THE GANDHIGRAM RURAL INSTITUTE – DEEMED UNIVERSITY

DEPARTMENT OF PHYSICS

Ph.D SYLLABUS

TEMPLATE FOR Ph.D., COURSE WORK

S.No	Items	Credits	Total
1	Core courses(prescribed) (i) Advanced Solid State Physics (ii) Energy Systems (iii) Materials Preparation and Characterization	 4 4 4	
2	Course on Area of Specialization (with 3 to 5 Thrust Areas of Research for the Department) (i) Luminescence materials (ii) Low dimensional semi conductors (iii) Electrochemical storage devices (iv) Solar energy applications (v) Advanced spectroscopy	 4	28
3	Supportive Courses (i) Research Methodology (ii) Quantitative Techniques – Numerical Methods	 4 4	
4	Seminars (i) Advanced Solid State Physics (ii) Energy Systems (iii) Materials Preparation and Characterization	 1 1 1	
5	Term Paper/ Topical Research	1	
6	Research Credits		42
	a) Project Planning including literature collection, finalization of objectives and methodology	4	
	b) Field/ Lab Studies, Data collection, compilation of results, statistical analysis, results and final conclusion	32	
	c) Synopsis and thesis submission, final viva	6	
	Total		**70**

17PHYH0101 - ADVANCED SOLID STATE PHYSICS

Credit: 4 Max. Marks: 100
Contact hours: 62

Objectives

- To expose the students with the advanced theory in Solid State Physics
- To develop skill to carry out and solve research problems in Materials science.

Learning outcomes: Upon completion of the course, the scholars will be able to:

- Acquire the knowledge on theory and principles behind solid state materials
- Identify and formulate a problem for research

UNIT-I: The semiclassical model of electron dynamics: – Wave packets of Bloch electrons – Semiclassical Mechanics -Static electric fields –General theory of holes –Uniform static magnetic fields –Hall effect and magnetoresistance.
The semiclassical theory of conduction in metals: The relaxation – time approximation – General form of non-equilibrium distribution function –DC electrical conductivity - AC electrical conductivity
(Solid State Physics-Neil W. Ashcroft and N. David Mermin, Cengage Learning, Indian Edn. Page 214 –252)

UNIT-II: Beyond the relaxation time approximation: Sources of electronic scattering – Scattering probability and relaxation time – General description of collisions – Boltzmann equation – Impurity scattering – Wiedemann – Franz law - Matthiessen's rule – Scattering in isotropic materials.
Beyond the independent electron approximation: Hartree equations – Hartree – Fock equations – Correlations – Screening: The dielectric function – Thomas – Fermi and Lindhard theory – Frequency dependent Lindhard Screening – Screening the Hartree – Fock approximation. (Ibid: Page 313–344)

UNIT-III:Classical theory of harmonic crystal: –Harmonic approximation – Adiabatic approximation –Specific heat of a classical crystal – One dimensional monoatomic Bravais lattice – One dimensional lattice with a basis –Threedimensional monoatomic Bravais lattice – Three dimensional lattice with a basis – relation to theory of elasticity.
Quantum theory of harmonic crystal: Normal modes and phonons – High temperature specific heat – Low temperature specific heat – Models of Debye and Einstein (Ibid: Page 421 – 462)

Unit-IV: Anharmonic effects in crystals: - Fundamental Inadequacy of harmonic models – General aspects of Anharmonic theories – Equation of state and thermal expansion of a crystal – Gruneisen parameter – Thermal expansion of metals – Phonon collisions – Lattice thermal conductivity – Umklapp processes – Second sound. (Ibid: Page 487 - 510).

Unit-V: Homogenous semiconductors: Carrier statistics in thermal equilibrium –Intrinsic and extrinsic semiconductors –Statistics of impurity levels in thermal equilibrium – Thermal equilibrium carrier densities of impure semiconductors –Impurity band conduction – Transport in non-degenerate semiconductors.

Inhomogeneous semiconductors: Semiclassical treatment of inhomogeneous solids – Fields and carrier densities in the equilibrium p-n junction –Elementary picture of rectification by a p-n junction (Ibid: Page 572–600)

Book for study:

Solid State Physics-Neil W. Ashcroft and N. David Mermin, Cengage Learning, Tenth Indian Reprint 2010.

Book for Reference:

1) Principles of the Theory of Solids, J. M. Ziman, Cambridge University Press,1964.
2) Solid State Theory, Walter A. Harrison, Mc Graw Hill,1970.

