new characterization tools and techniques for advanced materials.	
3.	Can handle state-of-the-art instruments and appreciate the importance of research and development in the everyday life.	

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	Measurement of resistivity of a semiconductor by Four-probe method and determination of Energy Band Gap	2	I,O		1,2
2.	To determine the type of charge carrier, carrier density and Hall coefficient of a given semiconductor	2	I,O		1,2
3.	a) To measure the photo-current as a function of the irradiance at constant voltage b) Current-voltage and current-load characteristics of a solar cell as a function of the irradiance	2	I,O		1,2
4.	Study optical absorption of liquid samples using UV-VIS spectrometer	2	I,O		1,2
5.	To study optical absorption of different nanoparticles	2	I,O		1,2

	and obtain their plasmonic peaks				
6.	Determine lattice parameter of crystals using X-ray diffractometer	2	I,O		1,2
	Total contact hours (Experiments +Demo + Extra class)	30			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	C. Suryanarayana, M. Grant Norton, " X-Ray Diffraction, A Practical Approach" Springer US, 1998 [ISBN: 978-1-4899-0148-4]
2	Trügler, Andreas, "Optical Properties of Metallic Nanoparticles", Springer Series in Materials Science, 2016 [ISBN: 978-3-319-25074-8]
3	John Singleton, "Band Theory and Electronic Properties of Solids" Oxford University Press UK, 2014 [ISBN: 978-0198506447]

Assessment:

Course nature				**Theory + Practical**			
Assessment Method – Theory Component (Weightage 70%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	Quiz	**Total**
	Weightage	**15%**	**15%**	**10%**	**5%**	**5%**	**50%**
End semester examination Weightage:							**50%**
Assessment Method – Practical Component (Weightage 30%)							
In-semester	**Assessment tool**	Lab performance	Practical model exam	Observation note			**Total**
	Weightage	**20%**	**20%**	**10%**			**50%**
End semester examination Weightage:							**50%**

PHY 311M	**Statistical Physics**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	CORE	Statistical Physics			

Course designed by	Department of Physics
Approval	-- Academic Council Meeting -- , 2018

PURPOSE	The purpose of this course is to introduce students about elementary as well advanced concepts of statistical physics using elements of classical and quantum statistics.

LEARNING OBJECTIVES		**STUDENT OUTCOMES**							
At the end of the course, student will be able to									
1.	Understand Elementary statistical concepts								
2.	Learn statistical descriptions of system of particles								
3.	Learn Statistical properties of Macroscopic systems								
4.	Learn micro-canonical, canonical and grand-canonical systems and Equipartition theorem								
5.	Fundamental concepts of Quantum Statistics								

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I - Elementary statistical concepts and examples	**9**			
1.	The simple random walk problem in one dimension	1	C		1,2
2.	Random walk problem in two dimensions	1	C		1,2
3.	Problem and Review of Random walks	1	C		1,2
4.	Examples of Brownian motion	1	C		1,2
5.	Calculation of mean values	1	C		1,2
6.	Binomial distribution – theory and examples	1	C		1,2
7.	Continuous probability distribution	1	C		1,2
8.	Gaussian probability distribution	1	C		1,2
9.	Review and problems on probability distributions	1	C		1,2
	UNIT II – Statistical descriptions of system of particles	**9**			
10.	Specification of the state of a statistical system	1	C		1,2
11.	statistical ensemble - basic postulates and probability calculations	1	C		1,2
12.	Review and problems on statistical ensembles	1	C		1,2

13.	Density of states of statistical ensembles	1	C		1,2
14.	Problems on density of states	1	C		1,2
15.	Thermal and mechanical interaction between macroscopic systems.	1	C		1,2
16.	Discussion on constraints of thermal and mechanical interaction between macroscopic systems.	1	C		1,2
17.	Discussion on equilibrium, non-equilibrium, reversibility and irreversibility in thermodynamic systems	1	C		1,2
18.	Review and problems on thermal and mechanical interaction, its constraints and Problems & examples on Equilibrium/non-equilibrium and reversibility /irreversibility of thermodynamic systems.	1	C		1,2
	UNIT III - Statistics of Macroscopic systems	**9**			
19.	Distribution of energy between macroscopic systems	1	C		1,2
20.	Discussion on the approach to thermal equilibrium	1	C		1,2
21.	Examples and problems on thermal equilibrium	1	C		1,2
22.	Temperature, mean energy and mean pressure of an ideal gas	1	C		1,2
23.	Introduction of the concept of entropy & discussion of second and third law of thermodynamics involving entropy.	1	C		1,2
24.	Review of all thermodynamic laws and basic statistical relations & related problems	1	C		1,2
25.	The partition function and its properties – relevant problems	1	C		1,2
26.	Calculation of thermodynamic quantities for an ideal monatomic gas – relevant problems.	1	C		1,2
27.	Discussion of the Gibbs paradox involving relevant examples	1	C		1,2
	UNIT IV: Equipartition theorem	**9**			
28.	Introduction various thermodynamics systems – Isolated, adiabatic, Isobaric, Isochoric etc.	1			1,2
29.	Examples and problems on important thermodynamic systems.	1			1,2
30.	Discussion on Canonical ensemble – comparison with micro-canonical ensemble	1			1,2
31.	Applications, examples and problems on the canonical ensemble	1			1,2

32.	Maxwell distribution and the Equipartition theorem	1			1,2
33.	Simple applications of the Equipartition theorem	1			1,2
34.	The grand canonical ensemble – comparison with micro-canonical and canonical ensemble	1			1,2
35.	Introduction of the chemical potential	1			1,2
36.	Review and problems on Equipartition theorem and canonical and grand-canonical ensemble	1			1,2
	UNIT V: Quantum statistics	**9**			
37.	Introduction of concept of Identical particles and symmetry requirements	1			1,2
38.	Discussion on quantum states of a single particle	1			1,2
39.	Introduction of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics	1			1,2
40.	Equation of states for Bose and Fermi gases	1			1,2
41.	PV = (2/3) E – the ideal gas in the classical limit	1			1,2
42.	Evaluation of the partition function	1			1,2
43.	partition function of ideal monatomic Boltzmann gas	1			1,2
44.	Simple ideas for Bose- Einstein condensation and recent observations	1			1,2
45.	Problems and examples on Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics & partition function	1			1,2
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Statistical Physics (In Si Units): Berkeley Physics Course - Vol.5, F Reif, 1 edition, 2017, McGraw Hill Education
2	Statistical Physics F. Mandl, 2nd Edition, 2003, Wiley

