VIII-Semester

Advanced Quantum Mechanics			
Course Code	**21BSP81**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hours

Course Objectives:

1. To study the application of quantum mechanics in case of particles moving in potential wells and barriers
2. To study the spherically symmetric systems and application to Hydrogen Atom
3. To Study the Matrix formulation of Quantum Mechanics
4. To Study the approximation methods for stationary problems
5. To study the angular momenta and the properties associated

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Apart from conventional lecture methods various types of innovative teaching techniques through videos, animation films may be adopted so that the delivered lesson can progress the students in theoretical, applied and practical skills in physics
2. Seminars and Quizzes may be arranged for students in respective subjects to develop skills.
3. Encourage the students for group learning to improve their creativity and analytical skills.
4. While teaching show how every concept can be applied to the real world. This helps the students to expand understanding level.
5. Support and guide the students for self-study.
6. Ask some higher order thinking questions in the class, which promotes critical thinking.
7. Inspire the students towards the studies by giving new ideas and examples.

Module-1

Applications of Quantum Mechanics **8 Hours**

Schrodinger Wave Equation, application : Free Particle, Particle in a Box, A Particle in three dimensional potential well of infinite height, The Square Potential Well, One Dimensional Linear Harmonic Oscillator, Rectangular Potential Barrier (Qualitative) Application of Barrier Potential (alpha decay).

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Schrodinger Wave Equation

Module-2

Spherically Symmetric Systems **8 Hours**

Schrodinger wave equation for spherically symmetric potentials, Three dimensional Harmonic Oscillator (Spherically symmetric systems), Rigid Rotator with free axis, Rigid rotator with fixed axis. The Hydrogen atom, Degeneracy, The normal state of hydrogen Atom.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** spherically symmetric potentials

Module-3

Matrix Formulation of Quantum Mechanics **8 Hours**

Matrix algebra: Hermitian and Unitary Matrices, Transformation and Diagonalization of matrices, Matrices of infinite Rank, Matrices in Quantum Mechanics : Unitary Transformation Matrix, Hamiltonian Matrix, Wave function as Unitary Matrices, The **r** Representation, Equations of Motion in Matrix form (Qualitative), Angular Momentum : Choice of Representation, Relations between matrix elements, Addition of angular Momenta.

Pedagogy	Chalk and talk, Power point presentation, Videos

Module-4

Approximation Methods for Stationary Problems

Stationary Perturbation Theory: Non degenerate case First Order perturbation, Second order Perturbation, Normalization, Perturbation of an Oscillator, Born Approximation : Perturbation Approximation, Green's function for a free particle, Scattering cross section, Validity of Born Approximation Variation Method (Qualitative), WKB Approximation (Qualitative)

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component;** Perturbation Theory

Module-5

Angular Momenta and Properties **8 Hours**

Angular Momentum Operator in position Representation, The Rotation operator and Angular Momentum, Spin Angular Momentum, Total Angular Momentum Operators, Commutation relations of Total Angular Momentum with Components, Eigen Values, Explicit form of the angular momentum matrices, Addition of angular momenta : Clebsh-Gordon Coefficients, Properties of Clebsh-Gordon coefficients, Calculation of Clebsh-Gordon Coefficients

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Angular Momentum, Spin Angular Momentum

Course outcome (Course Skill Set)

At the end of course the student will be able to

1. Describe the application of quantum mechanics to study the motion of particles in potential wells and barriers.
2. Discuss the spherical symmetric systems and its application to Hydrogen Atom.
3. Elucidate the Matrix formulation of Quantum Mechanics
4. Apply approximation methods for the stationary problems
5. Describe the implications of Angular Momenta and associated properties

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Text Books

1. Quantum Mechannics , Sathya Prakash and Swathi Saluja, Kedar Nath Ram Nath Co,
2. Quantum Mechanics, L I Schiff , McGraw Hil Education,
3. Introduction to Quantum Mechanics, D Griffiths, Prentice-Hall, 2004.
4. A Text book of Quantum Mechannics , Mathew's and Venkateshan, Tata Mcgraw Hill, 2nd Edition 2017.

