UTTARANCHAL UNIVERSITY

(Established vide Uttaranchal University Act, 2012)
(Uttarakhand Act No. 11 of 2013)
Arcadia Grant, P.O. Chandanwari, Premnagar, Dehradun, Uttarakhand

Programme Name	Pre-Ph.D. Course Work	Programme Code	23
Course Code	DSE704	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Applied Analytical & Instrumental Techniques in Research		

Objectives of the Course:

1. To understand the fundamental principles, instrumentation, and applications of major spectroscopic techniques including UV-Visible and Infrared spectroscopy for structural and qualitative analysis of chemical compounds.
2. To develop conceptual and practical knowledge of chromatographic and volumetric analytical methods for separation, identification, and quantitative estimation of chemical species.
3. To acquire knowledge of advanced microscopic and diffraction techniques such as XRD, SEM, and TEM for characterization of molecular and material structures.

UNIT I (Total Topics-12 and Hrs-12)
UV-Visible spectroscopy
Basic principle, Various electronic transitions, Beer-Lambert law, instrumentation and working UV spectrophotometer, Effect of solvent on electronic transitions, Molar extinction coefficient, maximum wavelength(lambda max) ,Concept of chromospheres and auxochromes, Bathochromic, Hypsochromic, Hyperchromic and Hypochromic, Woodward-Fiesher rule and its application for identification of chemical species

UNIT- II (Total Topics- 12 and Hrs-12)
Infrared spectroscopy
Basic principle, Instrumentation, Selection rules, Fundamental modes of vibration, overtones, combination bands, Fermi resonance, Factors affecting IR spectra, Effect of hydrogen bonding, Solvent effect on IR of gaseous, solids and polymeric interactions with molecules, Means of excitation (light sources), Detection of the signal, Advantages of FTIR, Interpretation of IR spectra of aliphatic, aromatic hydrocarbons, amines, amides, carbonyl compounds etc.

Unit-III (Total Topics-10 and Hrs-10)
Chromatography and Analytical Techniques
Types of Chromatography, TLC, Paper, HPLC and GC. Applications of chromatographic techniques, Instrumentation of HPLC and GC, Rf Value
Measurement of pH, Buffer solutions, Conductivity, Volumetric Analysis, Types of Volumetric Analysis: Acid Base, Precipitation, Complexometric and Redox Titrations, Advantages, applications

Unit-IV (Total Topics-8 and Hrs-6)
Microscopic & Xray Techniques
Principle, Different Microscopic Techniques, X- ray Diffraction: Interaction of X-ray with matter, Absorption, Scattering and Miller indices, Reciprocal lattice, Bragg's law, Instrumentation and applications. Introduction, principle and applications of SEM and TEM.

CO1: Demonstrate understanding of spectroscopic principles and interpret UV-Visible and IR spectra for molecular characterization.
CO2: Perform separation and quantitative analysis using chromatographic and volumetric analytical techniques.
CO3: Evaluate crystalline and surface morphology characteristics using XRD, SEM, and TEM techniques.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Advanced Research &Instrumentation Techniques		

Objectives of the Course:

1. To learn & apply concept of Thermogravimetric techniques in research.
2. To provide knowledge about spectroscopic techniques for research.

UNIT I (Total Topics-12 and Hrs-12)

UV-Visible spectroscopy

Basic principle, Various electronic transitions Beer-Lambert law, effect of solvent on electronic transitions, molar extinction coefficient, concept of chromospheres and auxochromes, bathochromic, hypsochromic, hyperchromic and hypochromic, UV spectra of conjugated enes and enones, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Woodward-Fiesher rules for conjugate dienes and carbonyl compounds.

Infrared spectroscopy

Infra-red spectroscopy: Basic principle, Instrumentation Selection rules, fundamental modes of vibration, overtones, combination bands, Fermi resonance, Factors affecting IR spectra. Effect of hydrogen bonding, solvent effect on IR of gaseous, solids and polymeric Interactions with molecules: absorption and scattering. Means of excitation (light sources), detection of the signal (heat differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR).Interpretation of IR spectra of aliphatic, aromatic hydrocarbons, amines, amides, carbonyl compounds etc

UNIT- II(Total Topics- 12 and Hrs-12)

NMR spectroscopy

Principle, Instrumentation, Factors affecting chemical shift, Uses of TMS equivalent and non-equivalent protons, chemical shifts, factors affecting chemical shifts, shielding of magnetic nuclei, deshielding, anisotropic effects in alkene, alkyne, aldehydes and aromatics, spin-spin coupling, coupling constant, chemical exchange,Simple applications, Interpretation of NMR spectra of aliphatic, aromatic hydrocarbons, carbonyl compounds etc.

