Course Structure and Scheme of the Programme B.Tech. (Department of Physics)

SEMESTER I & II

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PHCI-101	Applied Physics-A	3	1	-	3	4
2.	PHCI-102	Applied Physics-A Lab.	-	-	2	2	1
3.	PHCI-103	Applied Physics-B	3	1	-	3	4
4.	PHCI-104	Applied Physics-B Lab.	-	-	2	2	1

SEMESTER IV

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
2.	PHPC-204	Material Science & Engineering	3	1	-	3	4
3.	PHPC-224	Material Science & Engineering Lab.	-	-	2	2	1

SEMESTER V

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PHPC-301	Material Science (Nano Science)	3	0	0	3	3

Open Elective (VI, VII and VIII SEMESTER)

S.No.	Course Code	Course Title	Teaching Schedule			Duration of Exam. (hr.)	No. of Credit
			Lecture	Tutorial	Practical		
1.	PHOE-301	Material Science (Nano Science)	3	0	0	3	3
2.	PHOE-302	Statistical and Computational Techniques	3	0	0	3	3

Course Code	**PHCI-101**
Course Title	**Applied Physics – A**
Credits	**3-1-0-4**
Course Type	**Common for Mechanical Engg., Civil Engg., Industrial Engg., Chemical Engg. & Textile Technology**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: Following are outcomes of the course:

CO 1	Students are expected to know about the special theory of relativity and how it is different from Newtonian theory. They should have knowledge about various interesting consequences of special theory of relativity and about Einstein mass energy relationship.
CO 2	After completing the course students should know about the need of quantum mechanics. They should know about dual character of radiations as well as matter, about the Heisenberg uncertainty principle, the concept of wave function and about Schrodinger wave equation and its applications to simple one dimensional potential problem.
CO 3	Student should know basics of vector calculus and how to use that in electricity and magnetism. They should have knowledge of four Maxwell equations and their Physical significance.
CO 4	Student should know different types of crystal system, about Miller indices and their use and about different types of defects in the crystals.
CO 5	Students will learn aboutthe strength of materials, the processes leading to failure in materials and creep mechanism.
CO 6	Student will be familiar with the laws of thermodynamics, difference between classical and quantum statistical mechanics, application of statistical mechanics to calculate the specific heats of solids and for free electron gas.

SYLLABUS

PHCI-101 **Applied Physics – A** **3-1-0-4**

UNIT-I

Theory of Relativity: Galilean transformations, Galilean Invariance, concept of ether; Michelson-Morley experiment; Einstein's postulates and Lorentz transformation equations, Consequences of Special Theory of relativity: length contraction, Time dilation, and simultaneity of events, addition of velocity, variation of mass with velocity, mass-energy relation, energy-momentum relation. **[8]**

UNIT-II

Quantum Theory: Need of Quantum theory, Photoelectric effect, The Compton effect; matter waves, group and phase velocities; Uncertainty principle and its application; time independent and time dependent Schrödinger wave equation; Eigen values and Eigen functions, Born's interpretation and normalization of wave function, orthogonal wave functions; applications of Schrödinger wave equation for particle in one dimensional infinite potential well. [**8]**

UNIT-III

Electromagnetism: Gradient of a scalar, divergence and curl of a vector; electric potential due to arbitrary continuous charge distribution, multipole expansion; dielectrics: polarization, Gauss law in dielectrics, electric displacement, susceptibility & permittivity; continuity equation, derivation of integral and differential forms of Maxwell equations and their physical significance; EM waves in free space. **[10]**

UNIT-IV

Crystal Structure: Fundamental concepts, Crystal systems, Closed packed structures, Crystallographic planes and directions, Miller indices, Crystal defects. **[6]**

UNIT-V

Mechanical Properties: The elastic properties, model of elastic behavior, plastic deformation tensile stress-strain curve, shear strength of perfect and real crystals, mechanical failure, fatigue and fracture, creeps: mechanism of creep, characterization of creep curves. **[6]**

