Minor in Physics

DEPARTMENT OF PHYSICS

Amaravati 522502, Andhra Pradesh

INDIA

CURRICULUM AND SYLLABI

2022

CURRICULUM

Department of **Physics** offers **Minors** to the B. Tech and B.Sc. program students subjected to fulfilment of the following minimum credits criterion.

Sl	Course Code	Course Name	Semester Selection	L-T-P-C	Credit	Comments
1	PHY 202M	Quantum Mechanics	Odd	3-1-0-4	4	Mandatory
2	PHY 311M	Statistical Physics	Even	3-1-0-4	4	Mandatory
3	PHY 403M	Introduction to Astrophysics	Odd			Any one
	PHY 206M	Special Theory of Relativity				
	PHY 301M	Solid-state Physics		3-1-0-4	4	
4	PHY 314M	Introduction to Quantum Computation	Even	3-1-0-4	4	Any one
	PHY 315M	Introduction to Soft Matter Physics		3-1-0-4	4	
	PHY 316M	Electronic Materials & Device Physics		3-1-0-4	4	

Quantum Mechanics

Course Code	PHY 202M	**Course Category**	Core Course	**L-T-P-C**	3	1	0	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Physics	**Professional / Licensing Standards**						
Board of Studies Approval Date	19th July 2021	**Academic Council Approval Date**						

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To understand the concept of “Quantum mechanics” and different from classical mechanics.

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

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

Objective 4: Application of the 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 of Radiation Laws, Quantum uncertainty, and the 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 a 3D box and for another potential, and will know why the increase of band gap of materials happen in nano dimension	3	70%	65%
Outcome 4	Knowledge in Quantum Tunnelling angular momentum and Commutation relation	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	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**			
1	Detection of thermal radiation	1	1	1, 2
2	Prevost's theory	1	1	1, 2
3	Emissive power of different bodies	1	1	1, 2
4	Absorptive power of different bodies	1	1	1, 2
5	Black body radiation	1	1	1, 2
6	Kirchhoff's law	1	1	1, 2
7	Pressure of radiation	1	1	1, 2
8	Stefan-Boltzmann law and its experimental verification	1	1	1, 2
9	Nernst heat theorem	1	1	1, 2
10	Tutorial class (Black Body Radiation)	1	1	1, 2
11	Tutorial class (Stefan-Boltzmann law)	1	1	1, 2
12	Problem-practice class (Stefan-Boltzmann law)	1	1	1, 2
Unit 2	**Origin of Quantum Mechanics**			
13	Planck's Radiation Law	1	1, 2	1, 2
14	Photoelectric Effect	1	1, 2	1, 2
15	Numerical of Photoelectric effect	1	2	1, 2
16	Compton Effect	1	1	1, 2
17	Wave-particle duality	1	2	1, 2
18	Matter waves, De Broglie hypothesis	1	1, 2	1, 2
19	Concept of the wave packet, The Principle of Superposition	1	2	1, 2
20	Davisson and Germer experiment	1	1, 2	1, 2
21	Phase velocity, group velocity, and the relation between them	1	1	1, 2
22	Tutorial class (Photoelectric Effects)	1	2	1, 2

23	Tutorial class (Compton Effect)	1	1, 2	1, 2
24	Problem-practice class (De Broglie hypothesis)	1	1	1, 2
Unit 3	**Heisenberg Uncertainty Principle & Basic of Schrodinger equation I**			
25	Heisenberg's uncertainty principle with thought experiment	1	3	1, 2
26	Different forms of uncertainty, Electron diffraction experiment	1	3	1, 2
27	Wave function and its physical interpretation, Boundary Condition of Wavefunction	1	3	1, 2
28	Definition of an operator in Quantum mechanics	1	3	1, 2
29	Linear vector space & Hilbert Space	1	3	1, 2
30	Hermitian Operator, Linear Operator	1	3	1, 2
31	Position, Momentum and Total energy operator	1	3	1, 2
32	Commutator brackets- Simultaneous Eigen functions	1	3	1, 2
33	Commutator algebra, Commutation of position and momentum	1	3	1, 2
34	Tutorial class (Heisenberg's uncertainty principle)	1	3	1, 2
35	Tutorial class (Operator and Wavefunction)	1	3	1, 2
36	Problem-practice class (Operator, Commutator bracket)	1	3	1, 2
Unit 4	**Basic of Schrodinger equation II**			
37	Probability Amplitude, Probability Density, Probability	1	3,4	2,3
38	Stationary States	1	3,4	2,3
39	Expectation value	1	3,4	2,3
40	Eigen function and Eigen values	1	3,4	2,3
41	Ehrenfest's theorem	1	3,4	2,3
42	Schrodinger time dependent	1	3	2,3
43	Schrodinger time independent equation	1	3	2,3
44	Probability Current Density	1	3	2,3
45	Stationary States and Bound States	1	3	2,3
46	Tutorial class (Eigen function and Eigen values)	1	3	2,3
47	Tutorial class (Schrodinger time independent equation)	1	3	2,3
48	Problem-practice class (Expectation Value)	1	3	2,3
Unit 5	**Schrodinger time independent equation**			
49	Free particle, Particle in infinitely deep potential well (one – dimensional)	1	4	2,3
50	Particle in a three-dimensional rigid box	1	4	2,3
51	Step potential, potential barrier (Qualitative discussion)	1	4	2,3
52	Barrier penetration and tunnelling effect	1	4	2,3
53	Harmonic oscillator (one-dimension)	1	4	2,3
54	Schrodinger equation in spherical polar coordinate	1	4	2,3

