Detailed Syllabus
Lecture-wise Breakup

Course Code	19M21PH115	Semester: EVEN	Semester: 2nd Session 2022-23 Month from: Jan to June
Course Name	Classical Electrodynamics		
Credits	4	Contact Hours	3+1

Faculty (Names) **Coordinator** Manoj Kumar
Teacher Manoj Kumar

COURSE OUTCOMES		COGNITIVE LEVELS
CO1	Recall basics of electrostatics, magnetorstatics and electrodynamics	Remembering (C1)
CO2	Explain various physical phenomena and working of devices which involve the basic principles of electrostatics and electrodynamics	Understanding (C2)
CO3	Apply the laws of electrostatics and Maxwell's equation to solve boundary value problems and problems related to communication.	Applying (C3)
CO4	Analyze complex physical problem of relativistic and nonrelativistic electrodynamics	Analyzing (C4)

Module No.	Title of the Module	Topics in the Module	No. of Lectures for the module
1.	**Electrostatics and boundary value problems in electrostatics**	Coulomb's law, Gauss's law, Laplace and Poisson equations, Method of Images, Boundary value problems (in spherical and cylindrical coordinates), multipole expansion and Dielectrics (energy and forces in dielectric systems), minimum energy theorem, applications of electrostatic fields (e.g., electrostatics particle precipitators, photo duplication or Xerography and electrostatic lenses).	9
2.	**Magnetostatics, Faraday's law and quasi-static fields**	Biot-Savart law, differential equation of magnetostatics and Ampere's law, Faraday's law of induction, Magnetic vector potential, multipole expansion of the vector potential and magnetic field in matter, energy in the magnetic field	6
3.	**Electrodynamics**	Time varying field, continuity equation, Maxwell's equations, Pointing theorem, Gauge transformations, gauge invariance, Electromagnetic waves in free space, dielectrics and conductors, Fresnel's equations,	12
4.	**Radiation and special theory of relativity**	Retarded potentials, Lienard-Wiechert Potentials, fields due to a Point charge moving with constant velocity, Fields due to accelerated point charge, Recollection of the ideas of special theory of relativity, Four-vector and Lorentz transformation in four-dimensional space; Lorentz	13

		invariants of electromagnetic fields; Transformation of electric and magnetic field vectors.	
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Class Tests (6 M), Attendance (5 M), PBL (10 M) and Cass 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.	J D Jackson, Classical Electrodynamics, Wiley, New Delhi 2017
2.	D. J. Griffiths, Introduction to electrodynamics, Pearson (Prentice Hall), New Delhi 2008
3.	T L Chow, Introduction to Electromagnetic Theory: A modern perspective, Jones and Bartlett Learning, New Delhi, 2014

Project Based Learning: Small projects related to the course will be assigned to the students with an aim to increase their interest in the subject by establishing a connection between the topics taught in class and the devices used in house-hold and industry that uses electrostatic force, and the ideas of electrodynamics. Further, projects related to the optimal designs of air purifier, printer, etc., will be assigned to enhance entrepreneurial skill and employability.

Detailed Syllabus
Lecture-wise Breakup

Course Code	19M21PH116	**Semester: Even**	**Semester: II Session** 2022 -2023 **Month from: January to June**
Course Name	Atomic, Molecular and Laser Physics		
Credits	4	**Contact Hours**	3+1

Faculty (Names)	**Coordinator**	Prof. Papia Chowdhury
	Teacher	Prof. Papia Chowdhury