Thermal methods of analysis:

Thermal methods: Principle & application of Thermogravimatric analysis; TGA, DTA & DSG , DSC : Principle instrumentation and applications.

UNIT-III (Total Topics- 12 and Hrs- 12)

Microscopic Techniques: Preparation of Thin-films, Physical vapor deposition, Evaporation Techniques-Sputtering (RF & DC), Spin Coating, Pulsed Laser deposition, Working Principle of X-ray Diffractometer, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning tunneling microscopy (STM), Introduction & application of Bio analytical techniques

UNIT-IV (Total Topics- 12 and Hrs-12)
Physical instrumentation techniques: Physical Properties: Introduction, & applications of different physical Characteristics: Viscosity, optical activity & conductivity, Instrumentation: Viscometer, pH meter, Refractometer, Polarimeter.

CO-1: Inculcate knowledge about advanced techniques for physical parameters of materials.
CO-2: Apprcise UV visible&Spectroscopic techniques.
CO-3: Learn interpretation of data used in spectroscopy analysis.
CO-4: Learn principle and method of microscopic & thermogravimatric techniques for characterisation of material for research.

Reference Books:

1. Spectroscopy of Organic Compounds, New Age International Publishers; PS Kalsi
2. Spectrometric Identification of Organic Compounds, John Wiley; Silverstein, Robert M.; Webster, Francis X.; Kiemle
3. Practical NMR Spectroscopy, ML Martin, JJ Delpeach and GJ Martin, Heyden.
4. Fundamentals of Molecular Spectroscopy Colin N. Banwell and Elaine M. Mc Cash Tata McGraw Hill.
5. Introduction to NMR Spectroscopy: RJ Abraham, J Fischer and P Loftus, Wiley.
6. Spectroscopic Method in Organic Chemistry: DH Williams, I Fleming, Tata MacGraw Hill.
7. Instrumental Method of Analysis: Seventh Edition, Willard Merritt, Dean, Settle. CBS

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704 (i)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Spectroscopic Study, Thin Film Technology And Experimental Techniques		

Objectives of the Course:

1. To understand the fundamentals of molecular fluorescence, UV-visible and visible spectroscopy.
2. To illustrate the characteristics of fluorescence emission spectra.
3. To understand different techniques of thin film deposition and working principle of instruments used in the analysis of experimental results.

UNIT I (Total Topics - 07 and Hrs - 15)

Molecular Fluorescence: luminescence, fluorescence and phosphorescence, Fluorescence and other de-excitation processes of excited molecules, Fluorescent probes, Ultimate spatial and temporal resolution: femtoseconds, femtoliters, femtomoles and single-molecule detection.

UNIT II (Total Topics - 20 and Hrs - 20)

UV-Visible and Visible Spectroscopy: Introduction, The absorption laws, Measurement of absorption intensity, Instrumentation, Formation of absorption bands, theory of electronic spectroscopy, Types of electronic transitions in polyatomic molecules, Probability of transitions, Oscillator strength, Selection rules, The Franck–Condon principle, the chromophore concept, absorption and intensity shifts, types of absorption bands, solvent effect, effect of temperature and solvent on the fineness of absorption band, fluorescence and phosphorescence, applications of ultra-violet spectroscopy, important features in electronic spectroscopy, important terms and definitions in ultraviolet spectroscopy.

UNIT III (Total Topics - 23 and Hrs - 20)

Characteristics Of Fluorescence Emission: Radiative and non-radiative transitions between electronic states, Internal conversion, Fluorescence, Intersystem crossing, and subsequent processes, Intersystem crossing, Phosphorescence versus non-radiative de-excitation, Delayed fluorescence, Triplet–triplet transitions, Lifetimes and quantum yields, Excited-state lifetimes, Quantum yields, Effect of temperature, Emission and excitation spectra, Steady-state fluorescence intensity, Emission spectra, Excitation spectra, Stokes shift, Effects of molecular structure on fluorescence, Extent of p-electron system. Nature of the lowest-lying transition, Environmental factors affecting fluorescence, Homogeneous and inhomogeneous broadening. Red-edge effects.