Assessment:

Course nature				**Theory**		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	**Total**

	Weightage	15%	15%	10%	10%	50%
End semester examination Weightage :						50%

PHY304M	**Advanced Optics**	**L**	**T**	**P**	**C**
		3	**0**	**2**	**4**
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category		CORE	Atomic and Molecular Physics		
Course designed by	Department of Physics				

Approval	-- Academic Council Meeting -- , 2018

PURPOSE	The purpose of this course is to introduce students about the physical optics, interference and diffraction of light, polarization and fiber optics.

	LEARNING OBJECTIVES	STUDENT OUTCOMES							
	At the end of the course, student will be able to								
1.	Understand the concept of basic optics								
2.	Understand the concept of Interference								
3.	Study the fundamentals of diffraction								
4.	Apply the concept of optics in holography and fiber optics								

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I - Physical Optics	**9**			
1.	History of optics	1	C		1,2
2.	what is light?	1	C		1,2
3.	Huygen's principle	1	C		1,2
4.	Huygen's principle applications,	1	C		1,2
5.	Derivation of the laws of reflection	1	C		1,2
6.	Derivation of the laws of refraction	1	C		1,2
7.	Superposition of waves	1	C		1,2
8.	Coherence	1	C		1,2
9.	Problems	1	C		1,2
	UNIT II – Interference of light	**9**			1,2
10.	Two beam interference by division of wave front	1	C		2,3
11.	Interference by division of amplitude	1	C		2,3
12.	Classification of interference of thin films	1	C		2,3
13.	Interference by wedge shaped film: Interference due to reflected light and transmitted light	1	C		2,3
14.	Fringes of equal inclination	1	C		2,3

15.	Equal thickness and Equal chromatic order (FECO fringes)	1	C		2,3
16.	Colours of thin films	1	C		3,4
17.	Michelson’s interferometer	1	C		3,4
18.	Fabry-Perot interferometer	1	C		3,4
	UNIT III - Diffraction of Light	**9**			3,4
19.	Fraunhoffer diffraction due to a (i) single slit, and	1	C,D		3,4
20.	(ii) double slit, N silts	1	C,D		3,4
21.	(iii) plane transmission grating and their analytical treatments	1	C,D		3,4
22.	Plane diffraction grating	1	C,D		3,4
23.	Rayleigh’s criteria for resolution	1	C,D		3,4
24.	Resolving power of a grating	1	C,D		3,4
25.	Fraunhoffer’s diffraction	1	C,D		3,4
26.	Fresenel’s diffraction	1	C,D		3,4
27.	Problems	1	C,D		3,4
	UNIT IV: Polarization of light	**9**			3,4
28.	Introduction to polarization	1	C,D		3,4
29.	Types of polarization- plane, circular, elliptical	1	C,D		3,4
30.	Polarization by reflection of light,	1	C,D		3,4
31.	Brewster’s law,	1	C,D		3,4
32.	Law of Malus	1	C,D		3,4
33.	Polarisation by double refracting uniaxial crystals,	1	C,D		3,4
34.	Ordinary and extraordinary light	1	C,D		4,5

35.	Linear polarizer (Polaroid)	1	C,D		4,5
36.	Fabrication of linear polarizer by Nicol prism	1	C,D		4,5
	UNIT V: Fiber optics and Holography	**9**			4,5
37.	Optical fiber basics using ray optics	1	C,D		4,5
38.	Basic waveguide theory	1	C,D		4,5
39.	Concept of modes	1	C,D		4,5
40.	Single-mode	1	C,D		4,5
41.	Multimode fiber	1	C,D		4,5
42.	Optical fiber communication (discussion only)	1	C,D		4,5
43.	Introduction to holography techniques	1	C,D		4,5
44.	Applications of Holography	1	C,D		4,5
45.	Problems	1	C,D		4,5
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Optics, Eugune Hecht, A. R. Ganesan, 4 Edition, 2008, Pearson Education
2	Introduction to Optics, Frank L Pedrotti, 1 Edition, 2014, Pearson Education
3	Optics, Ajoy Ghatak, 5 Edition, 2012, McGraw Hill Education
4	Geometrical and Physical Optics, R.S. Longhurst, 3rd Revised edition, 19974, Longman
5	Optics, Miles V. Klein, Thomas Elton Furtak, Wiley series in pure and applied optics, 1986, Wiley

Laboratory: Advanced Optics

PURPOSE	The purpose of this course is to introduce the student into a realm world of optics where each and every principle of optics end up in using various spectrometries and also in real time optoelectronic technologies. Train and promote students to

	develop new optical techniques and applications for next generation scientific and technological challenges.

	LEARNING OBJECTIVES	STUDENT OUTCOMES						
At the end of the course, student will be able to								
1.	Measure the wavelength, refractive index, TE and TM losses of optical fibers.							
2.	Develop new techniques to detect light, polarization of light.							
3.	Can handle optical fibers.							