55	Hydrogen atom: Qualitative discussion on the radial and angular parts of the bound state energy	1	4	2,3
56	Quantum numbers ***n***, ***l***, m_l, m_s – Degeneracy	1	4	2,3
57	Angular Momentum	1	4	2,3
58	Tutorial class (Potential Barrier)	1	4	2,3
59	Tutorial class (Angular Momentum)	1	4	2,3
60	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,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	40%		60%		40%		70%		30%	
	Understand										
Level 2	Apply	60%		40%		60%		30%		70%	
	Analyze										
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*

Statistical Physics

Course Code	PHY 311M	**Course Category**	Core Course	**L-T-P-C**	3	1	0	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
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: Understand Elementary statistical concepts.

Objective 2: Learn statistical descriptions of system of particles.

Objective 3: Learn Statistical properties of Macroscopic systems.

Objective 4: Learn micro-canonical, canonical and grand-canonical systems and Equipartition theorem.

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 Elementary statistical concepts.	1	70%	65%
Outcome 2	Understand the importance of statistical descriptions of system of particles	2	70%	65%
Outcome 3	Understand the Statistical properties of Macroscopic systems	3	70%	65%
Outcome 4	Understand the micro-canonical, canonical and grand-canonical systems and Equipartition theorem	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	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	**Elementary statistical concepts and examples**			
1	The simple random walk problem in one dimension	1	1	1,2
2	Random walk problem in two dimensions	1	1	1,2
3	Problem and Review of Random walks	1	1	1,2
4	Examples of Brownian motion	1	1	1,2
5	Calculation of mean values	1	1	1,2
6	Binomial distribution	1	1	1,2
7	Theory and examples of Binomial distribution	1	1	1,2
8	Continuous probability distribution	1	1	1,2
9	Gaussian probability distribution	1	1	1,2
10	Review and problems on probability distributions	1	1,2	1,2
11	Tutorial class I	1	1,2	1,2
12	Tutorial class II	1	1,2	1,2
Unit 2	**Statistical descriptions of system of particles**			
13	Specification of the state of a statistical system	1	1	1,2
14	statistical ensemble - basic postulates and probability calculations	1	1	1,2
15	Review and problems on statistical ensembles	1	1	1,2
16	Density of states of statistical ensembles	1	1	1,2
17	Problems on density of states	1	1	1,2
18	Thermal and mechanical interaction between macroscopic systems.	1	1	1,2
19	Discussion on constraints of thermal and mechanical interaction between macroscopic systems.	1	1	1,2
20	Thermal and mechanical interaction between macroscopic systems.	1	1	1,2
21	Discussion on equilibrium, non-equilibrium, reversibility and irreversibility in thermodynamic systems	1	1,2	1,2
22	Review and problems on thermal and mechanical interaction, its constraints and Problems & examples on Equilibrium/non-equilibrium and reversibility /irreversibility of thermodynamic systems.	1	1,2	1,2
23	Tutorial Class I	1	1,2	1,2
24	Tutorial Class II	1	1,2	1,2
Unit 3	**Statistics of Macroscopic systems**			
25	Distribution of energy between macroscopic systems	1	1	1,2
26	Discussion on the approach to thermal equilibrium	1	1	1,2
27	Examples and problems on thermal equilibrium	1	1	1,2

28	Temperature, mean energy and mean pressure of an ideal gas	1	1	1,2
29	Introduction of the concept of entropy & discussion of second and third law of thermodynamics involving entropy.	1	1	1,2
30	Review of all thermodynamic laws and basic statistical relations & related problems	1	1	1,2
31	The partition function and its properties – relevant problems	1	1	1,2
32	Calculation of thermodynamic quantities for an ideal monatomic gas – relevant problems.	1	1	1,2
33	An ideal monatomic gas – relevant problems.			
34	Discussion of the Gibbs paradox involving relevant examples	1	1,2	1,2
35	Tutorial class I	1	1,2	1,2
36	Tutorial class II	1	1,2	1,2
Unit 4	**Equipartition theorem**			
37	Introduction various thermodynamics systems – Isolated, adiabatic, Isobaric, Isochoric etc.	1	1	1,2
38	Examples and problems on important thermodynamic systems.	1	1	1,2
39	Discussion on Canonical ensemble – comparison with micro-canonical ensemble	1	1	1,2
40	Applications, examples and problems on the canonical ensemble	1	1	1,2
41	Maxwell distribution and the Equipartition theorem	1	1	1,2
42	Simple applications of the Equipartition theorem	1	1	1,2
43	The grand canonical ensemble – comparison with micro-canonical and canonical ensemble	1	1	1,2
44	Introduction of the chemical potential	1	1	1,2
45	Review and problems on Equipartition theorem and canonical and grand-canonical ensemble	1	1,2	1,2
46	Review of Equipartition theorem and canonical and grand-canonical ensemble	1	1,2	1,2
47	Tutorial class I	1	1,2	1,2
48	Tutorial class II	1	1,2	1,2
Unit 5	**Quantum statistics**			
49	Introduction of concept of Identical particles and symmetry requirements	1	1	1,2
50	Discussion on quantum states of a single particle	1	1	1,2
51	Introduction of Maxwell-Boltzmann, Bose-Einstein and Fermi-Dirac statistics	1	1	1,2
52	Equation of states for Bose and Fermi gases	1	1	1,2
53	PV = (2/3) E – the ideal gas in the classical limit	1	1	1,2
54	Evaluation of the partition function	1	1	1,2
55	partition function of ideal monatomic Boltzmann gas	1	1,2	1,2

