Department of Physics

Prof. Rajendra Singh (Rajju Bhaiya) Institute of Physical Sciences for Study and Research

V. B. S. Purvanchal University, Jaunpur U.P.

Syllabus of Pre-Ph.D. course work

Post Graduate Diploma in Research

As per NEP-2020 guidelines

With effective from **academic session 2026-27**

Subject prerequisites: Post-Graduate in Science Subjects

Programme outcomes (POs): Upon successful completion of the Post Graduate Diploma in Research in Physics, graduates will demonstrate the following program outcomes:

PO1: Advanced Knowledge: Explain and apply advanced concepts, theories and principles of Physics, particularly in materials physics, experimental techniques and research methodology.

PO2: Research Skills: Design and conduct independent research using appropriate theoretical, experimental, computational and analytical methods.

PO3: Critical Thinking: Analyze complex and multidisciplinary research problems, evaluate available evidence and develop appropriate scientific solutions.

PO4: Effective Communication: Communicate research objectives, methodology, results and conclusions effectively through research papers, written reports, oral presentations and scientific discussions.

PO5: Ethical Conduct: Apply and evaluate ethical principles, publication standards and professional practices to ensure academic integrity and responsible conduct of research.

PO6: Interdisciplinary Collaboration: Collaborate effectively with peers, mentors, and researchers from diverse backgrounds, fostering an interdisciplinary approach to research in physics.

PO7: Computer Proficiency: Develop proficiency in using computer applications, computational tools, and software relevant to physics research, enhancing data analysis and modelling capabilities.

Programme specific outcomes (PSOs): Upon successful completion of the Post Graduate Diploma in Research in Physics, graduates will be able to

PSO1: Apply and analyze advanced microscopy and spectroscopy techniques for the structural, morphological and chemical characterization of materials.

PSO2: Perform and evaluate sample preparation, data collection and instrument-operation procedures for conducting independent research.

PSO3: Graduates will be skilled in designing research experiments, formulating hypotheses, and applying appropriate research methodologies for scientific investigations.

PSO4: Graduates will possess strong data analysis skills, enabling them to interpret research results accurately and draw meaningful conclusions.

PSO5: Graduates will understand and adhere to ethical principles in research, including authorship, citation, and responsible research publication practices.

PSO6: Graduates will be proficient in using computational tools and software for data analysis, modelling, and simulations, enhancing their research capabilities in the digital age.

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Prof. P. K. Yadawa
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List of all papers of Pre-Ph.D. course work or Post Graduate Diploma in Research (PGDR)

Year	Sem	Course Code	Course Title	Theory/ Research	Credit	Max. Marks
6	XI	B011101T	Physics of Matter	Theory	6	100 [25(CIE)+75(UE)]
		B011102T	Experimental Techniques	Theory	6	100 [25(CIE)+75(UE)]
		B011103T	Research Methodology, Research Publication Ethics and Computer Applications	Theory	4	100 [25(CIE)+75(UE)]
		B011104R	Research Project	Research	-	100 [25(CIE)+75(UE)]

Credit system:

- A four (4) credit theory course/paper will have four Lectures/periods (of one hour) in a week. In one full semester the course will be covered in 60 Lectures.
- Similarly, a six (6) credit theory course/paper will have six Lectures/periods (of one hour) in a week. In one full semester the course will be covered in 90 Lectures.

Continuous Internal Evaluation (CIE) of 25 marks:

- Continuous internal evaluation will be performed by the teacher/ course coordinator concerned.
- CIE shall be 25% of total assessment in a Theory paper and research project.
- 25 marks shall be distributed as 5 marks for attendance, 5 marks for presentation and assignment and remaining 15 marks for class test.

Marking system:

- All papers will have a total maximum mark of 100, including both CIE and University Examination (UE). Maximum marks of 25 will be allotted to CIE and 75 to UE in a theory paper/ research project.
- The CIE of the research project shall be evaluated by the research supervisor and co-supervisor (if any).
- 75 marks of **research project** shall be distributed as 50 marks (project work and presentation) and a viva voce of 25 marks.
- The evaluation (Max Marks 75 UE) of the research project shall be done by internal examiner/s (Supervisor and Co-supervisor (if any)) and one external examiner appointed by the University.

Research Project Submission:

- The evaluated research project report in two sets of hard copy (spiral binding) must be prepared. One copy of it shall be submitted to the university if it demands. A second copy of the evaluated research project report must be in the records of the college/research centre.
- The format of university Ph.D. thesis writing guidelines can be used as format of Research project writing guidelines.

