XXXIX Academic Council - Annexure 3.8

Department of Physics

Minutes of 6th Board of Studies Meeting

The Department BOS meeting is held on **24th March, 2023**, from 10:00 AM – 1:30 PM in Room No.F202 (online mode: Online Link: https://kluniversity.webex.com/kluniversity/j.php?MTID=ma1f6f85cd274f8eee4a9de0cc0a338d3)

The following members were present:

1. Dr. K. Swapna, Associate Professor & HOD, KLEF, BOS-Chairperson
2. Dr. M. Venkateswarlu, Assistant Professor & Dy. HOD & Prof. In-Charge, BOS-Secretary
3. Prof. C. Vijayan, Department of Material Science and Nanotechnology
4. Prof. M. V. Shankar, Department of Material Science and Nanotechnology
5. Prof. Balakrishnan Ramalingam, Project manager
6. Dr. A. Venkateswara Rao, Asst. professor, HoD Chemistry
7. Dr. N. S. M. P. Latha Devi, Associate Professor, KLEF
8. Dr. G. Sunita Sundari, Associate Professor, KLEF
9. Dr. Mahamuda Shaik, Associate Professor & RPAC, KLEF
10. Dr. M. Venkata Naresh, Assoc. Professor & Assoc Dean (Academics), KLEF
11. Dr. K. Raghavendra Kumar, Associate Professor PG Coordinator, KLEF
12. Dr. M V V K Srinivas Prasad, Assistant Professor & Asst. COE, KLEF
13. Dr. A Venkateswara Rao, Assistant Professor, KLEF
14. Dr. Shaik Babu, Assistant Professor, KLEF
15. Dr. S. Shanmughan, Assistant Professor, KLEF
16. Mr. M. Gnana Kiran, Assistant Professor, KLEF
17. Dr. Sonali Biswas, Assistant Professor, KLEF
18. Dr. S. Bharat Kumar, Assistant Professor, KLEF

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Dr.K. Swapna, Chairman of BOS opened the meeting by welcoming and introducing the external members, to the internal and co-opted members and thanked them for accepting to become the member of the Board of Studies.

After due deliberations, the following resolutions have been adopted:

AGENDA and RESOLUTIONS

BOS Chairman presented a detailed M.Sc Nanoscience and Technology curriculum for 2023-24 admitted batch to the all members. Upon due deliberations, the external members suggested the following courses in curriculum.

Item No.	Item Description
1	Follow-up actions on the Minutes of the previous meetings of the Board of Studies of Department of Physics, KLEF, Vaddeswaram campus
2	Propose to introduce the new program M.Sc Nanoscience and Technology for the academic year 2023-24 admitted batch students.

AGENDA ITEM 1

To consider and approved the previous 5th BoS meeting minutes held on 15th March, 2022.
Follow-up actions on the Minutes of the previous meetings of the Board of Studies of Department of Physics, KLEF

AGENDA ITEM-2

Proposed to introduce the new M.Sc., Program Nanoscience and Technology for the A.Y. 2023-24 batch students	Approved and Recommended to Academic council for Approval

Discussion:

Based on the identified local, regional, national and global needs a new program M.Sc Nanoscience and Technology is suggested by the Academic peers, Faculty, with 7 Core courses, and two professional elective courses in first year and, 2 core courses, One professional elective, One term paper and Dissertation in second year with a total of 80 credits, according National educational policy.

Swapna 24/5/23

Resolution It is approved to initiate new program M.Sc. Nanoscience and Technology suggested by the department DAC members (held on 16.03.2023), Academic peers, Industrial person, internal faculty and external BOS members for Y23 admitted batch students and syllabus is shown in Annexure – I and curriculum shown in annexure- 2.

AGENDA ITEM-3

Request for the necessary infrastructure, and introduction of the new program, M.Sc Nanoscience and Technology, for the upcoming academic year 2023-24.	Approved and Recommended to Academic council for Approval

To resolve and recommended necessary infrastructure, for the introduction of the new program, M.Sc Nanoscience and Technology, for the upcoming academic year 2023-24, to Planning and monitoring Board. It is resolved and approved in the BOS meeting the inclusion of PDD file prepared for the Y23 batch students. The same has been recommended to the Academic council for the necessary approval.

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MEMBERS ATTENDED THE 6th BOARD OF STUDIES MEETING, DEPT OF PHYSICS, KLEF.

S. No.	Name	Designation & Organization	Position in the BOS Meeting	Signature
1	Dr. K. Swapna	Associate Professor & HOD, KLEF	BOS-Chairperson	
2	Dr. M. Venkateswarlu	Assistant Professor & Dy. HOD & Prof. In-Charge	BOS-Secretary	
3	Prof. C. Vijayan	Professor, Department of Physics, IIT Madras, Chennai. Mobile: 044-22574877 Email: cvijayan@iitm.ac.in	External Member & Subject Expert	attended online
4	Prof. M. V. Shankar	Professor, Department of Material Science and Nanotechnology Yogi Vemana University, Kadapa 516005, AP. India. Mobile: 9966845899 Email: shankar@yogivemanauniversity.ac.in	External Member & Subject Expert	attended online
5	Prof. Balakrishnan Ramalingam	Researcher, Project Engineer Singapore University of Technology & Design (SUTD) SINGAPORE 487372 Mobile: +6583804054 Email: balakrishnan.sjc@gmail.com	External Member Subject & Industrial Expert	attended online
6	Dr. M. Venkata Naresh	Assoc. Professor & Assoc Dean (Academics), KLEF	BOS-Invitee from Academics office	attended online
7	Prof. K. Giridhar	HOD-Biotechnology, KLEF	Internal Subject Expert	**Absent**
8	Prof. B.V. Appa Rao	HOD-Mathematics, KLEF	Internal Subject Expert	**Absent**
9	Dr. A. Venkateswara Rao	HOD-Chemistry, KLEF	Internal Subject Expert	
10	Dr. N. S. M. P. Latha Devi	Associate Professor, KLEF	Internal Member	
11	Dr. G. Sunita Sundari	Associate Professor, KLEF	Internal Member	
12	Dr. Mahamuda Shaik	Associate Professor & RPAC, KLEF	Internal Member	24/3/23
13	Dr. K. Raghavendra Kumar	Associate Professor, & PG Coordinator, KLEF	Internal Member	
14	Dr. M V V K Srinivas Prasad	Assistant Professor & Asst. COE, KLEF	Internal Member	
15	Dr. A Venkateswara Rao	Assistant Professor, KLEF	Internal Member	
16	Dr. Shaik Babu	Assistant Professor, KLEF	Internal Member	
17	Dr. S. Shanmughan	Assistant Professor, KLEF	Internal Member	
18	Mr. M. Gnana Kiran	Assistant Professor, KLEF	Internal Member	
19	Dr. Sonali Biswas	Assistant Professor	Internal Member	
20	Dr. S. Bharat Kumar	Assistant Professor, KLEF	Internal Member	

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Annexure – I.

Syllabus

PROFESSIONAL COMMUNICATION SKILLS (PCS)

Course Code : 22UC5201
L-T-P-S : 0-0-4-0
Credits : 2
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO/PS O	BTL
CO1	To develop and demonstrate principles of listening, speaking, reading and writing in various functional contexts	PO5	3
CO2	To demonstrate different types of personal and professional skills and apply them for growth in professional zone.	PO5	3
CO3	Apply the concepts of Mathematical Principles to solve problems on Arithmetic, Algebra & Geometry to improve problem solving ability.	PO5	3
CO4	Apply the concepts and using Logical thinking to solve problems on verbal & Non-Verbal Reasoning to develop Logical thinking skills.	PO5	3

Syllabus:

A) Vocabulary: Synonyms, Antonyms and One-word substitutes, (B)Reading comprehension, Critical reading, (C) Writing skills: Email writing, report writing and paragraph writing (D) Listening/Speaking Skills: listen & speak, Functional grammar.

Personal Skills:

Intra & Interpersonal skills (B) Assertiveness (C) Group Discussion (D) Resume writing (E) Video resumes (F) Interview skills

Simple Equations, Ratio & Partnership, Averages, Percentages, Profit & Loss, Simple & Compound Interest, Numbers, Quadratic Equations & Inequalities, Time & Work, Time, Speed & Distance, Permutations & Combinations, Probability, Mensuration, Data Interpretation.

Syllogism, Logical Venn Diagrams, Cubes & Dice, Number& letter series, Number, letter & word Analogy, Odd Man Out, Coding & Decoding, Blood Relations, Directions, clocks, calendars, Number, ranking & Time sequence test, Seating Arrangements, Data Sufficiency.

Text books

1. Fisher, Julie and Bailey, Peter " The Business Student's Handbook: Skills for Study and Employment" Cengage Learning, 2014. This is a good book for review and reference. Vector analysis, coordinate systems, tensor analysis, determinants, matrices, infinite series, Green's functions.
2. Adams, John " The Complete Guide to mastering soft skills for workplace success ", Vol. I. Adams media, Inc. N.Y., 2019. Has good treatment of n-dimensional vectors, orthogonal systems, norms, unitary transformations and eigenvalue problems.
3. Roy Peter Clark "Writing Tools: 55 Essential Strategies for Every Writer", Little, Brown and Company, 2006.
4. R. S. Agarwal "Quantitative Aptitude", SCHAND.
5. R. S. Agarwal "A Modern Approach to Verbal Reasoning", SCHAND.

FUNDAMENTALS OF NANOSCIENCE AND NANOTECHNOLOGY (FNN)

Course Code : 23NS5101
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understanding the basic concepts, Background, scientific revolutions of nanoscience and technology and understanding multifunction materials	PO1	2
CO2	Understanding the uniqueness of nanomaterial properties by comparing bulk materials with nanomaterials and applying to size dependent properties and challenges in nanotechnology.	PO3	3
CO3	Apply the concepts of dimensionality and size dependent phenomena to nanoscale materials and to observe size dependent variation in basic properties.	PO1	3
CO4	Apply the concepts and properties to advance and recent special Nanomaterials like CNT, nano composites, carbon fullerenes and study their specific applications.	PO3	3

Syllabus:

Basics of Nanoscience and Nanotechnology:

Nanotechnology, Feynman predictions on Nanotechnology - scientific revolutions - nanosized effects-surface to volume ratio nanoscience-Nanotechnology-Nano materials-Nano composites- Multifunctional nano materials-definitions with examples, Definition of Nanotechnology, Moore's law.