56	Simple ideas for Bose- Einstein condensation and recent observations	1	1,2	1,2
57	Problems and examples on Maxwell-Boltzmann	1	1,2	1,2
58	Bose-Einstein and Fermi-Dirac statistics & partition function	1	1,2	1,2
59	Tutorial class I	1	1,2	1,2
60	Tutorial class II	1	1,2	1,2

LEARNING RESOURCES

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%**

Introduction to Astrophysics

Course Code	PHY 403M	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
Course Offering Department	Physics	**Professional / Licensing Standards**						
Board of Studies Approval Date		**Academic Council Approval Date**						

Course Objectives / Course Learning Rationales (CLRs)

Objective 1: To introduce the basics of Stellar Astrophysics.

Objective 2: To study the formation and evolution of the Stars.

Objective 3: To discuss the history of the Universe and cosmological evidence of Dark Matter

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, temperatures, and magnitude scales	1	70%	65%
Outcome 2	Classification of Stars and understand various radiation transfer processes	2	70%	65%
Outcome 3	Analyse the conditions of formation and the stages of the life cycle of Stars and Galaxies	3	70%	65%
Outcome 4	Calculate the Relic density for a given Dark Matter particle and estimate the Freeze-in/Freeze-out conditions	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	2				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	The Basics			
1	Lights as Electromagnetic Spectra	1	1	1, 2
2	Kepler's Laws, Orbits	1	1	1, 2
3	Black body radiation	1	1	1, 2
4	Emission and Absorption spectra	1	1	1, 2
5	Doppler Effect & Parallax	1	1	1, 2
6	Tutorial I	1	1	1, 2
7	Apparent & Absolute Magnitude	1	1	1, 2
8	Stellar Temperatures & Colour	1	1	1, 2
9	Tutorial II	1	1	1, 2
10	Virial Theorem	1	1	1,2
11	Optical Telescopes	1	1	1,2
12	Tutorial II	1	1	1,2
Unit 2	**Stellar Spectra, HR Diagrams and Radiation Transport**			
13	Stars & Stellar Spectra	1	2	1, 2,3
14	Clusters of stars and their associations	1	2	1, 2,3
15	HR diagrams & classification of stars	1	2	1, 2,3
16	Sun as a typical star	1	2	1, 2,3
17	Stellar Nuclear Reactions - Big Bang Nucleosynthesis	1	2	1, 2,3
18	Tutorial IV	1	2	1,2,3
19	Interaction of radiation with matter	1	2	1,2,3
20	Radiation Scattering	1	2	1,2,3
21	Radiative transfer equation	1	2	1, 2,3
22	Kirchhoff's law	1	2	1,2,3
23	Tutorial V	1	2	1, 2,3
24	Tutorial VI: Distance and Age Determination of Clusters Using Color-Magnitude Diagram	1	2	1, 2,3
Unit 3	**Star Formation and Stellar Evolution**			
25	Interstellar Medium and early stages of star formation	1	3	1, 2,3
26	Main Sequence stars	1	3	1, 2,3
27	Degenerate Free Electron Gas	1	3	1, 2,3
28	Tutorial VII	1	3	1, 2,3

