Minor in PHYSICS

DEPARTMENT OF PHYSICS

Amaravati 522502, Andhra Pradesh

INDIA

CURRICULUM AND SYLLABI

2021

CURRICULUM

Department of **Physics** offers **Minor in Physics** to the students of B. Tech and B.Sc 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 203M	Quantum Mechanics	Even	3-1-0-4	4	Mandatory
2	PHY 303M	Solid-state Physics	Odd	3-1-0-4	4	Mandatory
3	PHY 312M	Statistical Physics	Even	3-1-0-4	4	Mandatory
4	PHY 307M	Special Theory of Relativity	Odd	3-1-0-4	4	Any one
	PHY 706M	Nanotechnology in Energy Conversion and Storage	Open	3-1-0-4	4	
	PHY 306M	Electronic Materials & Device Physics	Odd	3-1-0-4	4	
	PHY 702M	Introduction to Photonics	Open	3-1-0-4	4	
5	PHY 213 M	Free Space and Optical Fiber Communication	Even	3-1-0-4	4	Any one
	PHY 233	Introduction to Soft Matter Physics	Open	3-1-0-4	4	
	PHY 223	Introduction to Quantum Computation	Open	3-1-0-4	4	
	PHY 316	Introduction to Astrophysics and Particle Physics	Even	3-1-0-4	4	

SRM University – AP, Andhra Pradesh
Neerukonda, Mangalagiri Mandal
Guntur District, Mangalagiri, Andhra Pradesh 522240

QUANTUM MECHANICS

Course Code	PHY xxx	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)	PHY 111	Co-Requisite Course(s)	-	Progressive Course(s)	PHY xxx			
Course Offering Department	Physics	Professional / Licensing Standards						
Board of Studies Approval Date	19th July 2021	Academic Council Approval Date	HOD will arrange it from Dean's office					

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To understand about the concept of "quantum mechanics" and difference from classical mechanics.

Objective 2: To understand the wave – particle duality, photon theory and matter wave.

Objective 3: To implement the concept and form a wave equation known as Schrodinger equation.

Objective 4: Application of Schrodinger equation to find the properties of microscopic particles.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Knowledge on Radiation Laws, Quantum uncertainty and origin of quantum mechanics	1	70%	65%
Outcome 2	Wave particle duality and superposition knowledge will help to learn the course Quantum Computation	2	70%	65%
Outcome 3	Solve the problem in particle in 3D box and for other potential, and will know why increase of band gap of materials happen in nanodimension	3	70%	65%
Outcome 4	Knowledge in Quantum Tunnelling angular momentum and Commutation relation	3	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)

	Scientific and Disciplinary Knowledge	Analytical Reasoning and Problem Solving	Critical and Reflective Thinking	Scientific Reasoning and Design Thinking	Research Related Skills	Modern Tools and ICT Usage	Environment and Sustainability	Moral, Multicultural and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Leadership Readiness Skills	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	3	2				3			2	3	1	2
Outcome 2	3	3	3	3	2				2			3	3	2	2
Outcome 3	3	3	3	3	2				3			3	3	2	2
Outcome 4	3	3	3	3	3				3			3	3	2	2
Course Average	**3**	**3**	**3**	**3**	**2**				**3**			**3**	**3**	**2**	**2**

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References
Unit 1	**Radiation**	**12**		
	Detection of thermal radiation	1	1	1, 2
	Prevost's theory	1	1	1, 2
	Emissive power of different bodies	1	1	1, 2
	Absorptive power of different bodies	1	1	1, 2
	Black body radiation	1	1	1, 2
	Kirchhoff's law	1	1	1, 2
	Pressure of radiation	1	1	1, 2
	Stefan-Boltzmann law and its experimental verification	1	1	1, 2
	Nernst heat theorem	1	1	1, 2
	Tutorial class (Black Body Radiation)	1	1	1, 2
	Tutorial class (Stefan-Boltzmann law)	1	1	1, 2
	Problem-practice class (Stefan-Boltzmann law)	1	1	1, 2
Unit 2	**Origin of Quantum Mechanics**	**12**		
	Planck's Radiation Law	1	1, 2	1, 2
	Photoelectric Effect	1	1, 2	1, 2
	Numerical of Photoelectric effect	1	2	1, 2
	Compton Effect	1	1	1, 2
	Wave particle duality	1	2	1, 2
	Matter waves, De Broglie hypothesis	1	1, 2	1, 2
	Concept of wave packet, The principle of Superposition	1	2	1, 2
	Davisson and Germer experiment	1	1, 2	1, 2

	Phase velocity, group velocity and relation between them	1	1	1, 2
	Tutorial class (Photoelectric Effects)	1	2	1, 2
	Tutorial class (Compton Effect)	1	1, 2	1, 2
	Problem-practice class (De Broglie hypothesis)	1	1	1, 2
Unit 3	**Heisenberg Uncertainty Principle & Basic of Schrodinger equation I**	12		
	Heisenberg's uncertainty principle with thought experiment	1	3	1, 2
	Different forms of uncertainty, Electron diffraction experiment	1	3	1, 2
	Wave function and its physical interpretation, Boundary Condition of Wavefunction	1	3	1, 2
	Definition of an operator in Quantum mechanics	1	3	1, 2
	Linear vector space & Hilbert Space	1	3	1, 2
	Hermitian Operator, Linear Operator	1	3	1, 2
	Position, Momentum and Total energy operator	1	3	1, 2
	Commutator brackets- Simultaneous Eigen functions	1	3	1, 2
	Commutator algebra, Commutation of position and momentum	1	3	1, 2
	Tutorial class (Heisenberg's uncertainty principle)	1	3	1, 2
	Tutorial class (Operator and Wavefunction)	1	3	1, 2
	Problem-practice class (Operator, Commutator bracket)	1	3	1, 2
Unit 4	**Basic of Schrodinger equation II**	12		
	Probability Amplitude, Probability Density, Probability	1	3,4	2,3
	Stationary States	1	3,4	2,3
	Expectation value	1	3,4	2,3
	Eigen function and Eigen values	1	3,4	2,3
	Ehrenfest's theorem	1	3,4	2,3
	Schrodinger time dependent	1	3	2,3
	Schrodinger time independent equation	1	3	2,3
	Probability Current Density	1	3	2,3
	Stationary States and Bound States	1	3	2,3
	Tutorial class (Eigen function and Eigen values)	1	3	2,3
	Tutorial class (Schrodinger time independent equation)	1	3	2,3
	Problem-practice class (Expectation Value)	1	3	2,3
Unit 5	**Schrodinger time independent equation**	12		

