2-YEAR NEP PG CURRICULUM

M.Sc. PHYSICS PROGRAMME

SUBJECT CODE = PHY

FOR POSTGRADUATE COURSES UNDER RANCHI UNIVERSITY, RANCHI

Implemented w.e.f.
Academic Session 2025-26 Onwards

UNIVERSITY DEPARTMENT OF PHYSICS

RANCHI UNIVERSITY, RANCHI

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Ref. No. : Phy P.G. .... Date : ....

Board of Studies

FYUGP 2025 Curriculum & 1-Year/2-Year PG Curriculum 2025

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University Department of Physics
Ranchi University, Ranchi

11/07/2025

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   Ranchi College, Ranchi. — S. C. Gupta 11-07-2025

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4. Dr. Raj Kumar Singh
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Student Representative:

1. Miss. Palak Priya Kumari. Sem-IV (2023-25) — Palak Priya Kumari 11/07/25
2. Miss. Roqayah Saman. Sem-I (2024-26) — Roqaiyah Saman 11/07/25

Approval by the Members of the NEP Implementation and Monitoring Committee of Ranchi University, Ranchi

The prepared Curriculum of the Master's Degree has been approved by the NEP Implementation and Monitoring Committee of R.U., duly forwarded by the Head of the Department; it will be offered to the Students of the 1-year and 2-year Postgraduate Programme. It is implemented from the 1st Semester of the Academic Session 2025-26 and onwards.

Anushka Rani 10/09/25

Member Secretory

Contents

COURSE STRUCTURE FOR PG **'PG DIPLOMA/ COURSEWORK ONLY/ COURSEWORK WITH RESEARCH/ RESEARCH ONLY'**

Table 1: Credit Framework for Two-Year Postgraduate Programme [Total Credits = 80]

Academic Level	Level of Courses	Semester	Coursework Level 400	Coursework Level 500	Research Preparedness	Research thesis/ Project/ Patent	Total Credits
YEAR 1							
Level 6	**Coursework**	**I**	**4+4+4**	**4+4**	**---**	**---**	**20**
		II	**4+4+4**	**4+4**	**---**	**---**	**20**
YEAR 2:	**Exit Point: Having an Internship of 4 credits Exit allowed with PG Diploma Certificate**						
Level 6.5	**Coursework**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**4+4+4+4+4**	**---**	**---**	**20**
OR							
Level 6.5	**Coursework + Research**	**III**	**---**	**4+4+4+4+4**	**---**	**---**	**20**
		IV	**---**	**---**	**20**		**20**
OR							
Level 6.5	**Research**	**III**	**---**	**---**	**20**	**---**	**20**
		IV	**---**	**---**	**---**	**20**	**20**
							Total credits of P.G. Programme = **80**

Note: **Every student has to take any one Value-added course of 2-credits compulsorily in the 1st Semester of the PG programme**.

HIGHLIGHTS OF NEP PG CURRICULUM

CREDIT OF COURSES

The term 'credit' refers to the weightage given to a course, usually in terms of the number of instructional hours per week assigned to it. The workload relating to a course is measured in terms of credit hours. It determines the number of hours of instruction required per week over a semester (minimum 15 weeks).

a) One hour of teaching/ Lectures or two hours of laboratory /practical work will be assigned per class/interaction.
   One credit for Theory = 15 Hours of Teaching
   One credit for Practicum = 30 Hours of Practical work
   One credit for Internship = 02 Weeks of Practical experience

b) For credit determination, instruction is divided into three major components:
   Hours (L) – Classroom Hours of one hour duration.
   Tutorials (T) – Special, elaborate instructions on specific topics of one hour duration
   Practical (P) – Laboratory or field exercises in which the student has to do experiments or other practical work of a two-hour duration.

   Internship – For the Exit option after 1st year of the 2-year P.G. Programme for the award of P.G. Diploma, Level 6.5, Students can either complete two 4-week internships worth 2 credits each or one 8-week internship for all 4 credits. This practical experience connects academic learning with real-world applications, offering valuable exposure to professional environments in their fields of study

PG CURRICULUM

1. The PG Curriculum will be either of 1-year duration for students who studied the four-year UG Programme (FYUGP) or a 2-year duration for students who studied a three-year UG programme from a CBCS/LOCF/FYUGP Curriculum.
2. There is a flexible mode in the PG programme offered to the students of Ranchi University, Ranchi. The total credit for any semester will be 20 credits.
3. **Two-year PG curriculum:** The First year of the PG curriculum offers coursework only. There will be 3 courses at level 400 and 2 courses at level 500 in the first and the second semesters of any 2-year PG programme.
4. **One-year PG curriculum:** The Courses in the 1-year PG programme and the second year of the 2-year PG programme are the same.
   a. **Course work only**: There will be 5 courses at level 500 of 4 credits each in every semester for the coursework offered in the programme.
   b. **Course work and Research**: There will be 5 courses at the level 500 bearing 4 credits each in the first semester of a 1-year PG or in the third semester of a 2-year PG. There will be Research work offered in the next semester for this mode offered in the programme. The eligibility for this mode is available in the NEP PG curriculum of Ranchi University, Ranchi.
   c. **Research work only**: The eligible student will be offered this mode to conduct extensive research under the supervision of a guide. Each semester will be equivalent to 20 credits. The selection of a candidate for the research mode will depend upon the eligibility of the student, availability of the guide and seat in the department/institution of Ranchi University, Ranchi.

PROMOTION CRITERIA

Two Years Post-graduation programme having coursework only:

i. Each course shall be of **100 marks** having two components: **30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College and 70 marks for the End Semester University Examination (ESUE), conducted by the University**.
ii. The marks of SIA shall further break into, 20 for Internal Written Examinations, 05 for Assignment/ Project/Seminar presentation and 05 for attendance in the classroom lectures and other activities of the Department/College.

iii. The Requisite Marks obtained by a student in a particular subject will be the criteria for promotion to the next Semester.

iv. There shall be two written internal examinations, each of 1 hour duration and each of 20 marks, in a semester out of which the '**Better One out of Two**' shall be taken for computation of marks under SIA.

v. It is compulsory to pass the Mid-Semester examination. If someone fails in the Mid-Semester exam of a particular course, he/she has to retake both the Mid-Semester and End-Semester exams next year, regardless of how many marks he/she obtained in the End-Semester Examination.

vi. In case a student fails to secure pass marks in End Semester Examination, then he/she has to appear only in End Semester Examination of the following Sessions within the period of Upper Limit of Four Years and the Marks of Mid Semester will be carried for the preparation of result.

vii. Students' final marks and the result will be based on the marks obtained in Mid Semester and End Semester Examination taken together.

viii. The pass marks in the programme will be 45% of the total marks obtained in each Core/ Elective/ Other Courses offered.

ix. In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE** and **a minimum of 17 marks is to be secured in the SIA** to clear the course. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

x. Every candidate seeking to appear in the ESUE shall be issued an Admit Card by the University. **No candidate will be permitted to appear in the examination without a valid admit card.**

xi. A candidate shall be permitted to proceed in next Semester (2^{nd}, 3^{rd} and 4^{th}) **provided he/she has passed at least in 3 courses out of 5 courses** in the respective semester in theory and practical/ project courses taken together.

xii. A student will have to clear all his papers within a maximum of Four Years of duration to qualify for the degree.

However, it will be necessary to procure pass marks in each of the papers before completion of the programme.

VALUE-ADDED COURSES

1. The Value-added course will be of **2 credits** to be covered during the first semester.
2. There will be objective-type questions asked in the End Semester University Examination (ESUE).
3. There will be an OMR-based examination and the correct answer is to be marked by a black ballpoint pen only on the OMR sheet provided by the University.
4. For the **50 Marks Examination,** the student will be provided **two hours** to mark their responses.
5. Students are not allowed to choose or repeat courses already undergone at the undergraduate level in the proposed major and minor streams.
6. The performance in this course will not influence the SGPA or CGPA of the PG Programme where the student is registered to obtain the Master's Degree. However, it will be mandatory to secure minimum pass marks in the course before exit from the PG Programme.
7. If the student fails to secure the minimum pass marks in the Value-added course in the first semester, he may appear in the examination of the said course with the following batch of the next session.
8. The student may appear in the examination of the said course further if could not clear the course in the following attempt, subject to the date of validation of the Registration.

The existing Regulations of the PG Curriculum of Ranchi University, Ranchi, shall govern any matters not mentioned above.

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AIMS OF MASTER'S DEGREE PROGRAMME IN PHYSICS

The M.Sc. Physics program wish to provide students a strong conceptual base, the ability to analyze things, the ability to do research, and an ethical scientific outlook. This is in line with the ideas of NEP-2020, which stress critical thinking, research orientation, employability, and lifelong learning. By combining theory, experimentation, computation, and innovation, the program gets students ready for college, research, teaching, and work. The program has certain objectives that will help students:

1. Develop advanced theoretical and experimental skills in both established and new areas of physics.
2. Use math, computers, and numbers to model and solve problems in the real world.
3. Learn how to do research, such as how to read scientific papers, come up with hypotheses, analyze data, and write scientific reports.
4. Learn how to use modern lab tools and computers in real life.
5. Use knowledge from different fields and apply physics principles to problems in the real world and in society.
6. Be able to talk about scientific ideas clearly and work well with others in a professional setting.
7. Be aware of your social responsibility, do ethical research, and be aware of sustainability.
8. Get ready for doctoral research, competitive exams, teaching, and jobs in the business world.

PROGRAMME LEARNING OUTCOMES

After completing the M.Sc. Physics program, graduates will be able to:

1. Show a deep understanding of the basic ideas and theories in most areas of physics.
2. Use analytical, mathematical, and numerical methods to find, formulate, and solve difficult physical problems.
3. Use the right tools, instruments, and error analysis methods to plan, carry out, and look at advanced experiments.
4. Use programming, simulation tools, and computational methods to model physical systems and look at data.
5. Do your own research that includes the literature survey, testing hypotheses, interpreting data, and making critical evaluations.
6. Use physics ideas in fields like materials science, nanotechnology, energy, electronics, and environmental science that are not strictly physics.
7. Use technical writing, presentations, and academic discussions to get scientific ideas across clearly.
8. Show that you are ethically responsible in your research, data management, intellectual property, and professional behaviour.
9. Be able to work well alone and as a member or leader of multidisciplinary teams.
10. Learn on your own and for the rest of your life so you can keep up with new scientific discoveries and professional challenges.

Programme Specific Outcomes (PSOs)

After completing the program, students will be able to

1. Use advanced ideas from classical mechanics, quantum mechanics, electrodynamics, and statistical mechanics to study physical systems.
2. Use advanced lab equipment, understand experimental data, and use uncertainty and error analysis in physics experiments.
3. Create and use computer models and numerical algorithms to solve physics problems and model physical events.
4. Look at the physical properties of materials and use ideas from solid-state and condensed matter physics to make things work better.
5. Do a supervised research project or dissertation on your own and present the results in a way that is scientifically sound.

The Courses in One Year P.G. Programme and in the Second year of Two years P.G. Programme are Common.