Comparison Bulk and Nanomaterials:

Nanostructured materials-metal semiconductor-ceramics and composites- size dependent properties - uniqueness in these properties compared to bulk and microscopic solids- nanomaterials and nanostructures in nature- super-hydrophobicity, self-cleaning-antifogging, Difference between Nanoscience and Nanotechnology, challenges in Nanotechnology.

Basics Properties:

Definition of a nano system-classification of nanocrystals-dimensionality andsize-dependent phenomena; Quantum dots, Nanowires and Nanotubes, 2D films; Nano & mesopores–Top Down and Bottom Up-Differences, Misconception of Nanotechnology-Importance of the nanoscale materials and their devices -size dependent variation in mechanical, physical, chemical, magnetic, electronic, transport, etc.

Advanced and Recent Special Nanomaterials:

Carbon Nano structures and types of Carbon Nano tubes, growth mechanisms Mechanical reinforcements, Solid Disordered carbon Nanostructures, Nano structured crystals. Graphene, Carbon nano-fibres. Electrical, Vibrational, Mechanical Properties of CNTs, optical properties; Carbon nanotubes, nano composites, carbon fullerenes-An overview over preparation, properties, applications.

Text Books:

1. Nanostructures & Nanomaterials: Synthesis, Properties & Applications G. Cao, Imperial College Press, 2004.
2. Nanomaterials, Nanotechnologies and Design: An introduction for engineers and Architects, Michael F. Ashby, P.J. Ferreira, D.L. Schodek.

Reference Books:

1. Introduction to Nanoscience and Nanotechnology, Gabor .L et al.
2. Introduction To Nanoscience and Nanotechnology by Chris Binns John Wiley & Sons, Inc., Publication, 2010

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PHYSICS OF NANOTECHNOLOGY (PON)

Course Code : 23NS5102
L-T-P-S : 3-1-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Apply the concepts of various concepts of quantum mechanics to solve the problems related to the motion of electrons in microscopic level	PO1	3
CO2	Understand the fundamental concepts of wave optics, electromagnetic waves, interference and polarization of light	PO2	2
CO3	Apply the spin and orbital motion of electrons in determining magnetic properties of materials and identifies their role in classification soft & hard magnetic materials having specific engineering applications.	PO2	3
CO4	Apply the knowledge of crystal structures and understand the electrical properties of semiconductors	PO2	3

Syllabus:

QUANTUM MECHANICS:

De-Broglie wavelength: in terms of energy and potential – Schrödinger time dependent equation – Time independent equation – Applications of Schrödinger wave equation – One dimensional harmonic oscillator: Eigen values of the total energy – Particle in a one dimensional box.

Wave Optics:

Electromagnetic waves and their characteristics – Theories of light –Wave, Electromagnetic and Quantum – Scattering of light: Rayleigh's and Tyndal scattering – Huygen's principle – Interference – Diffraction – Polarization of light waves..

MAGNETISM:

m Fundamental Concepts of Magnetism– Magnetic Materials – Dia, Para, Ferro, Anti ferro and ferrimagnetism–Magnetic Susecptibility – Curie Temperature – Hysteresis – Remanence – Coercivity – Saturation Magnetization –Small Particle Magnetism..

ELECTRONICS:

Classification of Solids, Crystal structure, Energy Levels, Intrinsic and Extrinsic Semiconductor, Conduction in Metals and Semiconductors. Diode Under Forward and Reverse Bias - Transistor Basics, Working Principles – Current-Voltage Characteristics..

Text Books & Reference Books:

1. S.O. Pillai, Solid State Physics, New Age International Publishers, 2022
2. C. Kittel, Introduction to Solid-State Physics, Wiley, 1986.
3. Nicola A. Spaldin, Magnetic Materials: Fundamentals and Applications, Cambridge University Press, 2nd Edition, 2014.

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CHEMISTRY OF NANOTECHNOLOGY (CNT)

Course Code : 23NS5103
L-T-P-S : 3-1-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understanding the basic Classification and Nomenclature of Nanomaterials	PO 1	2
CO2	Demonstrate of different types of chemical method to Synthesis of Nanomaterials.	PO 2	3
CO3	Understanding the concepts of Structure and Morphology of Nanoparticles	PO 2	2
CO4	Demonstrate the Novel Properties of Nanomaterials	PO 2	3

Syllabus:

Classification and Nomenclature of Nanomaterials:

Nanosized metals and alloys, semiconductors, ceramics – a comparison with respective bulk materials; Organic semiconductors, carbon materials; Zero-, one-, two- and three-dimensional nanostructures – quantum dots, quantum wells, quantum rods, quantum wires, quantum rings; bulk nanostructured, nanocomposites, Nanomachines and Devices.

Synthesis of Nanomaterials:

Nucleation and growth of nanosystems; self-assembly, mechanical milling, laser ablation, sputtering and microwave plasma, chemical reduction and oxidation, hydrothermal, micelles, sol-gel processes, photolysis, radiolysis, and metallo-organic chemical vapor deposition; designing of advanced integrated nanocomposites, functional nanomaterials and nanostructured thin films.

Structure and Morphology of Nanoparticles:

Fundamental Properties - size effects on structure and morphology of free or supported nanoparticles, size and confinement effects. Fraction of surface atoms - specific surface energy and surface stress, effect on the lattice parameter. Nanoparticle morphology - Equilibrium shape of a macroscopic crystal and nanometric crystals, morphology of supported particles...

Novel Properties of Nanomaterials:

Size and shape dependent optical, emission, electronic, transport, photonic, refractive index, dielectric, mechanical, magnetic, non-linear optical properties; Transition metal sols, origin of plasmon band, Mie theory, influence of various factors on the plasmon absorption. quantum confinement in semiconductors – particle in a box like model for quantum dots; origin of charge on colloidal sols, zeta potential, catalytic and photocatalytic properties, Mechanical properties.

Text Books & Reference Books:

1. Klabunde, K.J. (Ed.), Nanoscale Materials in Chemistry, John Wiley & Sons Inc, 2021
2. Schmid, G, Nanoparticles, Wiley, 2018.
3. Sergeev, G.B. Spaldin, Nanochemistry, Elsevier B.V. 2010.
4. Rao, C.N.R., Müller, A. and Cheentham, A.K. Chemistry of Nanomaterials, Wiley.
5. Shubra Singh M.S. Ramachandra Rao, Nanoscience and Nanotechnology: Fundamentals of Frontiers, Wiley, 2013

SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS-1 (SCNM-1)

Course Code : 23NS5104
L-T-P-S : 3-0-6-0
Credits : 5
Contact Hours : 9
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Apply the principles of different Physical and chemical routes to synthesis as per the required application and properties	PO-1	3
CO2	Apply the knowledge of structural characterization methods to analyse the performance of materials for required applications.	PO-2	3
CO3	Apply the knowledge of spectroscopic characterization methods to analyze the performance of materials for required applications	PO-2	3
CO4	Apply the knowledge of surface and thermal characterization methods to analyze the performance of materials for required applications.	PO-2	3
CO5	Apply the knowledge of synthesis and characterization of nanomaterials to perform experiments and analyze the samples	PO-2	4

Syllabus:

Physical and Chemical routes for synthesis of nanomaterials:

High Energy Ball Milling, Solid State method, Inert gas condensation, Role of inert gases- Post oxidation process; Chemical precipitation and co-precipitation; Metal nanocrystals by reduction, Sol-gel synthesis; Microemulsions or reverse micelles, Solvo-thermal synthesis.

Structural Characterization methods:

X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and EDAX analysis, Atomic force Microscopy (AFM), Scanning Probe Microscopy.

Spectroscopic Characterization:

Raman spectroscopy Basic concepts of spectroscopy, operational principle and application for analysis of nanomaterials, Fourier Transform Infrared Spectroscopy (FTIR), UV-VIS-IR Spectrophotometers, Photoluminescence (PL), Principle of operation and application for band gap measurement.

Surface & Thermal Characterization:

X-ray Photoelectron Spectroscopy (XPS), Auger electron spectroscopy, BET Analysis - Electron Spin Resonance (ESR), Ferromagnetic Resonance (FMR), Nuclear Magnetic Resonance (NMR), Mossbauer Spectroscopy, DTA, TGA, DSC (Principle and Applications).

1. Synthesis of Fe2O4 nanoparticles using co-precipitation method
2. Synthesis of ZnO nanoparticles using co-precipitation method
3. Synthesis of ZnO Nanoparticle using hydrothermal process.
4. Synthesis of Fe2O4 Nanoparticle using hydrothermal process.
5. Synthesis of Bi2O3 Nanoparticles using Sol-gel Method.
6. Synthesis of Bi2O3 Nanoparticles using co-precipitation method.
7. Synthesis of TiO2 Nanoparticles using sol-gel process.
8. Synthesis of Bi2O3 material using solid state method
9. To find the optical band gap of the given semiconducting materials by measuring UV- Visible spectrum.
10. To find the average grain/crystallite size, unit cell parameters, micro-strain by recording the X-ray diffraction pattern of the given sample.
11. To find out the defects in PL spectrum

12. To find the Chemical bonds of given material by FTIR
13. To find the Conductivity/Resistivity of the material using Four Probe method (VIRTUAL)
14. Synthesis of TiO2 Nanoparticles thin film using Spin Coating method
15. Make a Nanoparticle Virtually

Text Books

1. G. Cao, "Nanostructures & Nanomaterials: Synthesis, Properties & Applications", Imperial College Press, 2004.
2. Elton N. Kaufmann, characterization of materials, Wiley Interscience, 2003
3. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.

Reference books:

1.Chemistry of Nanomaterials: Synthesis, Properties and Applications - CNR Rao, H.C. mult.Achim Müller, A. K. Cheetham, Wiley-VCH Verlag GmbH & Co. KGaA, ISBN: 9783527306862, 9783527602476, 2004.
2. Carl. C Koch, "Nanostructured Materials: Processing, Properties and Potential Applications", William Andrew Publishing Norwich, 2006.