Programme: Post graduate Diploma in Research (PGDR)	**Year: six** (6)	**Semester:** XI
Subject: Physics		
Course Code: B011101T	**Course Title:** Physics of Matter	
Course Outcomes (COs): By the end of this course, students will be able to- CO1: Classify metals, alloys, ceramics, composites, intermetallic compounds, liquid crystals, and nanomaterials based on their structure and properties, and explain the effect of dimensionality on material properties. CO2: Explain the fundamentals of semiconductor physics and analyze the band structures, density of states, and Fermi levels of metals, insulators, and intrinsic and extrinsic semiconductors.		

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CO3: Apply semiconductor principles to design and characterize solar cells, thermoelectric devices, LEDs, and photodetectors
CO4: Analyze ultrasonic velocity, attenuation, and related parameters, and apply appropriate measurement techniques for the characterization of different materials.
CO5: Compare classical, Einstein, and Debye theories of specific heat and explain the relationship between thermal properties and material structure.
CO6: Explain the principles of Density Functional Theory, including functionals, functional derivatives, many-body problems, and the Hohenberg–Kohn theorems, and apply LDA, GGA, and hybrid exchange functionals to the structural optimization of materials.

Credits: 6	**Core Compulsory**
Max. Marks: 25 (CIE) + 75(UE)	**Min. Passing marks: 55**
Total number of lectures: Lectures-Tutorial-Practical (6 hours in a week) L-T-P: 6-0-0 **(90 hr)**	

Unit	Topics	No. of Lecture Hrs.
I	**Introduction to Material Science**: Types of Materials – Metals and alloy, ceramics, Composites, Intermetallics, Liquid Crystals and Nano-materials, Emergence of Nanotechnology, Historic Background, System classification confined to one two or three dimensions and their effect on properties,	15
II	**Review of semiconductor physics:** Band Structure of metals, insulators and semiconductors, E-K diagram, Density of States, Fermi Level Intrinsic and extrinsic semiconductors. Design and characterization of Solar Cells, Thermoelectric devices, Light Emitting Diodes (LEDs), Photo Detectors (PDs).	15
III	**Ultrasonic Properties of the Materials:** Characteristics and detection of ultrasonic wave, Classification of ultrasonic application and testing, Ultrasonic NDT as a material characterization, Ultrasonic velocity related parameters and its theoretical evaluation, measurement techniques of ultrasonic velocity, Source of ultrasonic attenuation; Measurement techniques of ultrasonic attenuation, Ultrasonic attenuation and velocity in different materials.	15
IV	**Thermal Properties of Materials**: Classical, Einstein and Debye theory of specific heat, Vibrations of Crystal lattices, Thermal Conductivity, Thermal Expansion, Specific heat capacity, thermal diffusivity, and Thermal stability.	18
V	**Thermoelectric properties of the materials**: Thermoelectric Effect, Seebeck coefficient, Peltier Effect, Thomson Effect, electric conductivity, Methods of tuning the thermoelectric parameters and their optimization. Thermoelectric Properties in Bulk and Low-Dimensional Structures. Applications of thermoelectric materials.	15
VI	**Density Functional Theory**: Functionals and the Functional Derivative, Many-body problems, The Hohenburg-Kohn Theorems, Local Density Approximation (LDA), Generalised Gradient Approximation (GGA), Hybrid Exchange Functionals. Structural optimization using DFT.	12

Suggested Readings:

Textbooks:

1. Chung YW, Kapoor M, "Introduction to Materials Science and Engineering" TAYLOR & FRANCIS, Boca Raton, 2022. 2nd Edition.
2. Kittel, C. Introduction to Solid State Physics. Wiley, 2018, 9th Edition.
3. Neamen, D. A. Semiconductor Physics and Devices. McGraw-Hill Education.
4. Grimvall G, "Thermophysical Properties of Materials", Elsevier, Holland, 1999.
5. Goldsmid, H. J. Introduction to Thermoelectricity. Springer, 2016.

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6. Sholl, DS, Steckel, JA, "Density Functional Theory: A Practical Introduction" John Wiley & Sons, Inc., Hoboken, New Jersey, 2009

Reference Books:

1. Sze SM, Kwok K Ng, "Physics of Semiconductor Devices", Wiley & Sons, 2006.
2. Jiles, DC, "Sound Waves: Acoustic and Ultrasonic Properties of Materials", Introduction to the Principles of Materials Evaluation, CRC Press, Boca Raton, 2013.
3. Martin, R. M. Electronic Structure: Basic Theory and Practical Methods. Cambridge University Press.
4. Park CR, "Advanced Thermoelectric Materials", Wiley, USA, 2019.