Table 2: Semester-wise Course Code and Credit Points

Sem	Core, AE/ GE/ DC/ EC & Compulsory FC Courses				Examination Structure		
	Paper	**Paper Code**	**Credit**	**Name of Paper**	**Mid Semester Evaluation (F.M.)**	**End Semester Evaluation (F.M.)**	**End Semester Practical/ Viva (F.M.)**
I	Foundation Course	FCPHY121	4	Advanced Mathematical Methods in Physics	30	70	----
	Core Course	CCPHY122	4	Advanced Quantum Mechanics-I	30	70	----
	Core Course	CCPHY123	4	Research Methodology	30	70	----
	Core Course	CCPHY124	4	Solid State Physics & General Electronics	30	70	----
	Practicals on Core	CPPHY125	4	Practical	----	----	100
II	Core Course	CCPHY221	4	Spectroscopy	30	70	----
	Core Course	CCPHY222	4	Advanced Quantum Mechanics-II	30	70	----
	Core Course	CCPHY223	4	Advanced Nuclear Physics-I	30	70	----
	Core Course	CCPHY224	4	Nano Materials and Applications	30	70	----
	Practicals on Core	CPPHY225	4	Practical	----	----	100
III	Core Course	CCPHY321	4	Ancient Indian Physics (IKS)	30	70	----
	Skill Enhancement Course	ECPHY322	4	A. Numerical Methods & Simulation/ B. Experimental Techniques	30	70	----
	Core Course	CCPHY323	4	Advanced Nuclear Physics-II	30	70	----
	Core Course	CCPHY324	4	Statistical Physics	30	70	----
	Practicals on Core	CPPHY325	4	Practical	----	----	100
IV	Elective	ECPHY421	4	A. Nanophysics and Nanomaterials-I/ B. Electronics and Communication-I/ C. Condensed Matter Physics-I	30	70	----
	Elective	ECPHY422	4	A. Nanophysics and Nanomaterials-II/ B. Electronics and Communication-II/ C. Condensed Matter Physics-II	30	70	----
	Core Course	CCPHY423	4	Atmospheric Physics	30	70	----
	Practicals on Elective	EPPHY424	4	A. Nanophysics and Nanomaterials Lab/ B. Electronics and Communication Lab/ C. Condensed Matter Physics Lab	----	----	100
	PROJECT	PRPHY425	4	Dissertation/ Project/ Teaching Aptitude	----	----	100

Note:

1. **Every student has to take any one Value-added course of 2 credits compulsorily in the 1st Semester of the PG programme.**
2. **Either One Internship of 4 credits or Two Internships of 2 credits each is required before opting for the 'Exit' option after the first year of the P.G. Programme.**

INSTRUCTION TO QUESTION SETTER

SEMESTER INTERNAL EXAMINATION (SIE):

Marks Weightage of a Course: Each non-practical/non-project course shall be of **100 marks** having two components: **70 marks shall be assigned to the End Semester University Examination (ESUE), conducted by the University, and, 30 marks for Sessional Internal Assessment (SIA), conducted by the Department/College**.

The marks of SIA shall further be divided into 20 for Internal Written Examinations, 05 for Assignment/Project/Seminar presentation, and 05 for attendance at classroom lectures and other activities of the Department/College. There shall be two written internal examinations, each of 1-hour duration and each of 20 marks, in a semester, out of which the **'Better One out of Two'** shall be taken for computation of marks under SIA.

In absolute terms of marks obtained in a course, **a minimum of 28 marks is essential in the ESUE and a minimum of 17 marks is to be secured in the SIA to clear the course**. In other words, a student shall have to pass separately in the ESUE and in the SIA by securing the minimum marks prescribed here.

A. (SIE 20+5+5=30 marks):

There will be a uniform pattern of questions for mid-semester examinations in all the courses and across all the programmes. There will be **two** groups of questions in 20-mark written examinations. **Group A is compulsory** and will contain five questions of **very short answer type** consisting of 1 mark each. **Group B will contain descriptive type five** questions of five marks each, out of which any three are to be answered. Department may conduct Sessional Internal Examinations in other format as per needs of the course.

The Semester Internal Examination shall have three components. (a) One Semester Internal Assessment Test (SIA) of 20 Marks, (b) Assignment/Project/ Seminar Presentation of 5 marks (c) Class Attendance Score (CAS) of 5 marks.

Conversion of Attendance into score may be as follows:

Attendance Upto 45%, 1mark; 45<Attd.<55, 2 marks; 55<Attd.<65, 3 marks; 65<Attd.<75, 4 marks; 75<Attd, 5 marks.

END SEMESTER UNIVERSITY EXAMINATION (ESUE):

A. (ESUE 70 marks):

There will be a uniform pattern of questions for all the courses and all the programmes. There will be **two** groups of questions. **Group A is compulsory** and will contain two questions. **Question No.1 will be very short-answer type** consisting of five questions of 1 mark each. **Question No.2 will be a short-answer type** of 5 marks. **Group B will contain descriptive type six** questions of fifteen marks each, out of which any four are to be answered. The questions will be so framed that examinee could answer them within the stipulated time.

[**Note:** There may be subdivisions in each question asked in Theory Examinations]

B. (ESUE 100 marks):

Practical/ Project courses would also be of 100 marks but there **shall be no internal written examinations** of the type specified above. The total 100 marks will have two components: **70 marks for the practical ESUE and 20 marks for the Viva-voce examination** conducted during the ESUE to assess the applied and practical understanding of the student.

The written component of the project (**Project Report**) shall be of **70 marks and 20 marks will be for the Viva-voce examination** jointly conducted by an external examiner, appointed by the University, and the internal supervisor/ guide.

10 marks will be assigned on the cumulative assessment of the examinee during the semester and will be awarded by the department/faculty concerned.

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FORMAT OF QUESTION PAPER FOR MID/ END SEMESTER EXAMINATIONS

Question format for **20 Marks**:

Subject/ Code

F.M. =20 **Time**=1Hr. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 1 out of 2** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [10]
4. .... [10]

Note: There may be subdivisions in each question asked in Theory Examination.

Question format for **70 Marks**:

Subject/ Code

F.M. =70 **Time**=3HrS. Exam Year

General Instructions:

i. **Group A** carries very short answer type compulsory questions.
ii. **Answer 4 out of 6** subjective/ descriptive questions given in **Group B**.
iii. Answer in your own words as far as practicable.
iv. Answer all sub parts of a question at one place.
v. Numbers in right indicate full marks of the question.

Group A

1. [5x1=5]
   i. ....
   ii. ....
   iii. ....
   iv. ....
   v. ....
2. .... [5]

Group B

3. .... [15]
4. .... [15]
5. .... [15]
6. .... [15]
7. .... [15]
8. .... [15]

Note: There may be subdivisions in each question asked in Theory Examination.

SEMESTER I

I. FOUNDATION COURSE [FCPHY121]
ADVANCED MATHEMATICAL METHODS IN PHYSICS

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE :28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
On successful completion of this course the student should know:
1. Revise the knowledge of Mathematical Physics.
2. Learn Green's function and its application to one, two, and three-dimensional problems.
3. Understand Electrodynamics and Relativity and apply them to basic problems.

Course Learning Outcomes:
1. Training in Mathematical Physics will prepare the student to solve various mathematical problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve a given mathematical equation arising out of it.
3. Learn the concepts of Electrodynamics and Relativity.
4. Develop skills to solve the equations of central electrodynamics and Relativity force problem.
5. Acquire basic knowledge of Advanced Mathematical Physics.

Course Content:

Matrices and Tensors: Introduction of matrices through rotation of co-ordinate systems, Orthogonal,Hermitian, Unitary, Null and Unit matrices, Singular and Non-singular matrices, Inverse of a matrix, Trace of a matrix, Eigenvalues and Eigenvectors, Diagonalization. Tensorial character of physical entities, Covariant, Contravariant and Mixed tensors, Contraction, Quotient rule, Differentiation, Kronecker tensor, Pseudo-tensor, Symmetric and Anti symmetric tensors.

(20 Lectures)

Green's Function: Introduction Construction of the Green's function for 1d, 2d and 3d problems.Solution of some standard problems using Green's function technique. **(8 Lectures)**

Laplace Transforms: Laplace Transform (LT) of Elementary functions. Properties of LTs, LTs of 1st and 2nd order Derivatives and Integralsof Functions, Derivatives and Integrals of LTs. LT of Unit Step function, Periodic Functions. Convolution Theorem. Inverse LT. Application of Laplace Transforms to 2nd order Differential Equations.

(7 Lectures)

Electrodynamics and Relativity: Lorentz transformation as orthogonal transformation in 4- dimensions, 4-vectors and light cone, energy-momentum 4-vectors, Relativistic force equation, Covariance of Maxwell's equation. Transformation of electromagnetic fields, Solution of wave equation in covariant form, Field due to a charge moving with constant velocity, Radiation from oscillating dipole, Total power radiated from an accelerated charge, Larmor formula, Principle of equivalence, Principle of covariance, Covariant differentiation, Curvature tensor, field equation, Reduction to Newton's laws of gravitation. **(25 Lectures)**

Books Suggested:

1. Mathematical Methods for Physicists, G. B. Arfken, H. J. Waber, E.E. Harris, 2013, 7thEdn., Elsevier.
2. Boas, M.L., Mathematical Methods in Physical Sciences, Wiley International Editions.
3. Group Theory and Quantum Mechanics, M. Timkham.
4. Mathematical Physics: Das and Sharma.
5. Mathematical Methods for Physicist & Engineers: Pipes & Harvel.
6. Mathematical Tools for Physics, James Nearing, 2010, Dover Publications.
7. Mathematical Methods for Scientists and Engineers: D. A. McQuarrie, 2003, Viva Book.
8. Advanced Engineering Mathematics: D. G. Zill and W. S. Wright, 5-Ed, 2012, Jones and Bartlett Learning.
9. Advanced Engineering Mathematics, Erwin Kreyszig, 2008, Wiley India.
10. Essential Mathematical Methods, K. F. Riley & M. P. Hobson, 2011, Cambridge Univ. Press.
11. Classical Electrodynamics, J. D. Jackson, 3rd Edn, 1988, Wiley.
12. The Classical Theory of Fields, L. D. Landau, E. M. Lifshitz, 4th Edn. 2003, Elsevier.
13. Electromagnetic Field Theory for Engineers & Physicists, P. Lorrain & D. Corson, 1970.

II. CORE COURSE [CCPHY122]
ADVANCED QUANTUM MECHANICS-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
On successful completion of this course the student should know:
1. Revise the knowledge of advanced Quantum Mechanics.
2. Learn different Quantum Dynamics and apply them to solve standard Quantum mechanical problems.
3. Understand Invariance Principle and Conservation laws for linear momentum, angular momentum, energy and parity.

Course Learning Outcomes:
1. Training in advanced Quantum Mechanics will prepare the student to solve various mathematical problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve a given mathematical equation arising out of it.
3. Learn the concepts of advanced Quantum Mechanics.
4. Develop skills to understand and solve the equations of central advanced Quantum Mechanics problems.
5. Acquire basic knowledge of Advanced Quantum Mechanics.