Reference Books

1. Quantum Mechanics TheTheoretical Minimum , Leonard Susskind, Penguine Science
2. Quantum Mechanics Through Problems, V K Thankappan, New Age International, 2003
3. CreateSpace Independent Publishing Platform, 2017.

Web links and Video Lectures (e-Resources):

1. https://archive.nptel.ac.in/courses/115/102/115102023/ 2. https://archive.nptel.ac.in/courses/122/106/122106034/ 3. https://www.youtube.com/watch?v=p7bzE1E5PMY
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning 1. https://vqm.uni-graz.at/movies.html 2. https://vqm.uni-graz.at/pages/software.html

VIII Semester

ELECTRO DYNAMICS			
Course Code	21BSP82	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hours

Course Objective:

1. To understand the basics of field boundary conditions.
2. To understand the concepts associated with Electromagnetic fields and Maxwell's equations.
3. To understand the phenomenon of different types of polarisation in EM waves

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Apart from conventional lecture methods various types of innovative teaching techniques through videos, animation films may be adopted so that the delivered lesson can progress the students in theoretical, applied and practical skills in physics.
2. Seminars and Quizzes may be arranged for students in respective subjects to develop skills.
3. Encourage the students for group learning to improve their creativity and analytical skills.
4. While teaching show how every concept can be applied to the real world. This helps the students to expand understanding level.
5. Support and guide the students for self-study.
6. Ask some higher order thinking questions in the class, which promotes critical thinking.
7. Inspire the students towards the studies by giving new ideas and examples.

Module-1

Magnetic and Electric Field Boundary conditions: **08 Hours**

Boundary conditions and its Physical significance (Qualitative), Boundary between two dielectrics- Tangential and normal components, Relation between the fields on either side of the interface, Boundary between dielectric and a Conductors-Tangential and normal component, Magnetic boundary conditions- Tangential and normal components.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Effect of boundary conditions in Capacitors

Module-2

Time varying fields and Maxwell's equations **08 Hours**

Faraday's Law: Relation between Induced emf and the line integral of the closed path, Integral and point forms of Faraday's law. Motional emf in a conductor: Moving conductor in time varying field, Maxwell's equations in point form for static fields, Modification of Static field Equations for time varying fields-equation of continuity, Modification of Ampere's law for time varying conditions ,Equivalence of conduction current and displacement current, Maxwell's equations in differential and integral form, word statement of Maxwell's equations

Pedagogy	Chalk and talk, Power point presentation, Videos Practical component: Faradays law **Self-study Component:** Faraday's laws of electromagnetic induction.

Module-3

Uniform Plane Wave **08 Hours**

Wave Equation in terms of Electric and Magnetic Fields, Uniform Plane waves, Transverse nature of Electromagnetic Waves, Propagation of Uniform Plane Wave Relation between $\vec{E}$ and $\vec{H}$ for Uniform Plane Wave, Orientation between $\vec{E}$ and $\vec{H}$ Characteristics or Intrinsic Impedance (η), Solution of Wave Equation for Uniform Plane Wave (Wave Propagation in Free Space or Lossless Medium),Wave Propagation in good conductors and dielectrics, Velocity of the Wave, Phase Velocity, Intrinsic Impedance, Wave Equation in $\vec{E}$ and $\vec{H}$ for a Conducting Medium, Uniform Plane Wave in a Conducting Medium, Distinction between Conductors and Dielectrics, Uniform Plane Wave in a Good Conductor, Uniform Plane Wave in a Perfect Dielectric, Uniform Plane Wave in a Good Dielectric.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Transverse nature of plane electromagnetic waves

Module-4

Skin Effect and Power Flow **08 Hours**

Skin Depth and Skin Effect, Intrinsic Impedance in Different Media, Poynting Theorem, Poynting Vector, Power

Flow Associated With Poynting Vector, **Application of Poynting Theorem-** Power Dissipation in a Resistor for Direct Current, Power Transmission in a Coaxial Cable, Instantaneous Poynting Vector (Instantaneous Power Flow), Average Poynting Vector.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** RMS and average value of AC.