29	Evolution beyond the Main Sequence - Eddington luminosity limit	1	3	1, 2,3
30	Population I and II Stars	1	3	1, 2,3
31	White Dwarfs and Neutron Stars	1	3	1, 2,3
32	Tutorial VIII	1	3	1,2,3
33	Chandrasekhar Limit	1	3	1,2,3
34	Black Holes	1	3	1, 2,3
35	Supernovae	1	3	1,2,3
36	Tutorial IX	1	3	1, 2,3
Unit 4	**Binary Stars and Galaxies**			
37	Classification and Kinematics of Binary Stars	1	3	2,3
38	Normal and Active galaxies	1	3	2,3
39	The Milky Way	1	3	2,3
40	Tutorial X	1	3	2,3
41	The Galactic Center	1	3	2,3
42	Distribution of Matter in the Milky Way	1	3	2,3
43	Rotation & Galactic Disk	1	3	2,3
44	Formation of the Spiral Arms	1	3	2,3
45	Tutorial XI	1	3	2,3
46	Clusters of galaxies	1	3	2,3
47	Gamma ray bursts	1	3	2,3
48	Tutorial XII	1	3	2,3
Unit 5	**Cosmology & Dark Matter**			
49	Thermal history of the universe	1	4	3,4
50	Hubble's law and Redshift	1	4	3,4
51	Friedmann-Robertson-Walker metric	1	4	3,4
52	Tutorial XIII	1	4	3,4
53	Cosmological models, ΛCDM model	1	4	3,4
54	Inflation	1	4	3,4
55	Tutorial XIV	1	4	3,4
56	Dark Matter – Evidence	1	4	3,4
57	Relic density, Freeze-in and Freeze-out	1	4	3,4
58	Types of Dark Matter	1	4	3,4
59	Dark Matter candidates, Direct and Indirect detection methods	1	4	3,4
60	Tutorial XV	1	4	3,4

Recommended Resources

1. "An Introduction to Modern Astrophysics", Second Edition, By Carroll B.W., Ostlie D.A., Pearson Addison Wesley.
2. "Astrophysics for Physicists", by Arnab Rai Choudhuri, Cambridge University Press.
3. "Universe", by Roger A. Freedman, Robert M. Geller, William J. Kaufmann III; Tenth Edition, W. H. Freeman and Company.
4. "An Introduction to Particle Dark Matter", First Edition, by Stefano Profumo, World Scientific Europe Ltd.

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%		60%		30%	
Level 2	Apply Analyse	60%		40%		60%		40%		70%	
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. *Dr. Pranab Mandal, Asst. Professor. Dept. Of Physics. SRM University – AP*
c. Prof. M. S. Ramachandra Rao, Professor, Department of Physics, Indian Institute of Technology, Madras
d. Prof. D. Narayana Rao, Raja Ramanna Fellow, University of Hyderabad

Special Theory of Relativity

Course Code	PHY 206M	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
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: Demonstrate knowledge and broad understanding of Special Relativity.

Objective 2: Explain the meaning and significance of the postulate of Special Relativity.

Objective 3: Learn Statistical properties of Macroscopic systems.

Objective 4: Explain relativistic momentum and Einstein field equations.

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	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.	1	70%	65%
Outcome 2	Understand the importance of One of its most famous aspects concerns objects moving at the speed of light.	2	70%	65%
Outcome 3	Explain Statistical properties of Macroscopic systems.	3	70%	65%
Outcome 4	Universality of Newton's second law in all inertial frames	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	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	**Elementary statistical concepts and examples**			
1	Inertial Frames	1	1	1,2
2	Universality of Newton's second law in all inertial frames	1	1	1,2
3	Classical Relativity, Does universal rest (ether) exists?	1	1	1,2
4	Michelson Morley Experiment Principle	1	1	1,2
5	Michelson Morley Experiment	1	1	1,2
6	Postulates of Special Theory of Relativity	1	1	1,2
7	Concept of transformation	1	1	1,2
8	Galilean Transformation	1	1	1,2
9	Simultaneity of two events in different inertial frames of reference and its frame dependence	1	1	1,2
10	Tutorial I	1	1,2	1,2
11	Tutorial II	1	1,2	1,2
12	Tutorial III	1	1,2	1,2
Unit 2	Lorentz Transformation			
13	Clock Synchronization in an Inertial Frame	1	1	1,2
14	Lorentz Transformation.	1	1	1,2
15	Length Contraction	1	1	1,2
16	Time dilation	1	1	1,2
17	Examples of Length Contraction and Time dilation	1	1	1,2
18	Simultaneity Part I	1	1	1,2
19	Simultaneity Part II	1	1	1,2
20	Transformation of Velocities Part I	1	1	1,2