Course Content:
Mathematical Foundation of Quantum Mechanics: Vectors and Linear vector space, Closure property, Linear independence of vectors, Bases and dimensions. Some examples of linear vector spaces, Dirac's notations, Bra and Ket vectors, Combining bras with kets, Inner product and inner product space, Orthonormality of vectors, Completeness condition,Outer product, Hilbert spaces, Operator on a linear vector space, Algebra of linear operators. **(20 Lectures)**

Hilbert Space Formalism of Quantum Mechanics: Postulates, Expectation values and probabilities, Explicit representation of operators, The general uncertainty relationship. **(8 Lectures)**

Quantum Dynamics: The equation of motion- The Schrodinger; Applications to the linear harmonic oscillator and the hydrogen atom. Linear harmonic oscillatorusing Creation and annihilation operators. **(12 Lectures)**

Heisenberg Matrix Mechanics: Matrix representation of states and operators, Matrix transformation, Diagonalizability of matrix, Application to linear harmonic oscillator problem. **(8 Lectures)**

Angular Momentum: Commutation relations for angular momentum operators, Eigenvalues andeigenvectors, Pauli spin matrices and spin eigenvectors, Motion in a centrally symmetric field. **(8 Lectures)**

Invariance Principle and Conservation Laws: Space-time symmetries and conservation Laws forlinear momentum, Angular momentum, Energy and Parity. **(4 Lectures)**

Books Suggested:

1. Mathews, P.M., &Venkatesan, K., "A Text Book of Quantum Mechanics", TMH.
2. Merzbacker, E., "Quantum Mechanics", John Wiley
3. Messiah, A., "Quantum Mechanics", North-Holland Publishing Co.
4. Schiff, L.I., "Quantum Mechanics", Tata McGraw-Hill, 3rd Edition 2010
5. Ghatak, A., Quantum Mechanics", Narosa Publishing House, New Delhi.
6. Agarwal, B. K., "Quantum Mechanics', PHI
7. Landau, L.D. & Lifshitz, E.M., "Quantum Mechanics", Pergman Press
8. Quantum Mechanics for Scientists and Engineers, D. A. B. Miller 2008, Cambridge UniversityPress
9. Introductory Quantum Mechanics, Richard L. Liboff, Pearson Education, New Delhi.
10. Quantum Mechanics, B.H. Bransden and C. J. Joachin, Pearson Education, New Delhi.

III. CORE COURSE [CCPHY123]
RESEARCH METHODOLOGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To introduce students to the basics of research and scientific inquiry
2. To enable students to identify and define research problems
3. To familiarize students with various research methods, tools, and ethical practices
4. To develop basic skills in data collection, analysis, and reporting

Course Objectives:

Students would be able to understand:

1. Characteristics of good research viz; a comprehensive study of research reviews, gaps, objective, methodology, results, discussion and conclusion with future scope.
2. How to keep ethical considerations and stay away from plagiarism.

Course Content:

Foundations of Research: *Introduction to Research:* meaning, objectives, and significance of research.
Nature of Scientific Knowledge: theory, empiricism, deductive and inductive reasoning. *Types of Research:* basic, applied, and translational research. Research Methods vs Methodology: distinction and scope. *Criteria of Good Research:* clarity, objectivity, reliability, and generalizability. *Research Theory and Practice:* foundations of research theory, linking theory with methodology, importance of structuring the research project. **(12 Lectures)**

Research Planning and Design: *Research Problem:* identification, selection, and precise definition of a research problem; necessity of defining the problem; techniques involved in defining a problem with illustrations. *Literature Review:* purpose, types of sources (books, journals, patents), use of databases (Scopus, Web of Science, Google Scholar), identifying gaps. *Hypothesis Formulation:* meaning, types (null and alternative), role in research, and features of a good hypothesis. *Research Design:* concept, meaning, and need for research design; features of a good design; important concepts relating to research design; types including exploratory, descriptive, diagnostic, and experimental; basic principles of experimental designs such as randomization, replication, and control. **(12 Lectures)**

Data Collection and Measurement: Data collection methods and tools, *Sampling Techniques:* concepts of population, sample, sampling frame, sampling errors, and non-response. *Measurement and Scaling:* levels of measurement – nominal, ordinal, interval, and ratio; common issues in measurement; reliability and validity. **(12 Lectures)**

Data Analysis, Interpretation, and Research Tools: *Data Preparation:* editing, coding, classification, and tabulation of data. *Data Presentation:* use of tables, bar diagrams, pie charts, and other visual formats. *Descriptive Statistics:* mean, median, mode, standard deviation. *Inferential Statistics:* hypothesis testing, correlation, regression analysis. *Interpretation of Results:* drawing conclusions and generalizations from data. *Use of Technology:* MS Excel/SPSS for data analysis. *Reference Management:* use of Zotero and Mendeley for citation and bibliography. *Formatting Tools:* MS Word/ LaTeX for research writing. **(12 Lectures)**

Research Reporting, Ethics, and Publication: *Research Reporting:* structure and format of research papers and thesis. *Citation Styles:* APA, MLA, Chicago, and others. *Research Ethics:* integrity and honesty in research; types of misconduct including fabrication, falsification, plagiarism, and self-plagiarism; authorship issues. predatory journals, role of COPE, use of plagiarism detection software/tool. *Publication and Research Metrics:* journal impact measures such as Impact Factor, CiteScore, SNIP; author-level metrics including h-index, i10-index, altmetrics. **(12 Lectures)**

Books Suggested:

1. Kothari, C. R. – Research Methodology: Methods and Techniques.
2. Online resources: SWAYAM, NPTEL, and Google Scholar.
3. Kothari, C.R. and Garg, Gaurav, Research methodology: Methods and techniques, New Age International.
4. Breakwell, Glynis M. Hammond, S. Fifeschaw, C., Smith, J.A. Research Methods in Psychology, Sage Publication.
5. Kerlinger, Fred N., Foundation of Behavioural Research, Hort, Rinehart and Winston publishing.
6. Ahuja, Ram., Research Methods, Rawat Publications.
7. Business Research Methods – Donald Cooper & Pamela Schindler, TMGH, 9th edition
8. Business Research Methods – Alan Bryman & Emma Bell, Oxford University Press.

IV. CORE COURSE [CCPHY124]
SOLID STATE PHYSICS & GENERAL ELECTRONICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To enable students to understand the crystal physics, electronic properties magnetism and superconductivity.
2. To enable students to learn the general electronics including microwave devices and photonic devices.

Course Learning Outcomes:

1. To determine the structure factor for standard crystal structure, identify the intensity distribution curve, Bloch theorem and various band models.
2. To understand the properties of magnetic materials and superconductors.

Contents:

Solid State Physics

Crystal Physics: Laue theory of X-ray diffraction, Geometrical structure factor and intensity of diffraction maxima. Calculation of structure factor for bcc, fcc and diamond structure, Intensity of diffraction maxima, Extinction due to Lattice centering. **(10 Lectures)**

Electronic Properties: Electron in a Periodic lattice, Block Theorem, Band Theory, Tight Binding, Cellular and Pseudopotential method, Fermi surface, de Haas van Alphen Effect, Cyclotron resonance, Magnetoresistance, Quantum Hall Effect. **(12 Lectures)**

Magnetism: Exchange interaction, Heisenberg model and molecular field theory, spin waves and magnons, Ferri and Antiferromagnetic order, Domains and Bloch Wall energy. **(10 Lectures)**

Superconductivity: Basic properties of superconductors, Josephson Effect, BCS theory, High temperature superconductivity. **(8 Lectures)**

General Electronics

Microwave Components / Devices: Attenuators, phase shifters, directional couplers, T junction, Magic Tee, Standing wave detectors and cavity resonators (circular). Reflex klystron, TWT, Velocity modulation, Magnetron, Cavity Magnetron, Principle of operation of magnetrons in pi-mode and anode strapping. **(10 Lectures)**

Photonic Devices: Radiative and non-radiative transitions, optical absorption, bulk and thin film photoconductive devices (LDR), diode photo detectors, solar cell (open circuit voltage and short circuit current, fill factor), LED (high frequency limit, effect of surface and indirect recombination current, operation of LED), Blue LED, LEDs as commercial sources of lighting, diode lasers conditions for population inversion in active region, optical gain and threshold current for lasing.

(10 Lectures)

Books Suggested:

1. Kittel, C., “Solid-State Physics”,
2. Arun Kumar, “Introduction to Solid State Physics”, PHI Learning
3. Aschroft, N.W. and Mermin, N. D., “Solid-State Physics”
4. Verma and Srivastava, Crystallography for Solid State Physics.
5. A. Khan & K. K. Dey, A first course in Electronics, PHI
6. Arun Kumar, Basic Electronics, Bharati Bhawan
7. S. O. Pillai, “Solid State Physics”, New Age International.
8. Allen, Optoelectronics, Theory & Practical, McGraw Hill
9. Pallabh Bhattacharya, Semiconductor Optoelectronics Devices, PHI
10. Jordon & Balmain, Electromagnetic Waves & Radiating System, PHI
11. Kulkarni, Microwave & Radar Engineering, Umesh Publication
12. Optical Electronics, Ajoy Ghatak and K. Thyagarajan, Cambridge University Press.
13. Dinesh C Dube, “Microwave Devices & Applications”, Narosa Publishing House.
14. Chattopadhay & Rakshit. “Electronic Fundamentals and Applications”, New Age techno Press

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V. CORE COURSE [CPPHY125]
PRACTICAL

Marks: 30 (MSE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	**Pass Marks = 45**

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter:
End Semester Practical Examination (ESE Pr):

The questions in practical examination will be of equal to 70 marks and will be so framed that the students are able to answer them within the stipulated time. 20 marks will be awarded on the performance in viva voce whereas 10 marks will be awarded on cumulative assessment which is further subdivided as 5 marks for Practical record and 5 marks for Attendance.

Note:
(Attendance Upto75%, 1mark; 75<Attd.<80, 2 marks; 80<Attd.<85, 3 marks; 85<Attd.<90, 4 marks; 90<Attd, 5 marks).

Practicals:

1. Studies with Michelson's Interferometer.
    a. Determination of wavelength separation of sodium D-lines.
    b. Determination of thickness of mica sheet.
2. Studies with Fabre-Perot Etalon.
3. Studies with Edser-Butler Plate.
4. Studies of phenomena with polarized light:
    a. Verification of Brewster's law.
    b. Verification of Fresnel's law of reflection of plane polarized light.
    c. Analysis of elliptically polarized light using □/4 plate and Babinet's compensator.
5. Verification of Rayleigh's criterion for the limit of resolution of spectral lines using
    a. prism spectrum and (b) grating spectrum.
6. Determination of optical constants of metal in thin film form.
7. Studies on Zeeman effect.
8. Young's modulus determination by optical method.
9. Experiments using, He-Ne laser source:
    a. Determination of laser parameters.
    b. Measurement of the angle of a wedge plate using Heidinger fringes.
    c. Determination of grating pitch using phenomena of self-imaging.
    d. Determination of wavelength with a vernier calliper

SEMESTER II

I. CORE COURSE [CCPHY221]
SPECTROSCOPY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. Revise the knowledge of Spectroscopy.
2. Learn different spectroscopy Physics and apply them to solve standard spectroscopy problems.
3. Understand the Rotation of molecules, the Born Oppenheimer approximation, Techniques and Instrumentation applications.

Course Learning Outcomes:
1. Training in Spectroscopy will prepare the student to solve various spectral problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation arising out of it.
3. Learn the concepts of Spectroscopy, including the concept of molecular spectra, resonance spectroscopy.
4. Develop skills to understand and solve the equations of Lasers and Holography.
5. Acquire basic knowledge of Spectroscopy.