UNIT IV (Total Topics - 21 and Hrs - 20)

Thin Film Technology and Experimental Techniques: Preparation of Thin-films, Physical vapor deposition, Evaporation Techniques-Sputtering (RF & DC), Spin Coating, Pulsed Laser deposition, Liquid Phase Epitaxy, Vapour Phase Epitaxy, Molecular Beam Epitaxy, Film growth and measurement of thickness, Thermodynamics and Kinetics of thin-film formation, Deposition parameters, and grain size, structure of thin films, Ellipsometry, and interferometers, Measurement of the rate of deposition using rate meter, cleaning of the substrate. Working Principle of X-ray Diffractometer, Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Scanning tunneling microscopy (STM), Fourier Transform Infrared Spectroscopy (FTIR), IR and UV-Visible Spectroscopy.

Course Outcomes (CO):

1. Illustrate the difference between luminescence, fluorescence and phosphorescence along with the concept of probe and resolution.
2. Illustrate the fundamentals of UV-Visible and Visible Spectroscopy along with their important applications or utilizations.
3. Demonstrate and analyse the significant characteristics of fluorescence emission along with quantitative analysis of important parameters.
4. Demonstrate and incorporate the acquired expertise of thin film deposition and experimental techniques for the applications in, real-world situations and problems.

References:

1. Sayer M. and Mansingh Abhai, Measurement, Instrumentation Experiment design in Physics and Engineering, Prentice Hall India, 2000.
2. Maissel Leon I. and Glang Reinhard, Handbook of Thin Film Technology, McGraw-Hill Handbooks
3. Valeur Bernard, Molecular Fluorescence: Principles and Applications, Wiley, 2001.
4. Goswami A., Thin Film Fundamentals, New Age international (P) Ltd. Publishers, New Delhi, 1996.
5. Feldman L. C. and Mayer J.W., Fundamentals of surface and Thin Films Analysis, North Holland, Amsterdam, 1986.
6. Banwell Colin N and Elaine M, Cash Mc Fundamental of molecular spectroscopy, McGraw-Hill Publication.
7. Sharma Y R, Elementary organic spectroscopy; Principles and chemical applications, S Chand Pub.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704 (ii)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Solar Energy Fundamentals And Applications		

Objectives of the Course:

1. To understand the fundamentals of solar radiation concepts along with its analytical analysis and measurement.
2. To illustrate the conversion of solar radiation by means of solar energy collectors.
3. To understand the mechanism of conversion of solar energy by means of different solar energy systems along with the comprehensive study of solar crop drying.

UNIT I (Total Topics - 21 and Hrs - 15)

Solar Radiation and its Measurement: Introduction, Solar spectrum, solar radiation; Terrestrial and Extraterrestrial Regions, Solar Time, Instruments; Pyrheliometer, Pyranometer, Sunshine recorder, Sun-earth angles, solar radiation on an inclined surface, monthly average daily radiation on sloped surfaces, estimation of average solar radiation, distribution of clear and cloudy days and hours, estimation of beam and diffuse components of hourly radiation, estimation of beam and diffuse components of daily radiation, estimation of the monthly average of daily total radiation on a horizontal surface, estimation of the monthly average of daily diffuse radiation on a horizontal surface, estimation of hourly radiation from daily data.

UNIT II (Total Topics - 17 and Hrs - 15)

Heat Transfer Concepts: Introduction, **conduction; temperature field, Fourier's law, thermal conductivity, differential equation of conduction, solution of heat conduction in a medium, Boundary conditions, overall heat transfer, Convection, Radiation; radiation involving real surfaces, Kirchoff's law, laws of thermal radiation, radiative heat transfer coefficient, radiation shape factor, heat and mass transfer.**

UNIT III (Total Topics - 12 and Hrs - 15)

Solar Energy Collectors: Introduction, Physical principles of the conversion of solar radiation into heat, flat plate collectors, Flat Plate Collectors; a typical liquid collector, Heat transport system, Typical air collectors or solar air heaters; non porous absorber plate type collectors, collectors with porous absorbers, applications of solar air heaters, advantages of flat plate collectors, Transmissivity of cover system, Energy balance equation and collector efficiency.