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	a) Determination of phase difference and wavelength using Michelson's interferometer b) Determination of Refractive index of glass plate using Michelson's interferometer	4	I,O		1,2
2.	To observe the diffraction patterns by holes/single slit double slit with He-Ne laser source	4	I,O		1,2
3.	To observe the diffraction patterns by grating and obtain resolving power of the grating	4	I,O		1,2
4.	To measure the light intensity of plane polarized light as a function of the analyzer position and verify Malus law (inverse square law)	4	I,O		1,2
5.	Experimental verification of Fresnel's equations for reflection of electromagnetic waves	4	I,O		1,2
6.	To determine the specific rotation of cane sugar solution using Polarimeter	4	I,O		1,2
7.	To measure the light intensity as a function of voltage across the Kerr cell using photo detector	4	I,O		1,2
8.	a) Calculate the numerical aperture and study the losses that occur in optical fiber cable b) To study losses at FIBER junctions c) To measure losses in dB of two optical FIBER patchcords and the coefficient of attenuation	4	I,O		1,2
	Total contact hours (Experiments +Demo + Extra class)	32			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Grant R. Fowles, " Introduction to modern optics" Dover Publications, Inc., New York, 1968 [ISBN: 978-0-4861-3492-5]

2	Ajoy Ghatak, K. Thyagarajan, "An Introduction to Fiber Optics", Cambridge University Press, 1998 [ISBN: 9781139174770]

Assessment:

Course nature							**Theory + Practical**
Assessment Method – Theory Component (Weightage 70%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	Quiz	**Total**
	Weightage	**15%**	**15%**	**10%**	**5%**	**5%**	**50%**
End semester examination Weightage:							**50%**
Assessment Method – Practical Component (Weightage 30%)							
In-semester	**Assessment tool**	Lab performance	Practical model exam	Observation note			**Total**
	Weightage	**20%**	**20%**	**10%**			**50%**
End semester examination Weightage:							**50%**

PHY 706M	**Nanotechnology in Energy Conversion and Storage**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	Academic Council Meeting, 2018 (**Regulation - 2018**)				

PURPOSE	The course aims to cover the fundamental formalism and applications of Physics. It mainly includes various aspects of renewable energy technologies.							
LEARNING OBJECTIVES		STUDENT OUTCOMES						
At the end of the course, student will be able to								
1.	apply the fundamental concepts of physics and relate to various energy technologies							
2.	Understand various device technologies							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I - Energy Resources	**9**			
1.	Energy resources: Introduction, prospects and challenges	1	C		1,2,3
2.	Introduction to various conventional sources of energy	1	C		1,2,3
3.	Introduction to various non-conventional sources of energy	1	C		1,2,3
4.	Renewable energy: Sources	1	C		1,2,3
5.	Non-Renewable energy: Sources	1	C		1,2,3
6.	Energy storage devices	1	C		1,2,3
7.	Solar thermal devices, PV devices	1	C		1,2,3
8.	Wind, biomass and new materials in energy technologies	1	C		1,2,3
	UNIT II – Solar Energy	**9**			
9.	Solar constant, solar radiation geometry, local solar time, day length,	1	C		1,2,3
10.	Solar radiation measurement, radiation on inclined surface, solar radiation data & solar charts	1	C		1,2,3

11.	Solar concentrators and solar collectors	1	C		1,2,3
12.	Tracking systems for solar concentrators, Heat transfer fluids for solar collectors	1	C		1,2,3
13.	Stand-alone and solar aided power generation	1	C		1,2,3
14.	Solar cooker, solar building heating and cooling, and solar refrigeration	1	C		1,2,3
15.	Solar cooker, solar building heating and cooling, and solar refrigeration	1	C		1,2,3
16.	Thermal energy storage systems: Sensible, Latent and Thermochemical energy storage system	1	C		1,2,3
17.	Materials for energy storage, design consideration	1	C		1,2,3
18.	Current challenges in solar thermal energy technologies	1	C		1,2,3
	UNIT III – Photovoltaic Devices	**9**			
19.	Introduction to photovoltaic conversion	1	C,D		1,2,3
20.	Theory of operation of photovoltaic devices	1	C,D		1,2,3
21.	PV device application	1	C,D		1,2,3
22.	PV Module and Circuit Design	1	C,D		1,2,3
23.	Module Structuring and assembly	1	C,D		1,2,3
24.	Environmental concerns	1	C,D		1,2,3
25.	Crystalline and thin film modules	1	C,D		1,2,3

26.	Solar PV modules: testing and analysis	1	C,D		1,2,3
27.	Current challenges in solar PV modules	1	C,D		1,2,3
	UNIT IV: Wind and Biomass Energy	**9**			
28.	Wind as a Source of Energy,	1	C,D		1,2,3
29.	Characteristics of wind and wind data	1	C,D		1,2,3
30.	Horizontal & Vertical axis wind Mills	1	C,D		1,2,3
31.	Introduction to biomass, biofuels & their heat content	1	C,D		1,2,3
32.	Bioconversion mechanism and biomass conversion technologies	1	C,D		1,2,3
33.	Aerobic & anaerobic systems (digester)	1	C,D		1,2,3
34.	biogas plants - types & description	1	C,D		1,2,3
35.	Advantages & problems in development of Gasifiers, use in I.C. engines.	1	C,D		1,2,3
36.	Utilisation of biogas - Gasifiers, direct thermal application of Gasifiers. Biodiesel	1	C,D		1,2,3
	UNIT V: Other Energy Technologies	**9**			
37.	Geothermal Energy: Introduction, current status and estimates, geothermal sources, Geothermal systems & their characteristics.	1	C,D		1,2,3
38.	Fuel Cells: Principles and various types, Electrochemistry basis of fuel cells	1	C,D		1,2,3
39.	Alkaline fuel cells (AFC): Description, working principle, components, general performance characteristics	1	C,D		1,2,3
40.	Solid oxide fuel cell (SOFC): History, materials,	1	C,D		1,2,3
41.	SOFC: Cell components, Cathode and Anode materials,	1	C,D		1,2,3