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NANO PHOTONICS (NPHT)

Course Code : 23NS5105
L-T-P-S : **4-0-0-0**
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Apply the concept of fundamental in Nano Photonics for optical devices	PO3	3
CO2	Apply nonlinear optics principles to analyze and design optical devices	PO4	3
CO3	Demonstrate the application of photonic crystals in real-world scenarios	PO2	2
CO4	Apply the principles of nano photonics to design the simple photonic devices	PO3	3

Syllabus:

Mathematical Methods in Nano photonics:

Algebraic techniques - solid-state quantum mechanics - linear algebra and eigen systems, group theory, Bloch's theorem and conservation laws, optical phenomena to nonlinear filters. Waveguides; Photonic crystals fibres and filter..

Nano-Plasmonic biosensors:

Basics of Plasmonics, Metallic nanoparticles, nanorods and nano shells, local field enhancement. Collective modes in nanoparticle arrays, particle chains and arrays. suface plasmons and waveguides. Applications of Metallic Nanostructures - Fabrication Adiabatic nanofabrication – Regulating the size and position of nanoparticles using size dependent resonance..

Nano photonics devices:

Basis of Nanophotonics - Optical near fields and effective - interactions as a base for nanophononics – Principles of operations of nanophotonic devices - using optical near fields – Principles of nanofabrication using optical near fields - Spontaneous emission control, Application of microcavities.

Medical Sensors:

Classical contrast mechanisms: bright field, dark field – Fluorescence contrast mechanism – Nonlinear microscopy based on second harmonic generation - coherent anti-Stokes Raman scattering –Stimulated emission depletion - nanoscale electronic energy transfer. Cooperative emissions..

Text Books:

1. Principles of Nanophotonics, Motoichi Ohtsu, Kiyoshi Kobayashi, CRC Press-Taylor & Francis Group, 2020.
2. Photonic Crystals: Towards Nanoscale Photonic Devices, Jean Michel Lourtioz, Springer, 2006.
3. Physics of Nonlinear Optics, Y.V.G.S. Murti and C. Vijayan, 2nd Edition, Springer Nature, 2021.

Reference Books:

1. Photonics crystals, John D Joannopoulos, Princeton University Press, 2008.
2. The Handbook of Photonics, Mool Chand Gupta, John Ballato, CRC Press, 2022.

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SYNTHESIS AND CHARACTERIZATION OF NANOMATERIALS-2 (SCNM-2)

Course Code : 23NS5206
L-T-P-S : 3-0-0-12
Credits : 6
Contact Hours : 15
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Apply the principles of different Physical and chemical routes to synthesis as per the required application and properties	PO1	3
CO2	Apply the knowledge of structural characterization methods to analyse the performance of materials for required applications.	PO1	3
CO3	Apply the knowledge of spectroscopic characterization methods to analyze the performance of materials for required applications	PO1	3
CO4	Apply the knowledge of surface and thermal characterization methods to analyze the performance of materials for required applications.	PO1	3
CO5	Apply the knowledge of synthesis and characterization of nanomaterials to perform experiments and analyze the samples	PO2	4

Syllabus:

Physical and Chemical routes for synthesis of nanomaterials:
Different types of Sputtering processes – Pulsed laser deposition – Rapid solidification – Arc discharge method- Fabrication of Nanostructures Microfabrication using Etching-Lithography; Thermolysis routes, Microwave heating synthesis; Sono-chemical synthesis; Electrochemical synthesis; Photochemical synthesis, Supercritical fluid nano materials synthesis..

Materials defects studies:
Scanning Tunnelling Microscopy(STM), Atomic Force Microscopy AFM)-Non-contact, contact-Tapping- conducting mode-.Near Field Scanning Optical Microscopy; Scanning Capacitance Microscopy- Magnetic Force Microscopes MFM)- Chemical Force Microscope (CFM) - Applications for analysis of nanomaterials.

Magnetic and electrical characterization:
Vibration Sample Magnetometer (VSM), Semiconducting Quantum Interference Device (SQUID), Impedance Spectroscopy- Four probe method, PPMS.

Bio-materials characterization: New Advances and challenges in biological and biomedical materials characterizations- Dynamic light scattering spectroscopy. Confocal Microscopes- Confocal Raman – Application in Nano-biotechnology. Fluorescence Microscope.

1. Synthesis of Fe2O3 Nano fibres using electrospinning.
2. Preparation of WO3 nanostructures using microwave synthesis.
3. Synthesis of ZnFe2O4 Nanoparticles by sol-gel Method.
4. SEM demo characterization of nanomaterials for size and surface morphology.
5. Fabrication of Thin Film by using Spin coating technique.
6. Photocatalytic activity of nanomaterials.
7. Gas Sensor Setup Demo Class
8. Electrochemical workstation demo class
9. Performing photolithography experiments and using a scanning electron microscope. https://www.uvu.edu/physics/nanotech/practice/vr_lab.html
10. Preparation of Sols: https://esc-iiith.vlabs.ac.in/List%20of%20experiments.html

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11. Preparation of Gels: https://csc-iiith.vlabs.ac.in/List%20of%20experiments.html

Text Books & Reference Books:

1. Dieter Vollath, Nanoparticles – Nanocomposites – Nanomaterials An Introduction for beginners, Wiley 2013
2. R.W. Cahn, E.M. Lifshitz, Concise Encyclopedia of Materials Characterization: Advances in Materials Sciences and Engineering, Elsevier, 2016.
3. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons, 2013.
4. Tseung-Yuen Tseng and Hari Singh Nalwa , Handbook of Nanoceramics and their Based Nanodevices (Vol. 2), American Scientific Publishers, 2005.

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EMERGING APPLICATIONS OF NANOTECHNOLOGY (EANT)

Course Code : 23NS5207
L-T-P-S : 4-0-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Student can understand the Basic Electronic devices and nano electronic devices, Mechanical Molecular Nano robotics Nano devices and Nano computers: Theoretical Models	PO-1	2
CO2	Student can understand the Molecular scale electronics - Molecular materials for electronics – Carbon materials: Fullerene and CNTs.	PO-2	2
CO3	Student can understand the Micro and Nano electrical Systems: - Overview	PO-2	2
CO4	Student can understand the Future Nanosystems -Nano machines, nano robots, electronics based on CNT, molecular Electronics.	PO-5	2

Syllabus:

Semiconductor Nanodevices-I: Single Electron devices- Nano scale MOSFET – Resonant Tunnelling Transistor – Single Electron Transistors manipulation Single Electron Dynamics Mechanical Molecular Nano robotics Nano devices and Nano computers: Theoretical Models.

Molecular Electronics:

Molecular scale electronics -Molecular materials for electronics – Carbon materials: Fullerene and CNTs, Graphene and RGO - Carbon Nanotubes, Structure and Unique Properties of Carbon Nanotubes – types of Carbon Nanotubes - Applications of Carbon Nanotubes–CNTs in field Emission, Shielding, Field-Effect Transistor and logic gates..

Micro and Nano electrical Systems:

Overview- Micro and Nano-Electromechanical systems - Fundamental concepts - fabrication process-choice of materials, calculations - the performance of different structures - Nanoelectronics Devices - Approaches to Nanoelectronics - advantages and disadvantages of different approaches, thermal sensors, radiation sensors, magnetic sensors, chemical sensors, mechanical sensors

Future Nano systems -Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Meso/ Nano electronics -Interfacing with the Brain, towards molecular medicine, Lab-on-Bio Chips- Guided evolution for challenges and the solutions in Nano Manufacturing technology.

Text Books:

1. Nanotechnology – Enabled sensors, Kourosh Kalantar-zadeha and Benjamin Fry, Springer, 2009.
2. Nanostructured Materials for Electrochemical Energy production and storage, David J. Lockwood, Springer, 2009.
3. Nanomedicine, Robert and Freitas, Springer, 2004.
4. Nanobiotechnology- concepts and applications in Health, Agriculture and Environment, R. Tomar Apple, Academic Press, 2012.

Reference Books:

1. Nanoscience and Nanotechnology, Murthy, Sankar, Murday, Springer and University press, 2013.
2. Nanoporous Materials: Synthesis and applications, Qiang Xu, CRC Press, 2013.
3. Heterogeneous Catalysis, D.K.Chakrabarty and B. Viswanathan, New Age International (P) Ltd, 2008.
4. Photocatalysis, Masao Kaneko and Ichiro Okura, Springer, 2003.
5. Catalysis: Principles and Applications, B. Viswanathan, S. Sivasankar, A. V. Ramaswamy, Narosa Publishing House, 2011.
6. Development and perspective applications of Nanoscience and Nanotechnology, Khan, Asiri, Akhtar, Bentham Books, 2018.

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ADVANCED NANOMATERIALS (ANM)

Course Code : 23NS6108
L-T-P-S : 4-0-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : Fundamentals of Nanoscience and Nanotechnology

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	To gain in-depth knowledge in the concepts of magnetism at nanoscale.	PO1	3
CO2	Gain good knowledge in Thermoelectric Materials and the advanced tools to study.	PO1	3
CO3	Understanding the various one dimensional semiconductors behaviour.	PO1	3
CO4	Understanding the structure properties of polymeric nanomaterials and applications.	PO1	3

Syllabus:

Nanostructured Magnetism: Nanostructure magnetism, Effect Bulk Nano structuring of magnetic property, Giant and colossal magnetic resistance, Nanomagnetic materials, Paramagnetism in metallic nanoparticles, semiconducting quantum dots.

Thermoelectric Materials: Concept of phonon, Thermal conductivity specific heat, exothermic and endothermic processes, Different types of thermoelectric materials, Bulk properties, One dimensional and composite thermoelectric materials, Applications..

One dimensional semiconductors: Fabrication strategies, quantum conductance effects in semiconductor nanowires, porous Silicon, nanobelts, nanoribbons, nanosprings.

Structure properties of Polymeric Nanomaterials and Applications: Structure-property relationship, stress-strain behaviour, crystalline melting point, effect of chain flexibility and other steric factors, entropy and heat of fusion, glass transition temperature, relationship between Tm and Tg. Effect of molecular weight, property requirements and its utilization. Synthetic procedure commercial polymers, Fire retarding and biomedical polymers.

Text Books & Reference Books

1. H J Moller, Artech House Inc, MA, USA., Semiconductor for solar cells, Wiley 2010
2. Ben G Streetman, Prentice Hall of India Pvt Ltd.,, Solis state electronic device, Wiley 2004.
3. C. Brabec, V. Dyakonov, U. Scherf, Organic Photovoltaics – Materials, Device Physics and Manufacturing Technologies, Wiley, 2003.
4. F.W. Billmeyer Jr, Text Book of Polymer Science, Wiley, 2010.
5. V.R. Gowariker, N.V. Viswanathan and J. Sreedhar , Polymer Science, Wiley, 2009.