Course Content:

Atomic Spectra: Quantum theory of Zeeman effect (normal and anomalous), Paschen-Back effect, Stark effect (linear and non-linear). Hyperfine structure of spectral lines, X-ray spectra characteristicsand absorption. **(8 Lectures)**

The Rotation of the Molecule: Rotational spectra-Rigid diatomic molecule, intensities of spectral lines, Effect of isotopic substitution, the non-rigid rotator, Simple harmonic oscillator, The anharmonic oscillator, Diatomic vibrating rotator, Born Oppenheimer approximation. **(15 Lectures)**

Molecular Spectra: Infrared and Raman spectra of diatomic molecules using anharmonic oscillator,non-rigid rotator and vibrating rotator as models. Electronic states and electronic transitions in diatomic molecules, Frank Frank-Condon principle. **(15 Lectures)**

Resonance Spectroscopy: Nature of spinning particle, Interaction between spin and a magnetic field,Larmor Precession, Theory of NMR, Chemical shift-relaxation Mechanism, experimental study of NMR, Theory and experimental study of NQR, Theory of ESR, Hyperfine structure and fine structureof ESR, Mossbauer spectroscopy, Principle-Isomer shift, Quadrupole effect, effect of magnetic field. **(15 Lectures)**

Laser and Holography: Modes of resonator and coherence length, The Nd, YAG laser, The Neodymium Glass laser, The CO_2 Laser, Organic Dye lasers, Semi-conductor Laser, Liquid Laser. Principle of Holography, Theory-practical applications including data storage. **(7 Lectures)**

Books Suggested:

1. Kuhn, "Atomic Spectra".
2. Ghatak & Loknathan, "Quantum Mechanics".
3. Herzberg, Spectra of diatomic molecules
4. Elements of Spectroscopy: Gupta, Kumar and Sharma, Pragati Prakashan.
5. Fundamentals of Molecular Spectroscopy: Colin and Elaine, TMH.
1. Laser and Non-linear Optics: B. B. Laud, New Age Publications

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II. CORE COURSE [CCPHY222]
ADVANCED QUANTUM MECHANICS-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. Revise the knowledge of advanced Quantum Mechanics-II.
2. Learn different Quantum Approximation methods and apply them to solve standard Quantum mechanical problems.
3. Understand the theory of scattering and relativistic quantum mechanics.

Course Learning Outcomes:
1. Training in advanced Quantum Mechanics-II will prepare the student to solve various quantum problems.
2. He/she shall develop an understanding of how to formulate a physics problem and solve the given mathematical equation arising out of it.
3. Learn the concepts of advanced Quantum Mechanics-II.
4. Develop skills to understand and solve the equations of central advanced Quantum Mechanics-II.

Course Content:

Approximation Methods: The WKB approximation and its applications to one-dimensional bound systems, The variational method (Ritz method) and its application to linear harmonic oscillators, Stationary perturbation theory, non-degenerate and degenerate cases and applications to anharmonic oscillators. Time-dependent perturbation theory, constant perturbation, transition to continuum and the Fermi Golden rule, harmonic perturbation, induced/stimulated emission and absorption (Einstein's A and B coefficients). **(26 Lectures)**

Theory of Scattering: Scattering amplitude and cross-section, Partial wave analysis, Born approximation. **(8 Lectures)**

Identical Particles: Many particles Schrodinger equation, The Indistinguishability principle, Symmetric and anti-symmetric wave functions, Pauli exclusion principle. **(13 Lectures)**

Relativistic Quantum Mechanics: Klein-Gordon equation for free particle, Dirac equation, Properties of Dirac matrices, Probability and current densities, Covariance of Dirac equation, Free particle solution and negative energy states, magnetic moment and spin of electron. **(13 Lectures)**

Books Suggested:

1. Thankappan, V.K., "Quantum Mechanics", Wiley Eastern
2. Mathews, P.M., &Venkatesan, K., "A Text Book of Quantum Mechanics", TMH.
3. Merzbacker, E., "Quantum Mechanics", John Wiley
4. Messiah, A., "Quantum Mechanics", North-Holland Publishing Co.
5. Schiff, L.I., "Quantum Mechanics", McGraw-Hill
6. Ghatak, A., Quantum Mechanics", Narosa Publishing House, New Delhi.
7. Agarwal, B. K., "Quantum Mechanics", PHI
8. Landau, L.D. & Lifshitz, E.M., "Quantum Mechanics", Pergamon Press
9. Introduction to Quantum Mechanics by D. J. Griffiths. II Edn., Pearson Education

……..also the books recommended earlier in Quantum Mechanics Course – I

III. CORE COURSE [CCPHY223]
ADVANCED NUCLEAR PHYSICS-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To enable students, understand the nucleus and its finer mechanisms and various standard nuclear models.
2. To gain deeper knowledge of the nuclear interactions and various nuclear reactions.
3. To learn about the various nuclear particles, symmetries, interaction and conservations.

Course Learning Outcomes:
1. Understanding of the basics of the nucleus, its fundamental properties, forces and various nuclear models.
2. Knowledge of nuclear interactions and reactions; finer details of the particle physics

Contents:

Fundamental Properties of Nuclei: Electric moments and magnetic moments of nucleus, Measurement of magnetic moment of neutron, proton and nuclear magnetic moments, Parity and statics of nucleus, *i*-spin formalism. **(12 Lectures)**

Two-Nucleon Forces: Theory of ground state of the deuteron, Partial wave analysis of low energy n-p and p-p scattering, Effective range theory of low energy n-p and p-p scattering, Coherent n-p scattering and spin dependence of nuclear force, Exchange forces and tensor forces, Meson theory of nuclear force, Yukawa interaction. **(12 Lectures)**

Nuclear Structure (models): Single particle shell model and its successes, Semi-empirical formula of Weizsaker energy, β-activity of isobars, Liquid-drop model and Bohr-Wheeler theory of fission, Collective model of Bohr and Mottelson. **(12 Lectures)**

Nuclear Interactions and Nuclear Reactions: Compound nucleus theory, Resonance reaction, Breit-Wigner dispersion formula for $l=0$ neutrons, Weak interaction-phenomenon of β-decay; Fermi's theory; selection rules for β transition; parity non-conservation in β decay. Experimental demonstration. **(12 Lectures)**

Particle Physics: Fundamental interactions, Conservation laws, Discrete symmetries - parity; charge conjugation and time reversal; G parity and CPT theorem, Internal symmetries -Isospin formalism; SU2 and SU3 groups and their applications to multiplet mesons and baryons; Quark model -Gell Mann - Okubo mass formula for octet and decuplet hadrons - charm, bottom and top quarks, Gluons as mediators of strong interaction. **(12 Lectures)**

Books Suggested:

1. Elements of Nuclear Physics, Nikhil Ranjan Roy & Rakesh Kumar Pandey, Atlantic P & D, 1/e, 2024
2. Introductory Nuclear Physics by Kenneth S. Krane, Wiley India Pvt. Ltd., 2008.
3. Concepts of nuclear physics by Bernard L. Cohen, Tata McGraw-Hill, 1998.
4. Introduction to Elementary Particles by D. Griffith, John Wiley & Sons
5. Introductory Nuclear Physics by S.S.M. Wong, PHI
6. Theoretical Nuclear Physics by J.M. Blatt, & V. F. Weisskoff, John Wiley
7. Introduction to Nuclear Physics by H.A. Enge, Addison Wesley
8. Nuclear Physics by R.R. Roy, & B. P. Nigam, John Wiley
9. Introductory Nuclear Theory by L.R.B Elton, Sir Isaac Pitman & Sons Ltd.
10. Physics of the Nucleus by M. A. Preston, Addison Wesley
11. Quarks and Leptons by F. Halzen and A.D. Martin, Wiley India, New Delhi
12. Basic ideas and concepts in Nuclear Physics - An Introductory Approach by K. Heyde (IOP- Institute of Physics Publishing, 2004).
13. Introduction to the physics of nuclei & particles by R.A. Dunlap. Thomson Asia, 2004.
14. The Atomic Nucleus by R.D. Evans, TMH

IV. CORE COURSE [CCPHY224]
NANO MATERIALS AND APPLICATIONS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To enable students to understand the physics of nanoscale materials, their synthesis, characterization, properties and applications.

Course Learning Outcomes:

1. Understanding of the nanoscale materials, various methods of their synthesis and characterization.
2. Understanding the optical and electronic properties of nanomaterials and their applications.

Contents:

Nanoscale Systems: Length scales in physics, Nanostructures: 1D, 2D and 3Dnanostructures (nanodots, thin films, nanowires, nanorods)**,** Band structure and density of states of materials at nanoscale, Size Effects in nano systems, Quantum confinement: Applications of Schrodinger equation- Infinite potential well, potential step, potential box, quantum confinement of carriers in 3D, 2D, 1D nanostructures and its consequences. **(10 Lectures)**

Synthesis Of Nanostructure Materials: Top down and Bottom-up approach, Photolithography. Ball milling. Gas phase condensation. Vacuum deposition. Physical vapor deposition (PVD): Thermal evaporation, E-beam evaporation, Pulsed Laser deposition. Chemicalvapor deposition (CVD). Sol-Gel. Electro deposition. Spray pyrolysis. Hydrothermal synthesis. Preparation through colloidal methods. MBE growth of quantum dots. **(8 Lectures)**

Characterization: X-Ray Diffraction. Optical Microscopy. Scanning Electron Microscopy. Transmission Electron Microscopy. Atomic Force Microscopy. Scanning TunnelingMicroscopy. **(8 Lectures)**

Optical Properties: Coulomb interaction in nanostructures. Concept of dielectric constant for nanostructures and charging of nanostructure. Quasi-particles and excitons. Excitonsin direct and indirect band gap semiconductor nanocrystals. Quantitative treatment of quasi- particles and excitons, charging effects. Radiative processes: General formalization-absorption, emission and luminescence. Optical properties of heterostructures and nanostructures. **14 Lectures)**

Electron Transport: Carrier transport in nanostructures. Coulomb blockade effect, thermionic emission, tunneling and hoping conductivity. Defects and impurities: Deep level and surface defects. **(6 Lectures)**

Applications: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, solar cells). Single electron transfer devices (no derivation). CNT based transistors. Nanomaterial Devices: Quantum dots heterostructure lasers, optical switching and optical data storage. Magnetic quantum well; magnetic dots - magnetic data storage. Micro Electromechanical Systems (MEMS), Nano Electromechanical Systems (NEMS). **(14 Lectures)**

Reference books:

1. C.P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.).
2. S.K. Kulkarni, Nanotechnology: Principles & Practices (Capital Publishing Company)
3. K.K. Chattopadhyay and A. N. Banerjee, Introduction to Nanoscience and Technology (PHILearning Private Limited).
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Naita, T. Yokoyama, Nanoparticle Technology Handbook(Elsevier, 2007).
6. Introduction to Nanoelectronics, V.V. Mitin, V.A. Kochelap and M.A. Stroscio, 2011,Cambridge University Press.
7. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004)..

VI. CORE COURSE [CPPHY225]
PRACTICAL

Marks: 30 (MSE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter:

End Semester Practical Examination (ESE Pr):

The questions in practical examination will be of equal to 70 marks and will be so framed that the students are able to answer them within the stipulated time. 20 marks will be awarded on the performance in viva voce whereas 10 marks will be awarded on cumulative assessment which is further subdivided as 5 marks for Practical record and 5 marks for Attendance.

Note:

(Attendance Upto75%, 1mark; 75<Attd.<80, 2 marks; 80<Attd.<85, 3 marks; 85<Attd.<90, 4 marks; 90<Attd, 5 marks).

