Detailed Syllabus
Lecture-wise Breakup

Course Code	19M21PH216	**Semester:** Even	**Semester: IV** **Session:** 2021-2022 **Month from:** January-June
Course Name	Advanced Condensed Matter Physics-2		
Credits	04	**Contact Hours**	04

Faculty (Names)	**Coordinator(s)**	Ashish Bhatnagar
	Teacher(s) (Alphabetically)	Ashish Bhatnagar

COURSE OUTCOMES		**COGNITIVE LEVELS**
C230-5.1	Understand the Physics behind the defects in materials	Remember Level (C1)
C230-5.2	Understand the role of defects in determining properties of materials	Understand Level (C2)
C230-5.3	Develop knowledge of conception or notion involved in various theories and models studied in this course	Apply Level (C3)
C230-5.4	Applying various experimental method/tools to understand the defects in solids	Apply level (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Defects and Diffusion in solids	Introduction to Defects. Equilibrium Point defects, Vacancy Formation, Vacancy Concentration Determination, Self-Interstitial Defects, Frenkel Defects, Extrinsic Defects, Equilibrium Concentration of Defects, Thermodynamics of Defects, Interstitial Diffusion. Non-Steady State Diffusion, Self Diffusion,, Diffusion Along Defects	12

2.	Extended Defects	Dislocations, Edge Dislocations, Mixed Dislocations, unit and Partial Disclocations, Multiplications of Dislocations, Interaction of Dislocations and Point Defects: Dislocations Loops, Dislocation climb, Decoration of Dislocation, Internal Boundaries, Low angle Boundaries, Twin Boundaries, Antiphase Boundaries	12
3.	Defects Dynamics	Dislocation in FCC, HCP and BCC, Partial Dislocation, Stacking Fault, Burger Vector and its properties	8
4.	Observation of Defects in Solids	Experimental method of detecting dislocations and sta cking faults, Electron Microscopy: Kinematical theory of diffraction contrast and lattice imaging.	8
		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. Richard J. D. Tilley, "Defects in Solids", John Wiley & Sons, Inc.

2 Weertman J. and Weertman J. R. "Elementary Dislocation Theory"

3 Anderson P.M. , Hirth J.P., Lothe J., "Theory of Dislocations" 3rd Edition

4 Hirsch, P.B., "Electron Microscopy of Thin Crystals"

Project based learning: Students would work on a project of their choice in the field of defects in materials. In this project student will identify the materials with a defect and then apply various experimental techniques like electron microscopy, X-Ray Diffraction to visualize/calculate the various parameter related to defects etc. The student will also compare the theory proposed about the given defects with their observations through above mentioned experimental techniques. This practice will improve their hands-on practical skill which is one of the main criteria for employability.

Detailed Syllabus

<table>
<tr><td>Course Code</td><td>19M27PH211</td><td colspan="2">Semester: EVEN</td><td colspan="2">Semester: 4th Session: 2021-22
Month from: Jan to June</td></tr>
<tr><td>Course Name</td><td colspan="5">Dissertation</td></tr>
<tr><td>Credits</td><td colspan="2">10</td><td>Contact Hours</td><td colspan="2">20</td></tr>
<tr><td rowspan="2">Faculty (Names)</td><td>Coordinator(s)</td><td colspan="4">Manoj Kumar</td></tr>
<tr><td>Teacher(s) (Alphabetically)</td><td colspan="4">Dinesh Tripathi</td></tr>
<tr><td colspan="5">COURSE OUTCOMES</td><td>COGNITIVE LEVELS</td></tr>
<tr><td>C250.1</td><td colspan="4">Review the contemporary scholarly literature, activities, and explore experimental and theoretical tools/ techniques/software/hardware for hands-on in the respective project area in various domain of theoretical and experimental condensed matter and applied optics.</td><td>Understanding (C2)</td></tr>
<tr><td>C250.2</td><td colspan="4">Acquire knowledge in the selected field of study. Analyze various feasible methods/techniques of solving a problem to slot a appropriate solution methodology</td><td>Analyzing (C4)</td></tr>
<tr><td>C250.3</td><td colspan="4">Employ latest techniques and software tools to accomplish the proposed objectives. Evaluate/validate obtained results based on evidence and analysis.</td><td>Evaluating (C5)</td></tr>
<tr><td>C250.4</td><td colspan="4">Demonstrate the technical report writing and oral communication skills. Illustrate the significance of possible future developments in the selected field.</td><td>Create Level (C6)</td></tr>
</table>