42.	benefits and limitations, Environmental impact of SOFC. Application and future of SOFC.	1	C,D		1,2,3
43.	Thermoelectric materials: Introduction, current status and challenges	1	C,D		1,2,3
44.	Newer Energy Materials: CNT, graphene, polymer composite and their uses in making energy devices	1	C,D		1,2,3
45.	Hydrogen energy: Principle of operation, Present status and future challenges	1	C,D		1,2,3
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Brendel R. and Goetzberger A., Thin Film Crystalline Si Solar cells, Wiley VCH, 2003.
2	Roger A.M.and VentreJ., Photovoltaic Systems Engineering, CRC Press, 2000.
3	Bagotsky V. S., Fuel Cell Problems and Solutions, John Wiley & Sons, 2009.
4	D Y Goswami, Frank Kreith and J F Kreider, Principles of Solar Engineering, Taylor & Francis, 1998

Assessment:

Course nature						**Theory**
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
End semester examination Weightage:						**50%**

PHY 319M	Nano DevicePhysics	L	T	P	C
		3	1	0	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	Academic Council Meeting, 201 (**Regulation - 2018**)				

PURPOSE	The course aims to cover the fundamental formalism and applications of Device Physics. It mainly includes basic properties of semiconductor nano-devices and their characterisations as well as applications							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								

1.		apply the fundamental concepts of low dimensional (0D, 1D and 2D) devices							
2.		students' physical intuition and thinking process through understanding the theory							
3.		Make simple 0D, 1D and 2D semiconductor devices for real-world applications							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I – Fundamentals of Quantum Devices	**9**	C		
1.	Introduction to low dimensional nanostructures (0D, 1D and 2D)	1	C		1,2,3,5
2.	Review of density of states and I-V characteristics of Metal, semiconductors and insulators	1	C		1,2,3,5
3.	Charge and spin in single quantum dots	1	C		1,2,3,5
4.	Coulomb blockade, Electrons in mesoscopic structures	1	C		1,2,3,5
5.	Single electron transfer devices (SETs),	1	C		1,2,3,5
6.	Electron spin transistor, resonant tunnel diodes	1	C		1,2,3,5
7.	Tunnel Field Effect Transistors (FET)	1	C		1,2,3,5
8.	Quantum interference transistors (QUITs)	1	C		1,2,3,5

9.	Quantum bits (qubits)	1	C		1,2,3,5
	UNIT II – NANOELECTRONIC DEVICES				
10.	Electronic transport in 1, 2 and 3 dimensions	1	C		1,2,3,5
11.	Quantum confinement, energy sub-bands	1	C		1,2,3,5
12.	Effective mass, Drude conduction, mean free path in 3D	1	C		1,2,3,5
13.	Ballistic conduction, phase coherence length	1	C		1,2,3,5
14.	Quantized conductance, Buttiker-Landauer formula	1	C		1,2,3,5
15.	Electron transport in p-n junctions, short channel Nano Transistor	1	C		1,2,3,5
16.	Metal Oxide Semiconductor (MOS)FETs	1	C		1,2,3,5
17.	Advanced MOSFETs and properties	1	C		1,2,3,5
18.	Trigate FETs, Fin-FETs, CMOS	1	C		1,2,3,5
	UNIT III – MOLECULAR NANOELECTRONICS	**9**			
19.	Electronic and optoelectronic properties of molecular materials	1	C		1,2,3,5

20.	Electrodes & contacts, functions	1	C		1,2,3,5
21.	Fundamentals of molecular electronic devices	1	C		1,2,3,5
22.	Elementary circuits using organic molecules	1	C		1,2,3,5
23.	Organic materials based rectifying diode switches	1	C		1,2,3,5
24.	TFTs, OLEDs, OTFTs, logic switches	1	C		1,2,3,5
25.	Fabrication of molecular devices	1	C		1,2,3,5
26.	Transport properties at molecular junctions	1	C		1,2,3,5
27.	I-V Characteristics and Analysis	1	C		1,2,3,5
	UNIT IV: Spintronics	**9**			
28.	Fundamentals of Spin tunnelling devices	1	C		4,5,6
29.	Magnetic tunnel junctions, Tunnelling spin polarization	1	C		4,5,6
30.	Giant tunnelling using MgO tunnel barriers	1	C		4,5,6
31.	Tunnel-based spin injectors,	1	C		4,5,6
32.	Spin injection and spin transport in hybrid nanostructures	1	C		1,2,3
33.	spin filters, spin-diodes, Magnetic tunnel transistor	1	C		4,5,6
34.	Memory devices and sensors	1	C		4,5,6
35.	Field Sensors, Multi ferroelectric sensors	1	C		4,5,6

36.	Spintronic Biosensors	1	C		4,5,6
	UNIT V: Fabrication Techniques	**9**			
37.	Substrate surface, Adsorption, Surface energy	1	C		6,7
38.	Film growth modes, nucleation model, manifestations of epitaxy	1	C		6,7
39.	Lattice misfit and defect formation	1	C		6,7
40.	Morphology, grain growth, texture, microstructure control	1	C		6,7
41.	Different 1D and 2D materials and their fabrication techniques	1	C		6,7
42.	Physical vapour deposition techniques, Physics and Chemistry of Evaporation	1	C		6,7
43.	Thermal evaporation, Pulsed laser deposition, Molecular beam epitaxy, Sputtering deposition	1	C		6,7
44.	Direct Current, Radio Frequency, Magnetron, Ion beam and reactive sputtering,	1	C		6,7
45.	Chemical methods, Chemical Vapour Deposition.	1	C		6,7
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/ REFERENCE BOOKS/OTHER READING MATERIAL
1	V. Mitin, V. Kochelap, M. Stroscio, Introduction to Nanoelectronics, Cambridge University Press (2008).
2	Rainer Waser, —Nanoelectronics and Information Technology: Advanced Electronic Materials and Novel Devices, Wiley-VCH (2003).
3	Karl Goser, Peter Glosekotter, Jan Dienstuhl, —Nanoelectronics and Nanosystems, Springer (2004).
4	Sadamichi Maekawa, —Concepts in Spin Electronics, Oxford University Press (2006).