	Free particle, Particle in infinitely deep potential well (one – dimensional)	1	4	2,3
	Particle in a three dimensional rigid box	1	4	2,3
	Step potential, potential barrier (Qualitative discussion)	1	4	2,3
	Barrier penetration and tunneling effect	1	4	2,3
	Harmonic oscillator (one-dimension)	1	4	2,3
	Schrodinger equation in spherical polar coordinate	1	4	2,3
	Hydrogen atom: Qualitative discussion on the radial and angular parts of the bound state energy	1	4	2,3
	Quantum numbers n, l, m_l, m_s – Degeneracy	1	4	2,3
	Angular Momentum	1	4	2,3
	Tutorial class (Potential Barrier)	1	4	2,3
	Tutorial class (Angular Momentum)	1	4	2,3
	Problem-practice class (Particle in a three dimensional rigid box)	1	4	2,3

Recommended Resources

1. Introduction to Quantum Mechanics, D. Griffiths 2 edition, 2004, Pearson
2. Quantum Mechanics, G. Aruldhas, 2nd Edition, 2013, PHI
3. Quantum Mechanics: Theory and Applications, Ajoy Ghatak, S. Lokanathan, 1st Edition, 2004, Mc. Millan.

Other Resources

1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, R. Eisberg and R. Resnik 2ed Edison, 2006, Wiley

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		Mid-1 (15%)		CLA-2 (10%)		Mid-2 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember / Understand	40%		60%		40%		70%		30%	
Level 2	Apply / Analyse	60%		40%		60%		30%		70%	
Level 3	Evaluate / Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Course Designers

a. *Prof. Ranjit Thapa, Professor. Dept. of Physics. SRM University - AP*
b. *Prof. M. S. Ramachandra Rao, Professor, Department of Physics, Indian Institute of Technology, Madras*
c. *Prof. D. Narayana Rao, Raja Ramanna Fellow, University of Hyderabad*

PHY 303	SOLID STATE PHYSICS	L	T	P	C
		3	1	0	4

Course Code	PHY 303	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)	PHY 213	**Co-Requisite Course(s)**	PHY 301, PHY 302	**Progressive Course(s)**	PHY 302			
Course Offering Department	Physics	**Professional / Licensing Standards**						
Board of Studies Approval Date	19.07.2021	Academic Council Approval Date						

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To understand the basic knowledge on crystal structures and crystal systems.
Objective 2: To acquire the knowledge on the classification solids into conductors, semiconductors and insulators.
Objective 3: To acquire knowledge on lattice vibrations, thermal properties and electric conductivity of solids.
Objective 4: To comprehend the concepts of dielectric and magnetic properties of solids.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Learn the crystallography.	1	70%	65%
Outcome 2	Understand the importance of phonons on thermal properties of matter.	2	70%	65%
Outcome 3	Understand the electrons transport, thermal transport.	3	70%	65%
Outcome 4	Understand the evolution of electronic band gaps in solid.	3	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)

	Scientific and Disciplinary	Analytical Reasoning and	Critical and Reflective	Scientific Reasoning and	Research Related Skills	Modern Tools and ICT	Environment and	Moral, Multicultural and	Individual and Teamwork	Communication Skills	Leadership Readiness	Self-Directed and Life	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	3	2				3			2	3	2	2
Outcome 2	3	3	3	3	2				2			3	3	3	3
Outcome 3	3	3	3	3	2				3			3	3	3	2
Outcome 4	3	3	3	3	3				3			3	3	3	3
Course Average	**3**	**3**	**3**	**3**	**2**				**3**			**3**	**3**	**3**	**3**

Course Unitization Plan

Session	**Description of Topic**	**Required Contact hours**	**CLOs Addressed**	**References**
	UNIT I - Crystallography	**9**		
1.	Crystalline and amorphous solids, Lattice, Basis, Translational vectors, Primitive unit cell.	1	1	1,2
2.	Symmetry operations, Different types of lattices-2D and 3D (Bravais lattices)	1	1	1,2
3.	SC, BCC and FCC structures, Packing fraction	1	1	1,2
4.	Miller indices, Inter-planer distances	1	1	1,2
5.	Crystal structures- NaCl, diamond, CsCl, ZnS	1	1	1,2
6.	Concept of reciprocal lattice and its properties with proof.	1	1	1,2
7.	Ionic, covalent, molecular and metallic binding in crystalline solids Cohesive energies of ionic crystals	1	1	1,2
8.	Bragg's law	1	1,2	1,2
9.	Debye Scherrer method	1	1,2	1,2
	UNIT II – Lattice Vibrations and specific heat of solids	**9**		

10.	Specific heats of solids	1	1	1,2
11.	Classical theory of Specific heat, Dulong-Petit Law	1	1	1,2
12.	Breakdown of classical theory, Einstein theory of specific heat	1	1,2	1,2
13.	Debye theory of specific heat, T^3 law	1	1,2	1,2
14.	Lattice vibrations. Concept of phonons.	1	1,2	1,2
15.	One dimensional monoatomic lattice	1	1	1,2
16.	Phase velocity and group velocity	1	1,2	1,2
17.	Phonon vibration of diatomic linear lattice	1	1,2	1,2
18.	Qualitative description of the phonon spectrum in solids. Acoustical and optical phonons	1	1,2	1,2
	UNIT III - Free electron theory of metals	**9**		
19.	Classical theory of free electrons, Drude-Lorentz theory	1	1	1,2,3
20.	Temperature dependent electrical resistivity of metals	1	1,2	1,2,3
21.	Thermal conductivity of metals,	1	1,2	1,2,3
22.	Wiedemann-Frank's law, Failure of classical theory	1	1	1,2,3
23.	Free electron gas in one dimension	1	1,2	1,2,3
24.	Fermi-Dirac distribution function	1	1,2	1,2,3
25.	Free-electron theory of metals	1	1	1,2,3
26.	Heat capacity of the electron gas	1	1	1,2,3
27.	Thermionic emission	1	1	1,2,3
	UNIT IV: Band theory of solids, Semiconductors	**9**		
28.	Failure of Free electron theory of metals	1	1,2	1,2,3
29.	Nearly free electron model, Bloch theorem	1	1	1,2,3
30.	Kronig Penny model	1	1	1,2,3