21	Transformation of Velocities Part II	1	1	1,2
22	Tutorial IV	1	1,2	1,2
23	Tutorial V	1	1,2	1,2
24	Tutorial VI	1	1,2	1,2
Unit 3	**Relativistic velocity and Momentum**			
25	Velocity Transformation	1	1	1,2
26	Relative velocity with examples	1	1	1,2
27	Time like and Space Like intervals	1	1	1,2
28	Causality	1	1	1,2
29	Need to redefine Momentum	1	1	1,2
30	Vector and Four-Vectors.	1	1	1,2
31	Proper time interval	1	1	1,2
32	Velocity and Momentum-Energy Four Vector	1	1	1,2
33	Example on Relativistic velocity and momentum	1	1	1,2
34	Tutorial VII	1	1,2	1,2
35	Tutorial VIII	1	1,2	1,2
36	Tutorial IX	1	1,2	1,2
Unit 4	**Mass Energy Relation**			
37	Mass-Energy Relationship	1	1	1,2
38	Relationship between new energy and momentum.	1	1	1,2
39	Relativistic Dynamics Part I	1	1	1,2
40	Relativistic Dynamics Part II	1	1	1,2
41	Zero mass particles.	1	1	1,2
42	Relativistic Mass	1	1	1,2
43	Geometry of Space-time	1	1	1,2
44	Spacelike and time-like interval	1	1	1,2
45	Light cone	1	1	1,2
46	Tutorial X	1	1,2	1,2
47	Tutorial XI	1	1,2	1,2
48	Tutorial XII	1	1,2	1,2
Unit 5	**Geometry of Space-Time**			
49	Four-Dimensional form of Maxwell's equations	2	1	1,2
50	Four dimensional Vector Potential. Stress-	2	1	1,2
51	Energy Momentum Tensor	1	1	1,2
52	Conservation Laws	1	1	1,2
53	Lagrangian formulation of Electrodynamics Part I	1	1	1,2
54	Lagrangian formulation of Electrodynamics Part II	2	1	1,2
55	Relativistic treatment of radiation.	1	1	1,2
56	Four-Dimensional form of Maxwell's equations	1	1	1,2
57	Four dimensional Vector Potential.	1	1	1,2
58	Tutorial XIII	1	1,2	1,2
59	Tutorial XIV	1	1,2	1,2
60	Tutorial XV	1	1,2	1,2

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)

<table>
<tr><td colspan="4">Course nature</td><td colspan="3">Theory</td></tr>
<tr><td colspan="7">Assessment Method (Weightage 100%)</td></tr>
<tr><td rowspan="2">In-semester</td><td>Assessment tool</td><td>Mid Term I</td><td>Mid Term II</td><td>CLA1</td><td>CLA2</td><td>Total</td></tr>
<tr><td>Weightage</td><td>15%</td><td>15%</td><td>10%</td><td>10%</td><td>50%</td></tr>
<tr><td colspan="6">End semester examination Weightage</td><td>50%</td></tr>
</table>

Solid-State Physics

Course Code	PHY 301M	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
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 of crystal structures and crystal systems.

Objective 2: To acquire knowledge on the classification of 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.	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 Lifelong Learning	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 1	**Crystallography**			
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	1	1	1,2
8	Cohesive energies of ionic crystals	1	1	1,2
9	Bragg's law	1	1,2	1,2
10	Debye Scherrer method	1	1,2	1,2
11	Tutorial class I	1	1,2	1,2
12	Tutorial class II	1	1,2	1,2
Unit 2	**Lattice Vibrations and specific heat of solids**			
13	Specific heats of solids	1	1	1,2
14	Classical theory of Specific heat, Dulong-Petit Law	1	1	1,2
15	Breakdown of classical theory	1	1,2	1,2
16	Einstein theory of specific heat	1	1,2	1,2
17	Debye theory of specific heat, T^3 law	1	1,2	1,2
18	Lattice vibrations. Concept of phonons.	1	1,2	1,2
19	One dimensional monoatomic lattice	1	1	1,2
20	Phase velocity and group velocity	1	1,2	1,2
21	Phonon vibration of diatomic linear lattice	1	1,2	1,2
22	Qualitative description of the phonon spectrum in solids. Acoustical and optical phonons	1	1,2	1,2
23	Tutorial class I	1	1,2	1,2
24	Tutorial class II	1	1,2	1,2

Unit 3	**Free electron theory of metals**			
25	Classical theory of free electrons, Drude-Lorentz theory	1	1	1,2,3
26	Temperature dependent electrical resistivity of metals	1	1,2	1,2,3
27	Thermal conductivity of metals	1	1,2	1,2,3
28	Wiedemann-Frank’s law	1	1	1,2,3
29	Failure of classical theory			
30	Free electron gas in one dimension	1	1,2	1,2,3
31	Fermi-Dirac distribution function	1	1,2	1,2,3
32	Free-electron theory of metals	1	1	1,2,3
33	Heat capacity of the electron gas	1	1	1,2,3
34	Thermionic emission	1	1	1,2,3
35	Tutorial class I	1	1,2	1,2
36	Tutorial class II	1	1,2	1,2
Unit 4	**Band theory of solids, Semiconductors**			
37	Failure of Free electron theory of metals	1	1,2	1,2,3
38	Nearly free electron model, Bloch theorem	1	1	1,2,3
39	Kronig Penny model	1	1	1,2,3
40	Brillouin zones, Concept of effective mass	1	1,2	1,2,3
41	Distinction between metal, semiconductor and insulator	1	1,2	1,2,3
42	Band theory of solids	1	2	1,2,3
43	Temperature-dependent resistivity of metals	1	1,2	1,2,3
44	semiconductors and insulators	1	1,2	1,2,3
45	Intrinsic and extrinsic semiconductors P-type and N-type semiconductors	1	1,2	1,2,3
46	Hall effect in semiconductors	1	1	1,2,3
47	Tutorial class I	1	1,2	1,2
48	Tutorial class II	1	1,2	1,2