Module-5

Reflection and Polarization of Plane Waves Wave: 08 Hours

Reflection of plane waves at the surface of the perfect conductor at normal incidence, Reflection of Plane Waves at the Surface of Dielectrics at Normal Incidence ,Standing Wave Ratio, Plane Wave Propagation in General Directions, General Expression for a travelling Plane Wave, Nature of an Electromagnetic Wave, Different Polarized Waves, Linear Polarization, Circular Polarization, Elliptical Polarization, Theory for Linear, Circular, Elliptical Polarization.

Pedagogy	Chalk and talk, Power point presentation, Videos **Practical Topics: Optical polarisation** **Self-study Component:** Basics of Polarisation

Course outcome (Course Skill Set)

Course outcomes: After a successful completion of the course, the student will be able to:

1. Describe boundary conditions of electric and magnetic fields between conductors and dielectrics..
2. Explain the Maxwell's equations on the basis of time varying fields.
3. Setup the wave equation for electromagnetic waves and study their properties.
4. Understand the power dissipation in transmission.
5. Describe the thermoelectric phenomenon and its applications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Text Books

1. Text Book of Electrodynamics, 4th Edition, David J Griffiths, Pearson.
2. Classical Electrodynamics, 3rd Edition, John David Jackson, 2007, Wiley
3. Electricity and magnetism by Brij Lal and N Subrahmanyam, Rathan Prakashan Mandir, Nineteenth Edition, (1993)
4. Electricity & Magnetism, DLSehgal, KLChopra, NKSehgal, SChand & Co, Sixth Edition, (1988)
5. Electricity and Magnetism, Edward M Purcell and David J Morin, Cambridge University Press.
6. Field Theory, U.A.Bakshi, A.V Bakshi, Technical Publication, Pune (2007)

Web links and Video Lectures (e-Resources):

1.https://youtu.be/LzabONBFSSM
2.https://youtu.be/jrxRFxg_WAE
3.https://youtu.be/_HL1Zgnb8oU
4. https://youtu.be/6NOIqhxvZ74

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1.https://youtu.be/yRdifN00Vuc
2. https://youtu.be/gvX29HPmBEI

VIII- Semester

Thermo Electric Materials and Devices			
Course Code	21BSP841	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hours

Course Objectives

1. To understand the fundamentals of thermoelectric materials
2. To understand the various types of thermoelectric materials and devices
3. To study the applications of thermoelectric materials and devices

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Apart from conventional lecture methods various types of innovative teaching techniques through videos, animation films may be adopted so that the delivered lesson can progress the students in theoretical, applied and practical skills in physics
2. Seminars and Quizzes may be arranged for students in respective subjects to develop skills.
3. Encourage the students for group learning to improve their creativity and analytical skills.
4. While teaching show how every concept can be applied to the real world. This helps the students to expand understanding level.
5. Support and guide the students for self-study.
6. Ask some higher order thinking questions in the class, which promotes critical thinking.
7. Inspire the students towards the studies by giving new ideas and examples.

Module-1

Thermoelectric Effects and Parameters **8Hours**

Seebeck Effect and Seebeck Coefficient, Peltier Effect and Peltier Coefficient, Thomson effect, Power Factor, Transport Parameters : Carrier Concentration, Carrier Mobility and Effective Mass, Scattering : Phonon Scattering by Defects, Thermoelectric Parameters : Thermal Conductivity(K), Electronic Thermal Conductivity (K_e), Lattice thermal conductivity(λ_L), Figure of Merit (ZT), Power Factor and Efficiency. Optimizing thermoelectric properties of materials, Thermoelectric Device Efficiency, Nano-structure for thermoelectric efficiency.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Qualitative discussion of center of mass, total angular momentum and total kinetic energy of system of particles.

Module-2

Thermoelectric Physical Mechanisms **8 Hours**

Electron Transport in Bulk Materials: Crystal Structure, Energy Bands, Electron Scattering , Kinetic Theory of Electron Transport, Phonon Transport in Bulk Materials: Phonon Dispersion Curves, Phonon Energy, Phonon Scattering, Phonon Thermal Conductivity, Phonon Drag, Figure of Merit (ZT): Strategies to Enhance ZT , Thermal Conductivity Control, Power factor enhancement, Nano-structured Thermoelectric Materials . Concept of Phonon Glass Electron Crystal (PGEC), Phonon Liquid Electron Crystal (PLEC).