31.	Brillouin zones, Concept of effective mass	1	1,2	1,2,3
32.	Distinction between metal, semiconductor and insulator	1	1,2	1,2,3
33.	Band theory of solids	1	2	1,2,3
34.	Temperature dependent resistivity of metals, semiconductors and insulators	1	1,2	1,2,3
35.	Intrinsic and extrinsic semiconductors P-type and N-type semiconductors	1	1,2	1,2,3
36.	Hall effect in semiconductors	1	1	1,2,3
	UNIT V: Dielectric and Magnetic properties of materials	**9**		
37.	Polarization	1	1	1,2,3
38.	Local electric field at an atom	1	1,2	1,2,3
39.	Depolarization field, Dielectric susceptibility and polarizability, Dielectric constant	1	1,2	1,2,3
40.	Clausius-Mosotti equation	1	1	1,2,3
41.	Diamagnetic, paramagnetic, Ferromagnetic and ferrimagnetic materials	1	1,2	1,2,3
42.	Classical Langevin’s theory of diamagnetism and paramagnetism, Curie law	1	1,2	1,2,3
43.	Weiss theory of ferromagnetism and magnetic domains	1	1,2	1,2,3
44.	Discussion on B-H curve, Magnetic hysteresis and energy loss	1	2	1,2,3
45.	Soft and hard magnetic materials	1	2	1,2,3

Recommended Resources

1. Introduction to Solid State Physics, Charles Kittel, 8th edition, 2004, John Wiley & Sons
2. Elementary Solid-state Physics, M Ali Omar, Revised Edition, 2015, Pearson

Other Resources

3. Solid State Physics, Neil W. Ashcroft, N. Mermin, Reprint edition, Brooks/Cole 1976.

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		Mid-1 (15%)		CLA-2 (10%)		Mid-2 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember Understand	40%		60%		40%		70%		30%	
Level 2	Apply Analyse	60%		40%		60%		30%		70%	
Level 3	Evaluate Create										
Total		**100%**		**100%**		**100%**		**100%**		**100%**	

Course Designers

a. *Prof. Ranjit Thapa, Professor. Dept. of Physics. SRM University - AP*
b. *Prof. M. S. Ramachandra Rao, Professor, Department of Physics, Indian Institute of Technology, Madras*
c. *Prof. D. Narayana Rao, Raja Ramanna Fellow, University of Hyderabad*

PHY 312M	**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**	Mid Term I	Mid Term II	CLA I	CLA II	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
End semester examination Weightage :						**50%**

PHY 307 M	Special Theory of Relativity	L	T	P	C
		3	1	0	4
Co-requisite:	NIL				
Prerequisite:	Mechanics I				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	-- Academic Council Meeting -- , 2020				

PURPOSE	The theory of special relativity explains how space and time are linked for objects that are moving at a consistent speed in a straight line. One of its most famous aspects concerns objects moving at the speed of light.							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, students will be able to								
1.	Demonstrate knowledge and broad understanding of Special Relativity							
2.	Explain the meaning and significance of the postulate of Special Relativity.							
3.	Explain true nature of Lorentz transformation and Doppler effect.							
4.	Explain relativistic momentum and Einstein field equations.							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT-I- Introduction to Relativity	**12**			
1.	Inertial Frames	1	C		1,2
2.	Universality of Newton's second law in all inertial frames	1	C		1,2
3.	Classical Relativity, Does universal rest (ether) exists?	1	C		1,2
4.	Michelson Morley Experiment Principle	1	D		1,2
5.	Michelson Morley Experiment	1	D		1,2
6.	Postulates of Special Theory of Relativity	1	C		1,2
7.	Concept of transformation	1	C		1,2
8.	Galilean Transformation	1	C		1,2
9.	Simultaneity of two events in different inertial frames of reference and its frame dependence	1	C		1,2

10.	Tutorial I	1	D-I		1,2
11.	Tutorial II	1	D-I		1,2
12.	Tutorial III	1	D-I		
	UNIT II – Lorentz Transformation	**12**			
13.	Clock Synchronization in an Inertial Frame	1	C		1,2
14.	Lorentz Transformation.	1	C		1,2
15.	Length Contraction	1	C		1,2
16.	Time dilation	1	C		1,2
17.	Examples of Length Contraction and Time dilation	1	D		1,2
18.	Simultaneity Part I	1	C		1,2
19.	Simultaneity Part II	1	C		1,2
20.	Transformation of Velocities Part I	1	D-I		1,2
21.	Transformation of Velocities Part II	1	D-I		1,2
22.	Tutorial IV	1	D-I		1,2
23.	Tutorial V	1	D-I		1,2
24.	Tutorial VI	1	D-I		1,2
	UNIT III – Relativistic velocity and Momentum	**12**			
25.	Velocity Transformation	1	C		1,2
26.	Relative velocity with examples	1	C		1,2
27.	Time like and Space Like intervals	1	C		1,2
28.	Causality	1	C-D		1,2
29.	Need to redefine Momentum	1	C-D		1,2
30.	Vector and Four-Vectors.	1	C		1,2
31.	Proper time interval	1	D		1,2
32.	Velocity and Momentum-Energy Four Vector	1	C-D		1,2
33.	Example on Relativistic velocity and momentum	1	D		1,2
34.	Tutorial VII	1	D-I		1,2
35.	Tutorial VIII	1	D-I		1,2
36.	Tutorial IX	1	D-I		1,2
	UNIT IV: Mass Energy Relation	**12**			
37.	Mass-Energy Relationship	1	C		1,2
38.	Relationship between new energy and momentum.	1	C		1,2