LECTURE SCHEDULE

Unit	Lecture no.	Topics to be covered	Mechanism
I	1.	**The semiclassical model of electron dynamics**: – Wave packets of Bloch electrons	Invited Lecture
	2.	Semiclassical Mechanics	Demo and Lecture
	3.	Static electric fields	Lecture and Power Point presentation
	4.	General theory of holes	Lecture and Power Point presentation
	5.	Uniform static magnetic fields	Lecture and Power Point presentation
	6.	Hall effect and magnetoresistance.	Assignment and Seminar
	7.	**The semiclassical theory of conduction in metals**: The relaxation – time approximation	Online sources and Lecture
	8.	General form of non-equilibrium distribution function	Lecture and Power Point presentation
	9.	DC electrical conductivity	Lecture and Power Point presentation
	10.	AC electrical conductivity	Lecture and Power Point presentation
II	11.	**Beyond the relaxation time approximation**: Sources of electronic scattering	Lecture and Power Point presentation
	12.	Scattering probability and relaxation time	Lecture and Power Point presentation
	13.	General description of collisions	Assignment and Seminar
	14.	Boltzmann equation	Assignment and Seminar
	15.	Impurity scattering	Lecture and Power Point presentation
	16.	Wiedemann – Franz law - Matthiessen's rule	Assignment and Seminar
	17.	Scattering in isotropic materials.	Assignment and Seminar
	18.	**Beyond the independent electron approximation:** Hartree equations	Lecture and Power Point presentation
	19.	Hartree – Fock equations	Assignment and Seminar
	20.	Correlations	Lecture and Power Point presentation

	21.	Screening: The dielectric function	Online sources and Lecture
	22.	Thomas – Fermi	Assignment and Seminar
	23.	Lindhard theory	Lecture and Power Point presentation
	24.	Frequency dependent Lindhard Screening	Assignment and Seminar
	25.	Hartree – Fock approximation.	Lecture and Power Point presentation
III	26.	**Classical theory of harmonic crystal**: Harmonic approximation	Assignment and Seminar
	27.	Adiabatic approximation	Assignment and Seminar
	28.	Specific heat of a classical crystal	Lecture and Power Point presentation
	29.	One dimensional monoatomic Bravais lattice	Lecture and Power Point presentation
	30.	One dimensional lattice with a basis	Assignment and Seminar
	31.	Three dimensional monoatomic Bravais lattice	Assignment and Seminar
	32.	Three dimensional lattice with a basis	Lecture and Power Point presentation
	33.	Relation to theory of elasticity.	Lecture and Power Point presentation
	34.	Quantum theory of harmonic crystal	Lecture and Power Point presentation
	35.	Normal modes and phonons	Assignment and Seminar
	36.	High temperature specific heat	Assignment and Seminar
	37.	Low temperature specific heat	Assignment and Seminar
	38.	Models of Debye	Lecture and Power Point presentation
	39.	Einstein Model	Lecture and Power Point presentation
	40.	**Anharmonic effects in crystals:** Fundamental Inadequacy of harmonic models	Lecture and Power Point presentation
	41.	General aspects of Anharmonic theories	Lecture and Power Point presentation
	42.	Equation of state and thermal expansion of a crystal	Assignment and Seminar

IV	43.	Equation of state and thermal expansion of a crystal	Assignment and Seminar
	44.	Gruneisen parameter	Online sources and Lecture
	45.	Thermal expansion of metals	Demo and Lecture
	46.	Thermal expansion of metals	Demo and Lecture
	47.	Phonon collisions	Assignment and Seminar
	48.	Lattice thermal conductivity	Assignment and Seminar
	49.	Umklapp processes – Second sound.	Assignment and Seminar
V	50.	Carrier statistics in thermal equilibrium	Lecture and Power Point presentation
	51.	Intrinsic semiconductors	Assignment and Seminar
	52.	extrinsic semiconductors	Lecture and Power Point presentation
	53.	Statistics of impurity levels in thermal equilibrium	Assignment and Seminar
	54.	Statistics of impurity levels in thermal equilibrium	Lecture and Power Point presentation
	55.	Thermal equilibrium carrier densities of impure semiconductors	Assignment and Seminar
	56.	Impurity band conduction	Lecture and Power Point presentation
	57.	Transport in non-degenerate semiconductors.	Assignment and Seminar
	58.	**Inhomogeneous semiconductors**:	Lecture and Power Point presentation
	59.	Semiclassical treatment of inhomogeneous solids	Lecture and Power Point presentation
	60.	Fields and carrier densities in the equilibrium p-n junction	Lecture and Power Point presentation
	61.	Fields and carrier densities in the equilibrium p-n junction	Lecture and Power Point presentation
	62.	Elementary picture of rectification by a p-n junction	Lecture and Power Point presentation
	63.	Elementary picture of rectification by a p-n junction	Lecture and Power Point presentation
		Total hours for unit 1-5	**63**

17PHYH0102 - ENERGY SYSTEMS

Credit: 4 Max. Marks: 100
Contact hours: 62

Objectives:

- To provide knowledge relating to the principles and the working of new and renewable energy systems.

Learning Outcome:

- The students would become capable of conducting performance tests to estimate the efficiency of the energy system.
- The scholars would gain the skill in identifying research problem area and would become capable of design and development of new energy systems.

Unit I- Solar thermal conversion and applications: Solar angles, day length, angle of incidence on tilted surface, sun path diagrams, shadow determination, extraterrestrial characteristics, effect of earth atmosphere, measurement & estimation on horizontal and tilted surfaces, analysis of Indian solar radiation data and applications.