COURSE OUTCOMES		**COGNITIVE LEVELS**
C121.1	Recall basics of one, two and many electron systems. Normal & anomalous Zeeman, Paschen-Back and Stark effects; L-S and J-J coupling schemes. Hartree-Fock approximation	Remembering (C1)
C121.2	Explain Born-Oppenheimer approximation. States for hydrogen molecule and molecular ion (H_2, H_2+). Term symbol for simple molecules	Understanding (C2)
C121.3	Apply concepts of rotational spectra, vibrational spectra, electronic spectra of diatomic molecules; Franck-Condon principle. Raman spectra. Electron Spin Resonance. Nuclear Magnetic Resonance	Applying (C3)
C121.4	Analyze spontaneous and stimulated emissions in laser; optical pumping population inversion, rate equations. Different laser systems like Ruby, He-Ne, CO_2 and Nd:YAG lasers	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Atomic Physics	Hydrogen atom and other one electron systems, two electron systems, many electron systems, spin-orbit term, intensity of fine structure lines. Effect of magnetic and electric fields: Normal and anomalous Zeeman, Paschen-Back and Stark effects. Interaction energy in L-S and J-J coupling schemes, Lande interval rule. Hartree-Fock approximation.	10
2.	Molecular Structure	Molecular electronic states, Born-Oppenheimer approximation. States for hydrogen molecule and molecular ion (H_2, H_2+). Spectroscopic terms, term symbol for simple molecules.	8
3.	Molecular Spectra	Rotational spectra of diatomic molecules-rigid and non-rigid rotors, isotope effect, Vibrational spectra of diatomic molecules- harmonic and anharmonic vibrators, Intensity of spectral lines, dissociation energy, vibration-rotation spectra, Electronic spectra of diatomic molecules-vibrational structure of electronic transitions. Rotational structure of electronic bands (Fine structure)-P,Q,R branches, Fortrat diagram. Intensities in electronic bands-The Franck-Condon principle. Raman spectra, X-ray emission spectra. Electron Spin Resonance. Nuclear Magnetic Resonance.	14
4.	Lasers	Introduction to Laser and Maser, spontaneous and stimulated emissions, Einstein A & B coefficients, optical pumping, population inversion, rate equations, modes of resonators and coherence length, Ruby, He-Ne, CO_2 and Nd:YAG lasers.	8
		Total number of Lectures	**40**
Evaluation Criteria			

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [(PBL:10+ Quiz: 5+ Internal: 5+ Attendance:5)]
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.	Physics of Atoms and Molecules by B. H. Bransden and C. J. Jochain (2nd Ed., Pearson Education, 2003)
2.	Atomic Spectra and Atomic Structure by G. Herzberg (Dover Publications, 2003)
3.	Atoms, Molecules and Photons by W. Demtroder (Springer, 2006)
4.	Fundamentals of Molecular Spectroscopy by C. N. Banwell (McGraw Hill, 1983)
5.	Basic atomic & Molecular Spectrocopy by J. M. Hollas(Royal Society of Chemistry, 2002)
6.	Principles of Lasers by O. Svelto (5th Ed., Springer, 2010)

Project based Learning (PBL): Core competency development in basics of application of Schrodinger equation on atoms and molecules. The course also deals with the working of different Lasers depending on their applicability in Industry. Students will make some individual projects on selected Topics of application of Quantum Mechanics on atoms, molecules like some approximation techniques. Students will also do some project work on LASER applications. Example: For drug designing different quantum mechanical approximation techniques are used, Lasers are used for the making of optical sensors, cutters, viewers which are applied in defence purpose and in medical science. Each project work will describe the detail about the specific applied field. Students will take help from available internet sources, current research papers, Text books for preparing the project. Throughout the preparation of the whole project and by presenting the project work students will gather deep learning about the applicability of atoms , molecules or Lasers for the requirement of current Industry. The overall knowledge will help them to prepare themself as an efficient Physicist according to the requirements of current Industry.

<u>Detailed Syllabus</u>
Lecture-wise Breakup

Course Code	**19M21PH117**	**Semester: Even**	**Semester:2022-2023Session** **Month from: January to June**
Course Name	**Statistical Mechanics**		

Credits	**3-1-0**	**Contact Hours**	**4**

Faculty (Names)	**Coordinator**	**Dr. Guruprasad Kadam**
	Teacher	**Dr. Guruprasad Kadam**