39.	Relativistic Dynamics Part I	1	C		1,2
40.	Relativistic Dynamics Part II	1	C		1,2
41.	Zero mass particles.	1	C		1,2
42.	Relativistic Mass	1	C		1,2
43.	Geometry of Space-time	1	C		1,2
44.	Spacelike and time-like interval	1	C		1,2
45.	Light cone	1	D		1,2
46.	Tutorial X	1	D-I		1,2
47.	Tutorial XI	1	D-I		1,2
48.	Tutorial XII	1	D-I		1,2
	UNIT V: Geometry of Space-Time	**12**			
49.	Four Dimensional form of Maxwell's equations	2	C		2,3
50.	Four dimensional Vector Potential.Stress-	2	C		2,3
51.	Energy Momentum Tensor	1	C		2,3
52.	Conservation Laws	1	C		2,3
53.	Lagrangian formulation of Electrodynamics Part I	1	C-D		2,3
54.	Lagrangian formulation of Electrodynamics Part II	2	C-D		2,3
55.	Relativistic treatment of Radiation.	1	C-D		2,3
56.	Four Dimensional form of Maxwell's equations	1	D		2,3
57.	Four dimensional Vector Potential.	1	D		2,3
58.	Tutorial XIII	1	D-I		2,3
59.	Tutorial XIV	1	D-I		2,3
60.	Tutorial XV	1	D-I		2,3
	Total contact hours	60			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Resnick, Robert. *Introduction to Special Relativity*. New York, NY: Wiley, 1968. ISBN: 9780471717256.
2	French, Anthony Philip. *Special Relativity*. New York, NY: Norton, 1968. ISBN: 9780393097931.

3	Einstein, Albert A. *Relativity: The Special and the General Theory*. New York, NY: Three Rivers Press/Random House, 1995. ISBN: 9780517884416. (recommended)

Course nature				**Theory**		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Mid Term I	Mid Term II	CLA1	CLA2	**Total**
	Weightage	**15%**	**15%**	**10%**	**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								
	apply the fundamental concepts of physics and relate to various energy technologies							
	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**	Mid Term I	Mid Term II	CLA I	CLA II	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
					End semester examination Weightage:	**50%**

PHY 306M	**ELECTRONIC MATERIALS & DEVICE PHYSICS**		**L**	**T**	**P**	**C**
			4	**0**	**0**	**4**
Co-requisite:	NIL					
Prerequisite:	PHY 203					
Data Book / Codes/Standards	NIL					
Course Category	**Elective**	ELECTRONIC MATERIALS & DEVICE PHYSICS				
Course designed by	Department of Physics					
Approval	-- Academic Council Meeting -- , 2020					

PURPOSE	The purpose of this course is to introduce the students to Semiconductor fundamentals and physical principles of *p-n* junctions and Schottky barrier diodes.

LEARNING OBJECTIVES		STUDENT OUTCOMES						
At the end of the course, students will be able to								
5.	Calculate the carrier concentrations and resistivity of a semiconductor using the given doping concentration and design a resistor of a given value							
6.	Explain carrier generation and recombination processes in semiconductors.							
7.	Analyze charge carrier transport in one-dimensional semiconductor structures using drift-diffusion equations.							
8.	Draw the energy band diagram of a *p-n* junction diode, extract its numerical model parameters from the given current-voltage (*I-V*), and relate the model parameters to the physical parameters of the device							
9.	Prepare a report on a project involving the analysis/design of a semiconductor device using computer aided design tools.							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I - Electronic materials	**12**			
61.	Allowed and forbidden energy bands in solids	1	C		1,2
62.	Electrical conduction in solids	1	C		1,2
63.	*k*-Space diagrams of Si and GaAs	1	C		1,2
64.	Density of states function in semiconductor	1	I		1,2
65.	Review of Fermi–Dirac distribution function and the Fermi energy in semiconductor material	1	C-D		1,2
66.	Charge carriers in semiconductors	1	C-D		1,2
67.	Extrinsic semiconductor - dopant atoms and energy levels	1	C-D		1,2
68.	Statistics of donors-acceptors and Charge neutrality	1	I		1,2
69.	Variation of Fermi energy level with doping concentration and Temperature	1	C		1,2
70.	Carrier drift transport phenomena	1	D-I		1,2
71.	Carrier diffusion transport phenomena	1	D-I		1,2
72.	Induced Electric Field and Einstein Relation	1	I		
	UNIT II – Non-equilibrium excess carriers in semiconductors	**12**			

73.	Carrier generation and recombination	1	C		1,2
74.	Continuity equations	1	C		1,2
75.	Time-dependent diffusion equations	1	C		1,2
76.	Derivation of the ambipolar transport equation	1	I		1,2
77.	Applications of the ambipolar transport equation	1	C		1,2
78.	Limits of extrinsic doping and low injection	1	C-D		1,2
79.	Dielectric relaxation in semiconductor	1	C-D		1,2
80.	Haynes–Shockley Experiment	1	I		1,2
81.	Quasi-Fermi Energy Levels	1	D-I		1,2
82.	Excess Carrier Lifetime	1	D-I		1,2
83.	Shockley–Read–Hall theory of recombination	1	D-I		1,2
84.	Surface states and Surface recombination velocity	1	I		1,2
	UNIT III – *p-n* Junction Devices	**12**			
85.	Fabrication of *p-n* Junctions	1	C		1,2
86.	Equilibrium (Zero applied bias) conditions and Space charge at a *p-n* Junction	1	C		1,2
87.	Forward-Biased *p-n* Junctions,	1	C		1,2
88.	Reverse applied bias *p-n* Junctions, Qualitative Description of Charge Flow in a *p-n* Junction	1	I		1,2
89.	Reverse-Bias Breakdown	1	D-I		1,2
90.	Non-uniformly Doped *p-n* Junctions	1	D-I		1,2
91.	Ideal Current–Voltage relationship of *p-n* Junction	1	D-I		1,2
92.		1	I		1,2
93.	Generation–recombination currents and high-injection levels	1	C		1,2
94.	Small-signal model of the *p-n* Junction	1	C		1,2
95.	Charge storage and diode transients	1	C,D		1,2
96.	The Tunnel diode	1	I		1,2