Unit 5	**Dielectric and Magnetic properties of materials**			
49	Polarization	1	1	1,2,3
50	The local electric field at an atom	1	1,2	1,2,3
51	Depolarization field, Dielectric susceptibility, and polarizability, Dielectric constant	1	1,2	1,2,3
52	Clausius-Mosotti equation	1	1	1,2,3
53	Diamagnetic, paramagnetic, Ferromagnetic and ferrimagnetic materials	1	1,2	1,2,3
54	Classical Langevin's theory of diamagnetism and paramagnetism, Curie law	1	1,2	1,2,3
55	Weiss theory of ferromagnetism and magnetic domains	1	1,2	1,2,3
56	Discussion on B-H curve	1	2	1,2,3
57	Magnetic hysteresis and energy loss	1	2	1,2,3
58	Soft and hard magnetic materials	1	2	1,2,3
59	Tutorial class I	1	1,2	1,2
60	Tutorial class II	1	1,2	1,2

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*

Introduction to Quantum Computation

Course Code	PHY 314M	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
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: The course represents a comprehensive survey of the concept of quantum computing with an exposition of qubits, quantum logic gates, quantum algorithms and Implementation.

Objective 2: 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.

Objective 3: know the definition of the qubit, quantum logic gates, quantum circuits and quantum algorithms.

Objective 4: understand how quantum parallelism is used in the simplest quantum algorithms such as Deutsch, period finding and quantum Fourier transform.

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	know the basic requirements for implementation of quantum computers and classify the schemes for implementation of quantum computers.	1	70%	65%
Outcome 2	Explain the concept of fluid flow and hydrodynamic instabilities	2	70%	65%
Outcome 3	Explain the interactions and energy scales involved in soft matter physics.	3	70%	65%
Outcome 4	Configurate 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	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	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	**Matrix, Tensor and Dirac Notation**			
1	Basis vectors and orthogonality	1	1	1,2
2	Matrices Hilbert spaces	1	1	1,2
3	Inner and outer products	1	1	1,2
4	Tensors in index notation	1	1	1,2
5	Metric tensors, covariant and contravariant tensors	1	1	1,2
6	Unitary operators and projectors	1	1	1,2
7	Hermetian operator, Adjoint of operator	1	1	1,2
8	Wavefunction as vector and operator as metrics	1	1	1,2
9	Dirac notation	1	1,2	1,2
10	Tutorial 1	1	1,2	1,2
11	Tutorial 2	1	1,2	1,2
12	Tutorial 3	1	1,2	1,2
Unit 2	**Introduction and Overview of Quantum Mechanics**			
13	Photon, Concept of Planck Constant	1	1	1,2
14	Photoelectric effect	1	1	1,2
15	Wave particle duality, Wave packet	1	1,2	1,2
16	Davisson and Germer Experiment	1	1,2	1,2
17	Superposition Principle	1	1,2	1,2
18	Young Double slit experiment	1	1,2	1,2
19	Qubits and pieces	1	1	1,2
20	Concept of Bloch sphere	1	1,2	1,2
21	Derivation on Bloch sphere representation	1	1,2	1,2

22	Tutorial 4	1	1,2	1,2
23	Tutorial 5	1	1,2	1,2
24	Tutorial 6	1	1,2	1,2
Unit 3	**Fundamentals of Quantum communication**			
25	No-cloning theorem	1	1	1,2,3
26	Hidden Information of state	1	1,2	1,2,3
27	Einstein-Podolsky-Rosen Paradox	1	1,2	1,2,3
28	Bell states	1	1	1,2,3
29	Bell inequalities	1		
30	Bell inequalities – Examples	1	1,2	1,2,3
31	Quantum entanglement	1	1,2	1,2,3
32	Quantum entanglement considering Heisenberg principal	1	1	1,2,3
33	Quantum teleportation	1	1	1,2,3
34	Tutorial 7	1	1	1,2,3
35	Tutorial 8	1	1,2	1,2
36	Tutorial 9	1	1,2	1,2
Unit 4	**Quantum Gate**	**12**		
37	Pauli Gates	1	1,2	1,2,3
38	Phase Gate	1	1	1,2,3
39	Controlled phase shift	1	1	1,2,3
40	Hadamard gates	1	1,2	1,2,3
41	SWAP Gates	1	1,2	1,2,3
42	CNOT Gates	1	2	1,2,3
43	Toffoli gates	1	1,2	1,2,3
44	Combination of Gates	1	1,2	1,2,3
45	Circuit of Gates	1	1,2	1,2,3
46	Tutorial 10	1	1	1,2,3
47	Tutorial 11	1	1,2	1,2
48	Tutorial 12	1	1,2	1,2
Unit 5	**Quantum Algorithm, Key Distribution and Error**	**12**		
49	Deutsch algorithm	1	1	1,2,3
50	Deutsch-Josza algorithm	1	1,2	1,2,3
51	Shor's Algorithm - Periodicity	1	1,2	1,2,3
52	Shor's period-finding algorithm	1	1	1,2,3
53	Introduction to Quantum key distribution	1	1,2	1,2,3
54	BB84 protocol	1	1,2	1,2,3
55	Quantum Error Correction	1	1,2	1,2,3
56	Quantum Error Correction Example	1	2	1,2,3
57	Physical Qubits	1	2	1,2,3
58	Tutorial 13	1	2	1,2,3
59	Tutorial 14	1	1,2	1,2
60	Tutorial 15	1	1,2	1,2

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 Soft matter physics

Course Code	PHY 315M	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)		**Co-Requisite Course(s)**		**Progressive Course(s)**				
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: Demonstrate The purpose of this course is to introduce the students with the physics of membranes, polymers and structural stability in biological and other objects.