Flat-plate collectors: effective energy losses, thermal analysis, heat capacity effect, testing methods, evaluated tubular collectors, air flat-plate collector types, thermal analysis, thermal drying.

Concentrating collector designs- classification, tracking systems, compound parabolic concentrators, parabolictroughconcentratorsand concentrators with point focus, heliostats, comparison of various designs, central receiver systems and parabolic trough systems.

Applications: solar water heating- solar distillation-solar cooking –solar greenhouses-solar heating and cooling of buildings- solar production of hydrogen.

Solarthermal energy storage- sensible storage, latent heat storage, thermo-chemical storage, solar still and solar cooker.

Unit II- Solar photovoltaic energy: Solar cell physics – p-n junction: homo and hetero junctions, metal-semiconductor interface, dark illumination characteristics, figure of merits of solar cell, efficiency limits, variation of efficiency with band-gap and temperature, efficiency measurements, high efficiency cells, tandem structure. SPV applications- centralized and decentralized SPV systems, stand alone, hybrid and grid connected system, system installation, operation and maintenances.

Unit III- Supercapacitors: Introduction- energy storage devices- comparison between battery and capacitor- electrochemical capacitors- electric double layer capacitors- pseudo capacitors- operational amplifier- current feedback- voltage feedback- potentiostats- galvanostats- difficulties with potential control- measurement of low currents- computer controlled instrumentation- trouble shooting

Cyclic Voltammetry- chronopotentiometry- open circuit potential- ac- impedance analysis- interpretation of the Faradic impedance- kinetic parameters- electrochemical impedance spectroscopy- ac voltammetry-chemical analysis by ac voltammetry- energy storage mechanism- nonfaradic process- Faradic processes-introduction to mass- transfer controlled reaction- carbon materials- transition metal oxides- conducting polymers- role of electrolytes- types of electrolytes- electrode preparation- device fabrication.

Unit IV- Fuel cells: History- principle- working- thermodynamics and kinetics of fuel cell process- performance evaluation of fuel cell- comparison on battery with fuel cell- types of fuel cells- PAFC, SOFC,PEMFC- relative merits and demerits.

Application of fuel cells: fuel cell usage for domestic power systems- large scale power generation- automobile and space- future trends in fuel cells.

Unit V- Introduction to electrochemical cells: Batteries- component of batteries, primary and secondary batteries- electrodes- electrolytes- electrode/electrolyte interphase (passivation layer, dendrite growth, solid electrolyte interphase) reaction kinetics- double layer, rate of reaction, electrodes away from equilibrium, battery testing – electrochemical studies.

Books for Study:

1. S.P. Sukhatme, Solar Energy, Tata McGraw Hill, 2008.Chapter-3 Page no:61-98**[Unit I]**
2. G.D.Rai., Non-conventional Energy Sources, Khanna Publishers, NewDelhi, 4th Edition 2002. Chapter-5 Page no:146-224 **[Unit I]**
3. W.C.Dickson and Paul N.Cheremisinoff, Solar Energy Technology Hand Book Part A, Marcel Dekker IncNewyork, 1980. Chapter-9 Page no:218-251 **[Unit I]**
4. Garg.H.P.,Prakash J., Solar Energy: Fundamentals & applications, Tata McGraw Hill, NewDelhi, 1997. Chapter-17 Page no: 370-410**[Unit II]**
5. Electrochemical Methods Fundamentals and applications by ALLEN.J.BARD and LARRY R. FAULKNER, Second edition, wiley (2004).**[Unit III]**
6. Electrochemical super capacitor scientific Fundamentals & Technological Applications by B.E.Conway, Kulwer Academic ilenum Publishers (1999).**[Unit III]**
7. Fuel cells- Principles and applications by Viswanathan, B and M AulicerScibioh, Universities Press (2006).**[Unit IV]**
8. High Energy Density Lithium Batteries, Materials Engineering, Applications, Katerina E Aiants, Stephen A. Hackney, R.Vasnath Kumar, WILEY-VCH Verlag GmbH &co, ISBN-978-3-527-32407-1,2010.Chapter-1 Page no:1-25.**[Unit V]**

Books for reference:

1. G.D.Rai., Solar Energy Utilisation, Khanna Publishers, NewDelhi, 5th Edition 2012.
2. S.Rao, Dr.B.B.Parulekar, Energy Technology Nonconventional, Renewable & Conventional, Khanna Publishers, NewDelhi, 3rdEdition 2013.
3. Chetan Singh Solanki, Solar Photovoltaic Technology and Systems-A Manual for Technicians, Trainers and Engineers, PHI Learning Private Limited, Delhi, ISBN-978-81-203-4711-3, 2014.