UNIT-VI

Thermal & Statistical Physics: The laws of thermodynamics, Maxwell-Boltazmann statistics and its applicability, Bose-Einstein statistics and its application to specific heat of solids, Fermi-Dirac statistics and its application to free electron gas. **[6]**

Books Recommended:

1. A. Beiser, "Concepts of Modem Physics", McGraw Hill, New Delhi, 6th Ed. (2002).
2. K S Krane, "Modern Physics", John Wiely& Sons, Inc., 3rd Ed. (2011).
3. Raymond A Serway"Modern Physics", Thomson, 3rd Ed.
4. D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall of India, New Delhi, 2nd Ed. (1998).
5. H K Malik & A K Malik, "Engineering Physics", McGraw Hill Education, 2nd Ed. (2017).
6. Callister W.D. "Material Science and Engineering", John Wiley & Sons, Inc. New York, (1997).
7. V. Raghavan "Introduction to Material Science and Engineering", Prentice Hall of India.
8. Daneil V Schroedar, "Introduction to Thermal Physics", Pearson, India (2014).
9. Stephen J. Blundell and Katherine M. Blundell, "Concepts in Thermal Physics", Oxford, Indian Ed. (2014).

Course Code	**PHCI-102**
Course Title	**Applied Physics-A lab**
Credits	**0-0-2-1**
Course Type	**Common for Mechanical Engg., Civil Engg., Industrial Engg., Chemical Engg. & Textile Technology**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All

Course Objective
The aim of the course "Physics laboratory-I" is to train the students in experimental sciences. Students will perform various experiments which will serve as experimental demonstration of the concepts learned in the corresponding theory course. The focus of experiments will be semiconductor devices, properties of materials, quantum physics and electromagnetism.

Course Outcomes: Following are outcomes of the course:

CO 1	Students will learn about the application and working of basic semiconductor devices.
CO 2	Students will learn about various aspects of waves.
CO 3	Students will learn about the thermal properties of materials.
CO 4	Students will learn how to experimentally calculate some of the quantities related to quantum physics.
CO 5	Students will learn about basics of experimental electromagnetism.
CO 6	Students will learn to use experimental set-up to calculate the elastic constants of materials and to study their mechanical properties.

List of experiments

PHCI-102 **Applied Physics-A lab** **0-0-2-1**

1. To verify the laws of vibrating strings by Melde's experiment.
2. To determine the impedance of A.C. Circuits.
3. To study the characteristic of PN diode.
4. To study the characteristics of Zener diode.
5. To find out the intensity response of a solar cell/Photo diode.
6. To analyze the suitability of a given Zener diode as a power regulator.
7. To determine the band gap of a semiconductor.
8. To study the effect of voltmeter resistance on voltage measurement.
9. To study the variation of magnetic field with distance along the axis of a circular coil carrying current and its estimate the radius of the coil.
10. To determine Planck's constant by LED method.
11. To determine the resistivity of a semiconductor by four probe method.
12. To confirm the de Broglie equation for electrons.
13. To find the coefficient of thermal conductivity of bad conductor by Lee's disc method.
14. To find Young's modulus, modulus of rigidity and Poisson's ratio for the material of a given wire by Searle's method.
15. To investigate creep of a copper wire at room temperature.
16. To determine the Hall coefficient of a semiconductor and hence to estimate the charge carrier concentration.
17. To confirm the de Broglie equation for electrons.

Books Recommended:

1. R S Sirohi "Practical Physics" Wiley Eastern, New Delhi.
2. C L Arora "B.Sc. Practical Physics", S Chand & Company.

Course Code	**PHCI-103**
Course Title	**Applied Physics – B**
Credits	**3-1-0-4**
Course Type	**Common for Computer Science, Electronics and Comm. Engg. & Instrumentation and Control &Engg.**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: Following are outcomes of the course:

CO 1	Students are expected to know about the special theory of relativity and how it is different from Newtonian theory. They should have knowledge about various interesting consequences of special theory of relativity and about Einstein mass energy relationship.
CO 2	After completing the course students should know about the need of quantum mechanics. They should know about dual character of radiations as well as matter, about the Heisenberg uncertainty principle, the concept of wave function and about Schrodinger wave equation and its applications to simple one dimensional potential problem.
CO 3	Student should know basics of vector calculus and how to use that in electricity and magnetism. They should have knowledge of four Maxwell equations and their Physical significance.
CO 4	Students should know the basic physics of semiconductors and how they are different from insulators and conductors. They should know the difference between intrinsic and extrinsic semiconductors and about the Fermi levels position in these semiconductors
CO 5	Students will learn fundamentals of the technologically important optoelectronic devices. They will learn about the fundamentals on which these devices are based. They will learn about solar cells, devices based on diodes, IR emitters, LCD and optocouplers.
CO 6	Students are expected to know about the basic of physical optics. They should know about basic properties of Laser beams and why they are important. They should know the physical principle behind the working of laser, different types of lasers and their applications. Students are also expected to know about physical principle behind the working of optical fibers and their applications.

SYLLABUS

PHCI-103 **Applied Physics – B** **3-1-0-4**

UNIT-I

Theory of Relativity: Galilean transformations, Galilean Invariance, concept of ether; Michelson-Morley experiment; Einstein's postulates and Lorentz transformation equations, Consequences of Special Theory of relativity: length contraction, Time dilation, and simultaneity of events, addition of velocity, variation of mass with velocity, mass-energy relation, energy-momentum relation. **[8]**

UNIT-II

Quantum Theory: Need of Quantum theory, Photoelectric effect, The Compton effect; matter waves, group and phase velocities; Uncertainty principle and its application; time independent and time dependent Schrödinger wave equation; Eigen values and Eigen functions, Born's interpretation and normalization of wave function, orthogonal wave functions; applications of Schrödinger wave equation for particle in one dimensional infinite potential well. **[8]**

UNIT-III

Electromagnetism: Gradient of a scalar, divergence and curl of a vector; electric potential due to arbitrary continuous charge distribution, multipole expansion; dielectrics: polarization, Gauss law in dielectrics, electric displacement, susceptibility & permittivity; continuity equation, derivation of integral and differential forms of Maxwell equations and their physical significance; EM waves in free space. **[10]**

UNIT-IV

Semiconductor Physics: Difference between semiconductors, insulators and conductors; Intrinsic semiconductors: intrinsic concentration of charge carriers and position of Fermi level; Extrinsic semiconductors: concept of doping, difference between p & n type semiconductors and position of Fermi levels. **[6]**

UNIT-V

Optoelectronic Device: Photoconductive cell, photovoltaic cell, Solar cell, Photodiode, Phototransistor, LED, IR emitters, LCD, Optocoupler. **[5]**

UNIT-VI

Engineering Optics: Basic of Interference, Diffraction and Polarization, Lasers and characteristics, Einstein's coefficient, He-Ne laser, semiconductor lasers, Applications of Lasers, Optical fibres; Numerical aperture, Classification of optical fibres, fibre Losses, fibre manufacturing, Applications of optical fibre in industry and communication. **[7]**

Books Recommended:

1. A. Beiser, "Concepts of Modem Physics", McGraw Hill, New Delhi, 6th Ed. (2002).
2. K S Krane, "Modern Physics", John Wiely& Sons, Inc., 3rd Ed. (2011).
3. Raymond A Serway"Modern Physics", Thomson, 3rd Ed.
4. D. J. Griffiths, "Introduction to Electrodynamics", Prentice Hall of India, New Delhi, 2nd Ed. (1998).
5. H K Malik & A K Malik, "Engineering Physics", McGraw Hill Education, 2nd Ed. (2017).
6. K. Thyagarajan and A. K. Ghatak, "Lasers, - Theory and Applications", Macmilan India Ltd., New Delhi, (2000).
7. AjoyGhatak, "Optics", McGraw Hill Companies, 3rd Ed. (2010).
8. Eugene Hecht, "Optics", Addison Wesley (2002).
9. S.M.Sze and Kwok K. Ng, "Physics of Semiconductor Devices", John Wiley & Sons.
10. John Wilson and John Hawkes ,"Optoelectronics" Prentice Hall.
11. Michael Bass, Eric W. Van Stryland, David R. Williams and William L. Wolfe, "Handbook of Optics: Fundamentals, Techniques, and Design", Mc-Graw Hill.