Practicals:

1. 'e/m' measurement by Braun's tube and by Magnetron valve method.
2. 'e' measurement by Millikan oil drop apparatus.
3. Design and characteristics of passive attenuators (T- and π-types)
4. BJT based voltage amplifier: design and performance study with and without negative feedback.
5. JFET based voltage amplifier: design and performance study.
6. Half- and Full wave rectifier with and without filters
7. Series and shunt voltage regulators using Zener diode.
8. Verification of Truth table of Logic circuit using NAND gates and its DC characteristics.
9. Characterization of Photo –resister.
10. Determine the plateau characteristics of the given GM counter.
11. Verification of Inverse Square Law for Gamma-rays.
12. To measure the absorption coefficient of gamma rays in Aluminium or Copper.
13. To plot the Gaussian or normal distribution curve for background radiation.
14. Determination of dead time of the GM Counter.

SEMESTER III

I. CORE COURSE [CCPHY321]
ANCIENT INDIAN PHYSICS (IKS)

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To understand the ancient Indian physics at the deepest level.
2. To gain deeper knowledge of the astronomical topics in Siddhantas, planetary motions and the governing laws, and the various astronomical instruments developed and in-use in the ancient days.

Course Learning Outcomes:

1. Understanding of the ancient Indian astronomy and its contribution to the development of the modern astronomy.
2. Understanding of the various Indian astronomers and their contribution in developing the foundational astronomical laws and instruments.

Contents:

Some Astronomical topics in Siddhantas. The Sphere and some important great circle, Coordinates, Latitude, Zenith, Distance and Declination, relation between the Declination, the Longitude and the Obliquity of the Ecliptic with the Equator, The Ascensional Difference or Cara, The Ahargana and the method of computing the Mean Longitudes of Planets. **(25 Lectures)**

Planetary Theories. Eccentric model, Epicyclic model, The planetary schemes, The size of the Sun, and the Moon, Their distance from the Earth, Eclipses and Parallax, The Diameters of the Sun and the Moon and their distance from the Earth, calculation of the Length and the Diameter of the Earth's Shadow, Condition of Eclipses. Aryabhatta planetary laws vis-à-vis Kepler's law of planetary motion. **(25 Lectures)**

Astronomical Instruments. The Water clock or Clepsydra, The Gnomon (Sanku), The Cakra or Circle, Capa, Dhanu, Kartari, Turiya, The Armillary Sphere (Gola Yantra), The Astrolabe, Masonry Instruments. **(10 Lectures)**

Reference Book:

1. A Concise History of Science in India by D. M. Bose, S.N. Sen & B.V. Subbarayappa
2. Kapil Kapoor – Text and Interpretation: The Indian Tradition
3. Subhash Kak – The Astronomical Code of the Rigveda
4. Debiprasad Chattopadhyaya – History of Science and Technology in Ancient India
5. S. R. Sarma – Indian Mathematics and Astronomy
6. K.S. Shukla & D. Sen – History of Science, Philosophy and Culture in Indian Civilization

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II. SKILL ENHANCEMENT COURSE - A [ECPHY322A]
NUMERICAL METHODS & SIMULATION

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To familiarize students with various numerical methods and their applications.
2. To understand the Monte-Carlo technique and other modelling and simulation methods and their use in numerical solutions and computations.

Course Learning Outcomes:

1. Understanding of different numerical methods and their applications, like Newton-Raphson method, Direct method, Gauss-Jordon elimination method, Picard's method, Euler's method, quadrature, trapezoidal and Simpson's rule, Runge-Kutte methods, Rayleigh-Ritz method, and so on.
2. Be able to perform Monte-Carlo operations, simulations using SCILAB / MATLAB / PYTHON / SIMULINK/ PSpice / LT Spice / LabView / ORCAD, etc. for various scholarly and research problems.

Contents:

Solution of Linear System: Numerical solution of algebraic equation, Iteration, Newton Raphson method, Solution of Linear system, Direct method, Gauss, Gauss-Jordon elimination method, Matrix inversion and LU decomposition, Eigenvalues and Eigenvectors, Applications. **(10 Lectures)**

Interpolation, Lagrange approximation, Newton and Chebyshev Polynomials, least square fitting, Application in some physical problems. **(10 Lectures)**

Numerical Differentiation and Integration: Numerical solution of ordinary differential equation, Iteration method, Picard's method, Euler's method and improved Euler's method. Introduction to quadrature, trapezoidal and Simpson's rule Applications. **(10 Lectures)**

Numerical Solution of Partial Differential Equations: First and second order, Linear and non-linear differential equations, Solution by method of iteration, Euler and Runge Kutte methods. Finite difference method, Relaxation, Fourier and cyclic reduction and the Rayleigh-Ritz method, Application to diffusion of dopant in a semiconductor, Wave equation in a coaxial cable, Vibrating strings and membranes, Poison equation, Schrodinger equations. **(15 Lectures)**

Monte Carlo Technique: Evaluation of single and multi-dimensional integrals, Optimization problems, Applications to statistical mechanics, Metropolis algorithm. **(05 Lectures)**

Simulation/ Modelling: Concept of modelling, Introduction to techniques of modelling, State variable model of system, Model parameters and simulation using SCILAB / MATLAB / SIMULINK, Time domain and frequency domain analysis of systems using SCILAB / MATLAB, Spice modelling of semiconductor devices (p-n diode and BJT) and programming methodology, Circuit simulation using Pspice / LabView / ORCAD **(10 Lectures)**

Basic programming concepts using Scilab/Matlab to solve the problems based on the following:

1. Interpolation and extrapolation: Least Square Fitting.
2. Solution of simultaneous equation: Polynomial equation, Polynomial equation fitting.
3. Matrix manipulations, Matrix inversion, Eigenvalues computations.
4. Numerical integration and differentiation.
5. Ordinary boundary-value problems, Two dimensional problems.
6. Monte Carlo method and its applications, Evaluation of two and three-dimensional integrals.

Books Suggested:

1. Introduction to Numerical Analysis, S.S. Sastry, PHI Learning Pvt. Ltd.
2. Schaum's Outline of Programming with C++., J. Hubbard, McGraw-Hill Pub.
3. Numerical Recipes in C: The Art of Scientific Computing W.H Pressetal, Cambridge University Press.
4. A First Course in Numerical Methods, U.M Ascher& C. Greif, PHI Learning.
5. Elementary Numerical Analysis, K. E. Atkinson, Wiley India Edition.
6. Numerical Methods for Scientists & Engineers, R.W. Hamming, Courier Dover Pub.
7. An Introduction to Computational Physics, T. Pang, Cambridge Univ.
8. Simulation of ODE/PDE Models with Matlab, Octave and Scilab, Scientific and Engineering Applications: A.V. Wouwer, P. Saucez, C. V. Fernandez. 2014 Springer.
9. Scilab by Example: M. Affouf 2012, ISBN: 978-1479203444.
10. Scilab (A free Software to Matlab): H. Ramchandran, A.S. Nair. 2011, S. Chand & Company.
11. Scilab Image Processing, Lamberr M.Surhone, 2010 Betascript Publishing.

OR SKILL ENHANCEMENT COURSE - B [ECPHY322B]
EXPERIMENTAL TECHNIQUES

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To understand various experimental techniques and their applications.
2. To perform certain lab work based on the taught experimental techniques.

Course Learning Outcomes:

1. Understanding of experimental techniques like thin film coating, spectroscopic techniques. NMR and EPR, X-ray diffraction, Electron microscopy, etc.
2. Be able to perform thin film coating, spectroscopic analysis, X-ray diffraction analysis, electron microscopy etc.

Contents:

Sensors: Characteristics, Sensitivity, reproducibility, Sensors for displacement, Velocity, acceleration, Strain, Temperature, Pressure, Magnetic field. **(05 Lectures)**

Thin Film Coating: Evaporative coating, DC and plasma sputtering, Laser ablation techniques for measuring thickness of thin film. **(08 Lectures)**

Low Temperatures Techniques: Properties of cryogenic fluids, bath cryostat and continuous flow cryostat, Cryogenic refrigerators, Temperature measurements, a Cryostat for resistivity measurement. **(08 Lectures)**

High Pressure Techniques: High pressure cell for resistivity measurement, Measurement of high pressure, Diamond anvil cell for very high pressure. **(08 Lectures)**

Spectroscopic Techniques: IR absorption to study molecular vibrations and rotations, band gap of semiconductors, superconducting energy gap, Visible and UV absorption for the study of electric energy levels, defects in solids etc. Raman effect for the study of molecular vibrations and vibrations in solids, Main components of spectrometers, Sources, Dispersing element and detector, IR, UV, Visible absorption spectra, Description of Raman spectrometer and Raman spectra. **(08 Lectures)**

NMR and EPR Spectrometers: Principle of operation, Basic components of the spectrometer, Typical NMR and EPR spectra and applications. **(08 Lectures)**

X-ray Diffraction Techniques and Electron Microscope: Principle of x-ray diffraction, Bragg's law and Laue pattern, Powder diffraction method, Transmission and Scanning electron microscopes and applications. **(08 Lectures)**

Surface Probe Techniques: Principle of AFM, STM, MFM and applications. **(07 Lectures)**

Lab Work for this Course: Fabrication of thin film using evaporation and sputtering technique, Raman spectra analysis if a sample, Study of EPR and NMR spectra, Study of X-ray diffraction pattern of powder sample, SEM photograph studies.

Books Suggested:

1. Molecular Spectroscopy, An Introduction, Jagmohan, Narosa Publication.
2. Advanced level Physics Practical, Michael Nelson and Jon M. Ogborn, 4th Edn, Reprint 1985, Heinemann Educational Publishers.
3. Advanced Practical Physics for Students, B. L. Flint & H.T. Worsnop, 1971, Asia Publishing.
4. Introduction to Measurement and Instrumentation, A. K. Ghosh, 3rd Edn., PHI Learning Pvt. Ltd.
5. A Text Book of Practical Physics, Indu Prakash and Ramakrishna, 11th Edn. 2011, Kitab Mahal, New Delhi.
6. Measurement, Instrumentation and Experiment Design in Physics & Engineering, M. Sayer, and A. Mansingh, 2005, PHI Learning.

III. CORE COURSE [CCPHY323]
ADVANCED NUCLEAR PHYSICS-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To study and understand about the working of various nuclear detectors and their applications.
2. To understand the various nuclear reactor mechanisms.

Course Learning Outcomes:
1. Understanding of the construction, working and applications of various solid-state detectors and high-energy detectors and their electronics.
2. Understanding of nuclear fission, neutron diffusion and moderation mechanisms, criticality of reactor and the power reactor.