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Electron transport

Module-3

Methods of Thermoelectric Material Production, Properties, and Thermoelectric Measurements. **8 Hours**

Methods: Growth from melt, Sintering, Thick and Thin films. Measurements: Electrical Conductivity, Seebeck Coefficient, Thermal Conductivity, Figure of Merit, Thermomagnetic measurements. Thermoelectric **P**roperties of Si-Ge Alloys: Material, Properties, modeling and Bulk Modeling (qualitative), Charge Transport in Nano-composites.

Organic Semiconductor Polymers, Half Heuslers

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Sintering

Module-4

Types of Thermoelectric Material:

Low Temperature – BiSb, CsBi4Te6, FeSb2, YbAgCu4,

Mid Temperature – Chalcogenides, Skutterudites and Calthrates, Tetrahedrites, BiCuSeO

High Temperature – Lanthanum Telluride, SiGe, WS_2.

(For Each : Structure, Energy Bands, Thermoelectric Parameters, Applications)

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Classification of thermoelectric materials

Module-5

Thermoelectric Devices and Applications:

Applications of TE Devices– Solar Thermoelectric Power Generators (STEG) , Solar Hybrid TEGs : Thermal, Photovoltaic and Phase-change material STEG. Other Applications: Exhaust of Automobiles, Thermoelectric Modules and Refrigerators, Industries, Space Programs (RTG), Electricity Generation, Air-conditioning, Biomedical Devices, Transverse Coolers and Generators, Biomass Cooking Stoves, Camping stoves and grills. Microprocessor cooling.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Camping stoves and grills.

Course outcome (Course Skill Set)

Course Outcomes

After the completion of the course student should be able to:

1. Explain the thermoelectric effects and parameters.
2. Elucidate the Thermoelectric Physical Mechanisms and Optimization.
3. Discuss the Thermoelectric material production, properties and measurements.
4. Describe the various types of therm-electric materials
5. Illustrate the applications of thermoelectric devices.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

Suggested Learning Resources:

Text books:

1. "Thermoelectrics Fundamentals, Materials Selection, Properties, and Performance", N. M. Ravindra , Bhakti Jariwala, Asahel Bañobre, Aniket Maske, Springer, 2019.
2. "Introduction to Thermoelectricity", H. Julian Goldsmid, Springer, 2010.
3. "Advanced Thermoelectrics: Materials, Contacts, Devices and Systems", Zhifeng Ren, Yucheng Lan, Qinyong Zhang, CRC Press, Taylor and Francis, 2017.
4. "Materials Aspects of Thermoelectricity", Edited by Ctirad Uher, CRC Press, Taylor and Francis, 2017.
5. "Thermoelectric Materials Advances and Applications",Enrique Maciá-Barber, PAN Stanford Publishing, CRC Press, Taylor & Francis Group, 2015

Web links and Video Lectures (e-Resources):

1. https://www.youtube.com/watch?v=cZodo_BxBIo
2. https://www.youtube.com/watch?v=fmsQJYPpZ2o
3. https://www.youtube.com/watch?v=AQzbmD7KB5Q
4. https://www.youtube.com/watch?v=G9NgoxHMPwk

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. Thermoelectric Effect
2. Peltier Modules

VIII - Semester

Quantum Computing and Logic			
Course Code	21BSP842	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	2:2:0:1	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	03 Hours

Course Objective

1. Understand the basic principles of quantum computing and information
2. Understand the Quantum Operators and Quantum Gates
3. Understand the basic features of quantum coding and algorithms
4. Understand the Physical Realization of Quantum computers and Quantum error Correction.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teacher can use to accelerate the attainment of the various course outcomes.

1. Apart from conventional lecture methods various types of innovative teaching techniques through videos, animation films may be adopted so that the delivered lesson can progress the students in theoretical, applied and practical skills in physics
2. Seminars and Quizzes may be arranged for students in respective subjects to develop skills.
3. Encourage the students for group learning to improve their creativity and analytical skills.
4. While teaching show how every concept can be applied to the real world. This helps the students to expand understanding level.
5. Support and guide the students for self-study.
6. Ask some higher order thinking questions in the class, which promotes critical thinking.
7. Inspire the students towards the studies by giving new ideas and examples.