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ADVANCED NANO BIOTECHNOLOGY (ANBT)

Course Code : 23NS6109
L-T-P-S : **4-0-0-0**
Credits : 4
Contact Hours : 4
Pre-requisite : PE-1

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Apply the basic concepts of energy conversion systems.	PO3	3
CO2	Appraise the working of fuel cells current status and future trends	PO3	3
CO3	Apply the knowledge of photovoltaic cells and energy conversion systems to improve their performance.	PO3	3
CO4	Apply the knowledge of photovoltaic systems to understand the working of Solar cells.	PO3	3

Syllabus:

Functional Principles of Nanobiotechnology- - Historical perspective of Integration of biology, chemistry, and material science. Opportunities and Promises of nanobiotechnology. Structure and functional properties of Biomaterials, Bimolecular sensing, Molecular recognition and Flexibility of biomaterials. - Protein based nanostructures building blocks and templates – Proteins as transducers and amplifiers of biomolecular recognition events. Microbial production of inorganic nanoparticles – Magnetosomes. DNA based nanostructures – Topographic and Electrostatic properties of DNA and proteins – Hybrid conjugates of gold nanoparticles – DNA oligomers.

Nanomaterials used in Biotechnology - Nanoparticles, carbon nanotubes, quantum dots and buckyballs interface with biological macromolecules. Biological perspectives of nanomaterials – impact of nanomaterials in biological processes – tolerance by immune systems and toxicity. Nucleic acid Engineering- Modifications of DNA for nano-technological applications. Nanostruture assembly using DNA.

Nanotechnology in Biomedical and Pharmaceutical Industry - Nanoparticles in bone substitutes and dentistry – Implants and Prosthesis - Reconstructive Intervention and Surgery – Nanorobotics in Surgery – Photodynamic Therapy – Nano sensors in Diagnosis. Design and types of nano-biosensors. DNA aptamers for nano-biosensing and drug discovery..

Nanotechnology in Agriculture and Food technology - Insecticides development using nanotechnology and Nanofertilizers. Nanotechnology in food processing, food safety and biosecurity, toxin and contaminant detection, Smart packaging.

Text Books & Reference Books:

1. Challa, S.S.R. Kumar, Josef Hormes, Carola Leuschaer, Nanofabrication Towards Biomedical Applications, Techniques, Tools, Applications and Impact, Wiley – VCH.
2. D.S. Goodsell, Bionanotechnology: Lessons from Nature, Wiley Press.
3. C. M. Niemeyer and C. A. Mirkin- (Editor),, Nanobiotechnology: Concepts, Applications and Perspectives, Wiley Press.

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MICRO AND NANO ELECTRONIC DEVICES (M&NED)

Course Code : 23NS6110
L-T-P-S : 4-0-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understand the Basic Electronic devices and nano electronic devices, Mechanical Molecular Nano robotics Nano devices and Nano computers: Theoretical Models	PO-1	2
CO2	Understand the Molecular scale electronics -Molecular materials for electronics – Carbon materials: Fullerene and CNTs.	PO-2	2
CO3	Understand the Micro and Nano electrical Systems: - Overview	PO-2	2
CO4	Understand the Future Nano systems -Nano machines, nano robots, electronics based on CNT, molecular Electronics.	PO-5	3

Syllabus:

Semiconductor Nano devices-I: Single Electron devices- Nano scale MOSFET – Resonant Tunneling Transistor – Single Electron Transistors manipulation Single Electron Dynamics Mechanical Molecular Nano robotics Nano devices and Nano computers: Theoretical Models.

Molecular Electronics:

Molecular scale electronics -Molecular materials for electronics – Carbon materials: Fullerene and CNTs, Graphene and RGO - Carbon Nanotubes, Structure and Unique Properties of Carbon Nanotubes – types of Carbon Nanotubes - Applications of Carbon Nanotubes–CNTs in field Emission, Shielding, Field-Effect Transistor and logic gates..

Micro and Nano electrical Systems:

Overview- Micro and Nano-Electromechanical systems - Fundamental concepts - fabrication process-choice of materials, calculations - the performance of different structures - Nanoelectronics Devices - Approaches to Nanoelectronics - advantages and disadvantages of different approaches, thermal sensors, radiation sensors, magnetic sensors, chemical sensors, mechanical sensors.

Future Nanosystems -Nano machines, nano robots, electronics based on CNT, molecular Electronics. Quantum Computation: Future of Meso/Nanoelectronics -Interfacing with the Brain, towards molecular medicine, Lab-on-Bio Chips- Guided evolution for challenges and the solutions in Nano Manufacturing technology.

Text Books & Reference Books:

1. Jacob Millman (Author), Arvin Grabel (Author), MICROELECTRONICS Paperback, McGraw Hill Education, 1 July 2017
2. Behzad Razavi (Author), Microelectronics, 2ed, Wiley, 1 January 2017.
3. Korkin Anatoli Et. Al (Author), Nanotechnology for Electronic Materials And Devices Paperback, Springer Nature (SIE), 1 January 2011.

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NANO-ELECTRONICS (NE)

Course Code : 23NS6121
L-T-P-S : 4-0-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understanding of the principles, limitations, and applications of nano electronics.	PO3	2
CO2	Understanding of the nano scale effects, techniques for nanoscale transistor fabrication, industrial CMOS technology, and non-classical elements of nano MOSFETs.	PO3	2
CO3	Understanding of the introduction to nanostructures, the fabrication and patterning techniques used to create nanostructures, and the characterization techniques.	PO3	2
CO4	Understanding of nano sensors, nano actuators, memory devices, photovoltaic cells, and their applications in communication, industry, commercial settings, agriculture, biomedical fields, and the Internet of Things (IoT).	PO3	2

Syllabus:

Overview of Nano Electronics:

Introduction to nano electronics, Development of Micro-Electronics, Limitation of Micro-Electronics, Micro-Electronics to Nano Electronics, Examples of Nano Devices, Application of Nano Devices in Electronics.

Scaling Theory:

Nano scale effects, Techniques for Nano Scale Transistor, Industrial CMOS Technology, Non-classical Elements of Nano MOSFET.

Nanofabrication Techniques:

Introduction to nano structures (Thin films, Nano wire, Nano rods, CNT), Fabrication/Patterning of nano structure (CVD, AFM, Lithography), Characterization techniques of nanostructures (SEM, TEM)..

Smart Nano Devices/Materials:

Nano Sensors, nano actuators and bio sensor, memory devices (Fin FET), photo voltaic cell. Applications: Communication, Industry, Commercial, Agriculture and bio medical, IOT..

Text Books & Reference Books

1. Y. Taur and T. Ning, Fundamentals of Modern VLSI Devices, Cambridge University Press, 2009
2. Plummer, Deal, Griffin, Silicon VLSI Technology, Pearson Education India, 2000.
3. W.R. Fahrner, Nanotechnology and Nanoelectronics: Materials, Devices, Measurement Techniques, Springer 2010.

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ARTIFICIAL INTELLIGENCE INTEGRATION WITH NANOTECHNOLOG (AIIN)

Course Code : 23NS6122
L-T-P-S : 4-0-0-0
Credits : 4
Contact Hours : 4
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Gain the in-depth knowledge in the concepts Artificial Intelligence, Machine Learning, and Deep Learning	PO-1	3
CO2	Gain and apply good knowledge of artificial intelligence in the nanotechnology.	PO-1	3
CO3	Applying the artificial intelligence in nanoscale simulations	PO-1	3
CO4	Apply the knowledge of artificial intelligence in Nano-Computing and High-Performance Computing.	PO-1	3

Syllabus:

Introduction–Definition – Future of Artificial Intelligence – Characteristics of Intelligent Agents– Typical Intelligent Agents – Problem-Solving Approach to Typical AI Problems. Introduction to Machine Learning Algorithms: Introduction to Machine Learning – Statistical Learning – types of Machine Learning –learning models: geometric, probabilistic, and logistic models, introduction to supervised, unsupervised, and reinforcement learning – model evaluation – model.

History of Deep Learning, McCulloch Pitts Neuron, Thresholding Logic, Perceptron's, Perceptron Learning Algorithm and Convergence, Multilayer Perceptron's (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feedforward Neural Networks, Backpropagation, Gradient Descent (GD), Momentum Based GD.

Introduction to nanotechnology, nanoscale and nanomaterials, history of nanotechnology, Approaches of Nanotechnology: Bottom-up or top-down, Real-world application of AI in Nanotechnology, AI in Material Design and Assembly. Understanding Atomic Force Microscopy (AFM) and Addressing Noise in AFM, The Application of AI in Atomic Force Microscopy (AFM), Artificial Intelligence in Nanoscale Simulations: Image Segmentation, Image Classification, Object Detection, Enhancing nanoscale images.

Introduction and History of Computing, Nano-Computing, Artificial Intelligence and Nano-Computing, Nanocomputing Technologies, Nano Information Processing, Prospects and Challenges, Physics of Nanocomputing: Digital Signals and Gates, Silicon Nanoelectronics, Carbon Nanotube, Electronics. Artificial Intelligence and High-Performance Computing, computers quantum, Approach to Parallelization and Parallelization Paradigm.

Text Books:

:1. Elaine Rich, Kevin Knight, & Shivashankar B Nair, Artificial Intelligence, McGraw Hill, 3rd ed.,2009.
2. Machine Learning. Tom Mitchell. First Edition, McGraw-Hill, 1997.
3. Introduction to Machine Learning Edition 2, by Ethem Alpaydin.
4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning. An MIT Press book. 2016.
5. Charu C. Aggarwal. Neural Networks and Deep Learning: A Textbook. Springer. 2019.