Contents:

Nuclear Radiation Detectors

Detection: Simple model of detector, energy measurement, position and time measurement.
Solid State Detectors: Semiconductor detectors, Surface barrier detectors, Scintillation counters: Organic and inorganic scintillators, Photomultiplier tubes, Gamma Ray Scintillation Spectrometer.
High Energy Particle Detectors: General principles, Nuclear emulsions, Cloud chambers, Bubble chamber.
Nuclear Electronics: Pulse shaping, Linear amplifiers, Pulse height discriminators, Single channel and Multichannel analyzer. **(20 Lectures)**

Nuclear Reactor Theory

Fundamentals of Nuclear Fission: Fission fuels, Prompt and delayed neutrons, Chain reaction, Multiplication factor, Condition for criticality, Breading phenomena. **(8 Lectures)**
Diffusion of neutrons: Neutron current density, The equation of continuity, Fick's law, The diffusion equation, Measurement of diffusion parameters. **(8 Lectures)**

Neutron Moderation: Moderation without absorption, Energy loss in elastic collisions, Average logarithmic energy decrement, slowing down power and moderating ratio of a medium. Slowing down densities, Moderation- Space dependent slowing down, Fermi's age theory, Moderation with absorption **(9 Lectures)**

Criticality of an Infinite Homogenous Reactor: The critical equation, Optimum reactor shapes, Material and geometrical bucklings, Neutron balance in a thermal reactor, Four factor formula, Calculation of critical size and composition in simple cases. **(10 Lectures)**

Power Reactor: Fast breeder reactors, Thermo-nuclear reaction, nuclear fusion in stars, Concept of fusion reactor. **(05 Lectures)**

Books Suggested:

1. Elements of Nuclear Physics, Nikhil Ranjan Roy & Rakesh Kumar Pandey, Atlantic P & D, 1/e, 2024
2. Segre, E., "Experimental Nuclear Physics", John Wiley
3. Singru, R.M., "Introduction to Experimental Nuclear Physics", John Wiley & Sons, 1974.
4. W.R. Leo, "Techniques for Nuclear and Particle Physics Experiments"
5. Kapoor S.S and Ramamurthy V.S., "Nuclear Radiation Detectors", New Age International Publishers 1986.
6. Syed Naeem Ahmed, "Physics and Engineering of Radiation Detection", Academic Press, Elsevier, 2007.
7. Glasstone, S. and Edlund, M. C., "The Elements of Nuclear Reactor Theory", Van Nostrand Co., 1953.
8. Stacey, W. M., "Nuclear Reactor Physics"
9. Lamarsh, J. R., "Introduction to Nuclear Reactor Theory', Addison Wesley, 1966
10. Murray, L., "Introductions of Nuclear Engineering".
11. Varma, J. "NUCLEAR Physics Experiments", New Age International Publishers 2001.
12. Singru, R.M., "Introduction to Experimental Nuclear Physics" Wiley Eastern Pvt. Ltd.

IV. CORE COURSE [CCPHY324]
STATISTICAL PHYSICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To understand quantum ensemble and quantum statistics.
2. To understand the properties of imperfect gases and high-density gases, and the non-equilibrium statistical mechanics.

Course Learning Outcomes:

1. Understanding of quantum ensemble theory and quantum statistics and its real-world applications.
2. Understanding of phase transitions, and the properties of imperfect gases and high-density gases, Chandrasekhar mass limit, White dwarf and neutron stars.

Contents:

Quantum Ensemble Theory: Micro-canonical Canonical and Grand Canonical ensembles, Phase space, Distribution functions, Partition function and relationship to thermodynamic quantities, Fluctuations in energy, particle density, Pressure and volume, Equivalence of ensembles. **(10 Lectures)**

Quantum Statistics: Equation of state of ideal Fermi and Bose gases, Degenerate electron gas and specific heat, Degenerate Bose gas, Bose-Einstein condensation, Evaluation of constant α and β and its thermodynamics interpretation, Thermal properties of Bose- Einstein and liquid He 4, the Lambda transition, two fluid model, Black body distribution law. Density matrix and classical limit for N-particles partition function. **(12 Lectures)**

Imperfect Gases: Classical and Quantum cluster expansion, Virial equation of state, Virial coefficients in classical limit, Second Virial coefficients for hard-sphere and square-well potentials. **(9 Lectures)**

Phase Transitions: Ising model, Bragg-Williums Approximation, Mean field theories of the Ising model in three, two and one dimensions, Exact solutions in one dimension, Landau theory of phase transition, Critical indices, Scale transformation and dimensional analysis. **(9 Lectures)**

High-Density Gases: Thermo-ionic and photoelectric emission, Spin Para-magnetism, Landau Diamagnetism, Equation of state at very high density, Equilibrium of bodies of large mass, Chandrasekhar mass limit, White dwarf and neutron stars. **(10 Lectures)**

Non-Equilibrium Statistical Mechanics: Boltzmann Transport equation, Boltzmann H-theorem, Equations of motion in classical mechanics, Time correlation function, Linear response theory,
Electrical conduction, Langevin equation and Brownian motion, Debye theory of dielectric relaxation. Motion due to fluctuating force. The Fokker-Planck Equation, Solution on Fokker-Planck Equation. **(10 Lectures)**

Books Suggested:

1. Sinha, S.K., "Statistical Mechanics",
2. Kerson & Huang, "Statistical Mechanics",
3. Friedman, H.L., "A Course in Statistical Mechanics",
4. McQuarrie, D.A., "Statistical Mechanics",
5. Landau, L, & Liefshitz, "Statistical Mechanics", Pergaman Press.
6. Statistical Mechanics, R. K. Patharia, Bufferworgh Heinemann
7. Fundamental of Statistical and Thermal Physics, F. Rief, McGraw Hill International Edition.
8. Fundamental of Statistical Mechanics, B.B. Laud, New Age International Pub.
9. R. K. Srivastava & J. Ashok, "Statistical Mechanics".
10. Hill, T.L., "Statistical Mechanics",
11. Gupta & Kumar, "Statistical Mechanics",
12. Agrawal, B.K., Statistical Mechanics.
13. Prakash Satya & Agrawal J.P., "Thermodynamics Statistical Physics & Kinetics"

VII. CORE COURSE PRACTICAL [CPPHY325]

Marks: 30 (MSE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter:

End Semester Practical Examination (ESE Pr):

The questions in practical examination will be of equal to 70 marks and will be so framed that the students are able to answer them within the stipulated time. 20 marks will be awarded on the performance in viva voce whereas 10 marks will be awarded on cumulative assessment which is further subdivided as 5 marks for Practical record and 5 marks for Attendance.

Note:

(Attendance Upto75%, 1mark; 75<Attd.<80, 2 marks; 80<Attd.<85, 3 marks; 85<Attd.<90, 4 marks; 90<Attd, 5 marks).

Practicals:

1. Frank Hertz Experiment.
2. Experiment with Hall apparatus.
3. Four-Probe set up for mapping the resistivity of large sample.
4. Measurement of magneto resistance of semiconductor sample.
5. Measurement of Susceptibility of paramagnetic solution by Quinke's tube method.
6. Study of the energy band gap and diffusion potential of p-n junction.
7. Study of Multivibrator.
8. Study of Characteristics of Semiconductor diodes: Si, Ge, Zener and LED.
9. Study of an Integrated Circuit Regulator.
10. Two Probe method for resistivity measurement of insulators at different temperatures

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SEMESTER IV

I. ELECTIVE COURSE-A [ECPHY421A]
NANOPHYSICS AND NANOMATERIALS-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To understand the physics of nanomaterials.
2. To gain deeper knowledge of the various synthesis and characterization methods of nanomaterials.

Course Learning Outcomes:
1. Understanding of the nanomaterials, dimensionalities, optical and transport properties, QHE, and principles and applications of scanning tunnelling microscopy.
2. Understanding of nanomaterial synthesis methods, like ball milling, chemical method, Co-precipitation technique, Sol-gel method, soft chemical technique, CVD, MOCVD, MBE, etc.
3. Understanding of nanomaterial characterization techniques like XPS, SEM, TEM, STM, various others.

Contents:

Nanophysics: Introduction to nanophysics and quantum size effect, Dimensionalities and density of states, Optical and transport properties of two-dimensional electron gas formed at heterostructures and within novel grapheme monolayers with internal folds, Quantum Hall effects, Physics of one-dimensional electron systems including carbon nanotubes and semiconductor nanowires, Fundamental Physics of zero-dimensional electron system, Single electron effects, Quantum dots and nanocrystals, Fundamental principles and applications of scanning tunnelling microscopy in the study of nanophysics. **(20 Lectures)**

Synthesis of Nanomaterials: Top down and Bottom up approach, Synthetic procedures and their significance, Types of nanomaterials synthesis processes, Photolithography, Advanced Ceramics (Solid State reaction method), Ball milling method, Chemical method, Co-precipitation technique, Sol-gel method, Soft chemical technique (citrate, tartarate, etc.), Hydrothermal method, Bio-chemical method, Thin film technology, Thermal Evaporation method, Sputtering (RF and DC), Spray pyrolysis method, Spin coating method, Pulsed laser deposition method, Vacuum arc discharge, Chemical vapor deposition method (CVD), MOCVD, MBE, Ion beam deposition, Electron-beam lithography. MBE growth of quantum dots. **(25 Lectures)**

Characterization Technique: Introductory remarks, Structural, X-ray and neutron diffraction, XPS, Electron beam techniques, Scanning Electron Microscope, Transmission Electron Microscope, Scanning Tunnelling Microscope, Atomic Force Microscope, Photo luminescence Cathodo-luminescence, Electro-luminescence, UV-visible and Fourier transformed infrared spectrophotometry, Thermal analysis, Thermogravimetry analysis, Differential Scanning Calorimeter, Dielectric and Impedance analysis, Magnetic measurements. **(15 Lectures)**

Books Suggested:

1. C. P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.)
2. S. K. Kulkarni, Nanotechnology, Principle & Practices (Capital Publishing Company).
3. K. K. Chatopadhyay and A. N. Banerjee, Introduction to Nanoscience& Technology, PHI
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Natia, T. Yokoyama, Nanoparticle Tech.Handbook (Elsevier, 2007)
6. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004)

OR ELECTIVE COURSE-B [ECPHY421B]

ELECTRONICS AND COMMUNICATION-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To develop an overall understanding of op-amp and its various important applications
2. To understand various electronic logic families and their applications.
3. To study about different types of antennae, configurations and their applications
4. To understand the basics of radar and satellite communication.

Course Learning Outcomes:

1. Understanding of applications of op-amp like, IA, NIC, inductance simulation, precision rectification, converters, etc.
2. Understanding and usage of current conveyor and logic families based on BJT and MOS.
3. Understanding of antenna, radar systems and satellite communications.

