Detailed Syllabus

Lecture-wise Breakup

Course Code	19M21PH212	**Semester: Odd**	**Semester: III** **Session** 2023-2024 Month from: July-December
Course Name	Advanced Quantum Mechanics		
Credits	4	**Contact Hours**	3+1
Faculty (Names)	**Coordinator**	Shiv Prasad Purohit	
	Teacher	Shiv Prasad Purohit	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall basic ideas of advanced quantum mechanics	Remembering (C1)
CO2	Explain various physical phenomena which can be explained only using advanced quantum mechanics	Understanding (C2)
CO3	Apply time-independent perturbation methods, time-dependent perturbation methods, quantum collision theory, quantum statistics and relativistic quantum mechanics for quantum mechanical systems.	Applying (C3)
CO4	Analyze advanced quantum mechanical problems.	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Approximation methods for time-dependent problems**	Time-dependent perturbation theory, General features, Fermi's golden rule, periodic perturbation, the adiabatic approximation and application to some atomic systems.	8
2.	**Quantum collision theory**	Scattering experiments and cross-sections, non-relativistic scattering theory, scattering by central potential, phase shift analysis, optical theorem, method of partial waves, scattering by a square well potential, the Born approximation, some applications of quantum collision theory.	8
3.	**Quantum statistics**	The density matrix, the density matrix for a spin-1/2 system, polarisation, the equation of motion of the density matrix, quantum mechanical ensembeles, applications to single-particle systems, systems of non-interacting particles, consequences of particle statistics, ideal quantum gases, Bose-Einstein condensation in atomic gases.	6
4.	**Relativistic quantum mechanics**	The Klein-Gordon equation, the Dirac equation, physical implementation and applications, covariant formulation of the Dirac theory, plane wave solutions of the Dirac equation.	6
5.	**Quantization of Wave Fields**	Classical and quantum field equations, coordinates of the field, time derivatives, classical Lagrangian and Hamiltonian equations, quantum equations for the field, fields with more than one components, quantisation of the non-relativistic Schrodinger equation, creation, destruction and number operators, anticommutation	8

		relations and operators, electromagnetic field in vacuum, interaction between charged particles and electromagnetic field.	
6.	**Some applications of quantum mechanics (only qualitative discussion)**	The van der Waals interaction, electrons in solids, the decay of K-mesons, semiconductor quantum devices, quantum communication	4
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [PBL (10 M); 2 Quizzes (3M+3M); Attendance (5 M) and Class performance (4 M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Leonard I. Schiff, Quantum Mechanics, McGraw-Hill, Singapore, 1985
2.	B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education Ltd., 2000
3.	J. J. Sakurai, Advanced Quantum Mechanics
4.	J. D. Bjorken& S. D. Drell, Relativistic Quantum Fields

Project Based Learning: The TA components of evaluation criteria involve the PBL component of MM: 10. The PBL exercise is given to each student in areas where the quantum mechanics plays a central role. The objective of the PBL exercises is chosen to enhance the employability of students in the areas of quantum technologies.

Detailed Syllabus

Lecture-wise Breakup

Course Code	19M21PH213	**Semester:** Odd	**Semester: III** **Session** 2023 -2024s **Month from:** July-December
Course Name	Numerical Techniques and Computer Programming		
Credits	03	**Contact Hours**	03

Faculty (Names)	**Coordinator(s)**	**Dr. Ravi Gupta**
	Teacher(s) (Alphabetically)	**Dr. Ravi Gupta**

COURSE OUTCOMES		**COGNITIVE LEVELS**
C213.1	Define key concepts used in programming, data structures, Numerical methods.	Remember Level (C1)
C213.2	Explain basics of programming, data structures, numerical analysis, parallel programming.	Understand Level (C2)
C213.3	Create programs using C to implement various problems in numerical analysis.	Apply Level (C3)
C213.4	Create programs using Mathematica and MATLAB to solve various problems in numerical physics.	Apply level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Introduction to Programming**	Fundamentals of Programming, high/low level languages, compilation and linking, Basic data types, Arithmetic operators, Elementary introduction to header files, print f, scan f and control functions of Turbo C/C++, Looping	10
2.	**Data Structures**	Oneand two dimensional arrays of various data types, Operations involving matrices and vectors, String of characters and related library functions, Functions and arrays, Structures, array of structures, unions and enumerations, Command line arguments. Dynamical memory allocation, Plotting simple geometric figures	10