	UNIT IV - Metal–semiconductor and Semiconductor heterojunctions	**12**			
97.	The Schottky barrier diode	1	C		1,2
98.	Comparison of the Schottky barrier diode and the *p-n* Junction diode	1	C		1,2
99.	Metal–Semiconductor Ohmic contacts	1	C		1,2
100.	Semiconductor heterojunctions	1	I		1,2
101.	Metal–Oxide–Semiconductor Junctions	1	C		1,2
102.	Two-Terminal MOS structure	1	C-D		1,2
103.	Capacitance–Voltage characteristics of MOS structure	1	C		1,2
104.	Metal–Oxide–Semiconductor Field-Effect Transistor (MOSFET) operation	1	I		1,2
105.	Bipolar Junction Transistors (BJT)	1	D		1,2
106.	Minority carrier distribution in BJT structure and Common-Base Current Gain current at low frequency	1	D-I		1,2
107.	Junction Field-Effect Transistor (JFET and MESFET)	1	D		1,2
108.	Electrical characteristics of JFETs	1	I		1,2
	UNIT V - Specialized semiconductor devices	**12**			
109.	Optical absorption in semiconductors	1	C		1,2
110.	Solar cells	1	C		1,2
111.	Photodetectors	1	C		1,2
112.	Photoluminescence and electroluminescence	1	I		1,2
113.	Light emitting diodes	1	C		1,2
114.	Design of Laser diodes	1	C-D		1,2
115.	Application of Laser diodes	1	C-D		1,2
116.	Tunnel diode and Gunn diode	1	I		1,2
117.	Power bipolar transistors	1	D		1,2
118.	Power MOSFETs	1	C-D		1,2
119.	The Thyristor	1	C-D		1,2
120.	Memristor devices	1	I		1,2
	Total contact hours	**60**			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Solid State Electronic Devices, Ben G. Streetman and Sanjay Kumar Banerjee, 7th Edition, 2016, Pearson Education Limited
2	Semiconductor Physics and Devices, Basic Principles, Donald A. Neamen, 4th Edition, 2011, McGraw-Hill Publication

Course nature						Theory
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Mid Term I	Mid Term II	CLA I	CLA II	**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	

	To provide a comprehensive background of optical principles							
	To provide a comprehensive background of quantum mechanical description of light							
	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	Mid Term I	Mid Term II	CLA I	CLA II	Total
	Weightage	15%	15%	10%	10%	50%
End semester examination Weightage :						50%

PHY 214 M	Free Space and Fiber Optical Communication	L	T	P	C
		3	1	0	4
Co-requisite:	NIL				
Prerequisite:	PHY 104, PHY 104L, PHY 203				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	Academic Council Meeting, 2019 (**Regulation - 2018**)				

PURPOSE	The course aims to cover the basics of optical communication through free space as well fibers. This course mainly concentrate on the propagation of light through required medium and study their communication ability.

LEARNING OBJECTIVES		STUDENT OUTCOMES						
At the end of the course, student will be able to								
1.	This introductory course on Optical Communication is proposed to give the basic idea about optical communication and its necessity to the present era.							
2.	This course mainly discusses about the free space and fibre optical communication protocols along with the description of fibers.							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT I – Free space optical channel models	**12**			
1.	Overview	1	C		1,2
2.	Free space optical communication	1	C		1,2
3.	Atmospheric channel – losses	1	C		1,2
4.	TUTORIAL - I	1	D-I		1,2
5.	Atmospheric channel – Turbulence	1	C		1,2
6.	Turbulence mitigation	1	C-D		1,2
7.	Optical transmitter – design	1	C-D		1,2
8.	TUTORIAL - II	1	D-I		1,2
9.	Optical receiver	1	C-D		1,2
10.	Post and pre-amplifiers	1	C-D		1,2
11.	channel link design	1	C-D		1,2
12.	TUTORIAL - III	1	D-I		1,2
	UNIT II – Tracking and pointing	**12**			
13.	acquisition link configuration	1	C-D		1,2
14.	Scanning technique	1	C-D		1,2
15.	Tracking and pointing – Necessity	1	C-D		1,2
16.	TUTORIAL - I	1	D-I		1,2
17.	Integration of ATP system	1	C-D		1,2
18.	ATP link budget	1	C-D		1,2
19.	BER performance I	1	C-D		1,2
20.	TUTORIAL - II	1	D-I		1,2
21.	BER performance II	1	C-D		1,2
22.	Different models for BER performance	1	C-D		1,2
23.	Experimental implementation	1	C-D		1,2
24.	TUTORIAL - III	1	D-I		1,2
	UNIT III – Optical Fibres	**12**			

25.	Introduction and Historical development	1	C		1,2
26.	Description of Fibres	1	C		1,2
27.	Classification of Fibres	1	C-D		1,2
28.	TUTORIAL - I	1	D-I		1,2
29.	Fibre fabrication and characteristics	1	C-D		1,2
30.	Fibre Materials	1	C-D		1,2
31.	Optical fibre cables	1	C-D		1,2
32.	TUTORIAL - II	1	D-I		1,2
33.	Transmission Characteristics	1	C-D		1,2
34.	Dispersion of light	1	C		1,2
35.	loss of light in Fibres	1	C		1,2
36.	TUTORIAL - III	1	D-I		1,2
	UNIT IV: Source and Detection systems	**12**			
37.	Development of lasers	1	C		1,2
38.	Lasers for fibre optical communication	1	C		1,2
39.	Materials for optical sources	1	C		1,2
40.	TUTORIAL - I	1	D-I		1,2
41.	Development of low loss Fibres	1	C-D-I		1,2
42.	Coupling of light to Fibres	1	D-I		1,2
43.	Fibre splices	1	D-I		1,2
44.	TUTORIAL - II	1	D-I		1,2
45.	Fibre connectors	1	C		1,2
46.	Photo Detectors	1	D		1,2
47.	Noise Analysis	1	C		1,2
48.	TUTORIAL - III	1	D-I		1,2
	UNIT V: Fibre Communication	**12**			
49.	Optical Transmitters	1	C		1,2
50.	Multi-Channel transmitter	1	C		1,2
51.	Optical Amplifiers	1	C-D		1,2
52.	TUTORIAL - I	1	D-I		1,2
53.	Fibre Amplifiers	1	D		1,2
54.	Photonic Integrated Circuits	1	C		1,2
55.	Other optical devices	1	C		1,2