Lecture Schedule

Unit	Lecture Number	Topics to be covered	Mechanism
1	1	Solar angles, day length, angle of incidence on tilted surface, sun path diagrams.	Lecture
	2	Shadow determination, extraterrestrial characteristics, effect of earth atmosphere.	Lecture and Demo
	3	Measurement & estimation on horizontal and tilted surfaces, analysisof Indian solar radiation data and applications.	Lecture and Demo
	4	Flat-plate collectors: effective energy losses, thermal analysis, heat capacity effect, testing methods.	Lecture and Demo
	5	Evaluated tubular collectors, air flat-plate collector types, thermal analysis, thermal drying.	Lecture and Demo
	6	Concentrating collector designs- classification, tracking systems.	Lecture and Demo
	7	Compound parabolic concentrators, parabolictrough concentratorsand concentrators with point focus.	Lecture and Demo
	8	Heliostats, comparison of various designs, central receiver systems and parabolic trough systems.	Lecture and Demo
	9	Applications: solar water heating- solar distillation.	Lecture and Demo
	10	Solar cooking – solar greenhouses.	Lecture and Demo
	11	Solar heating and cooling of buildings	Lecture and Demo
	12	Solar production of hydrogen.	Lecture
	13	Solar thermal energy storage- sensible storage, latent heat storage.	Lecture and Demo
	14	Thermo-chemical storage, solar still and solar cooker.	Lecture and Demo
II	13	Solar cell physics – p-n junction.	Lecture
	14	Homo and hetero junctions.	Lecture
	15	Metal-semiconductor interface	Lecture
	16	Dark illumination characteristics	Lecture
	17	Figure of merits of solar cell, efficiency limits	Lecture

	18	Variation of efficiency with band-gap and temperature	Lecture
	19	Efficiency measurements	Lecture
	20	High efficiency cells, tandem structure	Lecture
	21	SPV applications- centralized and decentralized SPV systems	Lecture and Power Point presentation
	22	Stand alone, hybrid and grid connected system	Lecture and Power Point presentation
	23	Solar Photovoltaic system installation	Lecture and Power Point presentation
	24	SPV operation and maintenances.	Lecture and Power Point presentation
III	25	Introduction- energy storage devices- comparison between battery and capacitor	Lecture
	26	Electrochemical capacitors- electric double layer capacitors	Lecture
	27	Pseudo capacitors- operational amplifier- current feedback	Lecture
	28	Voltage feedback- potentiostats- galvanostats- difficulties with potential control	Lecture and Demo
	29	Measurement of low currents- computer controlled instrumentation- trouble shooting	Lecture and Demo
	30	Cyclic voltammetry- chronopotentiometry- open circuit potential	Lecture and Demo
	31	Ac- impedance analysis- interpretation of the Faradic impedance	Lecture and Demo
	32	Kinetic parameters- electrochemical impedance spectroscopy	Lecture and Demo
	33	Ac voltammetry- chemical analysis by ac voltammetry	Lecture and Demo
	34	Energy storage mechanism- nonfaradic process- Faradic processes	Lecture and Power Point presentation
	35	Introduction to mass- transfer controlled reaction- carbon materials- transition metal	Lecture
	36	Conducting polymers- role of electrolytes- types of electrolytes- electrode preparation- device	Lecture and Power Point presentation
IV	37	Fuel Cells - History- principle- working-	Lecture and Power Point presentation
	38	Thermodynamics and kinetics of fuel cell process	Lecture and Power Point presentation
	39	Performance evaluation of fuel cell	Lecture and Power Point presentation

	40	Comparison on battery with fuel cell	Lecture and Power Point presentation
	41	Types of fuel cells	Lecture and Power Point presentation
	42	AFC, PAFC, SOFC,	Lecture
	43	MCFC, DMFC, PEMFC	Lecture
	44	Relative merits and demerits	Lecture
	45	Fuel cell usage for domestic power systems	Lecture and Power Point presentation
	46	Large scale power generation	Lecture
	47	Automobile and space	Lecture
	48	Future trends in fuel cells	Lecture and Power Point presentation
V	49	Introduction to electrochemical cells	Lecture
	50	Batteries- compounds of batteries	Lecture and Power Point presentation
	51	Primary and secondary batteries	Lecture and Power Point presentation
	52	Electrodes- electrolytes	Lecture and self study
	53	Electrode/electrolyte interphase	Lecture
	54	Passivation layer	Lecture
	55	Dendrite growth	Lecture
	56	Solid electrolyte interphase	Lecture
	57	Reaction kinetics	Lecture
	58	Double layer electrochemical cell,	Lecture and Power Point presentation
	59	Rate of reaction	Lecture
	60	Electrodes away from equilibrium	Lecture
	61	Battery testing	Lecture and Power Point presentation
	62	Electrochemical studies	Lecture and self study
		Total hours for unit 1-5	**62**

17PHYH0103 - MATERIALS PREPARATION AND CHARACTERIZATION

Credit: 4 Max. Marks: 100
Contact hours: 62

Objective:

- To learn the synthesis of different materials
- To characterize the materials
- To find the applications in the field of science
- To acquire in-depth knowledge of materials

Learning Outcome:

- To improve the research aptitude.
- Confidence for facing any problems will be improved.
- Research problem can be easily resolved.
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UNIT 1: Crystal Growth

Theories of nucleation – Classical theory of nucleation.