3.	**Numerical Techniques**	Simple C programs covering some elementary topics in numerical analysis such as root finding, interpolation, numerical differentiation and integration, numerical linear algebra, Euler and Runga-Kutta methods.	15
4.	**Approximation methods**	Basic ideas of parallel computing and introduction to the software popularly used in Physics such as Mathematica and MATLAB	05
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [Attendance (05 M), Class Test, Quiz, *etc* (6 M), PBL (10 M) Internal assessment (04 M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Greg Perry and Dean Miller, C Programming Absolute Beginner's Guide, Paperback, 2013.
2	Bjarne Stroustrup , C++ Programming Language, Paperback, 2013.
3	K. E. Atkinson, Numerical Analysis, John Wiley (Asia), 2004.
4	S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill, 2002.
5	Stephen Wolfram ,The Mathematica Book, Fifth Edition , Wolfram Media, Inc., 2012.
6	A. Gilat, MATLAB An Introduction With Applications 4th Edition, John Wiley, 2013.
7.	YashavantKanetkar, Let Us C, 16^{th} Edition, BPB Publications, 2018
8.	B. S. Grewal, Numerical Methods in Engineering and Science with Programs in C, C++, and MATLAB, Khanna Publishers, 2013

Project Based Learning: Students are required to write programming code individually using any of the tools or programs; and do a presentation in the end. This knowledge of coding can be utilized in different software organizations/firms/ industries.

Detailed Syllabus

Lecture-wise Breakup

Course Code	19M21PH214	**Semester:** Odd	**Semester: 3rd Session: 2023-2024** **Month from:** July-December
Course Name	**Advanced Condensed Matter Physics-1**		
Credits	3	**Contact Hours**	3
Faculty (Names)	**Coordinator(s)**	Manoj Kumar	
	Teacher(s) (Alphabetically)		

COURSE OUTCOMES		**COGNITIVE LEVELS**
C214.1	Recall basic concepts related to magnetism, transport phenomena, phase transition and super conductivity	Remember Level (C1)
C214.2	Explain the significance and value of condensed matter physics, both scientifically and in the wider community	Understand Level (C2)
C214.3	Develop knowledge of conception or notion involved in various theories and models studied in this course	Apply Level (C3)
C214.4	Make use of various methods and solve problems related to studied theories.	Apply level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Dielectrics and Ferroelectrics	Dielectrics, Maxwell Boltzmann equations, Polarization and macroscopic electric field, Local electric field of an atom, Lorentz field, Polarizabilty, Classius-Mossoti relation, Type of polarization and polarizabilities, Frequency dependence of polarizabilities. Ferroelectric crystals and structural phase transitions, Order-disorder phase transition, Displacive and soft mode transition, LST relation, Landau Theory of Phase transition, First order and second order phase transition, Anti-ferroelectricity, Ferroelectric domains (90^o and 180^o), Piezoelectricity and piezoelectric relations	12
2.	Magnetism	Magnetiztion and magnetic susceptibilty, Langevin theory of diamagnetism and Van Vleck paramagnetism, Quantum theory of Paramagnetism, Curie Brillouin law. Curie-Weiss ferromagnets, Magnons, Curie temperature and susceptibility of Ferrimagnets, Néel temperature and Anti-ferromagnetic order, Brags-Willium theory, Heisenberg model, Ising model; Elements of magnetic properties of metals, Landau diamagnetism, Pauli paramagnetism, Stoner ferromagnetism; Magnetic resonance; NMR and EPR.	12
3.	Transport Properties	Boltzmann equation; Relaxation time approximation; General transport coefficients; Electronic conduction in metals; Thermoelectric effects; Transport phenomena in magnetic field; Magnetoresistance; Hall effect and Quantum Hall effect.	10

4.	Superconductivity	Cooper pairing and BCS theory; Ginzburg Landau theory; Flux quantization; Supercurrent tunneling; DC and AC Josephson effects; High-Tc superconductors.	6
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [Attendance (5 M), Quizzes, *etc* (6 M), PBL mode (10 M), and Internal assessment (4 M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Kittel C, "Introduction to Solid State Physics", 8th Ed. Wiley eastern Ltd
2	Ashcroft N W and Mermin N D, "Solid State Physics", Holt-Saunders
3	Chaikin P M and Lubensky T C, "Principles of Condensed Matter Physics", Cambridge University Press
4	Harrison P, "Quantum Wells, Wires and Dots", Wiley & Sons Ltd.
5	B. D. Cullity and C. D. Graham, "Introduction to magnetic materials" John Wily & Sons, Inc, 2011
6	K. H. J. Buschow and F. R. de Boer, "Physics of Magnetism and Magnetic Materials" Kluwer Academic Publishers, 2003
7	Stephen Blundell, "Magnetism in Condensed Matter" Oxford University Press (2001)
8	M. Tinkham, "Introduction to superconductivity" McGrawHill, New York. (1996); Dover Books (2004)
9	P. G. de Gennes, "Superconductivity of metals and alloys" W. A. Benjamin, New York (1966); Perseus Books (1999)
10	A. A. Abrikosov, "Fundamentals of the theory of metals" North Holland, Amsterdam (1998)

Project Based Learning: This course contains the materials which are widely used in high tech industry. As a Physics course, students are trained to understand the properties of materials and to do assignment/project based on the theoretical and experimental fundamental they have learned. The project based on these studies to be evaluated.