56.	TUTORIAL - II	1	D-I		1,2
57.	Multiplexers and De-Multiplexers	1	C-D		1,2
58.	Wavelength Division multiplexing	1	C-D		1,2
59.	Other communication protocols	1	C-D		1,2
60.	TUTORIAL - III	1	D-I		1,2
	Total contact hours	**60**			

LEARNING RESOURCES	
	TEXTBOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Free space optical communication, (2009) – H. Kaushal, V. K. Jain, S. Kar (Publisher – Springer)
2	Optical Fiber Communication, (2015) – P Chakrabarti, McGraw Hill Publications

Course nature		**Theory**			
Assessment Method – Theory Component (Weightage 100%)					
In-semester	**Assessment tool**	Mid Term I	Mid Term II	CLA I	CLAII	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
End semester examination Weightage :						**50%**

PHY 711M	**Introduction to Soft matter physics**	**L**	**T**	**P**	**C**
		3	**1**	**0**	**4**
Co-requisite:	NIL				
Prerequisite:	Mechanics I				
Data Book / Codes/Standards	NIL				
Course Category	CORE				
Course designed by	Department of Physics				
Approval	-- Academic Council Meeting -- , 2020				

PURPOSE	The purpose of this course is to introduce the students with the physics of membranes, polymers and structural stability in biological and other objects.							
LEARNING OBJECTIVES		**STUDENT OUTCOMES**						
At the end of the course, students will be able to								
	Understand the interactions and energy scales involved in soft matter physics							
	Apply those concepts in understanding stability and fluctuations in biological cells and membranes							

	Understand the concept of fluid flow and hydrodynamic instabilities							
	Understand the concept of elastic properties of polymers							

Session	Description of Topic	Contact hours	C-D-I-O	IOs	Reference
	UNIT-I- Interactions in soft matters	**12**			
121.	What is soft matter?	1	C		1,2
122.	Forces, energies and time scales in soft matter	1	C		1,2
123.	Surface tension	1	C		1,2
124.	Surface energy	1	D		1,2
125.	Wetting phenomena: Young's equation and contact angle	1	D		1,2
126.	Hydrophobicity and hydrophilicity	1	C		1,2
127.	Capillarity	1	C		1,2
128.	Van der Waals interaction (molecules and colloids); stability and aggregation	1	C		1,2
129.	Entropy driven interactions	1	C		1,2
130.	Tutorial I	1	D-I		1,2
131.	Tutorial II	1	D-I		1,2
132.	Tutorial III	1	D-I		
	UNIT II – Elements of complex fluids motion	**12**			
133.	Random walks and diffusion equation	1	C		1,2
134.	Brownian motions of colloidal particles	1	C		1,2
135.	Langevin equation	1	C		1,2
136.	Fokker-Planck equation	1	C		1,2
137.	Hydrodynamics: Navier-Stokes equation	1	D		1,2
138.	Reynolds number	1	C		1,2
139.	Linearization: Stokes law	1	C		1,2
140.	Hard sphere suspension	1	D-I		1,2
141.	Linear viscoelasticity	1	D-I		1,2
142.	Tutorial IV	1	D-I		1,2
143.	Tutorial V	1	D-I		1,2
144.	Tutorial VI	1	D-I		1,2

	UNIT III – Self-assembly and membranes	**12**			
145.	Concept of self-assembly	1	C		1,2
146.	Aggregation of amphiphilic molecules; critical micelle concentration	1	C		1,2
147.	Self-assembly in viruses	1	C		1,2
148.	Self-assembly in colloidal systems	1	C-D		1,2
149.	Applications of self-assembly in nanotechnology	1	C-D		1,2
150.	Lipid bilayers and cell membranes	1	C		1,2
151.	Curvature elasticity in membranes	1	D		1,2
152.	Fluctuations in membranes	1	C-D		1,2
153.	Problems on Fluctuations in membranes	1	D		1,2
154.	Tutorial VII	1	D-I		1,2
155.	Tutorial VIII	1	D-I		1,2
156.	Tutorial IX	1	D-I		1,2
	UNIT IV: Polymers	**12**			
157.	Examples of polymers	1	D		1,2
158.	Polymers and biological macromolecules	1	C		1,2
159.	Polymer statistics: single polymer chain	1	C		1,2
160.	Self-avoiding walk	1	D		1,2
161.	Entropic forces and excluded volumes	1	C		1,2
162.	Persistence length	1	C		1,2
163.	DNA as polymer chain	1	C		1,2
164.	Phase transition and Flory theory of polymers	1	C		1,2
165.	Rubber elasticity	1	D		1,2
166.	Tutorial X	1	D-I		1,2
167.	Tutorial XI	1	D-I		1,2
168.	Tutorial XII	1	D-I		1,2
	UNIT V: Percolation theory	**12**			
169.	Concept of fractals; examples	2	D		2,3
170.	Fractal dimension	2	C		2,3

171.	Definition: site and bond percolation in regular lattices	1	C		2,3
172.	Percolation transition; order parameter	1	C		2,3
173.	Critical exponents in percolation; cluster statistics	1	C-D		2,3
174.	Lattice animals	2	C-D		2,3
175.	Application: Fluid flow through porous media	1	C-D		2,3
176.	Application: Cross-linking polymers; De Gennes' theory of polymer elasticity from percolation theory	1	D		2,3
177.	Rigidity percolation and fracture	1	D		2,3
178.	Tutorial XIII	1	D-I		2,3
179.	Tutorial XIV	1	D-I		2,3
180.	Tutorial XV	1	D-I		2,3
	Total contact hours	60			