Growth of crystal from melt- Bridgman Method - Czochralski Method - Zone Melting

Growth of crystals from solutions: Crystal growth system - Solvents and Solutions - solubility-preparation of solution-Saturation and supersaturation - Measurement and expression of supersaturation- Slow cooling method- Crystal growth in Gels

UNIT 2: Thin films

Theory of thin film nucleation - capillarity theory - statistical or atomistic theory -four stages of film growth - Zone models and Microstructures of vapour deposited films - Thermodynamics and phase diagrams

Thermal evaporation- sputtering– chemical vapour deposition- spray pyrolysis – dip coating - spin coating.

UNIT 3: Glass and Polymer membranes

Synthesis of glass - various methods - optical properties - thermal and mechanical properties - rare earth spectroscopy - optical fiber manufacture - White LED - factors affecting laser efficiencies - color coordinates

Polymer membranes - preparation and characterization

UNIT 4: Nanomaterials

Physical Methods: Mechanical methods – Methods based on evaporation- combustion synthesis Chemical methods: Synthesis by colloidal route- co precipitation method -Sol-gel Method – hydrothermal – Sonochemical synthesis - microwave synthesis.

UNIT 5: Characterization

X ray diffraction - X-ray Photoelectron spectroscopy (XPS) – SEM – TEM – AFM - DTA-TGA and DSC - UV-VIS –FTIR – Raman spectroscopy – Photoluminescence –dynamic light scattering.

Books for study:

1. Santahna Raghavan P and Ramasamy P, "Crystal growth: Proicesses and methods" KRU Publications, Kumbakonam .
2. Kasturi L Chopra "Thin film phenomena", McGraw Hill, Newyork.
3. Properties, processing and Applications of Glass and Rare Earth doped Glasses for Optical Fibers, Edited by DANHEWAK,Optoelectronics Research centre, University of Southampton, Published by: INSPEC, The Institution of Electrical Engineers, London, United Kingdom,(1998).
4. Nanotechnology: Principles and Practices, II Edn., Sulabha K. Kulkarni, Capital Publishing Company, 2015.
5. Willard, Merritt, Dean and Settle, "Instrumental Method of Analysis", 6th edition, CBS publishers, Delhi, 1986

Reference Books:

1. Bhat, H.L. "Introduction to crystal Growth: Principles and Practice" Taylor & Francis,2013.
2. CNR Rao," Chemistry of nanomaterials: Synthesis, properties and applications", Wiley publishing,2006.
3. Masuo Hosokawa, Kiyoshi Nogi, Makio Natio and Toyokazu Yokoyama, Nanoparticle Technology Handbook, 2nd edition, Elsevier publishing.2012.
4. Martinez-Duart. J.M., Martin-Plama. R.J., and Agullo Reuda. "Nanotechnology for Microelectronics and Optoelectronics", Elsevier Inc., 2006.

LECTURE SCHEDULE

Unit	Lecture Number	Topics to be covered	Mechanism
I	1.	Classical theory of nucleation	Lecture and Power Point presentation
	2.	Classical theory of nucleation	Lecture and Power Point presentation
	3.	Classical theory of nucleation	Lecture and Power Point presentation
	4.	Classical theory of nucleation	Lecture and Power Point presentation
	5.	Classical theory of nucleation	Lecture and Power Point presentation
	6.	Growth of crystal from melt- Bridgman Method	Lecture and Power Point presentation
	7.	Czochralski Method	Lecture and Power Point presentation
	8.	Zone Melting	Lecture and Power Point presentation
	9.	Growth of crystals from solutions: Crystal growth system	Lecture and Power Point presentation
	10.	Solvents and Solutions - solubility	Lecture and Power Point presentation
	11.	preparation of solution-Saturation and supersaturation	Lecture and Power Point presentation
	12.	Measurement and expression of supersaturation	Lecture and Power Point presentation
	13.	Slow cooling method	Lecture and Power Point presentation
	14.	Crystal growth in Gels	Lecture and Power Point presentation
II	15.	Theory of thin film nucleation - capillarity theory	Lecture and Power Point presentation
	16.	statistical or atomistic theory	Lecture and Power Point presentation

	17.	Four stages of film growth	Lecture and Power Point presentation
	18.	Zone models	Lecture and Power Point presentation
	19.	Microstructures of vapour deposited films	Lecture and Power Point presentation
	20.	Thermodynamics and phase diagrams	Lecture and Power Point presentation
	21.	Thermal evaporation	Lecture and Power Point presentation
	22.	Sputtering	Demo and Lecture
	23.	chemical vapour deposition	Lecture and Power Point presentation
	24.	spray pyrolysis	Demo and Lecture
	25.	dip coating - spin coating	Demo and Lecture
	26.	Synthesis of glass - various methods	Demo and Lecture
III	27.	Optical properties	Demo and Lecture
	28.	Thermal and mechanical properties	Demo and Lecture
	29.	rare earth spectroscopy	Demo and Lecture
	30.	optical fiber manufacture	Demo and Lecture
	31.	factors affecting laser efficiencies	Demo and Lecture
	32.	color coordinates	Demo and Lecture
	33.	Polymer membranes	Demo and Lecture
	34.	Preparation	Demo and Lecture
	35.	Characterization	Demo and Lecture
	36.	Nano material synthesis: Physical Methods	Assignment and Seminar
	37.	Mechanical methods	Assignment and Seminar
	38.	Mechanical methods	Assignment and Seminar
	39.	Methods based on evaporation	Assignment and Seminar