Contents:

Operational Amplifier: Operational amplifier (op amp) types, salient features, parameters and modelling, Voltage op-amp based circuits such as:

- Instrumentation amplifier (IA)
- Negative impedance converter (NIC)
- Inductance simulation
- Precision rectification
- Active Butterworth low pass, high pass and band pass 2nd order filters
- Simulation of differential equations
- Analog multiplier and its use in integer power generation, frequency multiplication, divider and generation of fractional powers
- D/A and A/D converters **(15 Lectures)**

Current Conveyor: Current conveyor types, their salient features, modelling and simple applications in realizing bandwidth independent gain amplifier, Current conveyor-based differentiator, integrator, adder and instrumentation amplifier, Advantages of current conveyor-based circuits over the conventional voltage op-amp based circuits. **(08 Lectures)**

BJT Logic Families: TTL logic NAND gate circuit, ECL logic OR/NOR gate circuit, analysis and evaluation of logic parameters. **(05 Lectures)**

MOS Logic Families: NMOS inverter circuit and its analysis with linear and non-linear loads, CMOS inverter. **(05 Lectures)**

Antenna: Antenna action, Short electric doublet, Linear array of n isotropic sources of equal amplitude and spacing, Broad-side array, Ordinary end-fire array, End fire array with increased directivity, Beam width of the main lobe, Yagi antenna, Resonant and non-resonant array arrangement. **(15 Lectures)**

Radar: Basic arrangement of radar system, Azimuth and range measurement, Operating characteristics of a radar system, Derivation of radar range equation. **(6 Lectures)**

Satellite Communication: Orbital and geostationary satellites, Orbital patterns, Look angles, Satellite system, Link modules. **(6 Lectures)**

Books Suggested:

1. A first course in Electronics, A. A. Khan & K. K. Dey, Prentice Hall India.
2. Basic Electronics, Arun Kumar, Bharati Bhawan
3. Millman & Brabel, "Microelectronics", McGraw-Hill (International Students' Edition).
4. Mitchell & Mitchell, "Introduction to Electronics Design", Prentice-Hall of India.
5. Nagrath, "Electronics: Analog and Digital", Prentice-Hall of India.
6. Soclof, "Design and Applications of Analog Integrated Circuits", Prentice-Hall of India.
7. Gayakwad, "Op-Amps and Linear Integrated Circuits",3 /e, Prentice-Hall of India
8. Sedra& Smith, "Microelectronic Circuits", 3/e, Sounders College Publishing.
9. Microwave and Radar Engineering Kulkarni, Umesh Publication.
10. Electromagnetic Waves and Radiating Systems: Jordan, PHI
11. Hand Book of Electronics, Gupta & Kumar, Pragati Prakashan, Meerut.
12. Electronics Communications: Roddy Coolen, PHI
13. Electronic Communication: Kennedy & Davis, TMH

OR ELECTIVE COURSE-C [ECPHY421C]

CONDENSED MATTER PHYSICS-I

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

Course Objectives:

1. To explore the physics behind different experimental techniques used in condensed matter physics, and that of x-ray diffraction and crystal structure.
2. To understand the finer details of magnetism, fermi surface and phonons.

Course Learning Outcomes:

1. Understanding of experimental techniques like, Weissenberg and Precession methods, The Diffractometer, Area Detector and Image Plate, etc.
2. Understanding of physics behind the x-ray diffraction and crystal structures.
3. Understanding of magnetism in details including Hund's rule, Curies law, Ising model, Bragg-William approximation

Contents:

X-ray Diffraction Theory: Coherent and incoherent scattering, Derivation of Laue equations and expression for structure factor, Data reduction. **(08 Lectures)**

Crystal Structure Determination: The phase problem in crystallography, Electron density as Fourier transform of structure factor and vice versa, Techniques to solve the phase problem –
Fourier and Patterson methods, Heavy atom technique, The Single Isomorphous Replacement (SIR) and Multiple Isomorphous Replacement (MIR) techniques, Anomalous scattering technique, Direct methods. **(15 Lectures)**

Experimental Techniques: The Weissenberg and Precession methods, The Diffractometer, Area Detector and Image Plate. **(7 Lectures)**

Fermi Surface: Construction of Fermi surface, Zone schemes, Electron, hole and open orbits, Cyclotron resonance. *Determination of Fermi surface* – Quantization of orbits in magnetic field; de-Hass – van-Alfen effect; External orbits; Outline of other methods. **(10 Lectures)**

Phonons: *Harmonic crystals,* Crystal potential; Harmonic and adiabatic approximations; Normal modes and phonons; Phonon spectrum by neutron scattering; Crystal momentum. *Anharmonic crystals,* Anharmonicity, Lattice thermal conductivity, Umklapp process; Second sound. **(8 Lectures)**

Magnetism: Interaction of solids with magnetic fields, Magnetization density and susceptibility, Calculation of atomic susceptibility, Susceptibility of insulators (Larmor diamagnetism), Ground state of ions with partially filled shells (Hund's rule), van Vleckpara magnetism, Curie laws for free ions and solids, Pauli paramagnetism, Conduction electron diamagnetism, Exchange interaction, Ferromagnetic domains, Anisotropy energy, Thickness and energy of Bloch walls, Ising model, Bragg-Williams approximation, Solution of Ising problem for a linear chain. **(12 Lectures)**

Books Suggested:

1. Philips, "An Introduction to Crystallography",
2. Woolfson, M.M., "An Introduction to X-ray Crystallography",
3. International Tables for X-ray Crystallography, Vol. I
4. Verma, A. R. & Krishna, P., "Polymorphism and Polytypism",
5. Kittel, C., "Solid-State Physics",
6. Raghavan, V., "Material Science and Engineering".
7. Aschrof, N.W. and Mermin, N. D., "Solid-State Physics".
8. Bunger, M.J., "Crystal Structure Analysis".
9. Bunger, M.J., "X-ray Crystallography".
10. Staut & Jenson, "A Practical Guide to X-ray Crystal Structure Determination"

II. ELECTIVE COURSE-A [ECPHY422A]
NANOPHYSICS AND NANOMATERIALS-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:
1. To understand the physics and applications of various properties of nanomaterials.
2. To discuss the details of various applications of nanomaterials.

Course Learning Outcomes:
1. Understanding of optical, electronic and magnetic properties of nanomaterials.
2. Understanding of nanomaterials-based applications like LED, CNT, NEMS, SQUIDS, quantum dots, etc.

Contents:

Optical Properties: Coulomb interaction in nanostructures, Concept of dielectric constant for nanostructures and charging of nanostructure, Quasi-particles and excitons, Excitons in direct and indirect band gap semiconductor Nano-crystals, Quantitative treatment of quasi-particles and excitons, charging effects, Radiative processes, General formalization, absorption, emission and luminescence, Optical properties of hetero-structure and nanostructures. **(16 Lectures)**

Electron Transport: Electrical properties of polymers, ceramics, dielectrics, amorphous materials, electrical conduction in metals, Alloys and semiconductors, band structure, carrier transport in nanostructures, Coulomb blockade effect, thermionic emission, tunnelling and hoping conductivity, Defects and impurities, Deep level and surface defects. **(16 Lectures)**

Magnetic Properties of Materials: Classification of magnetic materials, Magnetic materials of technical importance, Magnetization processes, Super-paramagnetism, Magnetic domain structure, Superconductivity, Phenomenology of superconductivity. **(10 Lectures)**

Applications: Applications of nanoparticles, quantum dots, nanowires and thin films for photonic devices (LED, Solar Cells). Single electron devices (no derivation). CNT based transistors. Nanomaterial Devices, Quantum dots hetero-structure lasers, optical switching and optical data storage. Magnetic quantum well, magnetic dots – magnetic data storage, Micro Electromechanical systems (NEMS), Nano, Electromechanical Systems (NEMS). Integrated optical devices, SQUIDS, Spintronic devices, Ferroelectric, Pyro-electric, Piezoelectric and electro-optic devices. **(18 Lectures)**

Books Suggested:

1. C. P. Poole, Jr. Frank J. Owens, Introduction to Nanotechnology (Wiley India Pvt. Ltd.)
2. S. K. Kulkarni, Nanotechnology, Principle & Practices (Capital Publishing Company).
3. K. K. Chatopadhyay and A. N. Banerjee, Introduction to Nanoscience& Technology, PHI
4. Richard Booker, Earl Boysen, Nanotechnology (John Wiley and Sons).
5. M. Hosokawa, K. Nogi, M. Natia, T. Yokoyama, Nanoparticle Tech.Handbook (Elsevier, 2007)
6. Bharat Bhushan, Springer Handbook of Nanotechnology (Springer-Verlag, Berlin, 2004)

OR ELECTIVE COURSE-B [ECPHY422B]

ELECTRONICS AND COMMUNICATION-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To study the physics behind the transmission of electromagnetic wave through different transmission channel.
2. To understand the detail architectural details of microprocessor and its application.

Course Learning Outcomes:

1. Understanding of transmission lines, waveguides and optical fiber as transmission channel for electromagnetic wave.
2. Understanding of finer details of microprocessor, addressing mode, instruction set, interrupts, memory access, etc.

Contents:

Transmission Line: Types of transmission line, distributed parameters, voltage and current relations on a radio frequency transmission line with respect to sending and receiving ends, propagation constant (γ), attenuation constant (α) and phase constant (β), expressions for α and β, transmission line distortion and attenuation, conditions for no distortion, low distortion and low loss, line termination across a short circuit, open circuit pure resistance and complex impedance, quarter wave and half wave lines and their impedance matching properties. **(16 Lectures)**

Wave Guide: Field expression for propagating TE and TM waves in hollow circular cylindrical wave guides, Impossibility of TEM waves in hollow wave guide, Attenuation in wave guides and Q-factor. **(8 Lectures)**

Fiber Optic Communication: Principle of light transmission in a fiber. Light sources for fiber optic communication, Effect of index profile on propagation, Modes of propagation, Number of modes a fiber may support, Single mode fiber (SMF), Losses in fibers. **(12 Lectures)**

Microprocessor Architecture: 8085 Microprocessor Architecture, Real Mode and protected modes of memory addressing, memory paging.

Addressing Modes: Data addressing modes, Program memory addressing modes, stack memory addressing modes.

Instruction Set: Data movement instructions, arithmetic and logic instructions, Program control instruction, Assembler details.
Interrupts: Basic interrupt processing, Hardware interrupt. Expanding the interrupt structure 8259A PIC.

Direct Memory Access: Basic DMA operation, 8237 DMA controller, Shared Bus operation Disk Memory systems. **(24 Lectures)**

Books Suggested:

1. Miah, "Fundamentals of Electromagnetic", TMH
2. Mano, "Computer System Architecture", Prentice-Hall of India.
3. Goankar, Microprocessors Architecture, Programming & Applications with 8085,
4. Senior, "Optical Fiber Communications: Principles and Practice", 2/e, Prentice-Hall.
5. Jordon &Balmain, "Electromagnetic waves and Radiating Systems", Prentice-Hall of India.

OR ELECTIVE COURSE-C [ECPHY422C]

CONDENSED MATTER PHYSICS-II

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To understand various condensed matter mechanism and their applications.
2. To understand the physics behind the phenomenon of superconductivity, thin films and dielectrics.

Course Learning Outcomes:

1. Understanding of phase transformation, Dielectrics, ESR, NMR and their applications.
2. Understanding of detail theories and applications of superconductor, viz. BCS theory, Cooper pairs, London equation, Josephson effects, Critical fields and moments, etc

Contents:

Phase Transformation and Diagrams: phase rule, single component system, Binary phase system, lever rule, Nucleation and growth, Nucleation kinetics, Growth and overall transformation kinetics and applications to steel and glass. (**8 Lectures)**

ESR: basic theory, relaxation mechanism, Effect of spin-orbit coupling and crystal fields on g values, Fine and hyperfine structures, Ferromagnetic resonance (FMR), General features of FMR, Shape effect in FMR, Antiferromagnetic resonance. **(8 Lectures)**

NMR: Basic theory, Spin lattice relaxation, Bloch equation and their steady state solutions, General features of NMR spectra, Chemical shifts, Fine structure due to spin-spin coupling, Application to molecular structure and bondings. **(8 Lectures)**

Superconductivity: BCS theory of superconductivity, Cooper pairs, superconducting ground state, Flux quantization in superconducting ring, Quasi-particles and energy gaps, Temperature dependence of energy gaps, London equation, Coherence length, Persistent current, Single particle tunnelling, Josephson tunnelling, Josephson effects (AC and DC), Microscopic quantum interference, Qualitative idea of high temperature superconductors, Critical fields and moments. **(12 Lectures)**

Thin Films: Deposition techniques, thermal, electron and sputtering methods, metallic semiconductor and insulator thin films and their electrical, electronic and optical properties. Magnetic superconducting thin films and applications. **(12 Lectures)**

Dielectrics: Structure of dielectrics, Polarization mechanism, Effect of temperature and frequency. Effect of conduction (ionic and electronic) in dielectrics, Dielectric losses and breakdown, Electrets and MIM. **(12 Lectures)**

Books Suggested:

1. Crystallography - Philips
2. Solid State Chernistry-Garner (Butterworth; London)
3. Solid State Chemistry -D. K. Chakraborty (New Age int Publication)
4. Solid State Chemistry- N. B. Hannay (Prentice Hall, New Jersay)
5. Physical Chemistry- Waller J. Moore
6. Principles of polymer chemistry, Cornell, P. J. Flory (Univ. Press)
7. Handbook of Conducting Polymers, Vol I & II" T A. Skolhia

III. CORE COURSE [CCPHY423]
ATMOSPHERIC PHYSICS

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 17 + ESE: 28) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

1. To develop an acquaintance with Earth's atmosphere and its dynamics.
2. To study about the atmospheric waves, aerosols, and various tools for atmospheric waves.