LEARNING RESOURCES	
	TEXT BOOKS/REFERENCE BOOKS/OTHER READING MATERIAL
1	Principles of condensed matter physics, P. M. Chaikin, T. C. Lubensky, Cambridge university press (2000)
2	Intermolecular and surface forces, J. N. Israelachvili, Elsevier, ISBN: 978-0-12-375182-9 (2011)
3	Wineman. A.S & Rajagopal, K.R., Mechanical response of polymers- An Introduction, Cambridge University Press

Course nature				**Theory**		
Assessment Method (Weightage 100%)						
In-semester	**Assessment tool**	Mid Term I	Mid Term II	CLA1	CLA2	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
End semester examination Weightage						**50%**

PHY 223	**Introduction to Quantum Computation**		**L**	**T**	**P**	**C**
			3	**1**	**0**	**4**
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, 2021 (**Regulation - 2021**)					

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								
	know the definition of qubit, quantum logic gates, quantum circuits and quantum algorithms							
	understand how quantum parallelism is used in the simplest quantum algorithms such as Deutsch, period finding and quantum Fourier transform							
	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	**Matrix, Tensor and Dirac Notation**	**12**			1,2
1.	Basis vectors and orthogonality	1	C		1,2
2.	Matrices Hilbert spaces	1	C		1,2
3.	Inner and outer products	1	C-D		1,2
4.	Tensors in index notation	1	C		1,2
5.	Metric tensors, covariant and contravariant tensors	1	C		1,2
6.	Unitary operators and projectors	1	C-D		1,2
7.	Hermetian operator, Adjoint of operator	1	C-D		1,2
8.	Wavefunction as vector and operator as metrics	1	C		1,2
9.	Dirac notation	1	C		1,2
10.	Tutorial 1	1	C		1,2
11.	Tutorial 2	1	C		1,2
12.	Tutorial 3	1	C		1,2
Unit 2	**Introduction and Overview of Quantum Mechanics**	12			

13.	Photon, Concept of Planck Constant	1	C-D		1,2
14.	Photoelectric effect	1	C-D		1,2
15.	Wave particle duality, Wave packet	1	C-D		1,2
16.	Davisson and Germer Experiment	1	C-D		1,2
17.	Superposition Principle	1	C-D		1,2
18.	Young Double slit experiment	1	C-D		1,2
19.	Qubits and pieces	1	C-D		1,2
20.	Concept of Bloch sphere	1	C-D		1,2
21.	Derivation on Bloch sphere representation	1	C-D		1,2
22.	Tutorial 4	1	C-D		1,2
23.	Tutorial 5	1	C-D		1,2
24.	Tutorial 6	1	C-D		1,2
Unit 3	**Fundamentals of Quantum communication**	**12**			
25.	No-cloning theorem	1	C-D		1,2
26.	Hidden Information of state	1	D-I		1,2
27.	Einstein-Podolsky-Rosen Paradox	1	D-I		1,2
28.	Bell states	1	D-I		1,2
29.	Bell inequalities	1	D-I		1,2
30.	Bell inequalities – Examples	1	D-I		1,2
31.	Quantum entanglement	1	D-I		1,2
32.	Quantum entanglement considering Heisenberg principal	1	D-I		1,2
33.	Quantum teleportation	1	D-I		1,2
34.	Tutorial 7	1	D-I		1,2
35.	Tutorial 8	1	D-I		1,2

36.	Tutorial 9	1	D-I		1,2
Unit 4	**Quantum Gate**	**12**			
37.	Pauli Gates	1	D-I		1,2
38.	Phase Gate	1	D-I		1,2
39.	Controlled phase shift	1	D-I		1,2
40.	Hadamard gates	1	D-I		1,2
41.	SWAP Gates	1	D-I		1,2
42.	CNOT Gates	1	D-I		1,2
43.	Toffoli gates	1	D-I		1,2
44.	Combination of Gates	1	D-I		1,2
45.	Circuit of Gates	1	D-I		1,2
46.	Tutorial 10	1	D-I		1,2
47.	Tutorial 11	1	D-I		1,2
48.	Tutorial 12	1	D-I		1,2
Unit 5	**Quantum Algorithm, Key Distribution and Error**	**12**			
49.	Deutsch algorithm	1	I		1,2
50.	Deutsch-Josza algorithm	1	I		1,2
51.	Shor’s Algorithm - Periodicity	1	I		1,2
52.	Shor’s period-finding algorithm	1	I		1,2
53.	Introduction to Quantum key distribution	1	I		1,2
54.	BB84 protocol	1	I		1,2
55.	Quantum Error Correction	1	I		1,2
56.	Quantum Error Correction Example	1	I		1,2
57.	Physical Qubits	1	I		1,2

58.	Tutorial 13	1	I		1,2
59.	Tutorial 14	1	I		1,2
60.	Tutorial 15	1	I		1,2
	Total contact hours	60			

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**	Mid Term I	Mid Term II	CLA I	CLA II	**Total**
	Weightage	**15%**	**15%**	**10%**	**10%**	**50%**
					End semester examination Weightage :	**50%**

Introduction to Astrophysics and Particle Physics

Course Code	PHY 316	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)	PHY102, PHY213, PHY307	Co-Requisite Course(s)	NIL	Progressive Course(s)				
Course Offering Department	Physics	Professional / Licensing Standards						
Board of Studies Approval Date		Academic Council Approval Date	HOD will arrange it from Dean's office					

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To introduce the basics of Stellar Astrophysics.

Objective 2: To study the evolution of the Stars and understand the history of Universe.

Objective 3: To discuss the cosmological evidence of Dark Matter in the universe and understand Freeze-in/Freeze-out mechanism.

Objective 4: To introduce the physics of elementary particles and their interactions.