Course Code	**PHCI-104**
Course Title	**Applied Physics-B lab**
Credits	**0-0-2-1**
Course Type	**Common for Computer Science, Electronics and Comm. Engg. & Instrumentation and Control & Engg.**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All

Course Objective
The aim of the course "Physics laboratory-II" is to train the students in experimental sciences. Students will perform various experiments which will serve as experimental demonstration of the concepts learned in the corresponding theory course. The focus of experiments will be electrical circuits, properties of materials, quantum physics and electromagnetism and optics.

Course Outcomes: Following are outcomes of the course:

CO 1	After completing the course, students should be familiar with practical training of basic electrical circuits.
CO 2	Students will learn how to use electrical devices to calculate some of the quantities related to quantum physics.
CO 3	Students will learn about the application and working of basic semiconductor devices.
CO 4	Students will learn about basics of experimental electromagnetism.
CO 5	Students will gain practical knowledge about the basics phenomenon related to physical optics i.e. interference, diffraction and polarisation.
CO 6	Students will learn about various optoelectronic devices and study their characteristics.

List of experiments

PHCI-104 **Applied Physics-B lab** **0-0-2-1**

1. To study the characteristic of PN diode.
2. To study the characteristic of Zener diode.
3. To find out the intensity response of a solar cell/Photo diode.
4. To analyze the suitability of a given Zener diode as a power regulator.
5. To determine the band gap of a semiconductor.
6. To determine the Refractive index of the Prism material using spectrometer.
7. To determine the wavelength using Diffraction grating.
8. To find out the wavelength of the given light source using single slit.
9. To find out the wavelength of the given light source using double slit.
10. To determine the wavelength of sodium light using Newton’s ring method.
11. To study the effect of voltmeter resistance on voltage measurement.
12. To study the variation of magnetic field with distance along the axis of a circular coil carrying current and its estimate the radius of the coil.
13. To verify Malus law.
14. To determine Planck's constant by LED method.
15. To determine the resolving power of a telescope. To determine the resistivity of a semiconductor by four probe method.
16. To confirm the de Broglie equation for electrons.
17. To find the coefficient of thermal conductivity of bad conductor by Lee’s disc method.
18.

Books Recommended:

1. R S Sirohi “Practical Physics” Wiley Eastern, New Delhi.
2. C L Arora “B.Sc. Practical Physics”, S Chand & Company.

Course Code	**PHPC-204**
Course Title	**MATERIAL SCIENCE AND ENGINEERING**
Credits	**3-1-0-4**
Course Type	**Chemical Science and Engineering**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: Following are outcomes of the course:

CO 1	Student should know different types of crystal systems, about reciprocal lattices and their importance in the understanding of the crystal structure. Student will also understand the uses of Miller indices and their significance in the determination of crystal structure.
CO 2	The student should understand the different types of imperfections in solids, their movements and multiplication of dislocations.
CO 3	Student should understand the concept of the diffusion in the solids along-with the understanding of the laws governing this mechanism and the role of diffusion in the materials properties.
CO 4	The student will learn about the strength of materials, the processes leading to failure in materials and creep mechanism.
CO 5	After completing the course students should know about the need of quantum mechanics in explaining the electric properties. They should know about dual character of radiations as well as matter, about the Heisenberg uncertainty principle, the concept of wave function and about Schrodinger wave equation and its applications to simple one dimensional potential problem.
CO 6	Students should learn the fundamentals of dielectrics and different methods of polarization. They will learn the fundamentals of optical storage devices.
CO 7	Students are expected to know about the origin of magnetism, classifications of different types of magnetic materials, process of magnetization in ferromagnetic materials and their different applications.
CO 8	Students are expected to know about the fascinating phenomenon of superconductivity, Meisner effect and their applications like high field superconducting magnet, maglev train, MRI etc. They should be aware about BCS theory.