Reference Books:

:1) Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI.,2010
2) S Kaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011.
3) Feynman R, There's Plenty of Room at the Bottom, Journal of Microelectromechanical Systems, 1992
4) Zohuri B, Mossavar FR, Artificial Intelligence Versus Human Intelligence: A New Technological Race, Acta Scientific Pharmaceutical Sciences, 2020.
5) Zohuri B, Moghaddam M, Neural Network Driven Artificial Intelligence: Decision Making Based on Fuzzy Logic, Science Publishers, Inc, 2017.
6) Zohuri B, Mossavar FR, A Model to Forecast Future Paradigms: Volume 1: Introduction to Knowledge Is Power in Four Dimensions, Apple Academic Press, 2003

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BIOLOGY OF NANOTECHNOLOGY (BNT)

Course Code : 23NS52E1
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understand the concepts of Biomolecules used in Biotechnologica processes	PO-1	2
CO2	Understand the interaction between Biomolecules, immune components and applications of recombinant DNA Technology	PO-2	2
CO3	Apply the principles of in-silico technology in designing drugs and concepts of Biosafety and bioethics	PO-1	3
CO4	Apply the concepts of analytical techniques to characterize the bioanalytes used in various Pharma and Biotechnological industries	PO-1	3

Syllabus:

Introduction Basic unit of life; macromolecules; prokaryotes; eukaryotes; cell com J)onents- sub-cellular organelles. Microbial life and fermentation process: Bacteria, fungi and viruses; basic concept of microbial growth, bioprocess technology and enzymes.

Molecular biology concepts:

Central dogma of molecular biology-replication, transcription and translation; recombinant DNA technology; basic concept of immune system, vaccines, GMOs.

Medical Biotechnology:

Introduction to biopharmaceuticals, herbal medicines, gene therapy, nanobiotechnology, bioinformatics and drug design, biosafety and bioethics.

Molecular techniques in Biotechnology:

Introduction to microscopy, spectroscopy, electrophoresis, chromatography, centrifugation, , radioisotope technique, PCR, northern blotting southern blotting, western blotting.

Text Books & Reference Books:

1. Walker, J.M. and Gingold, E.B., Molecular Biology and Biotechnology, The Royal Society of Chemistry UK.
2. Wilson, K. and Walker, J, Principles and Techniques of Practical Biochemistry, 5th edition, Cambridge University Press.
3. Bernard R. G., Jack J. P, Molecular Biotechnology : Principles and Recombinant DNA, ASM Press 4th Edition.

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BIOCHEMISTRY (BC)

Course Code : 23NS52E2
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understand the functions and properties of Proteins in biological systems	PO-1	2
CO2	Understand the functions of Enzymes and kinetics in physiological systems	PO-1	2
CO3	Understand the structure, Functions and classification of Carbohydrates, Nucleic acids and Lipids in Biological system	PO-1	2
CO4	Apply the importance of Metabolic pathways in Biotechnology sector.	PO-1	3

Syllabus:

Chemical basis of life; Water-properties of water, acid and base, pH, buffers, 5 physiological buffers; Non-covalent interactions; Macromolecular assemblies. Proteins-classification, structure, function, dynamics, specificity, and basics of 9 protein purification and analysis;

Functional and structural proteins-Hemoglobin, - myoglobin, collagen. Enzymes-introduction, classification, kinetics and catalysis; Enzyme inhibitors; 8 Enzyme mechanisms and regulation.

Nucleic acids-structure and properties of DNA and RNA, DNA double helical 5 structure, A, B & Z DNA; Carbohydrates-Mono! di and polysaccharides, glycoproteins and glycolipids; Lipids-Classification, structure, function, lipid bilayer.

Metabolism- basic concepts and design; Metabolism of carbohydrates-glycolysis & 11 gluconeogenesis, citric acid cycle, electron transport chain and oxidative phospborylation; Metabolism ofli pid amino acid and nucleotides. Integration of metabolism, coordinated control and regulation.

Text Books & Reference Books:

1. Stryer, L., Biochemistry, 7th edition, W. H. Freeman, 2010
2. Horton, H.R., Moran, L.A., Ochs R.A., Rawn, J. D. and Scrimgeor, R.S.,, Principles of Biochemistry, 3rd edition Prentice Hall, 1 January 2001.
3. Voet D. and Voet, J. G.,, Biochemistry, 3rd edition, John Wiley and Sons, 2004.

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NANOMAGNETIC MATERIALS AND DEVICES (NMD)

Course Code : 23NS52E3
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Gain and Apply in-depth knowledge in the concepts of magnetism at both micro and nanoscale.	PO-1	3
CO2	Gain and apply good knowledge in Nanomagnetism and the advanced tools to study.	PO-1	3
CO3	Applying the various imaging techniques to study the magnetic behaviors.	PO-1	3
CO4	Identity and apply the suitable applications of the magnetic materials based on the functional Properties in nanomagnetic data storage and biomedicine.	PO-1	3

Syllabus:

Fundamentals of magnetism – classification of magnetic materials - Antiferromagnetic materials – Domains and the magnetization process– Coercivity of fine particles - Super paramagnetism in fine particles – Exchange anisotropy - Induced anisotropy in thin films - Electron transport in magnetic multi-layers – Spin polarized electron tunneling - Interlayer exchange coupling - Spin relaxation in magnetic metallic layers and multi-layers - Nonequilibrium spin dynamics in laterally defined magnetic structures.

Two-spin channel model - Two terminal spin electronics – Three terminal spin electronics - Spin tunneling - Study of ferromagnetic and antiferromagnet interfaces – Photoemission Electron Microscopy - X-ray Absorption Spectroscopy - X-ray Magnetic Linear Dichroism (XMLD) - X-ray Magnetic Circular Dichroism (XMCD) - Temperature dependence of X-ray Magnetic Dichroism.

Molecular Nano magnets – Mesoscopic magnetism - Particulate nanomagnets – Geometrical nanomagnets – Fabrication techniques scaling – Characterization using various techniques – Imaging magnetic microspectroscopy – Optical Imaging – Lorentz Microscopy – Electron Holography of Magnetic Nanostructures –Magnetic Force Microscopy.

Magnetic sensors and Giant Magnetoresistance - Optically transparent materials - Soft ferrites- Nanocomposite magnets- Magnetic refrigerant – High TC superconductor – Ferro/biofluids– Biomedical applications of magnetic nanoparticles - Diagnostic applications - Therapeutic applications - Physiological aspects - Toxic effects.

Text Books:

1.Magnetic Microscopy of Nanostructures, Hans. P.O, and Hopster. H, Springer, 2010
2.Ulltra-thin Magnetic Structures III – Fundamentals of Nanomagnetism Bland. J.A.C, and B. Heinrich. B, Springer, 2005.
3.Magnetic Materials: Fundamentals and Device Applications, Nicola. A.S, Cambridge, University Press, 2003

4.Magnetism and Magnetic Materials, J. M. D. Coey, Pearson Education, 2010,
5.Introduction to Magnetic Materials, B. D. Cullity,C. D. Graham, John Wiley & Sons, Inc, 2009.

Reference Books:

1. Hans .P.O, and Hopster. H, Magnetic Microscopy of Nanostructures, Springer, 2010
2. Bland. J.A.C, and B. Heinrich. B,, Ultra thin Magnetic Structures III – Fundamentals of Nanomagnetism, Springer, 2005.
3. Nicola. A., Magnetic Materials: Fundamentals and Device Applications, Cambridge, University Press, 2003.
4. J. M. D. Coey, Magnetism and Magnetic Materials. Pearson Education, 2003

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SOCIETAL IMPACTS OF NANOTECHNOLOGY (SINT)

Course Code : 23NS52E4
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understand the economic and societal impacts of nanotechnology	PO4	2
CO2	Apply the economical and societal impacts of nanotechnology in society	PO4	3
CO3	Apply the ethics, laws and governance related to nanotechnology	PO5	3
CO4	Apply the public perception, societal implications of nanotechnology	PO5	3

Syllabus:

Protection and Regulation for Nanotechnology Patentability requirements-riding the patent office pony-infringement issues-nanotech patents outside the united states-copyright requirements-nanotech creation as artist Works-Delegation of power of Agencies-Examples of regulation of nanotechnology environmental regulations-regulation of exports-political and judicial control over agency action. The applications of civil &criminal laws-civil liability, Health and safety issues.

Economic Impacts and Commercialization of Nanotechnology and Social Scenarios Introduction - Socio-Economic Impact of Nanoscale Science: Initial Results and Nanobank-Managing the Nanotechnology Revolution: Consider the Malcolm Baldrige National Quality Criteria -The Emerging NanoEconomy: Key Drivers, Challenges, and Opportunities-Transcending Moore's Law with Molecular Electronics and Nanotechnology- Navigating Nanotechnology Through Society - Nanotechnology, Surveillance, and Society: Methodological Issues and Innovations for Social Research-Nanotechnology: Societal Implications: Individual Perspectives Nanotechnology and Social Trends-Five Nanotech

Ethics, Law and Governance: Ethics and Law-Ethical Issues in Nanoscience and Nanotechnology: Reflections and Suggestions-Ethics and Nano: A Survey-Law in a New Frontier- An Exploration of Patent Matters Associated with Nanotechnology -The Ethics of Ethics -Negotiations over Quality of Life in the Nanotechnology Initiative, Governance of Nanotechnology and problems.

Public Perceptions and Education

Public Perceptions-Societal Implications of Nanoscience: An Agenda for Public Interaction Research -Communicating Nano technological Risks- A Proposal to Advance Understanding of Nanotechnology's Social Impacts -Nanotechnology in the Media: A Preliminary Analysis-Public Engagement with Nanoscale Science and Engineering -Nanotechnology: Moving Beyond Risk-Communication Streams and Nanotechnology: The (Re)Interpretation of a New Technology-Nanotechnology: Societal Implications Nanotechnology.

Text Books & Reference Books:

1. Mihail C Roco and William Sims, Nanotechnology: Risk, Ethics and Law, Springer, 2007
2. Geoffrey Hunt and Michael D Mehta, Microelectronics, 2ed, James & James Publication, 2006.
3. Jurgen Schulte, Nanotechnology: Global Strategies, Industry Trends and Applications, Wiley & Sons LTD, 2005.
4. Mark R Weisner, Environmental Nanotechnology applications and impact of nanomaterial, The Mc Graw Hill, 2007.