Objective 2: Understand the interactions and energy scales involved in soft matter physics.

Objective 3: Apply those concepts in understanding stability and fluctuations in biological cells and membranes.

Objective 4: Understand the concept of fluid flow and hydrodynamic instabilities

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	Understand the concept of elastic properties of polymers	1	70%	65%
Outcome 2	Explain the concept of fluid flow and hydrodynamic instabilities	2	70%	65%
Outcome 3	Explain the interactions and energy scales involved in soft matter physics.	3	70%	65%
Outcome 4	Configurate 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	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	**Interactions in soft matters**			
1	What is soft matter?	1	1	1,2
2	Forces, energies and time scales in soft matter	1	1	1,2
3	Surface tension	1	1	1,2
4	Surface energy	1	1	1,2
5	Wetting phenomena: Young’s equation and contact angle	1	1	1,2
6	Hydrophobicity and hydrophilicity	1	1	1,2
7	Capillarity	1	1	1,2
8	Van der Waals interaction (molecules and colloids); stability and aggregation	1	1	1,2
9	Entropy driven interactions	1	1	1,2
10	Tutorial I	1	1,2	1,2
11	Tutorial II	1	1,2	1,2
12	Tutorial III	1	1,2	1,2
Unit 2	**UNIT II – Elements of complex fluids motion**			
13	Random walks and diffusion equation	1	1	1,2
14	Brownian motions of colloidal particles	1	1	1,2
15	Langevin equation	1	1	1,2
16	Fokker-Planck equation	1	1	1,2
17	Hydrodynamics: Navier-Stokes equation	1	1	1,2
18	Reynolds number	1	1	1,2
19	Linearization: Stokes law	1	1	1,2
20	Hard sphere suspension	1	1	1,2
21	Linear viscoelasticity	1	1	1,2
22	Tutorial IV	1	1,2	1,2
23	Tutorial V	1	1,2	1,2

24	Tutorial VI	1	1,2	1,2
Unit 3	**UNIT III – Self-assembly and membranes**			
25	Concept of self-assembly	1	1	1,2
26	Aggregation of amphiphilic molecules; critical micelle concentration	1	1	1,2
27	Self-assembly in viruses	1	1	1,2
28	Self-assembly in colloidal systems	1	1	1,2
29	Applications of self-assembly in nanotechnology	1	1	1,2
30	Lipid bilayers and cell membranes	1	1	1,2
31	Curvature elasticity in membranes	1	1	1,2
32	Fluctuations in membranes	1	1	1,2
33	Problems on Fluctuations in membranes	1	1	1,2
34	Tutorial VII	1	1,2	1,2
35	Tutorial VIII	1	1,2	1,2
36	Tutorial IX	1	1,2	1,2
Unit 4	**UNIT IV: Polymers**			
37	Examples of polymers	1	1	1,2
38	Polymers and biological macromolecules	1	1	1,2
39	Polymer statistics: single polymer chain	1	1	1,2
40	Self-avoiding walk	1	1	1,2
41	Entropic forces and excluded volumes	1	1	1,2
42	Persistence length	1	1	1,2
43	DNA as polymer chain	1	1	1,2
44	Phase transition and Flory theory of polymers	1	1	1,2
45	Rubber elasticity	1	1	1,2
46	Tutorial X	1	1,2	1,2
47	Tutorial XI	1	1,2	1,2
48	Tutorial XII	1	1,2	1,2
Unit 5	**UNIT V: Percolation theory**			
49	Concept of fractals; examples	2	1	1,2
50	Fractal dimension	2	1	1,2
51	Definition: site and bond percolation in regular lattices	1	1	1,2
52	Percolation transition; order parameter	1	1	1,2
53	Critical exponents in percolation; cluster statistics	1	1	1,2
54	Lattice animals	2	1	1,2
55	Application: Fluid flow through porous media	1	1	1,2
56	Application: Cross-linking polymers; De Gennes' theory of polymer elasticity from percolation theory	1	1	1,2
57	Rigidity percolation and fracture	1	1	1,2
58	Tutorial XIII	1	1,2	1,2
59	Tutorial XIV	1	1,2	1,2
60	Tutorial XV	1	1,2	1,2

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%**

Electronic Materials & Device Physics

Course Code	PHY 316M	Course Category	Core Course	L-T-P-C	3	1	0	4
Pre-Requisite Course(s)		Co-Requisite Course(s)		Progressive Course(s)				
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: Demonstrate the purpose of this course is to introduce the students to Semiconductor fundamentals and physical principles of *p-n* junctions and Schottky barrier diodes.