Module-1

Introduction to quantum computing and quantum information **8 Hours**

Introduction to quantum computing, Moore's law & its end, relation between quantum mechanics and information theory, power of quantum computing, differences between classical & quantum computing.

Relationship between quantum information and classical information: bits to qbits, how quantum physics differs from classical physics: single particle interference.

Concept of qubit and its properties. Representation of qubit by Bloch sphere. Single qubit, two qubits and multiple qubits. Computer science perspectives. Probability, quantum superposition, quantum register.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** classical computing

Module-2

Complex linear algebra **8 Hours**

Complex vector spaces, Hilbert space, basis set, Dirac Bra and Ket notations and properties inner product, linear dependence and independence, dual vector space, computational basis, outer product.

Matrices and operators:

Operators, rules for operators, matrix representation of linear operator, Pauli matrices, symmetric matrix, transpose operation, orthogonal matrices, identity operator, adjoint operator, Hermitian operator, unitary operators and properties, projection operator.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** vector space

Module-3

Quantum gates **8 Hours**

Single qubit gates: quantum not gate, unitary constraints on quantum gates, √not gate, pauli – x, y and z gates, Hadamard gate, visualization of Hadamard gate using Bloch sphere, relationship between Hadmard and Pauli gates, phase gate (or s gate), t gate. relation between s and t gates.

Multiple qubit gates: controlled gate, cnot gate, (discussion for 4 different input states). representation of swap gate, controlled -z gate, Toffoli gate. Fredkin gate, matrix representation of quantum circuits, Bell states, principles of deferred and implicit measurements, quantum half adder and subtractor.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Logic gates

Module-4

Features of quantum computing, coding and quantum algorithms **8 Hours**

Features of quantum computing: tensor product, superposition, entanglement, decoherence. Quantum teleportation, no-cloning theorem, super dense coding

Quantum algorithms: Deutsch's algorithm, Deutsch-Josza algorithm, Simon's periodicity algorithm, Grover's search algorithm, Shor's factoring algorithm. Quantum cryptography (qualitative explanation)

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** Tensors

Module-5

Physical realization of quantum computers and quantum error correction **8 Hours**

Physical realization of quantum computers: guiding principles, conditions for quantum computation, harmonic oscillator quantum computer, optical photon quantum computer, optical cavity quantum electrodynamics, ion traps, nuclear magnetic resonance.

Quantum error corrections: classical and quantum error correction codes, Shor's 3-qubit bit-flop code, error correction : bit-flip and phase error type, Shor's 9 qubit code.

Pedagogy	Chalk and talk, Power point presentation, Videos **Self-study Component:** guiding principle

Course outcome (Course Skill Set)

Course Outcomes

After the completion of the course student should be able to :

1. Describe the principles of Quantum Computing and Information.
2. Elucidate the operators and operations of Quantum Linear Algebra
3. Discuss the Quantum Gates and their operation.
4. Illustrate the Quantum Coding and Algorithms.
5. Realize the Quantum Computers and Quantum Error Correction.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 35% (18 Marks out of 50)in the semester-end examination(SEE).

Continuous Internal Evaluation:

Three Unit Tests each of **20 Marks (duration 01 hour**)

1. First test at the end of 5th week of the semester
2. Second test at the end of the 10th week of the semester
3. Third test at the end of the 15th week of the semester

Two assignments each of **10 Marks**

4. First assignment at the end of 4th week of the semester
5. Second assignment at the end of 9th week of the semester

Group discussion/Seminar/quiz any one of three suitably planned to attain the COs and POs for **20 Marks** (**duration 01 hours**)

6. At the end of the 13th week of the semester

The sum of three tests, two assignments, and quiz/seminar/group discussion will be out of 100 marks and will be **scaled down to 50 marks**

(to have less stressed CIE, the portion of the syllabus should not be common /repeated for any of the methods of the CIE. Each method of CIE should have a different syllabus portion of the course).

CIE methods /question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the subject (**duration 03 hours)**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.

The students have to answer 5 full questions, selecting one full question from each module.