SYLLABUS

PHPC-204 Material Science and Engineering 3-1-0-4

Structure of Crystalline Solids: Crystal structures and crystal system, reciprocal lattice, miller indices, closed packed structures, determination of crystal structures.
Imperfection in Solid: Point imperfections and their equilibrium concentration, Edge and screw dislocations; burgers vector and the dislocations; burgers vector and the dislocation leap, stress fields and energies of dislocations, dislocations forces, dislocation sources; Multiplication of dislocations.
Diffusion in Solids: Fick's laws of diffusion, solution to fick's second law, applications based on second law solution, the kirkendall effect, the atomic model of diffusion.
Mechanical Properties: The elastic properties, model of elastic behaviour, plastic deformation tensile stress-strain curve, shear strength of perfect and real crystals, mechanical failure, fatigue and fracture, creeps: mechanism of creep, characterization of creep curves.
Electrical Properties: Classical and quantum theory of free electronics; relaxation time, collision time and mean free path, density of energy states and Fermi energy, electron motion under periodic potential, origin of energy bands in solids, classification of material on the basis of band gap, effective mass, intrinsic and extrinsic semi-conductors, hall effect and its applications.
Dielectric Properties: Mechanism of polarization concept of polarizability and internal fields, dielectrics in alternating field; frequency dependence of polarizability.
Magnetic Properties: Magnetic moments and its origin, dia-and para-magnetism, ferro and ferri-magnetism, soft and hard magnetic materials, ferrites, application of magnetic materials.
Super Conductivity: Properties of superconductors. London equations, quantum explanation of super conductivity, flux quantization, application of super conductors.

Books Recommended:

1. William D. Calister, Jr. "Materials Science and Engineering" John Wiley and Sons, Inc. New York, (1997).
2. Dekker A.J., "Solid State Physics" Macmillan, India Limited, Madra, (1991).
3. Azaroff. L.V. "Introduction to Solid", Tata McGraw Hill, New Delhi, (1992).
4. Raghvan V. "Material Science and Engineering", Prentice Hall of India, New Delhi, (1998).
5. Kittel "Solid State Physics "Wiley Eastern Limited, New Delhi, (1987).

PHPC – 224 MATERIAL SCIENCE & ENGINEERING LAB

Course Objective
The aim of the course on Material Science and Engineering Laboratoryis to enable the students to understand and practically experience the underlying phenomenon deriving the various properties of the solids. To do this many historical and modern day experiments have been setup to provide the hands-on experience to the students. The focus of experiments will be on the different properties of materials (transport and mechanical).

Course Outcome:-Students will be able to understand and practically measureddifferent properties of materials (transport and mechanical) as a function of temperature or at ambient temperature.

CO 1	The student will be able to learn how to measure the magnetic susceptibility of a paramagnetic salt.
CO 2	The student will have the hands on experience to measure the resistivity of semiconducting material and able to find out the band gap of semiconductor.
CO 3	The student will able to measure the Hall coefficient and carrier concentration of semiconductor materials. This will help them to understand the effect of magnetic field on charge carriers.
CO 4	The student will be able to learn how to measure the capacitance/dielectric constant of a materials and will able to find the Curie temperature of ferroelectric materials.
CO 5	The student will able to experience the creep behaviour of copper/tin wire at room temperature and visualize the effect of constant load as function of time.
CO 6	The student will able to find out the mechanical strength of materials.
CO 7	The student will learn how to experimentally calculate some of the quantities related to quantum physics.
CO 8	The student will able to understand the interaction of light with matter.