Objective 2: Calculate the carrier concentrations and resistivity of a semiconductor using the given doping concentration and design a resistor of a given value.

Objective 3: 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

Objective 4: Explain relativistic momentum and Einstein field equations.

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	Analyze carrier concentrations and resistivity of a semiconductor using the given doping concentration and design a resistor of a given value.	1	70%	65%
Outcome 2	Explain relativistic momentum and Einstein field equations.	2	70%	65%
Outcome 3	Explain the purpose of this course is to introduce the students to Semiconductor fundamentals and physical principles of *p-n* junctions and Schottky barrier diodes.	3	70%	65%
Outcome 4	Configurate 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	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	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	**Electronic materials**			
1	Allowed and forbidden energy bands in solids	1	1	1,2
2	Electrical conduction in solids	1	1	1,2
3	*k*-Space diagrams of Si and GaAs	1	1	1,2
4	Density of states function in semiconductor	1	1	1,2
5	Review of Fermi–Dirac distribution function and the Fermi energy in semiconductor material	1	1	1,2
6	Charge carriers in semiconductors	1	1	1,2
7	Extrinsic semiconductor - dopant atoms and energy levels	1	1	1,2
8	Statistics of donors-acceptors and Charge neutrality	1	1	1,2
9	Variation of Fermi energy level with doping concentration and Temperature	1	1	1,2
10	Carrier drift transport phenomena	1	1,2	1,2
11	Carrier diffusion transport phenomena	1	1,2	1,2
12	Induced Electric Field and Einstein Relation	1	1,2	1,2
Unit 2	**Non-equilibrium excess carriers in semiconductors**			
13	Carrier generation and recombination	1	1	1,2
14	Continuity equations	1	1	1,2
15	Time-dependent diffusion equations	1	1	1,2
16	Derivation of the ambipolar transport equation	1	1	1,2
17	Applications of the ambipolar transport equation	1	1	1,2
18	Limits of extrinsic doping and low injection	1	1	1,2

19	Dielectric relaxation in semiconductor	1	1	1,2
20	Haynes–Shockley Experiment	1	1	1,2
21	Quasi-Fermi Energy Levels	1	1	1,2
22	Excess Carrier Lifetime	1	1,2	1,2
23	Shockley–Read–Hall theory of recombination	1	1,2	1,2
24	Surface states and Surface recombination velocity	1	1,2	1,2
Unit 3	***p-n* Junction Devices**			
25	Fabrication of *p-n* Junctions	1	1	1,2
26	Equilibrium (Zero applied bias) conditions and Space charge at a *p-n* Junction	1	1	1,2
27	Forward-Biased *p-n* Junctions,	1	1	1,2
28	Reverse applied bias *p-n* Junctions, Qualitative Description of Charge Flow in a *p-n* Junction	1	1	1,2
29	Reverse-Bias Breakdown	1	1	1,2
30	Non-uniformly Doped *p-n* Junctions	1	1	1,2
31	Ideal Current–Voltage relationship of *p-n* Junction	1	1	1,2
32		1	1	1,2
33	Generation–recombination currents and high-injection levels	1	1	1,2
34	Small-signal model of the *p-n* Junction	1	1,2	1,2
35	Charge storage and diode transients	1	1,2	1,2
36	The Tunnel diode	1	1,2	1,2
Unit 4	**Metal–semiconductor and Semiconductor heterojunctions**			
37	The Schottky barrier diode	1	1	1,2
38	Comparison of the Schottky barrier diode and the *p-n* Junction diode	1	1	1,2
39	Metal–Semiconductor Ohmic contacts	1	1	1,2
40	Semiconductor heterojunctions	1	1	1,2
41	Metal–Oxide–Semiconductor Junctions	1	1	1,2
42	Two-Terminal MOS structure	1	1	1,2
43	Capacitance–Voltage characteristics of MOS structure	1	1	1,2
44	Metal–Oxide–Semiconductor Field-Effect Transistor (MOSFET) operation	1	1	1,2
45	Bipolar Junction Transistors (BJT)	1	1	1,2
46	Minority carrier distribution in BJT structure and Common-Base Current Gain current at low frequency	1	1,2	1,2
47	Junction Field-Effect Transistor (JFET and MESFET)	1	1,2	1,2
48	Electrical characteristics of JFETs	1	1,2	1,2
Unit 5	**Specialized semiconductor devices**			
49	Optical absorption in semiconductors	1	1	1,2
50	Solar cells	1	1	1,2
51	Photodetectors	1	1	1,2
52	Photoluminescence and electroluminescence	1	1	1,2
53	Light emitting diodes	1	1	1,2
54	Design of Laser diodes	1	1	1,2
55	Application of Laser diodes	1	1	1,2

56	Tunnel diode and Gunn diode	1	1	1,2
57	Power bipolar transistors	1	1	1,2
58	Power MOSFETs	1	1,2	1,2
59	The Thyristor	1	1,2	1,2
60	Memristor devices	1	1,2	1,2

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%**