Suggested Learning Resources:

Text Books

1. Quantum Computing, Vishal Sahni, Tata McGraw-Hill Publishing, 2007.
2. Quantum Computing by Parag Lala, McGraw-Hill, Indian Edition, Reprint 2020.

Reference Books

1. Quantum computing and Quantum information ,Michael A. Nielsen & Isaac L. Chuang, 10th Anniversary edition, Cambridge University Press, 2010.
2. Quantum Computing for Computer Scientists, Noson S. Yanofsky and Mirco A. Mannucci, Cambridge University Press, 2008.
3. "Thermoelectric Materials Advances and Applications",Enrique Maciá-Barber, PAN Stanford Publishing, CRC Press, Taylor & Francis Group, 2015

Web links and Video Lectures (e-Resources):

1. https://nptel.ac.in/courses/106106232
2. https://archive.nptel.ac.in/courses/115/101/115101092/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

1. IBM Quantum Computing : https://www.ibm.com/quantum
2. QISKIT : https://qiskit.org/
3. QUIRK: https://algassert.com/quirk

VIII- Semester

General Physics Lab			
Course Code	21BSPL83	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	1:0:2	/SEE Marks	50
Credits	2	Exam Hours	3 Hours

Course objectives:

1. To Determine the physical properties of interest for semiconductors, liquids, Thermoelectric and magnetic materials.
2. To Analyze of XRD data and SEM images and interpret.
3. To conduct the experiments in the virtual mode.

List of Experiments:

Sl.NO	Experiments
1	Determination of Hall Coefficient of the given semiconductor.
2	Determination of velocity of the ultrasonic waves in a given liquid using Ultrasonic Interferometer.
3	Determination of resistivity and Energy Gap using Four-Probe Method.
4	Tracing of BH Curves for ferromagnetic material.
5	Visual Analysis of SEM Images of a Sample.
6	Analysis of given XRD data, crystallite size and composition.
7	Thermo Couple-Seebeck Effect using, Virtual Lab (https://vlab.amrita.edu/?sub=1&brch=194)
8	Determination of Volume Magnetic Susceptibilities of Paramagnetic Liquids using Quinke's Method, Virtual lab,(https://vlab.amrita.edu/?sub=1&brch=192&sim=854&cnt=1)

Course outcomes (Course Skill Set):

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

1. Demonstrate the skills in setting up and conduction of experiments and determination of physical properties.
2. Practice the Analysis of XRD data and SEM images and interpret.
3. Demonstrate the ability to use the virtual platform for conduction of experiments.
4. Practice working in groups and making accurate measurements.

Assessment Details (both CIE and SEE)

Continuous Internal Evaluation (CIE): The CIE marks awarded in case of Practical shall be based on the weekly evaluation of laboratory journals/ reports after the conduction of every experiment and one practical test.

Semester End Evaluation (SEE students): The practical examinations to be conducted as per the time table of University in a batch wise with strength of students not more than 10-15 per batch.

1. All laboratory experiments are to be included for practical examination.
2. Breakup of marks and the instructions printed on the cover page of answer script to be strictly adhered by the examiners.
3. Students can pick one experiment from the questions lot prepared by the examiners.
4. Change of experiment is allowed only once and 15% Marks allotted to the procedure part to be made zero.

Books:

1. Advanced Practical Physics for students, B.L. Flint and H.T. Worsnop, 1971, Asia Publishing House
2. A Text Book of Practical Physics, I.Prakash and Ramakrishna, 11th Ed., 2011, Kitab Mahal
3. Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th Edition, reprinted 1985, Heinemann Educational Publishers
4. A Laboratory Manual of Physics for undergraduate classes, D.P.Khandelwal, 1985, Vani Pub
5. Geeta Sanon, BSc Practical Physics, 1st Edn. (2007), R. Chand & Co.
6. Nelson and Jon Ogborn, Practical Physics

7. Practical Physics, Gupta &kumar voli &I
8. B.Sc. Practical Physics, C. L. Arora, S. Chand company

Suggested Learning Resources:

1. **https://vlab.amrita.edu**
2. **https://virtuallabs.merlot.org/vl_physics.html**