Suggested Online Platforms:

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

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Programme: Post graduate Diploma in Research (PGDR)	**Year: six** (6)	**Semester:** XI
Subject: Physics		
Course Code: B011102T	**Course Title:** Experimental Techniques	

Course Outcomes (COs): By the end of this course, students will be able to-

CO1: Classify nanomaterials synthesis methods into top-down and bottom-up approaches, and explain the principles of physical and chemical synthesis techniques.
CO2: Apply appropriate synthesis techniques, including sol-gel, CVD, PVD, and MBE, to prepare nanomaterials and analyze their suitability for different applications.
CO3: Explain the principles of XRD, XPS, and SEM, and analyze structural, morphological, and surface-chemical information obtained from these techniques.
CO4: Operate and interpret TEM and AFM data to evaluate the morphology, size, and nanoscale surface characteristics of materials.
CO5: Apply TGA, DTA, and DSC techniques to analyze the thermal stability, phase transitions, and thermal behavior of nanomaterials.
CO6: Apply Raman, UV–Vis/NIR, and FTIR spectroscopy, along with thermal conductivity and ultrasonic measurement techniques, to characterize the composition and physical properties of nanomaterials, and integrate the results to evaluate their suitability for specific applications.

Credits: 6	**Core Compulsory**
Max. Marks: 25 (CIE) + 75(UE)	**Min. Passing marks: 55**

Total number of lectures: Lectures-Tutorial-Practical (6 hours in a week) L-T-P: 6-0-0 **(90 hr)**

Unit	Topics	No. of Lecture Hrs.
I	**Nanomaterial Synthesis Techniques**: Top-down and bottom-up synthesis approaches, Physical and chemical techniques for nanomaterial synthesis	15
II	**Advanced Nanomaterial Synthesis**: Preparation of nanomaterials, Sol-gel, CVD, PVD, and M.B.E etc, Nanowires synthesis, Carbon nanotubes synthesis, Graphene synthesis	15
III	**Structural Characterization Techniques:** X-ray Diffraction (XRD), X-ray photoelectron spectroscopy (XPS), Scanning electron microscopy (SEM)	15
IV	**Microscopy and Imaging Techniques**: Transmission electron microscopy (TEM), Atomic force microscopy (AFM)	15
V	**Thermal Analysis Techniques:** Thermo gravimetry analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC)	12
VI	**Spectroscopic and Advanced Measurement Techniques:** Raman spectroscopy, UV/Vis/NIR spectroscopy, UV-visible spectrophotometry, Thermal Conductivity Measurement Techniques, Ultrasonic Spectroscopy	18

Suggested Readings:

Text Books:

1. Poole, C. P. Jr., & Owens, F. J. Introduction to Nanotechnology. Wiley-Interscience, John Wiley & Sons, Hoboken, New Jersey, 2003.
2. Callister, W. D. Jr., & Rethwisch, D. G. Materials Science and Engineering: An Introduction. 10th Edition. John Wiley & Sons, 2018.
3. Goldstein, J. I., et al. Scanning Electron Microscopy and X-Ray Microanalysis. Springer, 3rd Edition, 2003.

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4. Gaisford, S., Kett, V., & Haines, P. (Eds.). Principles of Thermal Analysis and Calorimetry. 2nd ed., Royal Society of Chemistry, Cambridge, UK, 2016
5. Incropera, F. P., DeWitt, D. P., Bergman, T. L., & Lavine, A. S. Introduction to Heat Transfer. 6th ed., John Wiley & Sons, 2011.
6. Tse, P. W., & Shung, K. K. Ultrasonic Spectroscopy: Applications in Condensed Matter Physics and Materials Science.
7. Vitha, M. F. Spectroscopy: Principles and Instrumentation. John Wiley & Sons, 2018.

Reference Books:

1. Cullity, B. D., & Stock, S. R. Elements of X-Ray Diffraction. Pearson, 3rd Edition, 2014.
2. Williams, D. B., & Carter, C. B. Transmission Electron Microscopy: A Textbook for Materials Science. Springer.
3. Gauglitz, G., & Moore, D. S. (Eds.). Handbook of Spectroscopy. 2nd ed., Wiley-VCH, 2014.