5	L. Banyai and S.W.Koch, ―Semiconductor Quantum Dots, World Scientific (1993).
6	Edward L. Wolf, ―Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Wiley-VCH (2006)
7	K. Oura, V.G. Lifshits, A.A. Saranin, A.V. Zotov, M. Katayama, Surface Science: an Introduction, Springer Science & Business Media (2003)

Assessment:

Course nature				**Theory**		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
					End semester examination Weightage:	**50%**

PHY 702M	**Introduction to Photonics**	**L**	**T**	**P**	**C**
		3	**1**	**0**	4
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	BASIC SCIENCES	SEAS			
Course designed by	Department of Physics				
Approval	-- Academic Council Meeting -- , 2018				

PURPOSE	The purpose of this course is to introduce students about the basics of optical principles and the ways to develop the photonic devices such as lasers and detectors.

LEARNING OBJECTIVES	**STUDENT OUTCOMES**						
At the end of the course, student will be able to							

3.	To provide a comprehensive background of optical principles							
4.	To provide a comprehensive background of quantum mechanical description of light							
5.	To discuss the various analytical techniques for analyzing the optical signals							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I –Introduction to photonics	**9**			
1.	Introduction to light ~ wave vs particle I	1	C		3
2.	Introduction to light ~ wave vs particle II	1	C		3
3.	Polarization of electromagnetic waves	1	C		1,3
4.	Polarization ellipse	1	C		1,3
5.	Mueller and Jones matrices	1	C,O		1,3
6.	Fresnel and Fraun-hoffer diffraction of light	1	C		3
7.	Coherence of light I	1	C		3
8.	Coherence of light II	1	C		3
9.	Van-Cittert Zernike theorem	1	C,O		3
	UNIT II – Interaction of light with matter	**9**			
10.	Interaction of radiation with matter – threshold conditions	1	C		5
11.	2-level and 3-level laser systems	1	C		5
12.	Einstein's theory for lasers	1	C.D		5
13.	CW and Pulsed operations in lasers	1	C		5
14.	Characteristics of laser beam	1	C		5
15.	Non-linear materials – higher harmonic generations	1	C		5
16.	Optical resonators I	1	C		5
17.	Optical Resonators II	1	C		5
18.	Q-switching and Mode locking of lasers	1	C		5
	UNIT III – Introduction to Fibre Optics	**9**			
19.	Introduction to fibres	1	C		6
20.	Description of fibres – Numerical aperture	1	C		6

21.	Propagation of light through fibre	1	C		6
22.	Preparation of fibres	1	C,D		6
23.	Fibre couplers and connectors	1	C,D		6
24.	Optical detectors	1	C		6
25.	Fibre Amplifiers	1	C		6
26.	Fibres for different spatial modes of light	1	C		6
27.	Integrated fibre optics	1	C		6
	UNIT IV: Photon Statistics	**9**			
28.	Introduction	1	C		4
29.	Photon statistics of laser light	1	C,D		4
30.	Derivation of Poissonian statistics	1	C		4
31.	Description of thermal light – Bunching of photons	1	C		4
32.	Anti-bunching of light	1	C		4
33.	Sub and super Poissonian statistics	1	C		4
34.	Description of Quantum light	1	C		4
35.	Ideal single photon sources	1	C		4
36.	Heralded single photon sources	1	C		4
	UNIT V: Holography and Optical Imaging	**9**			
37.	Introduction to Holography	1	C		3
38.	Computer generated holography	1	C		3
39.	Generation of structured light using holography	1	C		3
40.	Review of Imaging	1	C		3
41.	Fourier transforms for imaging	1	C		3

42.	Reconstruction of phase using holography	1	C		3
43.	Bio-imaging	1	C		3
44.	Optical Trapping and tweezers	1	C		3
45.	Optical Coherence tomography	1	C		3
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Polarized light by Goldstein
2	Nonlinear Optics, 3rd Ed. by Robert Boyd
3	Introduction to Optics by Hecht
4	Quantum optics by Mark Fox
5	Lasers by Silfvast
6	Fibre Optics by Ajoy Ghatak

Assessment:

Course nature		**Theory**				
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
					End semester examination Weightage :	**50%**

PHY 201M	**WAVES, OSCILLATIONS, AND OPTICS**				
		L	**T**	**P**	**C**
		3	**0**	**2**	**4**
Co-requisite:	NIL				
Prerequisite:	NIL				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	-- Academic Council Meeting -- , 2018				

PURPOSE	The purpose of this course is to understand the physics behind various phenomena associated with oscillations, waves and optical instruments.

LEARNING OBJECTIVES		**STUDENT OUTCOMES**							
At the end of the course, student will be able to									
1.	Address different types of oscillations and its various applications								

2.		Understand transverse and longitudinal waves and their propagation							
3.		Learn Doppler'e effect and its applications							
4.		Gain the basic principles of several optical instruments							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	Unit -1: Undamped and Damped Oscillations	**9**			
1.	Different types of equilibria (stable, unstable, neutral equilibrium, Saddle points)	1	C		1-7
2.	Definition of linear and angular S.H.M	1	C		1-7
3.	Differential equation of S.H.M. and its solution (exponential form)	1	C		1-7
4.	Composition of two perpendicular linear S.H.Ms. for frequencies 1:1 and 1:2 (analytical method)	1	C		1-7
5.	Lissajous's figures and its uses	1	C		1-7
6.	Lissajous's figures and its Applications (mechanical, electrical and optical)	1	C		1-7
7.	Differential equation of damped harmonic oscillator and its solution, discussion of different cases	1	C		1-7
8.	Logarithmic decrement, Energy equation of damped oscillations	1	C		1-7
9.	Power dissipation, Quality factor	1	C		1-7
	Unit – II: Forced Oscillations	**9**			
10.	Forced oscillation with one degree of freedom	1	C		1-7
11.	Differential equation of forced oscillation and its solution (transient and steady state)	1	C		1-7
12.	Amplitude of forced oscillation	1	C		1-7
13.	Resonance and its examples: mechanical (Barton's pendulum)	1	C		1-7
14.	Resonance and its examples: optical (sodium vapor lamp), electrical (LCR Circuit) (description only)	1	C		1-7
15.	Velocity and Amplitude resonance, Sharpness of resonance	1	C		1-7
16.	Energy of forced oscillations, Power dissipation	1	C		1-7