S.N.	**Topics in module**
Module 1	Identification of the dissertation problem and literature review in the related field and explore experimental and theoretical tools/ techniques/software/hardware.
Module 2	Acquire knowledge and analyze various methods/techniques to be used in solving the defined problem and find a suitable methodology.

Module 3	Utilize latest techniques/software/hardware tools to achieve the proposed objectives and obtain results. Evaluation/analysis of the obtained results and their interpretation.
Module 4	Compilation of the results and report writing with ethics (plagiarism less than 10%) and presentation of the dissertation work.

Evaluation Criteria

Components	**Maximum Marks**
Day to Day Evaluation	40 (To be awarded by supervisor)
End Semester Evaluation	50 (To be awarded by a panel of 3 examiners)
Special Contribution	10 (To be awarded by a panel of 3 examiners)
Total	**100**

Detailed Syllabus

Lecture-wise Breakup

Course Code	20M22PH215	**Semester: Even**	**Semester 4th Session 2021-22** **Month from: Feb to June**
Course Name	Introduction to Nanoscience		
Credits	**3**	**Contact Hours**	**3**

Faculty (Names)	**Coordinator**	Dr. Sandeep Chhoker
	Teacher	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall basics of nanoscience and nanomaterials	Remembering (C1)
CO2	Explain various physical phenomena under the domain of nanoscience	Understanding (C2)
CO3	Apply the concept and principles to solve problems related to nanoscience	Applying (C3)
CO4	Analyze and examine the concepts of nanoscience and nanomaterials for application-oriented outcomes	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Introduction to nanoscience**	Development of nanoscience and nanotechnology, naturally occurring nanomaterials, Introduction to Quantum Mechanics (with relevance to nanotechnology), Electron confinement using Schrodinger wave equation, Particle confinement in 1-D, 2-D, 3-D box, Density of states. Potential barrier and Particle tunneling; Its applications	6
2.	**Properties of nanomaterials**	Classification of nanomaterials, Bulk to Nano, Surface to volume ratio, Surface states and energy (Reactivity and fluctuations), Semiconducting nanoparticles (optical properties), Metallic nanoparticles (surface plasmons), Magnetic nanoparticles (superparamagnetism/nanomagnetism), Mechanical properties of nanomaterials, Chemical Properties of Nanomaterials (Reactivity etc.)	8
3.	**Synthesis of nanomaterials**	Top to Bottom approach and Vice Versa, Nucleation and Growth, Physical Methods, Mechanical Methods (Ball milling and Melt Method), Evaporative methods,	10

		CVD and Sputtering, Epitaxial Growth, Chemical Methods (Sol Gel, precipitation, Hydrothermal, Spray), Langmuir-Blodget Method	
4.	**Some special nanomaterials**	Carbon nanomaterials (Fullerenes, CNT and Graphene), Nanomagnetism, Superconducting nanomaterials, Solar materials, Sensing Materials, High mobility and 2-D electron gas materials, Metal-Organic Framework, Porous Materials, Core-Shell Materials,	10
5.	**Applications of nanomaterials**	Energy Applications, Si-based solar cells, DSSC, Hydrogen Storage, Battery and Fuel cells, Photo detector, Quantum well nanostructures for LEDs, GaN and its Applications, Environmental and Agricultural Medical, space, food and others	6
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (10 M) PBL (10 M) and class performance (5 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. Nanostructures and nanomaterials: synthesis properties and application, Guozhong Cao, Imperial college press, London.
2. Introduction to nanotechnology, Charles Poole et al J John Wiley & Sons, Singapore.
3. Nanotechnology: Principles and Practises by Sulbha Kulkarni 3rd edition Springer

Project Based Learning: Each student will be given a small project in which they will carry out the theoretical or experimental work on the selected topic from energy applications, Si-based solar cells, DSSC, hydrogen Storage, battery and fuel cells, photo detector, quantum well nanostructures for LEDs, GaN and its applications, environmental and agricultural medical, space, food and others. Synthesis part for the experimental project will be carried out in the laboratory facility of the Department and the theoretical part will be kept feasible for the student to execute. This project will make them prepared for industry jobs in the nanomaterial industry as well as for higher studies.