IV	40.	Methods based on evaporation	Assignment and Seminar
	41.	Methods based on evaporation	Assignment and Seminar
	42.	Chemical methods: Synthesis by colloidal route	Assignment and Seminar
	43.	Chemical methods: Synthesis by colloidal route	Assignment and Seminar
	44.	Sol-gel Method	Assignment and Seminar
	45.	Sol-gel Method	Assignment and Seminar
	46.	hydrothermal synthesis	Assignment and Seminar
	47.	hydrothermal synthesis	Assignment and Seminar
	48.	Sonochemical synthesis	Assignment and Seminar
	49.	Microwave synthesis	Assignment and Seminar
	50.	Microwave synthesis	Assignment and Seminar
V	51.	X ray diffraction -	Lecture and Power Point presentation
	52.	X-ray Photoelectron spectroscopy (XPS)	Lecture and Power Point presentation
	53.	SEM	Lecture and Power Point presentation
	54.	TEM	Lecture and Power Point presentation
	55.	AFM	Lecture and Power Point presentation
	56.	DTA-TGA and DSC	Lecture and Power Point presentation
	57.	UV-VIS	Lecture and Power Point presentation
	58.	FTIR	Lecture and Power Point presentation
	59.	Raman spectroscopy	Lecture and Power Point presentation
	60.	Raman spectroscopy	Lecture and Power Point presentation

	61.	Photoluminescence	Lecture and Power Point presentation
	62.	Dynamic light scattering	Lecture and Power Point presentation
		Total hours for unit 1-5	**62**

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17PHYH0104 - RESEARCH METHODOLOGY

Credit: 4 Max. Marks: 100
Contact hours: 62

Objectives

- To develop scientific skills and expertise in formulating problem for research
- To evolve research methods and techniques in conducting research, and
- To develop professional skill in writing a research report

Learning outcomes: Upon completion of the course, the scholars will be able to:

- Identify and formulate a problem for research
- Prepare a suitable research design for carrying out the research
- Choose appropriate tools and techniques for data collection
- Professional drawing of inferences
- Prepare research report and disseminate research findings

Unit – 1: Scientific Research – Methods of acquiring knowledge; Objectivity and Subjectivity in Research; Epistemology, Phenomenology, Positivism, Constructivism, Pragmatism- Inductive and Deductive Reasoning, Scientific Method and its applications. Research Paradigms and Ethics in Research.

Unit - 2: Research Process: Identification, Selection and Formulation of problem, Sources and criterion for selection; Review of literature and Summarizing, Conceptual Model; Objectives, Hypothesis formulation, Variables and its types.

Unit - 3: Research Design and Methods: Experimental, explorative, descriptive and historical research; Qualitative and Quantitative studies, Trend and Futuristic studies. Purpose and preparation of research design. Types of research design – Historical, Descriptive, and Experimental. Field surveys, diagnostic and evaluation research. Qualitative and quantitative methods, problem solving, development and interdisciplinary research.

Unit IV: Statistics – Measures of Central Tendency, Dispersion, Skewness and Relationship – Sampling Fundamentals-Concept of Standard Error – Estimation – Estimating the Population Mean and Population Determination – standard deviation – correlation – regression.

Unit V: Report writing - Significance of Report writing- Layout of the Research Report- Types of Reports. Steps in writing Research Report, Bibliography, Reference management system (Mendeley) - Webliography, Style of writing. Evaluation of a research report; Dissemination of research findings - Presentation and Publication, ethics of publication and plagiarism.

BOOKS FOR STUDY:

Unit – I

1. Earl Babbie, "The Practice of social Research", Tenth edition, Pg.no 5 – 82
2. John Best, " Research Methodology in Education"

Unit – II

1. Ranjit Kumar, " Research Methodology", Pg. no. 31 – 89 New Delhi: Sage Publication, 2010
2. John W. Creswell, " Research Design – Qualitative & Quantitative approaches" Pg.no 69– 114 (4th ed). Thousand Oaks, CA: Sage, 2014.

Unit – III

1. Deepak Chawla, Neena Sondhi, "Research Methodology (Concepts and Cases) Pg. No 607 – 629 New Delhi: Vikas Publication House Pvt Ltd, 2011

2. Kerlinger, "Foundations of Behavioral Research",Delhi; Surjeet Publications, 1983.

Unit – IV & Unit – V

1. C. R. Kothari, "Research Methodology Methods and Techniques" New Age International (P) Ltd, Publishers, New Delhi

BOOKS FOR REFERENCES:

- Bridget Somekh and Cathy Lewin, Theory and Methods in Social Science Research, New Delhi: Sage Publication, 2012
- Debasis Chakraborthy, Research Methodology, New Delhi: Sourath Publishing House, 2012
- Kenneth's Barden and Bruce B.Abbott, Research Design: Qualitative and Quantitative Approaches, Tata MaGrewHill Education Pvt, New Delhi, 2011.
- Kundra S., Reporting Methods, New Delhi: Anmol Publications Pvt. Ltd., 2005.
- Vijayalakshmi G. and Sivapragasam C., Research Methods: Tips and Techniques, Chennai : MJP Publishers, 2009.