17.	Quality factor and Bandwidth	1	C		1-7
18.	Equation of coupled oscillations, electrically coupled oscillations	1	C		1-7
	UNIT III - Wave Motion	**9**			
19.	Differential equations of wave motion in continuous	1	C		1-7
20.	Equations for longitudinal waves	1	C		1-7
21.	Equations for longitudinal waves and one	1	C		1-7
22.	Equation for transverse waves	1	C		1-7
23.	Equation for transverse waves and its solution (one	1	C		1-7
24.	Wave propagation in solid, liquid, gases	1	C		1-7
25.	Wave propagation in solid, liquid, gases, and its solution	1	C		1-7
26.	Energy density and intensity of a wave	1	C		1-7
27.	Discussion of seismic waves	1	C		1-7
	UNIT IV: Sound and Doppler Effect	**9**			
28.	Definition of sound intensity, loudness, pitch, quality and timber	1	C,D		1-7
29.	Interference of sound waves, beats, combination	1	C,D		1-7
30.	Application of Fourier’s series to the vibration of	1	C,D		1-7
31.	Acoustic intensity level measurement, Acoustic	1	C,D		1-7
32.	Sabine’s formula (without derivation), Stroboscope	1	C,D		1-7
33.	Waves generated by high-speed projectiles, Shock	1	C,D		1-7
34.	Explanation of Doppler Effect in sound, Expression	1	C,D		1-7
35.	Doppler Effect in light, symmetric nature of	1	C,D		1-7
36.	Applications: Red shift, Violet shift, Radar, Speed	1	C,D		1-7
	UNIT V: Geometrical Optics	**9**			
37.	Fermat’s principle and its application to reflection	1	C,D		1-7

38.	Dispersive power of prisms, angular magnification	1	C,D		1-7
39.	Cardinal points of optical systems, Paraxial optics	1	C,D		1-7
40.	Helmholtz-Lagrange Law; Combination of lenses	1	C,D		1-7
41.	The matrix method in paraxial optics	1	C,D		1-7
42.	Qualitative discussions of aberrations, Chromatic	1	C,D		1-7
43.	Optical Instruments - Simple microscope and	1	C,D		1-7
44.	Telescopes, Reflection and transmission type of	1	C,D		1-7
45.	Eyepieces: Huygen’s eyepiece, Ramsden’s	1	C,D		1-7
	Total contact hours	**45**			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Advanced Acoustics D. P. Roy Chowdhury, Reprint Edition, 2015, Chayan Publisher
2	Vibrations and Waves, Anthony Philip French, reprint Edition, 1971, Nelson
3	Introduction to Geometrical and Physical Optics, B. K. Mathur, 7 Edition, 1967, Gopal Printing
4	Fundamentals of Optics, Francis Jenkins, Harvey White, 4 edition, 2017 McGraw Hill
5	Waves Oscillations and Acoustics, Kakani S.L., 2 Edison, 2018, CBS Publishers & Distributors
6	Textbook of sound A. B. Wood, 2 Edison, 1941, London, G. Bell and sons, ltd.
7	A Textbook on Light, K G Mazumdar and B Ghosh, 3rd revised Edition, 2010, Sreedhar

Laboratory: Oscillations, Waves and Optics

PURPOSE	The purpose of this course is to introduce students about how principles of waves & oscillations are manifested in real world environment through properly designed experiments.							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
1.	Understand crucial concepts of waves & oscillations like damped oscillation, forced oscillations and resonance through examples and experiments.							
2.	handle and utilize a telescope							
3.	handle and utilize a prism and find its various optical properties like							

	angle of deviation (i) – deviation (D) , Refractive Index, dispersion power etc.							

Sl. No.	Description of experiments	Contact hours	C-D-I-O	IOs	Reference
1.	To investigate the damping effect of an oscillating spring in high viscosity liquid like oil or glycerine.	4	I,O		1,2
2.	To investigate resonance in forced oscillations	4	I,O		1,2
3.	To determine particle size of a given powder using wave optics method	4	I,O		1,2
4.	To determine the resolving power of a telescope	4	I,O		1,2
5.	Determine angle of deviation (i) – deviation (D) of a given prism.	4	I,O		1,2
6.	To determine the Refractive Index of the Material of a given Prism using Sodium Light.	4	I,O		1,2
7.	To determine the dispersion power of a prism material	4	I,O		1,2
8.	To Determine Cauchy's A and B constant with μ $vs. 1/\lambda^2$ graph.	4	I,O		1,2
	Total contact hours (Experiments +Demo + Extra class)	32			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	K.G. Mazumdar and B. Ghosh, "*Advanced Practical Physics*" Sreedhar Publishers, Revised edition Jan 2004
2	R.K. Shukla and Anchal Srivastava, "*Practical Physics*" New Age international (P) limited Publishers, 2006 [ISBN(13) – 978-81-224-2482-9]
3	Hugh D.Young, Roger A. Freedman and Lewis Ford "*University Physics with Modern Physics*" (12th Edition, 2015) –(Publisher – Pearson Education)

Assessment:

Course nature							**Theory + Practical**
Assessment Method – Theory Component (Weightage 70%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	Quiz	**Total**
	Weightage	**15%**	**15%**	**10%**	**5%**	**5%**	**50%**
End semester examination Weightage:							**50%**

Assessment Method – Practical Component (Weightage 30%)					
In-semester	**Assessment tool**	Lab performance	Practical model exam	Observation note	**Total**
	Weightage	**20%**	**20%**	**10%**	**50%**
End semester examination Weightage:					**50%**

PHY 301M	**Atomic and Molecular Physics**		**L**	**T**	**P**	**C**
			3	**0**	**2**	**4**
Co-requisite:	NIL					
Prerequisite:	NIL					
Data Book / Codes/Standards	NIL					
Course Category	CORE	Atomic and Molecular Physics				
Course designed by	Department of Physics					
Approval	-- Academic Council Meeting -- , 2018					

PURPOSE	The purpose of this course is to introduce students about the atomic structure, Vector atom model, valence electron systems, different spectroscopy and laser to understand about atomic and molecular physics and its application.