Course Learning Outcomes:

1. Understanding of earth's atmosphere, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms. And its dynamics involving basic conservation laws, circulations, vorticity, oscillations, etc.
2. Understanding of processing tools for atmospheric waves like, RADAR, LIDAR, AGW, etc.
3. Understanding of atmospheric aerosols and their implications including Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, etc.

Contents:

General features of Earth's atmosphere: Thermal structure of the Earth's Atmosphere, Ionosphere, Composition of atmosphere, Hydrostatic equation, Potential temperature, Atmospheric Thermodynamics, Greenhouse effect and effective temperature of Earth, Local winds, monsoons, fogs, clouds, precipitation, Atmospheric boundary layer, Sea breeze and land breeze. Instruments for meteorological observations, including RS/RW, meteorological processes and different systems, fronts, Cyclones and anticyclones, thunderstorms. **(12 Lectures)**

Atmospheric Dynamics: Scale analysis, Fundamental forces, Basic conservation laws, The Vectorial form of the momentum equation in rotating coordinate system, scale analysis ofequation of motion, Applications of the basic equations, Circulations and vorticity, Atmospheric oscillations, Quasi biennial oscillation, annual and semi-annual oscillations, Mesoscalecirculations, The general circulations, Tropical dynamics. **(12 Lectures)**

Atmospheric Waves: Surface water waves, wave dispersion, acoustic waves, buoyancy waves, propagation of atmospheric gravity waves (AGWs) in a nonhomogeneous medium, Lamb wave, Rossby waves and its propagation in three dimensions and in sheared flow, wave absorption, non-linear consideration. **(12 Lectures)**

Atmospheric Radar and Lidar: Radar equation and return signal, Signal processing and detection, Various type of atmospheric radars, Application of radars to study atmospheric phenomena, Lidar and its applications, Application of Lidar to study atmospheric phenomenon. Data analysis tools and techniques. **(12 Lectures)**

Atmospheric Aerosols: Spectral distribution of the solar radiation, Classification and properties of aerosols, Production and removal mechanisms, Concentrations and size distribution, Radiativeand health effects, Observational techniques for aerosols, Absorption and scattering of solar radiation, Rayleigh scattering and Mie scattering, Bouguert-Lambert law, Principles of radiometry, Optical phenomena in atmosphere, Aerosol studies using Lidars. **(12 Lectures)**

Reference Books:

1. Fundamental of Atmospheric Physics – Murry L Salby; Academic Press, Vol 61, 1996
2. The Physics of Atmosphere – John T. Houghton; Cambridge University press;3rd edn. 2002.
3. An Introduction to dynamic meteorology – James R Holton; Academic Press, 2004
4. Radar for meteorological and atmospheric observations – S Fukao and K. Hamazu, SpringerJapan, 2014

IV. ELECTIVE COURSE-A [EPPHY424A]
PRACTICAL-A

Marks: 30 (ESE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter:

End Semester Practical Examination (ESE Pr):

The questions in practical examination will be of equal to 70 marks and will be so framed that the students are able to answer them within the stipulated time. 20 marks will be awarded on the performance in viva voce whereas 10 marks will be awarded on cumulative assessment which is further subdivided as 5 marks for Practical record and 5 marks for Attendance.

Note:

(Attendance Upto75%, 1mark; 75<Attd.<80, 2 marks; 80<Attd.<85, 3 marks; 85<Attd.<90, 4 marks; 90<Attd, 5 marks).

Practicals:

1. Synthesis of metal nanoparticles by chemical route.
2. Synthesis of semiconductor nanoparticle.
3. Surface Plasmon study of metal nanoparticles by UV-Visible spectrophotometer.
4. XRD pattern of nanomaterials and estimation of particle size.
5. To study the effect of size on colour of nanomaterials.
6. To prepare composite of CNTs with other materials.
7. Growth of quantum dots by thermal evaporation.
8. Prepare a disc of ceramic of a compound using ball milling, pressing and sintering and study its XRD.
9. Fabricate a thin film of nanoparticles by spin coating (or chemical route) and study transmittance spectra in UV-Visible region.
10. Prepare a thin film capacitor and measure capacitance as a function of temperature or frequency.
11. Fabricate a PN diode by diffusing Al over the surface of N-type Si and study its V-I characteristic.

OR ELECTIVE COURSE-B [EPPHY424B]

PRACTICAL-B

Marks: 30 (ESE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter:

End Semester Practical Examination (ESE Pr):

The questions in practical examination will be of equal to 70 marks and will be so framed that the students are able to answer them within the stipulated time. 20 marks will be awarded on the performance in viva voce whereas 10 marks will be awarded on cumulative assessment which is further subdivided as 5 marks for Practical record and 5 marks for Attendance.

Note:

(Attendance Upto75%, 1mark; 75<Attd.<80, 2 marks; 80<Attd.<85, 3 marks; 85<Attd.<90, 4 marks; 90<Attd, 5 marks).

Practicals:

1. Operational amplifier parameters measurements and their dependence on frequency.
2. Basic operational amplifier configurations: inverting amplifier, non-inverting amplifier, voltage follower, differentiator, integrator and instrumentation amplifier.
3. Butterworth second order active low pass and high pass filters.
4. Studies on second order band-pass and band-elimination active filters.
5. Design and study of Wein bridge oscillator circuit.
6. Design and study of op amp based square wave oscillator.
7. To draw the characteristic curve of SCR and to determine its holding voltage, holding current and break-over voltage
8. Use of IC 555 timer.
9. To simulate electronic circuits using PSpice.
10. BCD adder and subtractor.
11. Precision rectification: half- and full- wave.
12. DIAC and TRIAC characteristics and applications.
13. Studies on the polar pattern of microwave transmitting horn antenna.
14. Familiarity with microwave components, microwave propagation in hollow rectangular wave-guide and measurement of dielectric constant in X-band.
15. Amplitude modulation and demodulation.
16. Studies on Phase Locked Loop (PLL) IC 565 and its use in frequency multiplication.
17. Design, construct and test electronically regulated power supplies using Zener diode, 3-pin regulators (78xx/79xx) and IC 723.
18. Design and study of the characteristics of TTL logic NAND gate and the evaluation of its parameters.

OR ELECTIVE COURSE-C [EPPHY424C]

PRACTICAL-C

Marks: 30 (ESE: 20 Viva + 5 Attd. + 5 Record) + 70 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Practical-04, 120 Hours)

Instruction to Question Setter:

End Semester Practical Examination (ESE Pr):

The questions in practical examination will be of equal to 70 marks and will be so framed that the students are able to answer them within the stipulated time. 20 marks will be awarded on the performance in viva voce whereas 10 marks will be awarded on cumulative assessment which is further subdivided as 5 marks for Practical record and 5 marks for Attendance.

Note:

(Attendance Upto75%, 1mark; 75<Attd.<80, 2 marks; 80<Attd.<85, 3 marks; 85<Attd.<90, 4 marks; 90<Attd, 5 marks).

Practicals:

1. Studies on semiconductors: 4-Probe method for the determination of band gap and the dependence of resistivity on temperature.
2. Hall Effect study: Hall co-efficient, carrier concentration and carrier mobility.
3. Electrical properties of thin film samples.
4. ESR study.
5. Determination of magnetic parameters of some minerals using hysteresis loop tracer.
6. Crystal structure analysis using 3D – X-ray diffraction data (Data supplied).
    a. Use of heavy atom technique.
    b. Use of Direct Methods.
    c. Computation of 3 –D Fourier and its interpretation.
    d. Computation of Bond length, bond angle and H-bond & other geometrical parameters of known structures.
7. (e) ORTEP plot of molecule.
8. Determination of polarazibality of sugar solution.
9. Determination of magnetic susceptibility using Guoy's method.
10. Determination of Curie temperature by dielectric constant apparatus.
11. Determination of modulus of rigidity and internal friction by modulus of rigidity apparatus.
12. Study of impedance spectrometry of a given sample using LCR meter.
13. Study of temperature dependence of Hall coefficient.
14. Synthesis of materials under different stoichiometric ratio.
15. Study of absorption pattern of a given sample using FTIR spectrometer.

V. PROJECT [PRPHY425]
DISSERTATION/ PROJECT/ TEACHING APTITUDE

Marks: 100 (ESE Pr: 6 Hrs) = 100	**Pass Marks = 45**

(Credits: Theory-04, 120 Hours)

Guidelines to Examiners for End Semester Examination (ESE):
Evaluation of project dissertation work may be as per the following guidelines:
Project model (if any) and the Project record notebook = 70 marks
Project presentation and viva-voce = 30 marks

The evaluation of the dissertation will be done in 100 marks (70 marks + 30 marks of the session). The sessional component will be evaluated by the concerned supervisor.

The end term evaluation (70 marks) will be done by a board of examiners. The end term evaluation in 70 marks will include the literary and scientific presentation of the dissertation and the performance in the viva-voce.

The overall project dissertation may be evaluated under the following heads:
- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organisation*
- *Application of Research techniques in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Course Objectives:
1. To develop research skills and scientific inquiry through independent investigations on a topic/ problem.

Course Outcomes:
On successful completion of this course, the student should know:
1. About conducting research with approved stages of research methodology.
2. A dissertation will enable students to further investigate and navigate different aspects and events of life through research.

PROJECT WORK
Each student has to submit three copies of hard-bound dissertation work (along with the raw data), duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the concerned University Department, Ranchi University, Ranchi for evaluation (one month before the viva voce examination).

The paper may involve:
a) Laboratory research/ Field work/ Lab work related to the project.
b) Survey research, Case Study or any other type of research related to the subject.
c) One Large study/ Experiment or several studies/ Experiments, depending on the objectives of the research.
d) The writing of the dissertation must be within 80 to 100 pages, including references and appendices.
e) Content must be typed in Font: Times New Roman with Line Spacing: 2.0 and Font Size 12 points.

The project work will be presented in a seminar on the assigned topic in the concerned department of Ranchi University, Ranchi, followed by an open viva voce examination.

Topics: As decided by the Supervisor/Guide

Teaching Aptitude: As an alternative to a dissertation, only a few selected meritorious candidates may be assigned the responsibility to teach the pre-decided topics in selected colleges. The performance may be evaluated based on the structured feedback for the candidate.