Detailed Syllabus
Lecture-wise Breakup

Course Code	19M25PH211	**Semester:** Odd	**Semester: III Session** 2023 -2024 **Month from:** July-December
Course Name	Laboratory-3 (Solid State Physics)		
Credits	04	**Contact Hours**	08

Faculty (Names)	**Coordinator(s)**	R.K. Gopal
	Teacher(s) (Alphabetically)	Ashish Bhatnagar, Dinesh Tripathi, Manoj Kumar, R.K. Gopal

COURSE OUTCOMES		**COGNITIVE LEVELS**
C216.1	Explain the principal and working of experimental setup.	Understand Level (C2)
C216.2	Plan the experiment and take measurements.	Apply Level (C3)
C216.3	Analyze the data obtained and calculate the error.	Analyze level (C4)
C216.4	Interpret and justify the results.	Evaluate Level (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**CO**
1.	Structural characterization	1. Structural determination of given samples ($BaTiO_3$, $CoFe_2O_4$, ZnO etc) by X-ray diffraction technique. 2. Determination of structural parameters (lattice parameters, crystallite size etc) of given samples from XRD data.	2, 3, 4, 5
2.	Dielectric measurements	3. Temperature dependent dielectric measurements of given sample and their analysis. 4. Frequency dependent dielectric measurements of given sample and their analysis. 5. To measure the coercive field (Ec), Remanent Polarization (Pr), and Spontaneous Polarization (Ps) of Barium Titanate (BaTiO3) sample.	2, 3, 4, 5
3.	Spectroscopic measurements	6. Determination of optical band gap of prepared given sample by UV-Vis spectroscopy, 7. Analysis of various bonding in given samples by Infrared spectroscopy.	2, 3, 4, 5
4.	Transport Properties	8. To study the temperature dependence of Hall coefficient of N and P type semiconductors. 9. Electrical resistivity of high resistive material as a function of temperature using DC four probe method. 10. Determination of co-efficient of linear thermal expansion of polymer as a function of temperature.	2, 3, 4, 5

		11. To study C-V characteristics of various solid state devices & materials. (like p-n junctions and ferroelectric capacitors)	

Evaluation Criteria

Components	**Maximum Marks**
Mid Term Viva	20
End Term Viva	20
Day To Day Evaluation	60
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)	
1.	Melissinos A.C. and Napolitano J, **"**Experiments in Modern Physics**",** Academic Press

Detailed Syllabus
Lecture-wise Breakup

Course Code	20M22PH213	**Semester: Odd**	**Semester: IIII Session: 2023-2024** **Month from: July to December**
Course Name	Semiconductor and Electronic Devices		
Credits	3	**Contact Hours**	3-0-0
Faculty (Names)	**Coordinator**	Dinesh Tripathi	
	Teacher	Dinesh Tripathi	

COURSE OUTCOMES		**COGNITIVE LEVELS**
C230-3.1	Define terminology and concepts of semiconductors in correlation with semiconductor related electronic devices	Remembering (C1)
C230-3.2	Explain optical, thermal and electronic properties of semiconductor and devices in equilibrium as well as in steady state condition.	Understanding (C2)
C230-3.3	Apply mathematical equations and laws of semiconductor physics to solve related problems	Applying (C3)
C230-3.4	Analyze and compare different semiconductor and electronic devices for understanding their performances	Evaluating (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Semiconductors	Energy bands, direct and indirect semiconductors, charge carriers, mobility, drift of carriers in field, Diamond and Zinc-Blende structure, bonds and bands in semiconductors, intrinsic and extrinsic semiconductors, law of mass action, Hall effect and cyclotron resonance in semiconductors.	12
2.	Optical Injection	Carrier life time, direct and indirect recombination of electron and holes, steady state carrier generation, Diffusion and drift of carriers, the continuity equation, steady state carrier injection, The Haynes-Shockley experiment.	8
3.	Junctions	Metal-Semiconductor contact: under equilibrium, and non-equilibrium conditions, the junction diode theory, tunnel diode, photodiode, LED, solar cell, Hetro-junctions and Laser diode.	10
4.	Devices	Bipolar Junction Transistors: Charge transport and amplification, minority carrier distribution and terminal currents switching behavior in bipolar transistor, FET and MOSFET: Ideal MOS capacitor, effect of work function and interface charge on threshold voltage. Gunn Diode	10
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [Attendance (07 M), Class Test/Quizzes, *etc*(07 M), Assignments in PBL mode (06 M), and Internal assessment (05 M)]

Total	**100**
Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)	
1.	Semiconductor Physics and Devices, 4th Edison by Donald A Neamen and Dhrubes Biswas
2.	Physics of Semiconductor devices, Wiley-Interscience by S. M. Sze,
3.	Solid State Electronic devices by Ben G.Streetman,
4.	Semiconductor Devices, Mc Graw Hill by Mauro Zambuto

Project Based Learning: Students will be given small projects in groups to enhance their understanding and interest in the course by correlating topics taught and their applications in solving different physical problems of real worlds. Students will be asked to submit the report of given project and give presentations of the same.