LEARNING OBJECTIVES	**STUDENT OUTCOMES**					
At the end of the course, student will be able to						

1.		Understand about the atomic structure, Rutherford model, Bohr atom, Energy levels and spectra, and magnetic moments of atoms,							
2.		Learn the electron configuration, quantum states, spectral notations of quantum, States, spin orbit interaction, and Zeeman effect							
3.		Familiarize with various atomic models and atomic spectra							
4.		To prepare students with knowledge in LASER and its techniques							

Session	**Description of Topic**	**Contact hours**	**C-D-I-O**	**IOs**	**Reference**
	UNIT I - Atomic structure	**9**			
1.	Rutherford model of atom	1	C		1,2
2.	Rutherford Model numerical	1	C		1,2
3.	Electron orbits	1	C		1,2
4.	Bohr atom	1	C		1,2
5.	Energy levels and spectra	1	C		1,2
6.	Numerical on energy level and spectra	1	C		1,2
7.	Sommerfield’s elliptic orbits	1	C		1,2
8.	Numericals on Somerfield’s theory	1	C		1,2
9.	Relativistic Corrections of Sommerfield’s Theory	1	C		1,2
	UNIT II – Vector atom model	**9**			
10.	Vector atom model	1	C		1,2
11.	Concept of space	1	C		1,2
12.	Concept of quantization	1	C		1,2
13.	Electron spin	1	C		1,2
14.	Magnetic moments of atoms	1	C		1,2
15.	Numerical on quantization	1	C		1,2
16.	Stern-Gerlach experiment	1	C		1,2
17.	Atomic excitation and atomic spectra	1	C		1,2
18.	Numericals on atomic excitation and atomic spectra	1	C		1,2
	UNIT III - One and two valence electron systems	**9**			
19.	Pauli Exclusion Principle	1	C		2,3
20.	Electron configuration	1	C		2,3
21.	Quantum states, Electron spin	1	C		2,3
22.	Spin-Orbit Interaction, Energy levels of Na atom	1	C		2,3
23.	Sodium Doublet, Spectral terms of two electron atoms	1	C		2,3
24.	Terms for equivalent electrons, L-S and J-J coupling schemes	1	C		2,3
25.	Singlet-Triplet separation for interaction energy of L-S coupling	1	C		2,3

26.	Landé g-factor Landé Interval rule	1	C		2,3
27.	Spectra of Helium atom, Zeeman Effect	1	C		2,3
	UNIT IV: Atomic and Molecular spectroscopy	**9**			
28.	EM spectrum, X-ray	1	C,D		3,4,5
29.	Daune and Hunt's Rule	1	C,D		3,4,5
30.	X-ray emission spectra	1	C,D		3,4,5
31.	Bremsstrahlung effect	1	C,D		3,4,5
32.	Mosley's law and its applications	1	C,D		3,4,5
33.	Auger effect, Electronic spectra of molecules	1	C,D		3,4,5
34.	Rotational spectra of diatomic molecules	1	C,D		3,4,5
35.	Raman Effect	1	C,D		3,4,5
36.	Molecular Polarizability	1	C,D		3,4,5
	UNIT V: Lasers	**9**			
37.	Optical absorption and emission	1	C,D		3,4,5
38.	Einstein coefficients	1	C,D		3,4,5
39.	Optical pumping	1	C,D		3,4,5
40.	Masers principles	1	C,D		3,4,5
41.	Lasers principles	1	C,D		3,4,5
42.	Numerical of Lasers	1	C,D		3,4,5
43.	Ruby Laser principles	1	C,D		3,4,5
44.	He-Ne Laser Principles	1	C,D		3,4,5
45.	Solid state and semiconductor lasers	1	C,D		3,4,5
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS
1	Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, R. Eisberg and R. Resnik 2nd Edison, 2006, Wiley
2	Concepts of Modern physics, Arthur Besier, S. Rai Choudhury, Shobhit Mahajan, 7th Edition, 2015, Mcgraw Higher Ed
3	Atomic Physics, J. M. Rajam, Revised Edition, 2010, S Chand Publication
	REFERENCE BOOKS/OTHER READING MATERIAL
4	The Fundamentals of Atomic and Molecular Physics, Brooks, Robert L. 1 Edition, 2013, Springer-Verlag New York
5	Physics of Atoms and Molecules, B. H. Bransden, C. J. Joachain, 2 Edition, Pearson Education India

Laboratory: Atomic and Molecular Physics

PURPOSE	The purpose of this course is to introduce students about how the fundamental atomic, molecular physics and basic Laser characteristics aid in the advanced technology through properly designed experiments.

		LEARNING OBJECTIVES	**STUDENT OUTCOMES**						
	At the end of the course, student will be able to								
1.		Correlate Atomic and Molecular physics theories with real life examples							
2.		Realize the profound importance of atomic and molecular spectroscopy in the basic and inter disciplinary science.							
3.		Handle up to class 3 Lasers and realize the importance of safety, scientific and industrial applications of various Lasers.							