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NANOTECHNOLOGY FOR RENEWABLE ENERGY MATERIALS (NREM)

Course Code : 23NS61E5
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Apply the basic concepts of energy conversion systems.	PO-1	3
CO2	Appraise the working of fuel cells current status and future trends	PO-1	3
CO3	Apply the knowledge of photovoltaic cells and energy conversion systems to improve their performance.	PO-1	3
CO4	Apply the knowledge of photovoltaic systems to understand the working of Solar cells.	PO-1	3

Syllabus:

Fundamental Concepts in Electrochemistry Electrochemical Cell, Faraday's laws, Electrode Potentials, Thermodynamics of electrochemical cells, Polarization losses in electrochemical cells, Electrode process and kinetics, Electrical double layer, Photo-electrochemical cell, thermoelectric effect..
Energy Conversion Systems Issues and Challenges of functional Nanostructured Materials for electrochemical Energy, Conversion Systems, Fuel Cells, Principles and nanomaterials design for; Proton exchange membrane fuel cells (PEMFC); Direct methanol fuel cells (DMFC); Solid-oxide fuel cells (SOFC), Current status and future trends

Photovoltaic Systems Principles of photovoltaic energy conversion (PV), Types of photovoltaic Cells, Physics of photovoltaic cells, Organic photovoltaic cell cells, thin-film Dye-Sensitized Solar Cells, Quantum dot (QD) Sensitized Solar Cells (QD-SSC), Organic-Inorganic Hybrid Bulk Hetero junction (BHJ-SC) Solar cells, Current status and future trends.

Energy Storage System - Batteries Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage Systems, Primary and Secondary Batteries (Lithium-ion Batteries), Cathode and anode materials, Nanostructured Carbon-based materials, Nano-Oxides, Novel hybrid electrode materials, Current status and future trends.

Text Books & Reference Books:

1. Gang Zhang; Navin Manjooran, Prof. Dr Gang Zhang, Nanofabrication and its Application in Renewable Energy, Royal Society of Chemistry, 2014
2. Flavio Leandro de Souza, Edson Roberto Leite, Nanoenergy Nanotechnology Applied for Energy Production, Springer Berlin, Heidelberg, 2013.
3. Anatoli Korkin, Predrag S. Krstić, Jack C. Wells, Nanotechnology for Electronics, Photonics, and Renewable Energy, Springer New York, NY, 2010.

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NANOTECHNOLOGY IN HEALTH CARE (NHSC)

Course Code : 23NS61E6
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	To be introduced to recent advancements in nano medicine.	PO-1	3
CO2	learn developments in nanostructured materials used for medical implants	PO-1	3
CO3	learn about nano diagnostics and understand the harmful effects of nanoparticles.	PO-1	3
CO4	understand need of nanotechnology in health care	PO-1	3

Syllabus:

Nano molecular Diagnostics - Array and Chips Introduction - Nano diagnostics -Rationale of Nanotechnology for Molecular Diagnostics -Nano arrays for Molecular Diagnostics. Nano ProTM System - Nano fluidic/Nano array Devices to Detect a Single Molecule of DNA-Self-Assembling Protein Nano arrays -Fullerene Photodetectors for Chemi-luminescence Detection on Micro Fluidic Chips - Nano bio chip Nanoparticles for Molecular Diagnostics -Gold Nanoparticles - Applications of Nano pore Technology for Molecular Diagnostics DNA–Protein and DNA–Nanoparticle Conjugates.

Nano machines and Nano barcodes, Nano biosensor :DNA Nano machines for Molecular Diagnostics - Nano barcodes Technology -Nano barcode Particle Technology for SNP Genotyping -Qdot Nano barcode for Multiplexed Gene Expression Profiling-Biobarcode Assay for Proteins Single-Molecule Barcoding System for DNA Analysis Nanoparticle-Based Colorimetric DNA Detection Method Cantilevers as Biosensors for Molecular .

NANOPHARMACEUTICALS : Introduction -Nano-biotechnology for Drug Discovery -Gold Nanoparticles for Drug Discovery - Use of Quantum Dots for Drug Discovery –Nano-lasers for Drug Discovery -Cells Targeting by Nanoparticles with Attached Small Molecules -Role of AFM for Study of Bio-molecular Interactions for Drug Discovery Nanoscale Devices for Drug Discovery - Nanotechnology Enables Drug Design at Cellular Level Nano-biotechnology-Based Drug Development -Dendrimers as Drugs- Fullerenes as Drug Candidates -Nano-bodies Nano-biotechnology in Drug Delivery -Nanoscale Delivery of Therapeutics.

Application in Cancer Therapy & Nano-medicine: Introduction and Rationale for Nanotechnology in Cancer Therapy - Passive Targeting of Solid Tumors: Pathophysiological Principles and Physicochemical Aspects of Delivery Systems -Active Targeting Strategies in Cancer with a Focus on\Potential Nanotechnology Applications-Pharmacokinetics of Nanocarrier-Mediated Drug and Gene Delivery - Multifunctional Nanoparticles for Cancer Therapy- Neutron Capture Therapy of Cancer.

Text Books & Reference Books:

1. Kewal. K, Jain,, The Handbook of Nanomedicine, Humana Press, 2008
2. Zhang,, Nanomedicine: A Systems Engineering Approach, Pan Stanford Publishing, 2005.
3. Robert. A, Freitas Jr, Nanomedicine Volume IIA: Biocompatibility, Landes, Bioscience Publishers, 2000.

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(Deemed to be University)
Green Fields, Vaddeswaram-522 302.
Guntur Dist., A.P. India.

MATERIAL SCIENCE AND ENGINEERING (MSE)

Course Code : 23OENS01
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understands structure of crystalline solids, kinds of crystal imperfections and appreciates structure-property relationship in crystals.	PO-1	2
CO2	Understands spin and orbital motion of electrons in determining magnetic properties of materials and identifies their role in classification soft & hard magnetic materials having specific engineering applications.	PO-1	2
CO3	Understands role of molecular level vibrations in determining thermal properties of materials for identification of materials having specific engineering applications.	PO-1	2
CO4	Understands the role of electronic energy band structures of solids in governing various electrical properties of materials.	PO-1	2

Syllabus:

Crystallography: Bonding in materials, Space lattice, basis, unit cell, Seven Crystal systems, Bravais lattice system, Reciprocal lattice, Crystal directions, Miller Indices, problems, Diffraction of Crystals, Bragg's Law, XRD, Laue, Rotating Crystal and powder XRD Techniques, Problems.

Crystal Imperfections: Point Defects, Line Defects, Surface Defects, Volume Defects, and Effects of Defects on Crystalline Properties.

Magnetic properties: Origin of Magnetic Moment, Dia, Para, Ferro, Antiferro and Ferri Magnetism, Domain theory and Hysteresis Effect of Ferro and Ferri Magnetism, Soft and Hard Magnetic Materials.

Thermal properties: Iron-Carbon Diagram, Heat capacity, Thermal Expansion and Thermal Conductivity in Metals, Ceramics and Polymers, Heat treatment of Materials, Hardening, Tempering, Quenching and Nitriding.

Mechanical Properties: Stress, Strain, Hooke's Law, Elasticity, Plasticity, Creep, Ductility, Brittle, Hardness, Strength, Modulus of Elasticity, Fracture, Fatigue, Stress- Strain Behavior of Ductile and Brittle Materials, Hardness Tests- Vickers, Rockwell and Brinell.

Electrical Properties: Energy band theory, Band structures in Conductors, Semi conductors and Insulators, Electrical properties of conductors- Ohms, Mathiessen rule, conductivity, Mobility, Electrical properties of Semi conductors, Factors effecting the carrier concentration, Conductivity and Mobility of charge carriers. Electric properties of Insulator-Dielectrics- Types of Dielectrics, Dielectric Constant, Polarization, Types of Polarizations, Frequency Dependence of Polarization, Ferro, Piezo Electrics.

Text Books & Reference Books:

1. William D. Callister,Jr, Materials Science and Engineering: An Introduction, Wiley India Pvt.Ltd. 6th editio, 2007
2. Adrianus J. Dekker, Solid State Physics, 1st Edition Macmillan India Ltd,2002.
3. S. O. Pillai,, Solid state physics, Revised 6th edition, New Age International Publishers.

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EXPERIMENTAL PHYSICS (EXP)

Course Code : 23OENS02
L-T-P-S : 3-0-0-0
Credits : 3
Contact Hours : 3
Pre-requisite : NIL

Mapping of Course Outcomes with PO:

CO#	Course Outcome	PO	BTL
CO1	Understanding the basic concepts, Background, scientific revolutions of nanoscience and technology and understanding multifunction materials.	PO-1	2
CO2	Apply the principles of different chemical routes to synthesis as per the required application and properties.	PO-1	3
CO3	Understanding the basic difference between nano and bulk materials properties.	PO-1	2
CO4	Apply the knowledge of structural characterization methods to analyse the performance of materials for required applications.	PO-1	3

Syllabus:

Basics of Nanoscience and Nanotechnology: Background to Nanoscience and Nanotechnology, Feynman predictions on Nanotechnology - scientific revolutions – nano sized effects- surface to volume ratio Nanoscience-Nanotechnology-Nano Materials-Nano composites- Multifunctional nano materials-definitions with examples, Definition of Nanotechnology.

Physical and Chemical routes for synthesis of nanomaterials: Sol-gel method, Hydrothermal method, co–precipitation method and electrospinning method – thin film technique.

Properties of Nanomaterials: Magnetic properties, electrical properties, mechanical properties and optical properties of nanomaterials.

Structural Characterization methods: X-ray diffraction (XRD), Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM) and EDAX analysis, Atomic force Microscopy (AFM), Scanning Probe Microscopy.

Text Books & Reference Books:

1. G. Cao, Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Imperial College Press, 2004
2. Elton N. Kaufmann, characterization of materials, Wiley Inter science, 2003
3. Y. Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.