Suggested Online Platforms: .

1. Swayam – Government of India, https://swayam.gov.in/explorer?category=Physics
2. National Programme on Technology Enhanced Learning (NPTEL), https://nptel.ac.in/course.html
3. Uttar Pradesh Higher Education Digital Library, https://heecontent.upsdc.gov.in/SearchContent.aspx
4. MIT Open Learning – Massachusetts Institute of Technology, https://openlearning.mit.edu/
5. edX, https://www.edx.org/course/subject/physics

Programme: Post graduate Diploma in Research (PGDR)	**Year: six** (6)	**Semester:** XI
Subject: Physics		
Course Code: B011103T	**Course Title:** Research Methodology, Research Publication Ethics and Computer Applications	

Course Outcomes (COs) By the end of this course, students will be able to-

CO1: Explain the objectives, significance and types of research, and formulate a suitable research problem, research design, sampling strategy and data-collection method.
CO2: Apply the stages of the research process, including literature review, material collection, classification, analysis and interpretation, to prepare a research synopsis, article or report
CO3: Analyze the principles of research ethics and scientific conduct, and distinguish between fabrication, falsification, plagiarism and other forms of publication misconduct.
CO4: Evaluate journals and research publications using appropriate criteria such as peer-review practices, indexing, impact factor, CiteScore, SJR, SNIP and other relevant research metrics.
CO5: Use computer applications such as word processors, spreadsheets and presentation software, together with LaTeX or LibreOffice, to prepare research papers, theses, reports, tables, figures and presentations.

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CO6: Apply reference-management, plagiarism-detection and academic-search tools while maintaining academic integrity, protecting research data and following basic computer-security practices.	
Credits: 4	**Core Compulsory**
Max. Marks: 25 (CIE) + 75(UE)	**Min. Passing marks: 55**
Total number of lectures: Lectures-Tutorial-Practical (4 hours in a week) L-T-P: 4-0-0 **(60 hr)**	

Unit	Topics	No. of Lecture Hrs.
I	**Research Methodology** Definition, and Objectives, Motivation and Significance of Research, Types of Research, Truth and Facts of Research, Similarity and Contrast in Literary Research and Scientific Research, Research and Criticism, Research Problem and Research Design, Sampling Design and Methods of Data Collection.	12
II	**Research standards:** Layout of the Research Report, Research Process: subject Selection, Outline of the Research, Review of Literature, Material Collection; Testing and Classification, Analysis, Discussion and Conclusions, Precautions in Writing Synopsis/Research Paper/Thesis/Research Report.	12
III	**Philosophy, Ethics, Scientific Conducts and misconducts** Moral Philosophy, Nature of Moral Judgments and Reactions, Publication Ethics, Best Practices/Standards Setting Initiatives and Guidelines: Committee on Publication Ethics (COPE), World Association of Medical Editors (WAME) etc., Intellectual Honesty and Research Integrity: Falsification, Fabrication and Plagiarism (FFP), Open Access Publishing, and Publication Misconduct.	08
IV	**Databases and Research Metrics** Databases: Indexing Databases, Citation Databases: Web of Science, Scopus etc., Research Metrics: Impact Factor of Journal as Per Journal Citation Report, SNIP, SJR, IPP, Cite Score; Metrics: h-Index, g-Index, i-10 Index, and Altimetric.	08
V	**Fundamentals of Computers and application Software** Types Of Computers, Computer Peripherals and internal component, Types of Operating Systems, Web Browser, Web Search Engine, Spreadsheet Processing, Presentation (MS PowerPoints Preparation or Beamer or Libre Office (Optional), Project/Thesis/Report writing, Using MS-Word or LaTeX or LibreOffice documentation style Labelling, References Style, Footnotes etc.	12
VI	**Scientific Softwares** Use of Reference Management Software Like Mendeley, Zotero, Reference Manager, Endnote, Authorea Etc. Anti-Plagiarism Software Like Turnitin, iAuthenticate, Ebooks and Virtual Library, UGC-Infonet, Computer Hazards and Security	08

Suggested Readings:

Text Books:

1. Kothari, C. R., & Garg, G. Research Methodology: Methods and Techniques. 4th Edition, New Age International Publishers, 2014
2. Creswell, J. W., & Creswell, J. D. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. 5th Edition, SAGE Publications, 2018.
3. Thareja, R. Fundamentals of Computers. 2nd Edition, Oxford University Press, 2019.
4. Lamport, L. LaTeX: A Document Preparation System. 2nd Edition, Addison-Wesley Professional, 1994.
5.