Course Outcomes / Course Learning Outcomes (CLOs)

	At the end of the course, the learner will be able to	Bloom's Level	Expected Proficiency Percentage	Expected Attainment Percentage
Outcome 1	Calculate the stellar masses and stellar radius, and discuss the time evolution of a Star	2	70%	65%
Outcome 2	Write down the FRW metric and apply the Hubble's Law to estimate the redshift	2	70%	65%
Outcome 3	Calculate the Relic Density for a given Dark Matter particle and estimate the Freeze-out/Freeze-in condition	3	70%	65%
Outcome 4	Classify the elementary particles using their quantum numbers and write down the Lagrangian of the Standard Model of Particle Physics.	4	70%	65%

Course Articulation Matrix (CLO) to Program Learning Outcomes (PLO)

CLOs	Program Learning Outcomes (PLO)

	Scientific and Disciplinary Knowledge	Analytical Reasoning and Problem Solving	Critical and Reflective Thinking	Scientific Reasoning and Design Thinking	Research Related Skills	Modern Tools and ICT Usage	Environment and Sustainability	Moral, Multicultural and Ethical Awareness	Individual and Teamwork Skills	Communication Skills	Leadership Readiness Skills	Self-Directed and Life Long Learning	PSO 1	PSO 2	PSO 3
Outcome 1	3	3	3	3					1			2	2	2	3
Outcome 2	3	3	2	2	2				2			2	2	2	2
Outcome 3	3	2	3	3	3				2			2	3	2	3
Outcome 4	3	3	2	3	3				2			2	3	2	3
Course Average	**3**	**3**	**3**	**3**	**3**				**2**			**2**	**3**	**2**	**3**

Course Unitization Plan

Unit No.	Unit Name	Required Contact Hours	CLOs Addressed	References
Unit 1	**UNIT-I: Stellar Astrophysics Basics**	**12**		
	Review of Black body radiation	1	1	1, 2
	Lorentz transformation and Four vectors	1	1	1, 2
	Kepler's Laws	1	1	1, 2
	Virial theorem	1	1	1, 2
	Tutorial I	1	1	1, 2
	Radiation Scattering	1	1	1, 2
	Brightness, Color, Stellar Distances	1	1	1, 2
	Stellar Masses and Stellar Radius	1	1	1, 2
	Tutorial II	1	1	1, 2
	Spectral Lines	1	1	1,2
	Optical Telescopes	1	1	1,2
	Tutorial III	1	1	1,2
Unit 2	**UNIT II: Stars, Galaxies and their structure**	**12**		
	Formation of Stars	1	2	1, 2
	Stellar atmosphere	1	1, 2	1, 2
	Radiation Transport	1	2	1, 2
	Energy sources of Stars	1	2	1, 2
	Tutorial IV	1	2	1, 2
	Sun as a typical star	1	2	1, 2
	Binary Stars, Galaxies, HR diagrams	1	2	1,2
	Stellar Evolution, Chandrasekhar Limit	1	2	1,2
	Tutorial V	1	2	1, 2
	Supernovae	1	2	1,2
	Black Holes	1	2	1, 2
	Tutorial VI	1	2	1, 2

Unit 3	**UNIT III: Cosmology - A Preview**	**12**		
	Universe today, homogeneity and isotropy, expansion, energy balance	1	2	1, 2
	Thermal history of the universe	1	2	1, 2
	Big Bang Nucleosynthesis	1	2	1, 2
	Tutorial VII	1	2	1, 2
	Hubble's law and Redshift	1	2	1, 2
	Friedmann-Robertson-Walker metric	1	1,2	1, 2
	Cosmic microwave background	1	1,2	1, 2
	Tutorial VIII	1	2	1,2
	Cosmological models	1	2	1,2
	The ΛCDM model	1	2	1, 2
	Inflation	1	2	1,2
	Tutorial IX	1	2	1, 2
Unit 4	**UNIT IV: Dark Matter**	**12**		
	History and Early Indications	1	3	2
	Cosmological evidences	1	3	2
	Production in the Early Universe	1	3	2
	Tutorial X	1	3	2
	Relic density	1	3	2
	Freeze-in and Freeze-out	1	3	2
	Types of Dark Matter	1	3	2
	Dark Matter Candidates	1	3	2
	Tutorial XI	1	3	2
	Direct and Indirect detection	1	3	2
	Dark Energy	1	3	2
	Tutorial XII	1	3	2
Unit 5	**UNIT V: Particle Physics - A Preview**	**12**		
	Historical introduction, Nucleus, Fundamental forces of nature, Natural Units	1	4	3
	Quantum numbers - mass, charge, spin, isospin, intrinsic parity, hypercharge	1	4	3
	Leptons, Baryons, Hadrons	1	4	3
	Tutorial XIII	1	4	3
	Weak interactions, Photon, W/Z bosons	1	4	3
	Quark Model	1	4	3
	Neutrinos	1	4	3
	Tutorial XIV	1	4	3
	Higgs boson	1	4	3
	Standard Model of Particle Physics and Beyond	1	4	3
	Particle Accelerators	1	4	3
	Tutorial XV	1	4	3

Recommended Resources

1. An Introduction to Modern Astrophysics, Second Edition, By Carroll B.W., Ostlie D.A., Addison Wesley.
2. An Introduction to Particle Dark Matter, First Edition, by Stefano Profumo, World S Europe Ltd
3. Introduction to Elementary Particles, Second Edition, by David Griffiths, Wiley-VCH

Learning Assessment

Bloom's Level of Cognitive Task		Continuous Learning Assessments (50%)								End Semester Exam (50%)	
		CLA-1 (10%)		Mid-1 (15%)		CLA-2 (10%)		Mid-2 (15%)			
		Th	Prac	Th	Prac	Th	Prac	Th	Prac	Th	Prac
Level 1	Remember	40%		60%		40%		60%		30%	
	Understand										
Level 2	Apply	60%		40%		60%		40%		70%	
	Analyse										
Level 3	Evaluate										
	Create										
Total		100%		100%		100%		100%		100%	

Course Designers

a. *Dr. Amit Chakraborty. Asst. Professor. Dept. Of Physics. SRM University - AP*
b. *Prof. M. S. Ramachandra Rao, Professor, Department of Physics, Indian Institute of Technology, Madras*
c. *Prof. D. Narayana Rao, Raja Ramanna Fellow, University of Hyderabad*