COURSE OUTCOMES		**COGNITIVE LEVELS**
C122.1	Define the basic laws and parameters related to Thermodynamics and Statistical Mechanics.	Remember Level (C1)
C122.1	Explain the concepts of different Thermodynamic and Statistical Systems and Ensembles.	Understand Level (C2)
C122.1	Apply the concepts of Thermodynamics and Statistical ensembles to conclude its properties.	Apply Level (C3)
C122.1	Evaluating the behavior of equilibrium, non-equilibrium or a random process on the basis of suitable thermodynamic parameters, distribution functions and phase transition.	Evaluate Level (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Evaluation of Energy States**	Micro- and Macro-states, Degenerate and Non-degenerate states, Two State Systems, Harmonic Oscillators, Einstein's Model of Crystalline Solid, Density of States, Particle in a box.	**6**
2.	**Classical Statistical Mechanics**	Classical Phase space, Number of Microstates, Ideal gas, Entropy: Gibbs' Paradox, Liouville's Theorem in Classical Statistical Mechanics,	**5**
3.	**Ensembles and Distribution Functions**	Micro-canonical, canonical and grand-canonical ensembles and partition functions; Free energy and its connection with thermodynamic quantities; Classical and quantum statistics. Boltzmann Limit, Sackur-Tetrode equation.	**10**
4.	**Applications of Distribution Functions**	Degenerate Fermi gas; Ideal Bose and Fermi gases; Principle of detailed balance. Blackbody radiation and Planck's distribution law; Bose-Einstein condensation, Diamagnetism, paramagnetism, and ferromagnetism, White Dwarf Stars, Saha-Ionsization Equation.	**10**
5.	**Phase Transition and Stochastic Processes**	First- and second-order phase transitions. phase equilibria, critical point. Introduction to nonequilibrium processes, Ising model. Diffusion equation. Random walk and Brownian motion.	**9**
		Total number of Lectures	**40**
Evaluation Criteria			

Components	Maximum Marks
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (6 M), Internal assessment (4 M), Attendance (5 M) and PBL (10 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.	Frederick Reif , *Fundamentals of Statistical and Thermal Physics*, Waveland Pr Inc, 2008.
2.	Kerson Huang , *Statistical Mechanics*, Wiley, 2nd Ed., 1987.
3.	R K Pathria, Paul D. Beale, *Statistical Mechanics*, Academic Press, 3rd Ed., 2011.
4.	Statistical Mechanics, Richard P. Feynman, Westview Press, USA, 2008
5.	Statistical Mechanics: An Elementary Outline (Rev.Ed.), AvijitLahiri, Universities Press, 2015

Project based learning: Students would work on a project of their choice in the field of materials science processing, property determination and application. In such projects students can not only apply the basic concepts to recognise the appropriate ensemble and distribution function but also should be able to analyze the type and behaviour of Phase transitions; analysis of an equilibrium or nonequilibrium system to determine the properties, predict its time-evolved behaviour employing Ising model, diffusion equation, Random walk etc. The learning obtained through this project would not only provide deeper understanding of the pertinent concepts of this course but also develop the skills of applying the statistical mechanics to solve the related problems in condensed matter physics, material science etc. and hence paves the way for employability prospects in all such fields where research and development usually require the analysis of systems with thermodynamic limit.

CO-PO MAPPING:

COs	PO1	PO2	PO3	PSO1
C122.1	1			
C122.2	1			
C122.3	2	1		1
C122.4	3	2		2

3: Strongly Related 2: Moderately Related 1: Weakly related Left Blank: Not related

Detailed Syllabus
Lecture-wise Breakup

Course Code	19M21PH118	**Semester:** Even	**Semester: II Session:** 2022-23 **Month from:** January-June
Course Name	Condensed Matter Physics		
Credits	04	**Contact Hours**	04