LECTURE SCHEDULE

Unit	Lecture Number	Topics to be covered	Mechanism
I	1.	Scientific Research - Methods of acquiring knowledge	Lecture and Power Point presentation
	2.	Objectivity and subjectivity in Research	Lecture and Power Point presentation
	3.	Epistemology	Lecture and Power Point presentation
	4.	Phenomenology	Lecture and Power Point presentation
	5.	Positivism	Lecture and Power Point presentation
	6.	Constructivism	Lecture and Power Point presentation
	7.	Pragmatism	Lecture and Power Point presentation
	8.	Inductive reasoning	Lecture and Power Point presentation
	9.	Deductive reasoning	Lecture and Power Point presentation
	10.	Scientific Methods	Lecture and Power Point presentation
	11.	Applications	Lecture and Power Point presentation
	12.	Research Paradigms	Lecture and Power Point presentation
	13.	Ethics in Research	Lecture and Power Point presentation
II	14.	Research process-Identification	Online sources and SWAYAM
	15.	Selection and Formulation of problem	Online sources and Lecture
	16.	Sources and criterion for selection	Online sources and SWAYAM
	17.	Review of literature	Online sources and Lecture
	18.	Conceptual Model	Online sources and SWAYAM
	19.	Conceptual Model	Online sources and Lecture
	20.	Objectives	Online sources and Lecture

	21.	Hypothesis formulation	Online sources and SWAYAM
	22.	Variables and its types	Online sources and Lecture
III	23.	Research design and Methods	Online sources and SWAYAM
	24.	Research design and Methods	Online sources and SWAYAM
	25.	Experimental design	Demo and Lecture
	26.	Explorative design	Demo and Lecture
	27.	Descriptive design	Demo and Lecture
	28.	Historical research	Demo and Lecture
	29.	Qualitative studies	Demo and Lecture
	30.	Quantitative studies	Demo and Lecture
	31.	Quantitative studies	Demo and Lecture
	32.	Trend and Futuristic studies	Demo and Lecture
	33.	Purpose and preparation of research design.	Demo and Lecture
	34.	Types of research design	Demo and Lecture
	35.	Historical, Descriptive, and Experimental.	Demo and Lecture
	36.	Qualitative methods	Demo and Lecture
	37.	quantitative methods	Demo and Lecture
	38.	Problem-solving	Invited Lecture
	39.	Development and interdisciplinary research.	Demo and Lecture
IV	40.	Statistics	Lecture and Power Point presentation
	41.	Measures of Central Tendency	Assignment and Seminar
	42.	Dispersion	Assignment and Seminar
	43.	Skewness and Relationship	Assignment and Seminar
	44.	Sampling Fundamentals	Assignment and Seminar
	45.	Concept of Standard Error	Assignment and Seminar
	46.	Estimation	Assignment and Seminar

	47.	Estimating the Population Mean	Assignment and Seminar
	48.	Population Determination	Assignment and Seminar
	49.	Standard deviation	Assignment and Seminar
	50.	Correlation	Assignment and Seminar
	51.	Regression	Assignment and Seminar
V	52.	Report writing	Lecture and Power Point presentation
	53.	Significance of Report writing	Lecture and Power Point presentation
	54.	Layout of the Research Report	Lecture and Power Point presentation
	55.	Types of Reports	Lecture and Power Point presentation
	56.	Steps in writing Research Report	Lecture and Power Point presentation
	57.	Bibliography	Lecture and Power Point presentation
	58.	Webliography	Lecture and Power Point presentation
	59.	Style of writing	Lecture and Power Point presentation
	60.	Evaluation of a research report	Lecture and Power Point presentation
	61.	Dissemination of research findings	Lecture and Power Point presentation
	62.	Presentation and Publication	Lecture and Power Point presentation
		Total hours for unit 1-5	**62**

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17PHYH0205 – QUANTITATIVE TECHNIQUES : NUMERICAL METHODS

Credit: 4 Max. Marks: 100
Contact hours: 62

Objective:

- To learn to solve equations, Matrices, Differential equations, Integrations, etc. numerically.
- To apply different methods of solving and understand the superiority of one over the other.
- To know the need for accuracy of solving the numerical eqautions.
- To find the possibility of learning the convergence of any equation towards the solution.

Learning outcomes:

- Confidence for facing any problems will be improved.
- Research problem can be easily resolved.
- Through understanding of numerical methods will be achieved.

UNIT – I : Interpolation; Differences – relation between differences and derivatives – differences of a polynomial – Newton's formula for forward interpolation – Backward interpolation – Central differences – Gauss's forward formula – backward formula and Stirling's interpolation formula- interpolation with unequal intervals – Lagrangian method .