LIST OF EXPERIMENTS

PHPC – 224 MATERIAL SCIENCE & ENGINEERING LAB 0-0-2-1

1. To determine the magnetic susceptibility of a paramagnetic salt by Guoy's balance method.
2. To calibrate an electromagnet.
3. To study temperature dependence of resistivity of semiconductor materials using four probe method and further deduce the band gap of this semiconductor.
4. To find Young's modulus, modulus of rigidity and Poisson's ratio for the material of a given wire by Searle's method.
5. To determine the Hall coefficient of a semiconductor and hence to evaluate the charge carrier concentration, type and mobility of charge carrier in a given semiconductor material.
6. To investigate creep of a copper wire at room temperature.
7. To determine the Curie temperature of a ferroelectric material by measuring dielectric constant as a function of temperature.
8. To study the hysteresis loop of magnetic material (iron and steel) and determine its retentivity, coercivity and energy dissipated per unit volume per cycle of hysteresis.
9. To find the value of Planck's constant and evaluate the work function of cathode material by use of photoelectric cell.
10. To study the quantized energy of the first excited state in Argon using the Frank-Hertz Set-up.
11. To study various characteristics of photovoltaic cell: (a) Voltage-current characteristics (b) loading characteristics (c) power-resistance characteristics and (d) inverse square law behavior of photocurrent with distance of source of light from photovoltaic cell.
12. Determining the superconducting temperature of $YBa_2Cu_3O_7$ superconductor.
13. Understand the frequency dependence (RF range) of real and imaginary part of complex dielectric.
14. Current-voltage characteristic curves of semiconductor.

Course Code	**PHPC-301**
Course Title	**Material Science (Nano Science)**
Credits	**3-0-0-3**
Course Type	**ICE and ECE**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: Following are outcomes of the course:

CO 1	Student should know different types of crystal systems, about Miller indices and their uses and about different types of defects in the crystals.
CO 2	After completing the course students should know about the need of quantum mechanics. They should know about dual character of radiations as well as matter, about the Heisenberg uncertainty principle, the concept of wave function and about Schrodinger wave equation and its applications to simple one dimensional potential problem. They should know the classification of different materials on the basis of their conductivity.
CO 3	Students should know the basic physics of semiconductors and how they are different from insulators and conductors. They should know the difference between intrinsic and extrinsic semiconductors and about the Fermi levels in these semiconductors.
CO 4	Students are expected to know about the origin of magnetism, classifications of different types of magnetic materials, process of magnetization in ferromagnetic materials and their different applications.
CO 5	Students are expected to know about the fascinating phenomenon of superconductivity, Meisner effect and their applications like high field superconducting magnet, maglev train, MRI etc. They should be aware about BCS theory.
CO 6	Students should learn the fundamentals of dielectrics and different methods of polarization. They will learn the fundamentals of optical storage devices.
CO 7	Students are expected to know the effect of size on their physical properties, fabrication methods of nanotubes. Benefits and challenges of nanotechnology.

SYLLABUS

PHPC-301 **Material Science (NanoScience)** **3-0-0-3**

Crystal Structure: Fundamental concepts, Crystal systems, Closed packed structures, Crystallographic planes and directions, Miller indices, Crystal defects.

Electrical Properties: Classical free electron theory of metals, Quantum theory – Particle in a box, Wave function and energy states, Finite potential barrier, tunneling, Fermi-Dirac distribution law, Density of energy states, Classification of solids into conductors, Semiconductors and insulators, Hall effect and its applications.

Semiconductor Materials: Intrinsic and extrinsic materials, Electron and hole concentrations at equilibrium, Temperature dependence of carrier concentrations, Conductivity and mobility.

Magnetic Properties: Basic concepts, Soft and hard magnetic materials, Ferrites, Selection techniques for applications, Magnetic recording, Magnetic memories.

Superconductivity: Properties of superconductors, London equations, Quantum explanation of superconductivity, Applications of superconductors.

Dielectric & Optical Properties: Dielectric materials, Polarization mechanisms, Dipole moment, Dielectric strength, Methods for producing polarization, Application of dielectric materials, Index of refraction, Damping constant, Characteristic penetration depth and absorbance, Reflectivity and transmissivity, Optical storage devices.