Faculty (Names)	**Coordinator**	Prof. R.K. Dwivedi
	Teacher	Prof. R.K. Dwivedi

COURSE OUTCOMES		**COGNITIVE LEVELS**
C123.1	To recall the basic concept of space lattice, lattice type and crystal structure, Bonding, band diagrams, heat capacity, thermal expansion, thermal and electronic conduction in solids like metals, semiconductors, dielectrics, magnetics and superconductors	Remembering (C1)
C123.2	To Illustrate the Lattice vibrations, Debye and Einstein's model, Croning-Penny model and various physical phenomena with interpretation based on the mathematical expressions involved.	Understanding (C2)
C123.3	Apply the concepts/principles to solve the problems related to Solid State Physics.	Applying (C3)
C123.4	Analyze and examine the crystal structure of solids, thermal, electrical and electronic properties and establish a correlation between structure and properties	Analyze level (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Crystal Physics	Concept of space lattice, basis and primitive cell, bravais lattices, Crystal Symmetry, intercepts of plane and miller indices, lattice type, packing efficiency, reciprocal lattice, structure factor, crystal structures (NaCl, CsCl, Diamond and cubic ZnS) and Brag's law and X-ray diffraction methods. Bonding in solids, ionic bonding, Cohesive energy and Madelung Constant in ionic crystals.	12
2.	Thermal Properties	Phonon heat capacity, specific heat, Density of states in one dimension, Density of states in three dimension, Debye's model for density of space, Debye T^3 Law, Einstein model density of states, Thermal conductivity, A brief introduction to Imperfections.	10
3.	Band theory of solids	Free electron model, Origin of energy gap, Bloch theorem, Croning-Penney model, Wave function of electron in a periodic potential, Energy band formation in solids, Classification of solids into metals, semiconductors and insulators.	8
4.	Electrical properties in solids	Electrical conduction in metals and semiconductors, Intrinsic and Extrinsic semiconductors, mobility, Intrinsic carrier concentration, impurity diffusion, Carrier	5

		concentration of n-type and p-type semiconductors.	
5.	Superconductivity	Occurrence of superconductivity, Meissner effect, Type –I and Type-II superconductor, Heat capacity, Energy gap, Isotope effect. Microwave and Infrared properties. London equations and BCS theory.	5
		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.	Solid State Physics by A. J. Dekker
2.	Solid State Physics by Charles Kittel, Wiley Publication, Eight Edition (2017)
3.	Solid State Physics by N. W. Ashcroft & N. D. Mermin
4.	Solid State Physics by S.O. Pillai, New Age Publications (Revised sixth Ed. (2007)

Project based learning: Students would work on a project of their choice in the field of Condensed Matter Physics. In such projects, students can not only learn the basic concepts but also realize how to analyses data of its electrical and magnetic behaviors. The learning obtained through the project would not only provide deeper understanding of the pertinent concepts of this course but also develop the skills to use the material properties for the desired industry. In this subject, PBL may explore the employability aspects in research and development field of material design and its applications.

Detailed Syllabus
Lab-wise Breakup

Course Code	19M25PH112	Semester: EVEN	Semester: 2nd Session: 2022 -2023 Month from: Jan to June
Course Name	Laboratory-2		
Credits	4	Contact Hours	8

Faculty (Names)	Coordinator(s)	B. C. Joshi
	Teacher(s) (Alphabetically)	B. C. Joshi Dinesh Tripathi Ravi Gupta Dr. Anuraj Panwar

COURSE OUTCOMES		COGNITIVE LEVELS
CO1	Recall components of electronic circuits used in the experiments.	Remembering (C1)
CO2	Explain key applications of electronic circuits and devices used in the experiments.	Understanding (C2)
CO3	Model the circuits using electronic components and perform the experiments.	Applying (C3)
CO4	Analyze the data obtained and calculate the error.	Analyzing (C4)
CO5	Interpret and justify the results.	Evaluating (C5)

Module No.	Title of the Module	List of Experiments	CO
1.	Electronics	1. To assemble a two stage common emitter RC coupled amplifier and to measure the gain as a function of frequency and hence find the gain band width 2. Design and realize Inverting and Non-inverting amplifier using 741 Op-amp. 3. To design and test the performance of an integrator using 741 OP AMP 4. To study and calculate the frequency of oscillations of Colpitts oscillator. 5. To study and calculate frequency of oscillations of OP-AMP based Hartley Oscillator. 6. Design of an RC Phase Shift Oscillator (Using IC 741 OP AMP) and calculation of its frequency of oscillation. 7. To design and set up (a) half adder & half subtractor and (b) full adder & full subtractor using NAND gate. 8. To study the single stage amplifiers; using BJT in common emitter (CE) configuration and to learn its application as a	1-5

		small signal amplification. 9. To use the operational amplifier as filers of different frequency range. 10. Design and study of regulated power supply. 11. FET and MOSFET characteristics and its applications as amplifier. Besides above experiments, students will be trained in mechanical workshop. (Training on lathe and grinding, drilling and threading etc.)	

Evaluation Criteria

Components	**Maximum Marks**
Mid Term Viva (V1)	20
End Term Viva (V2)	20
D2D	60 (Attendance-10, Lab Record-10, PBL-10, Daily Viva voice (6 experiment 5 marks)-30)
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.	Experiment hand-outs.