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Annexure-2

PROPOSED M. SC (PHYSICS) COURSE STRUCTURE FOR Y22 (2023-24) (CHOICE BASED CREDIT SYSTEM (CBCS)

SNO		SEM	COURSE NAME	Short Name	Mode (REG/ MOOCS)	Type	L	T	P	S			New course/ Revised/Retained	Focused on
1	23UC5201	1	Professional Communication Skills	PCS	R	AUC	0	0	4	0	0	4	New Course	Employability
2	23NS5101	1	Fundamentals of Nanoscience & Nanotechnology	FNST	R	PCC	3	0	0	0	3	3	New Course	
3	23NS5102	1	Physics of Nanotechnology	PNT	R	PCC	3	1	0	0	4	4	New Course	
4	23NS5103	1	Chemistry of Nanotechnology	CNT	R	PCC	3	1	0	0	4	4	New Course	Employability
5	23NS5104	1	Synthesis and Characterization of Nanomaterials-I	ScNM-I	R	PCC	3	0	6	0	6	10	New Course	Employability/Skilling
6	23NS5105	1	Nano Photonics	NPHT	R	PCC	4	0	0	0	4	4	New Course	Employability
8	23IE5201	2	Essentials of Research Design	ERD	R	PRI	1	1	0	0	2	2	New Course	Skilling
9	23NS5106	2	Synthesis and Characterization of Nanomaterials-II	ScNM-II	R	PCC	3	0	0	12	6	15	New Course	Employability/Skilling
10	23NS5107	2	Emerging Applications of Nanotechnology	EANT	R	PCC	4	0	0	0	4	4	New Course	Employability
	PE 1													
11	23NS52E1	2	Biology of Nanotechnology	BNT	R	PEC	3	0	0	0	3	3	**New Course**	
12	23NS52E2	2	Biochemistry	BC	R	PEC	3	0	0	0	3	3	**New Course**	Employability
	PE 2													

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13	23NS52E3	2	Nano magnetic Materials and Devices	NM13D	R	PEC	3	0	0	0	3	3	**New Course**	Employability
14	23NS52E4	2	Societal Impacts of Nanotechnology	SINT	R	PEC	3	0	0	0	3	3	**New Course**	
16	23OENS01	2	Material Science and Engineering	MSE	R/M	OEC	3	0	0	0	3	3	New Course	
17	23CC5201	2	Value Added Course	VAC	R/M	AUC	2	0	0	0	0	0	New Course	
18	23NS6108	3	Advanced Nanomaterials	ADNM	R	PCC	4	0	0	0	4	4	New Course	Employability
19	23NS6109	3	Advanced Nanobiotechnology	ANBT	R	PCC	4	0	0	0	4	4	New Course	Employability
20	23NS6110	3	Micro and Nano Electronic Devices	MNED	R	PCC	4	0	0	0	4	4	New Course	Employability
21	23IE6103	3	Term Paper	TP	R	PRI	0	0	4	0	2	4	New Course	Skilling
	PE 3													
23	23NS61E5	3	Nanotechnology for Renewable Energy Materials	NREM	R	PEC	3	0	0	0	3	3	**New Course**	
24	23NS61E6	3	Nanotechnology in Health Care	NHSC	R	PEC	3	0	0	0	3	3	**New Course**	
25	23OENS02	3	Experimental Physics	EXP	R/M	OEC	3	0	0	0	3	3	**New Course**	**Skilling**
			Flexi Core Course	FCC										
26	23NS6121	3	Nao Electronics	NE	R/M	FCC	4	0	0	0	4	4	New Course	Employability
27	23NS6122	3	Artificial Intelligence Integration with Nanotechnology	AIN	R/M	FCC	4	0	0	0	4	4	New Course	Employability/Skilling
28	23IE6205	4	PROJECT WORK/DISSERTATION	DISS	R	PRI	0	0	32	0	16	32	New Course	Skilling
			GRAND TOTAL				**44**	**3**	**48**	**12**	**80**	**122**		

*PC/M – Professional Core/Mandatory; PE – Professional Elective; PW/M – Project Work/Mandatory.

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Reference for Program Structures and Syllabus Revision

S.No	Course Code	Course Name	Course Category	Existing Syllabus	New Syllabus	Topics Added/Removed/ Replaced	Change in outcome	Justification for modification	Revision Percentage
1	23UC5201	Professional Communication Skills	AUC	-	Yes	-	-	-	-
2	23NS5101	Fundamentals of Nanoscience & Nanotechnology	Professional core	-	Yes	-	-	-	-
3	23NS5102	Physics of Nanotechnology	Professional core	-	Yes	-	-	-	-
4	23NS5103	Chemistry of Nanotechnology	Professional core	-	Yes	-	-	-	
5	23NS5104	Synthesis and Characterization of Nanomaterials-I	Professional core	-	Yes	-	-	-	-
6	23NS5105	Nano Photonics	Professional core	-	Yes	-	-	-	-
7	23IE5102	Colloquium series-1		-	Yes	-	-	-	-
8	23IE5201	Essentials of Research Design	PRI	-	Yes	-	-	-	
9	23NS5106	Synthesis and Characterization of Nanomaterials-II	Professional core	-	Yes	-	-	-	-
10	23NS5107	Emerging Applications of Nanotechnology	Professional core	-	Yes	-	-	-	-
11	23NS52E1	Biology of Nanotechnology	Professional Elective	-	Yes	-	-	-	-
12	23NS52E2	Biochemistry	Professional Elective	-	Yes	-	-	-	-
13	23NS52E3	Nano magnetic Materials and Devices	Professional Elective	-	Yes	-	-	-	-
14	23NS52E4	Societal Impacts of Nanotechnology	Professional Elective	-	Yes	-	-	-	-

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15	23IE5203	Colloquium series-2	**Professional core**	-	**Yes**	-	-	-	-
16	OENS0001	Material Science and Engineering	**Open Elective**	-	**Yes**	-	-	-	-
17	23CC5201	Value Added Course	**AUC**	-	**Yes**	-	-		-
18	23NS6108	Advanced Nanomaterials	**Professional core**	-	**Yes**	-	-	-	-
19	23NS6109	Advanced Nano biotechnology	**Professional Core**	-	**Yes**	-	-	-	-
20	23NS6110	Micro and Nano Electronic Devices	**Professional Core**	-	**Yes**	-	-	-	-
21	23IE6103	Term Paper	**PRI**	-	**Yes**	-	-	-	-
22	23IE6104	Colloquium series-3	**Professional Core**	-	**Yes**	-	-	-	-
23	23NS61E5	Nanotechnology for Renewable Energy Materials	**Professional Elective**		**Yes**				-
24	23NS61E6	Nanotechnology in Health Care	**Professional Elective**		**Yes**				
25	OENS0002	Introduction to Artificial Intelligence	**Open Elective**	-	**Yes**	-	-	-	
26	23NS6121	Nao Electronics	**FCC**	-	**Yes**				
27	23NS6122	Artificial Intelligence Integration with Nanotechnology	**FCC**		Yes	-	-	-	-
28	23IE6205	PROJECT WORK/DISSERTATION	**Professional Core**	-	**Yes**	-	-	-	-
Average percentage of revision= (sum of revision in all courses/ Total no. of courses)									**100**

Percentage of Courses focusing on Employability= No. of courses focusing on Employability/ Total number of courses=51.16
Percentage of Courses focusing on Entrepreneurship= No. of courses focusing on Entrepreneurship / Total number of courses=0
Percentage of Courses focusing on Skill Development = No. of courses focusing on Skill Development / Total number of courses=25

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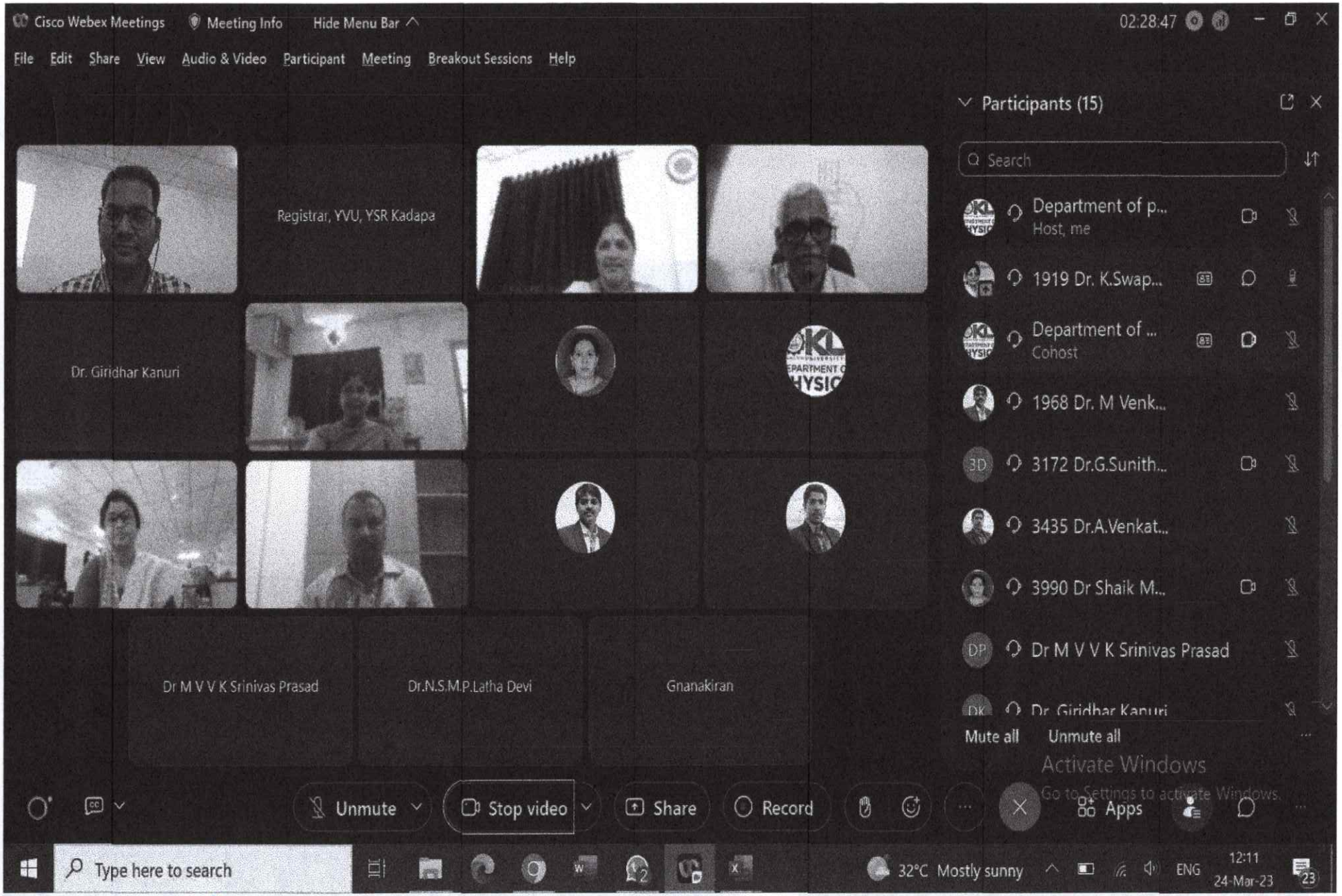