Nanomaterials: Introduction to nanotechnology, Nanowire and Nanotube, Carbon nanotubes, Single wall carbon nanotubes, Multiwall carbon nanotubes, Fabrications, Properties and applications.

Books Recommended:

1. Hummel R E, "Electronic Properties of Materials", Narosa Publishing House, New Delhi (1997).
2. William D Callister, Jr, "Materials Science and Engineering", John Wiley and Sons, Inc. New York (2002).
3. Dekker A J, "Solid State Physics", MacMillan, India Limited, Madras (2000).
4. Pillai S O, "Solid State Physics", New Age International Publishers, New Delhi (1999).
5. Van Vlack L H, "Elements of Material Science and Engineering", Addison Wesley Publishers (1980).
6. Poole C P and Owens F J, "Introduction to Nanotechnology", Wiley Edition (2003).

Course Code	**PHOE-301**
Course Title	**Open Elective(Material Science)**
Credits	**3-0-0**
Course Type	**Open elective**

Pre-requisites: None
Course Assessment Method: Both continuous and semester end examination.
Topics to be covered: All.
Course Outcomes: Following are outcomes of the course:

CO 1	Student should know different types of crystal system, about Miller indices and their use and about different types of defects in the crystals.
CO 2	After completing the course students should know about the need of quantum mechanics. They should know about dual character of radiations as well as matter, about the Heisenberg uncertainty principle, the concept of wave function and about Schrodinger wave equation and its applications to simple one dimensional potential problem. After this they should be aware about metals and their conductivity. Most important thing is they should know about classification of different materials
CO 3	Students should know the basic physics of semiconductors and how they are different from insulators and conductors. They should know the difference between intrinsic and extrinsic semiconductors and about the Fermi levels position in these semiconductors.
CO 4	Students are expected to know about the origin of magnetization and different types of magnetic material and their practical application.
CO 5	Students are expected to know about the superconductivity and their applications like Superconducting magnet, maglev train etc They should be aware about BCS theory.
CO 6	Students will learn fundamentals of the technologically important optical storage devices. They will learn about the fundamentals on which these devices are based. They will learn about Polarization which is main concept of these devices.
CO 7	Students are expected to know about the fabrication methods. Benefits and challenges of nanotechnology.

SYLLABUS

PHOE-301 **Material Science (NanoScience)** **3-0-0-3**

Crystal Structure: Fundamental concepts, Crystal systems, Closed packed structures, Crystallographic planes and directions, Miller indices, Crystal defects.

Electrical Properties: Classical free electron theory of metals, Quantum theory – Particle in a box, Wave function and energy states, Finite potential barrier, tunneling, Fermi-Dirac distribution law, Density of energy states, Classification of solids into conductors, Semiconductors and insulators, Hall effect and its applications.

Semiconductor Materials: Intrinsic and extrinsic materials, Electron and hole concentrations at equilibrium, Temperature dependence of carrier concentrations, Conductivity and mobility.

Magnetic Properties: Basic concepts, Soft and hard magnetic materials, Ferrites, Selection techniques for applications, Magnetic recording, Magnetic memories.

Superconductivity: Properties of superconductors, London equations, Quantum explanation of superconductivity, Applications of superconductors.

Dielectric & Optical Properties: Dielectric materials, Polarization mechanisms, Dipole moment, Dielectric strength, Methods for producing polarization, Application of dielectric materials, Index of refraction, Damping constant, Characteristic penetration depth and absorbance, Reflectivity and transmissivity, Optical storage devices.

Nanomaterials: Introduction to nanotechnology, Nanowire and Nanotube, Carbon nanotubes, Single wall carbon nanotubes, Multiwall carbon nanotubes, Fabrications, Properties and applications.

Books Recommended:

1. Hummel R E, "Electronic Properties of Materials", Narosa Publishing House, New Delhi (1997).
2. William D Callister, Jr, "Materials Science and Engineering", John Wiley and Sons, Inc. New York (2002).
3. Dekker A J, "Solid State Physics", MacMillan, India Limited, Madras (2000).
4. Pillai S O, "Solid State Physics", New Age International Publishers, New Delhi (1999).
5. Van Vlack L H, "Elements of Material Science and Engineering", Addison Wesley Publishers (1980).
6. Poole C P and Owens F J, "Introduction to Nanotechnology", Wiley Edition (2003).