UNIT – II: Numerical differentiation – Numerical integration: General quadrature formula – Trapezoidal rule – Simpson's rule – Weddle's rule –curve fitting: principles of least squares – fitting a straight line, a parabola and exponential curve.

UNIT – III: Numerical algebra and Transcendental equation: finding approximate values of the roots – Iteration method – Bisection method– regula falsi method – Newton-Raphson method.

UNIT – IV: Solution to simultaneous linear equation: Gauss elimination method – Gauss – Jordon method – Matrix inversion method- Itertative methods – Gauss –Jacobies , Gauss – Seidal methods.

UNIT – V: Numerical solution of first order ordinary differential equations (ODE): Taylor's series method - Euler's method.

BOOKS FOR STUDY AND REFERENCE:

1. Numerical Mathematical Analysis – James B- Scarborough – Sixth Edn., Oxford and IBH Publishing Co., Pvt., Ltd., (1996)
2. Numerical Methods – A. Singaravelu , Meenakshi Publications, 1992.

LECTURE SCHEDULE

UNIT	Lecture Number	Topics to be covered	Mechanism
I	1.	Interpolation; Differences	Lecture and Power Point presentation
	2.	Interpolation; Differences	Lecture and Power Point presentation
	3.	relation between differences and derivatives	Lecture and Power Point presentation
	4.	differences of a polynomial	Assignment and Seminar
	5.	Newton's formula for forward interpolation	Assignment and Seminar
	6.	Backward interpolation	Assignment and Seminar
	7.	Central differences	Lecture and Power Point presentation
	8.	Gauss's forward formula	Lecture and Power Point presentation
	9.	backward formula	Assignment and Seminar
	10.	Stirling's interpolation formula	Assignment and Seminar
II	11.	**Numerical differentiation-Numerical integration:** General quadrature formula	Assignment and Seminar
	12.	General quadrature formula	Lecture and Power Point presentation
	13.	Simpson's rule	Lecture and Power Point presentation
	14.	Simpson's rule	Lecture and Power Point presentation
	15.	Weddle's rule	Lecture and Power Point presentation
	16.	Weddle's rule	Lecture and Power Point presentation
	17.	Trapezoidal rule	Assignment and Seminar
	18.	Trapezoidal rule	Assignment and Seminar
	19.	**Curve fitting:** Principles of least squares	Lecture and Power Point presentation

	20.	Fitting a straight line	Lecture and Power Point presentation
	21.	Fitting a straight line	Lecture and Power Point presentation
	22.	Parabola	Assignment and Seminar
	23.	Parabola	Assignment and Seminar
	24.	Exponential curve.	Assignment and Seminar
	25.	Exponential curve.	Assignment and Seminar
III	26.	**Numerical algebra and Transcendental equation**: Finding approximate values of the roots	Lecture and Power Point presentation
	27.	Finding approximate values of the roots	Lecture and Power Point presentation
	28.	Iteration method	Self study
	29.	Iteration method	Self study
	30.	Iteration method	Self study
	31.	Bisection method	Self study
	32.	Bisection method	Self study
	33.	Bisection method	Self study
	34.	Newton Raphson method	Assignment and Seminar
	35.	Newton Raphson method	Assignment and Seminar
	36.	Newton Raphson method	Assignment and Seminar
	37.	Regula Falsi method	Assignment and Seminar
	38.	Regula Falsi method	Assignment and Seminar
	39.	Regula Falsi method	Assignment and Seminar
	40.	Gauss elimination method	Lecture and Power Point presentation
	41.	Gauss elimination method	Lecture and Power Point presentation

IV	42.	Gauss elimination method	Lecture and Power Point presentation
	43.	Gauss elimination method	Lecture and Power Point presentation
	44.	Gauss – Jordon method	Lecture and Power Point presentation
	45.	Gauss – Jordon method	Lecture and Power Point presentation
	46.	Gauss – Jordon method	Lecture and Power Point presentation
	47.	**Itertative methods:** Gauss –Jacobies iteration method	Lecture and Power Point presentation
	48.	Gauss –Jacobies iteration method	Lecture and Power Point presentation
	49.	Gauss – Seidal Iterative method.	Assignment and Seminar
	50.	Gauss – Seidal Iterative method.	Assignment and Seminar
V	51.	**Numerical solution of ordinary differential equations (ODE):** Taylor's series method	Lecture and Power Point presentation
	52.	Taylor's series method	Lecture and Power Point presentation
	53.	Taylor's series method	Lecture and Power Point presentation
	54.	Taylor's series method	Self study
	55.	Euler's method	Self study
	56.	Euler's method	Self study
	57.	Euler's method	Self study
	58.	Euler's method	Self study
	59.	Runge-Kutta method of ODE.	Self study
	60.	Runge-Kutta method of ODE	Demo and Lecture
	61.	Runge-Kutta method of ODE	Demo and Lecture
	62.	Runge-Kutta method of ODE	Demo and Lecture
		Total hours for unit 1-5	**62**