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Reference Books and Online Resources:

1. Resnik, D. B. What Is Ethics in Research & Why Is It Important? National Institute of Environmental Health Sciences, 2011.
2. Indian National Science Academy. Ethics in Science Education, Research and Governance. Indian National Science Academy, New Delhi, 2019
3. Reema Thareja (2019) Fundamentals of Computers (2nd Edition), Oxford University Press
4. Microsoft Office 365: A complete Guide to Master Word, Excel, and PowerPoint 365 for Beginners, Matt Vic
5. Leslie Lamport, LaTeX, A Document Preparation System, 2nd Edition, Addison-Wesley Professional Publisher, July, 1994.
6. Latex tutorials https://www.tug.org/twg/mactex/tutorials/ltxprimer-1.0.pdf
7. Libre Office tutorial: www.documentation.libreoffice.org/en/english-documentation

Suggested equivalent online courses: https://epgp.inflibnet.ac.in/

Programme: Post graduate Diploma in Research (PGDR)	**Year: six** (6)	**Semester:** XI
Subject: Physics		
Course Code: B011104R	**Course Title: Research Project**	
Course Outcomes (COs): After the completion of the course, the students will be able to CO1: Apply fundamental and disciplinary concepts, theories and research methods appropriately to a selected area of Physics CO2: Demonstrate sound technical and conceptual knowledge of the selected research-project topic and apply relevant experimental, computational or theoretical techniques CO3: Identify, analyze and solve research problems through critical thinking, systematic investigation and creative approaches. CO4: Apply appropriate personal, societal and professional ethical standards in conducting, documenting and presenting research. CO5: Communicate research objectives, methodology, results and conclusions effectively through oral presentations and written reports CO6: Execute a research-level project, interpret and document its findings, and prepare the work for presentation at workshops, seminars or conferences.		
Credits: Non -Credit	**Core Compulsory**	
Max. Marks: 25 (CIE) + 75(UE)	**Min. Passing marks: 55**	

Suggested Readings: As per the field of the project.

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The format of the question paper and evaluation will be as follows –

The duration of each question paper is 3 hours.

Types of Question	Total No of Questions	Questions to be Attempted	Maximum Marks = 75 (UE) (Questions x marks)
Very Short Answer Type Questions (50 words)	10	10	10 x 2 = 20
Short Answer Type (200 words)	8	5	5 x 7 = 35
Longs Answer Type (500 words)	4	2	2 x 10 = 20
			= 75 (Maximum Marks)

10-point grading system for evaluation of the Pre-Ph.D. course work

As per the UP GOs 1567/सत्तर-3-2021-16 (26)/2011 TC dated 13 July 2021, 401/सत्तर-3-2022, dated 09 Feb. 2022, and 1032/सत्तर-03-2022-08(35)/2020, dated 20 April 2022 regarding NEP-2020, the grading system for the Pre-Ph.D. course work shall be followed as given in Table -1

Table-1

Letter Grade	Details	Limit of Marks	Grade Point
O	Outstanding	91-100	10
A+	Excellent	81-90	9
A	Very Good	71-80	8
B+	Good	61-70	7
B	Above Average	55-60	6
F	Fail	<55	0
AB	Absent	Absent	0
Q	Qualified		
NQ	Not Qualified		

In pre-Ph.D. course work, there is a mandatory research project that is qualifying in nature. This research project shall be a **non-credit course**. The letter grade for the research project will be Q or NQ. The grade of research project will not be included in the computations of the CGPA.

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Computation of CGPA:

Calculations for SGPA and CGPA shall be followed as given table 2:

Table 2

For j^{th} Sem. SGPA $(S_j) = \frac{\sum Ci.Gi}{\sum Ci}$	Here: C_i = number of credits of the i^{th} course in the j^{th} semester G_i = grade point scored by the student in the i^{th} course in j^{th} semester
$CGPA = \frac{\sum Cj.Sj}{\sum Cj}$	Here: S_j = SGPA of the j^{th} semester C_j = total number of credits in the j^{th} semester

Allocation of CGPA Into Division:

The allocation of CGPA into division in pre-Ph.D. course work follows as given in Table 3:

Table 3

Division	**CGPA**
First	Greater than or equal to 6.5 and less than or equal to 10
Second	Greater than or equal to 5.5 and less than 6.5

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