Sl. No.	**Description of experiments**	**Contact hours**	**C-D-I-O**	**IOs**	**Reference**
1.	To record the Franck-Hertz characteristic curve for neon emission	4	I,O		1,2
2.	a) To determine the wavelengths of Balmer series in the visible region from atomic emission b) To determine the Rydberg constant	4	I,O		1,2
3.	To determine Planck’s Constant by Cs Photocell	4	I,O		1,2
4.	To observe the Zeeman splitting of the green (546.1nm) mercury line using Fabry-Perot etalon for normal transverse and longitudinal configuration.	4	I,O		1,2
5.	Measuring the speed of sound, by measuring the Bragg angle using an acousto-optics modulator and laser diffraction.	6	I,O		1,2
6.	To determine beam divergence and M-parameter of a He-Ne laser beam and compare it with commercial laser pointer beam.	6	I,O		1,2
7.	To determine beam divergence and M-parameter of a commercial laser pointer beam	4	I,O		1,2
	Total contact hours (Experiments +Demo + Extra class)	32			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	K.G. Mazumdar and B. Ghosh, “*Advanced Practical Physics*” Sreedhar Publishers, Revised edition Jan 2004
2	R.K. Shukla and Anchal Srivastava, “*Practical Physics*” New Age international (P) limited Publishers, 2006 [ISBN(13) – 978-81-224-2482-9]

3	http://www.atomic.physics.lu.se/education/mandatory-courses/fystc11-atomic-and-molecular-physics-for-science-faculty/laboratory-exercises/

Assessment:

Course nature							**Theory + Practical**
Assessment Method – Theory Component (Weightage 70%)							
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	Quiz	**Total**
	Weightage	**15%**	**15%**	**10%**	**5%**	**5%**	**50%**
End semester examination Weightage:							**50%**
Assessment Method – Practical Component (Weightage 30%)							
In-semester	**Assessment tool**	Lab performance	Practical model exam	Observation note			**Total**
	Weightage	**20%**	**20%**	**10%**			**50%**
End semester examination Weightage:							**50%**

PHY 709M	**Quantum Computation**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**
Co-requisite:	NIL				
Prerequisite:	PHY213 Quantum Mechnics				
Data Book / Codes/Standards	NIL				
Course Category	Elective				
Course designed by	Department of Physics				
Approval	Academic Council Meeting, 2019 (**Regulation - 2019**)				

PURPOSE	The course represents a comprehensive survey on the concept of quantum computing with an exposition of qubits, quantum logic gates, quantum algorithms and Implementation. Starting with the main definitions of the theory of computation, the course mostly deals with the application of the laws of quantum mechanics to quantum computing and quantum algorithms.							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, student will be able to								
6.	know the definition of qubit, quantum logic gates, quantum circuits and quantum algorithms							

7.	understand how quantum parallelism is used in the simplest quantum algorithms such as Deutsch, period finding and quantum Fourier transform							
8.	know the basic requirements for implementation of quantum computers and classify the schemes for implementation of quantum computers							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
Unit 1	**Introduction and Overview**	**9**			1,2
1.	Qubits and pieces	1	C		1,2
2.	Bloch sphere	1	C		1,2
3.	Qquantum mechanical probabilities	1	C-D		1,2
4.	Quantum behaviors	1	C		1,2
5.	History of quanta	1	C		1,2
6.	Base states and superposition	1	C-D		1,2
7.	Structural randomness	1	C-D		1,2
8.	Measurement: how long is a qubit?	1	C		1,2
9.	Heisenberg's Uncertainty Principle	1	C		1,2
Unit 2	**Matrix and Tensor**				
10.	Basis vectors and orthogonality	1	C-D		1,2
11.	Matrices Hilbert spaces	1	C-D		1,2
12.	Tensors in index notation	1	C-D		1,2
13.	Inner and outer products	1	C-D		1,2
14.	Kronecker and Levi Civita tensors	1	C-D		1,2
15.	Contraction, symmetric and antisymmetric tensors, quotient law	1	C-D		1,2
16.	Metric tensors, covariant and contravariant tensors	1	C-D		1,2
17.	Unitary operators and projectors	1	C-D		1,2

18.	Dirac notation	1	C-D		1,2
Unit 3	**Fundamentals of Quantumness and Quantum Circuit**	**9**			
19.	Abramsky-Coecke semantics	1	C-D		1,2
20.	no-cloning theorem	1	D-I		1,2
21.	quantum entanglement	1	D-I		1,2
22.	Bell states	1	D-I		1,2
23.	Bell inequalities	1	D-I		1,2
24.	Pauli, Hadamard gates	1	D-I		1,2
25.	phase, CNOT, Toffoli gates	1	D-I		1,2
26.	quantum teleportation	1	D-I		1,2
27.	universality of two-qubit gates	1	D-I		1,2
Unit 4	**Quantum Algorithms**	**9**			
28.	Deutsch-Josza algorithm	1	D-I		1,2
29.	Deutsch-Josza algorithm application	1	D-I		1,2
30.	Simon’s problem	1	D-I		1,2
31.	quantum Fourier transform	1	D-I		1,2
32.	Shor’s Algorithm - Periodicity	1	D-I		1,2
33.	Shor’s period-finding algorithm	1	D-I		1,2
34.	Shor’s Algorithm – Preparing and Data Modular Arithmetic	1	D-I		1,2
35.	Shor’s Algorithm - Superposition Collapse, Entangelment and QFT	1	D-I		1,2
36.	Grover's searching algorithms	1	D-I		1,2
Unit 5	**Quantum Computer**	**9**			
37.	Quantum key distribution	1	I-O		1,2
38.	Physical realization of quantum computation: ion trap	1	I-O		1,2

39.	Physical realization of quantum computation: cavity QED	1	I-O		1,2
40.	Physical realization of quantum computation: nuclear magnetic	1	I-O		1,2
41.	Quantum Error Correction	1	I-O		1,2
42.	Quantum Error Correction Example	1	I-O		1,2
43.	physical qubits	1	I-O		1,2
44.	noise and decoherence	1	I-O		1,2
45.	Quantum cryptography	1	I-O		1,2
	Total contact hours	45			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Phillip Kaye, Raymond Laflamme, and Michele Mosca (2007). An Introduction to Quantum Computing. Oxford University Press.
2	Michael A. Nielsen and Isaac L. Chuang (2000). Quantum Computation and Quantum Information. Cambridge University Press.

Assessment:

Course nature						**Theory**
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Cycle test I	Cycle test II	Assignment	Class Test	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
					End semester examination Weightage :	**50%**