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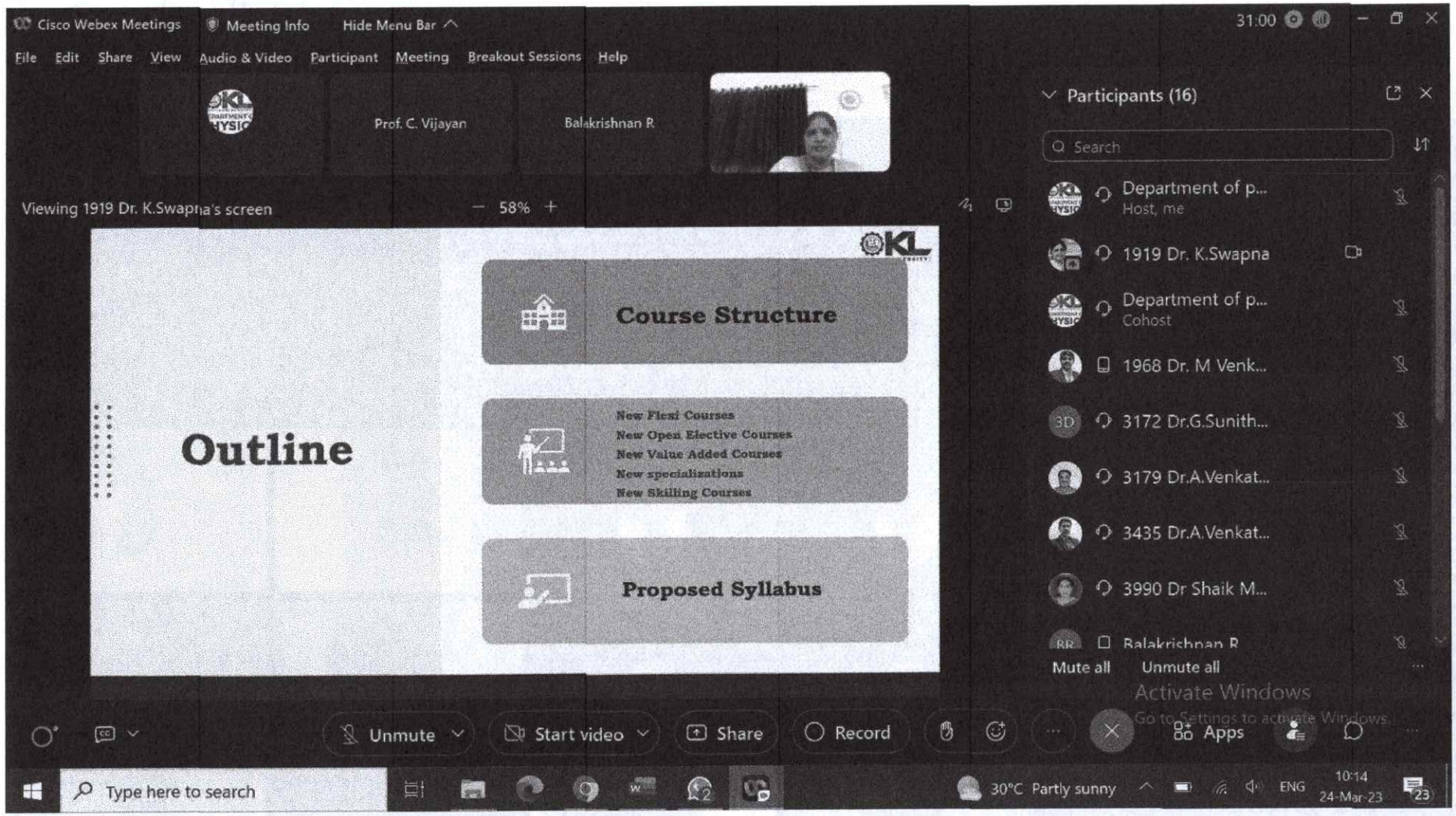

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Meeting Minutes of DAC-3 held on 03-03-2023

The Head of the Department of Physics conducted the DAC-3 meeting on 03/03/2023, i.e., on Friday from 10:30 am to 1:00 pm in the Physics Lab (Offline mode, Room No: F201A).

The DAC members were concerned and discussed the following points:

Members Present:

1. Dr. K. Swapna	Assoc. Professor, HOD & APEX Member
2. Dr. N.S.M.P. Latha Devi	Assoc. Professor
3. Dr. G. Sunita Sundari	Assoc. Professor
4. Dr. Shaik Mahamuda	Assoc. Professor & RPAC Chairman
5. Dr. K. Raghavendra Kumar	Assoc. Professor
6. Dr. M.V.V.K. Srinivas Prasad	Asst. Professor& Asst COE
7. Dr. M. Venkateswarlu	Asst. Professor & Professor In-charge
8. Dr. A.Venkateswara Rao	Asst. Professor
9. Dr. Shaik Babu	Asst. Professor & Dy. HOD
10. Dr. A. Sendil Kumar	On long leave from June 2022
11. Dr. S. Shanmugan	Asst. Professor
12. Mr. M. Gnana Kiran	Asst. Professor
13. Dr. Sonali Biswas	Asst. Professor
14. Dr. S. Bharat Kumar	Asst. Professor & PG Coordinator

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- Dr. K. Swapna, Assoc. Prof., & Head of the Department of Physics welcomed all committee members to the DAC-3 meeting.

Points discussed:

1. To change the current program name from MSc Physics to MSc Nano Science and Technology.
2. To propose the list of the new courses and design the new curriculum for MSc Nano Science and Technology program with a maximum of 80 credits offered from the AY 2023-24, Odd Sem.
3. To propose to include professional core/mandatory courses, skilling courses related to logical communications and design of research essentials, and professional electives along with the purely laboratory-based courses MSc Nano Science and Technology program.
4. To identify the benchmarks (mapping of courses with global/national universities, professional society bodies) for the offered courses, skill-based courses and cohorts required for skilling.
5. To identify the Professional Society bodies related to the program.
6. Any other item with the permission of the chair.

- Considering the suggestions and recommendations from the internal department committee members, we proposed to introduce the new program MSc Nanoscience and Technology instead of MSc Physics for the benefit of students and providing more opportunities in placements with favorable consideration and approval from the Director-PG Program and Principal, College of Sciences, KLEF. Also, the internal committee members gave suggestions and recommendations for designing a new curriculum for the newly offered courses in the MSc Nanoscience and Technology program.

- All members who attended the DAC meeting approved the proposal of the new program mentioned above; hence, the same is recommended to the BOS Chairman for approval.

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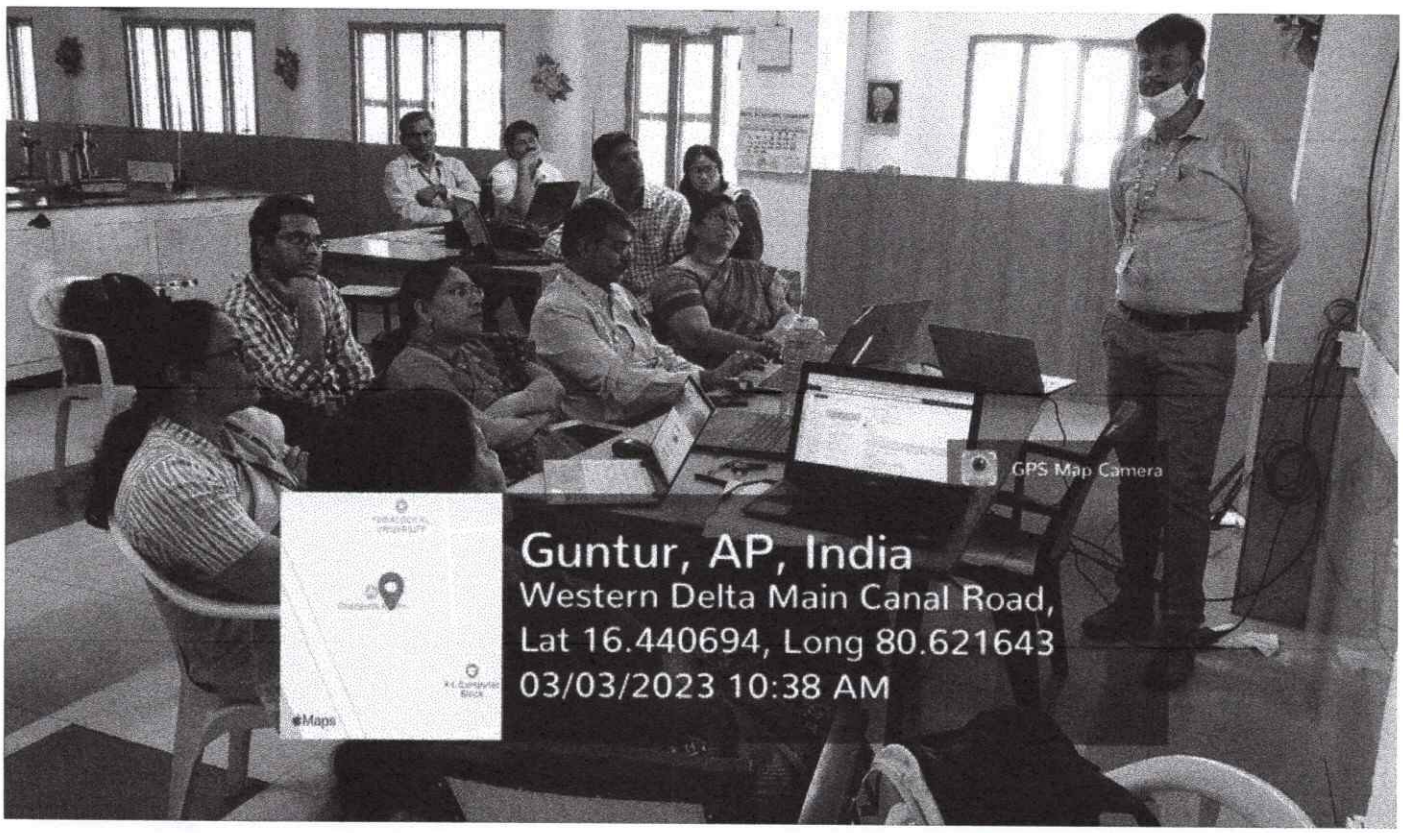
HOD-Physics



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