Detailed Syllabus

Lecture-wise Breakup

Course Code	20M22PH216	**Semester: Even**	**Semester:** IV **Session: 2021-2022** **Month: January to June**
Course Name	Design and Fabrication of Solar Cells		
Credits	3	**Contact Hours**	3
Faculty (Names)	**Coordinator(s)**	Manoj Kumar	
	Teacher(s)		

COURSE OUTCOMES		**COGNITIVE LEVELS**
C231-2.1	Classify the various types of renewable and nonrenewable energy resources and explain the working of photovoltaic devices.	Understand Level (C2)
C231-2.2	Demonstrate the basic principles to design, model and fabricate photovoltaic devices.	Understand Level (C2)
C231-2.3	Identify challenges and apply strategies to optimize performance of various type of solar cells	Apply Level (C3)
C231-2.4	Analyze Solar PV module, mismatch parameter and rating of PV module	Analyze Level (C4)
C231-2.5	Evaluate the performance of various stand-alone PV systems with battery and AC and DC load	Evaluate Level (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Review	Energy issues, conventional energy sources, Renewable energy sources, Solar Energy	02
2.	Solar cell fundamentals	Semiconductor materials, carriers generation and recombination, p-n junction diode, p-n junction under illumination, Current-Voltage (I-V), open circuit voltage (V_{OC}), short circuit current (I_{SC}), Maximum power, current and voltage and Efficiency, Quantum Efficiency	08
3.	Solar cell Design and Technologies	Upper limits of cell parameters, loses in solar cell, solar cell design, design for high I_{sc}, V_{oc}, FF, Production of Si, Si wafer based solar cell technology, thin film solar cell technologies (CIGS, microcrystalline and polycrystalline Si solar cells, amorphous Si thin film solar cells), multijunction solar cells, Emerging solar cell technologies: organics solar cells, Dye-sensitized solar cell (DSSC), GaAs solar cell, Introduction of perovskite soar cell.	12
4.	Fabrication and characterization of solar cells	Fabrication of Si solar cells: Surface preparation, texturization, diffusion, etching, cleaning, oxide passivation, metal print, back contact print, firing/sintering, testing, Characterization: Solar Simulators and Quantum Efficiency measurement	10

5.	Solar Photovoltaic Applications	Solar Photovoltaic Modules, Series/parallel connection, mismatch, bypass diode, Effect of temperature, Balance of system- BOS (Inverters, Controllers, Wiring, Batteries), Photovoltaic system, Standalone system, Grid connected system, Hybrid system, Designing of PV system, Estimating PV system size and cost, Photovoltaic safety.	08
		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, Quizzes, *etc* (05 M), Assignments in PBL mode (10 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.	Tom Markvart and Luis Castaner, "Solar Cells: Materials, Manufacture and Operations," Elsevier, 2006
2.	Stuart R. Wenhem, Martin A. Green, M.E. Watt, "Applied Photovoltaics," Earthscan, 2007
3.	Jenny Nelson, "The Physics of Solar Cells" Imperial college press," Aatec publications, 1995.
4.	C S Solanki, "Solar Photovoltaics: Fundamentals, Technologies and Applications", PHI, 2015
5.	Richard J. Komp "Practical Photovoltaics: Electricity from Solar Cells", Aatec Publications, 1990

Project based learning: Students will have to submit a working project/model based on design & fabrication of solar cells. This will enhance their basic understanding of solar cell, issues in designing & fabrication of solar cells and their applications. At the end of the semester, students will be asked to submit and present their projects on the basis of which PBL marks will be awarded.