Course Title: Statistical and Computational Techniques	Code: PHOE-302
Course Objective: The aim of the course on **Statistical and Computational Techniques** is to introduce basics of statistical methods and modern day advanced data analysis techniques, as required in all fields working with data. This course will also help the students to deepen their understanding of how data analysis works for small and large data samples. This course will further help the students to obtain a comprehensive set of tools to analyse data.	

	Course Outcome (CO):-After the completion of this course students will achieve the ability to:
CO1	Demonstrate an understanding of the basics of the statistical analysis of data.
CO2	Explain methods of data analysis and their idea.
CO3	Apply a set of analysis techniques as required for basic and advanced datasets.
CO4	Critically assess new results derived from datasets.
CO5	Use the knowledge of statistical data analysis to understand more advanced and new techniques.

SYLLABUS

PHOE-302 Statistical and Computational Techniques 3-0-0-3

Python Programming:

Writing and running programs -Variables and data types-Basic control flow: looping, branching and function calls -Functional programming-Computational thinking-Python libraries (for mathematics, data analysis and display) - Designing algorithms (Moving from problem to solution).

Probability and The Monte Carlo method

Definition and interpretation, Bayes' theorem, random variables, probability density functions, expectation values, transformation of variables, error propagation. Markov chains, Binomial, multinomial, Poisson, uniform, exponential, Gaussian, chi-square, Cauchy distributions. Random number generators, the transformation method, the acceptance-rejection method.

Statistics and Statistical Tests

Descriptive statistics, frequentist statistics, Bayesian statistics, hypothesis testing, linear regression introduction to concentration bounds, laws of large numbers, central limit theorem, Maximum a posteriori and maximum likelihood estimation, minimum mean-squared error estimation, confidence intervals. probability distribution functions, cumulative distribution functions, parameter estimation and model fitting and parameter estimation via least-squares and Chi-squared. Goodness of fit tests, Limit setting, Introduction to Multivariate Analysis Techniques.

Linear algebra and Optimization:

Vector spaces, linear transformations, singular value decomposition, eigen decomposition, principal component analysis, least squares, regression, Matrix calculus, gradient descent. Introduction to Optimization, Objective function; Constraints and Constraint surface; Formulation of design problems as mathematical programming problems, Classification of optimization problems, Stationary points; Functions of single and two variables; Global

Optimum, Optimization of function of one variable and multiple variables; Gradient vectors; Examples, Optimization of function of multiple variables subject to equality constraints; Lagrangian function multiple variables subject to equality constraints; Hessian matrix formulation; Eigen-values, KKT condition. Introduction to linear programming (LP), nonlinear programming (NLP) and dynamic programming.

Books Recommended:

1. Berger R and Casella G, "Statistical Inference", S.Chand (G/L) & Company Ltd; 2nd edition (2001)
2. Lecture Notes on "Introduction to Probability", Bertsekas and Tsitsiklis. Massachusetts Institute of Technology Cambridge, Massachusetts.
3. Wasserman, "All of Statistics: A Concise Course in Statistical Inference", Springer (2004)
4. Freedman D, Pisani R and Purves R, "Statistics", W. W. Norton & Company; 4 edition (2007)
5. Ganesh A, "Linear Algebra and Its Applications" CBS; 1ST edition (2005).
6. Python Cookbook, Third edition by David Beazley and Brian K. Jones.
7. Rao SS,"Engineering Optimization: Theory and Practice", New Age International P. Ltd.(2000).
8. Hadley G,"Linear programming", Narosa Publishing House, New Delhi, 1990.
9. Taha HA,"Operations Research:An Introduction", 5th Edition, Macmillan, New York (1992).
10. Deb K,"Optimization for Engineering Design-Algorithms and Examples",Prentice-Hall of India Pvt. Ltd. (1995).