Project based learning: Each student in a group of 3-4 or individually will develop a mini project with the help of various concepts of Electronic circuits and Devices. Individually or in a team they will learn how to apply the concepts for problem solving in a meaningful way.

Detailed Syllabus
Lecture-wise Breakup

Course Code	20M22PH219	**Semester** **Even**	**Semester:** 4th **Session** 2022 -2023 **Month from January to June**
Course Name	Plasma Physics		
Credits	3	**Contact Hours**	L (3)

Faculty (Names)	**Coordinator(s)**	Dr. Anuraj Panwar
	Teacher(s)	Dr. Anuraj Panwar

COURSE OUTCOMES		**COGNITIVE LEVELS**
C231-5.1	Define terminology and concepts of plasma physics with various astrophysical phenomena.	Remembering (C1)
C231-5.2	Summarize plasma and explain propagation of waves in plasmas, and derive the dispersion relation for these waves.	Understanding (C2)
C231-5.3	Develop two fluid and magneto-hydrodynamic fluid models to explain various phenomena taking place in astrophysical environment.	Applying (C3)
C231-5.4	Analyse and formulate mathematical / analytical expressions for various nonlinear processes in plasma astrophysics.	Analysing (C4)
C231-5.5	Evaluate physical problems, estimate their numerical solutions and draw inferences from the results.	Evaluating (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Introduction and Description Plasmas**	Definition of Plasma, Debye shielding, Criteria for Plasmas, Single particle model: Charge particle in uniform and nonuniform electric and magnetic fields, Grad-B drift, Curvature drift, Polarization drift, Adiabatic invariants, Magnetic mirror machine. Plasma two-fluid model, Generalized Ohm's law, MHD plasma model, frozen-in condition. Diamagnetic drift.	8
2.	**Waves in Plasmas**	Plasma oscillations, Electron plasma waves, Ion waves, Upper hybrid wave, Lower hybrid wave, Electromagnetic waves in plasmas, Ordinary wave, Extraordinary wave, Whistler wave. Faraday rotation.	10

		MHD waves: Magnetosonic wave, Shear Alfven wave, Kinetic Alfven wave and Inertial Alfven wave.	
3.	**Shocks and Discontinuities**	Rankine-Hugoniot relations, MHD discontinuities (rotational, tangential), shock thickness, intersecting characteristics.	4
4.	**The Energy Principle and Instabilities**	The Energy Principle, Rayleigh-Taylor instability, Kelvin-Helmholtz instability, Parker instability, Magneto-rotational instability, Jeans instability, Current-driven (kink) instability.	6
5.	**Astrophysical Dynamos**	Cowling's Theorem, Parker's Model for the Earth's Dynamo, The Mean Field Dynamo Theory, Dynamo Modes in the Galactic Disk, Protogalactic Origin of the Magnetic Field, The Biermann Battery, The Protogalactic Dynamo, Small-Scale Fields.	6
6.	**Magnetic Reconnection**	Magnetic reconnection in laboratory, planetary magnetosphere and in the sun, Magnetic diffusion, Spitzer resistivity, Sweet-Parker Model, and Petschek Model, Hall Reconnection, Tearing instability.	6
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 (PBL:10+ Quiz: 5+ Internal: 5+ Attendance:5)
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.	Introduction to Plasma Physics and Controlled Fusion by Francis F. Chen, Springer.
2.	Fundamentals of Plasma Physics, J. A. Bittencourt, Springer.
3.	Introduction to Plasma Physics with Space, Laboratory and Astrophysical Applications by Donald A. Gurnett, Amitava Bhattacharjee, Cambridge University Press.
4.	Plasma Physics for Astrophysics, Russell M. Kulsrud, Princeton University Press 2005.

Project based Learning: Short projects will be assigned to students to submit project reports on natural and engineering applications of plasma physics. Students may be asked to make presentations on astrophysics topics like magnetic reconnection, astrophysical dynamos, plasma shocks and fluid instabilities. Students may be asked to present recent published articles on plasma applications. Students may be asked to solve astrophysical plasma physics problems by using their expertise computer language.