UNIT IV (Total Topics - 14 and Hrs - 15)

Application of Solar Energy: Introduction, solar water heating, Space heating, space cooling, solar thermal electric conversion, solar electric power generation; solar photo-voltaic, agriculture and industrial process heat, solar distillation, solar pumping, solar furnace, solar cooking, solar green houses and solar crop drying.

UNIT V (Total Topics - 15 and Hrs - 15)

Solar Crop Drying: Introduction, Working principle; open sun drying, direct solar drying, indirect solar drying, Thermal modelling of open sun drying, computational procedure for convective heat transfer, prediction of crop temperature and moisture evaporation, analysis for steady state condition, experimental setup for open sun drying, methodology and input parameters for computation, thermal analysis of cabinet dryer, energy balance for reverse absorber cabinet dryer; thin layer drying, deep bed grain drying, Energy balance for indirect solar drying system; solar air heater, drying chamber.

Course Outcomes (CO):

1. Demonstrate and analyse solar radiation intensity along with the operating skill of measuring instruments.
2. Illustrate and apply the fundamentals of heat transfer concept in the field of solar energy applications.
3. Appraise the knowledge of design, working principle and evaluation of efficiency of solar collector to design and its best utilization.
4. Illustrate the mechanism, importance and applications of renewable energy systems in compare to conventional energy systems.
5. Incorporate the fundamental and analysis/operational techniques of solar crop dryers in practical, real-world situations and problems.

References:

1. Tiwari, G. N., Solar Energy fundamental, Design, Modelling and application, Narosa Publishing house, New Delhi, 2002.
2. Tiwari G N and Sangeeta Suneja, Solar Thermal Engineering System, Narosa Publishing House, New Delhi, 1997.
3. Rai G D, Non-Conventional sources of Energy, Khanna Publishers, New Delhi, 2000.
4. ASHRAE, Handbook of fundamentals American society of heating refrigerating and air conditioning Engineers, New York, 1967, 1974, 1977.
5. Duffie J A and Beckman W A , Solar Engineering of thermal processes , John Wiley and Sons, New York, 1991
6. Garg H P, Treatise on solar Energy, Fundamentals of solar energy, Vol.- 1, John Wiley and Sons, New York, 1982.

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Programme Name	**Pre-Ph.D. Course Work**	Programme Code	23-
Course Code	DSE704 (iii)	Credit	3
Year/Sem	1/1	L-T-P	3-0-0
Course Name	Condensed Matter Physics & Material Science		

Objectives of the Course:

1. To understand the fundamentals of crystal structure and concepts concern with semiconductor and superconductors.
2. To understand the concepts of thermodynamics and interpretation of statistical methods.
3. To understand the perception of field theory
4. To understand the models and methods for polymeric systems.

UNITS I (Total Topics - 11 and Hrs - 20)

Basic Structures: Bravais lattices. Reciprocal lattice. Diffraction and the structure factor. Phonons, lattice specific heat. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Electron motion in a periodic potential, band theory of solids: metals, insulators and semiconductors. Superconductivity.

UNITS II (Total Topics - 05 and Hrs - 20)

Thermodynamics and Statistical Physics: Basics of thermodynamics, review of statistical methods, spatial correlations in classical systems, ordered systems, symmetry and order parameters, and functional derivatives.

UNITS III (Total Topics - 13 and Hrs - 20)

Mean-Field Theory: The ising and n-vector model, Landau theory, extension to first - order transitions, applications to magnetism, liquid crystals and multiferroics, variational mean- field theory, density functional theory and its applications to ordered systems Breakdown to mean-field theory, mean-field transitions revisited, self-consistent field approximation, critical exponents, universality and scaling, Kadnoff construction, Momentum shell renormalization group

UNITS IV (Total Topics - 03 and Hrs - 15)

Models and methods for Polymeric Systems: Continuous models, lattice models, renormalization group approach and its application to polymeric systems

Course Outcomes (CO):

1. Illustrate lattices, phonons and many more concepts related to semiconductors and superconductors.
2. Illustrate the basic concepts of thermodynamics and statistical parameters and functional derivatives.
3. Illustrate and interpret different concepts and parameters involving in filed theory.
4. Illustrate different models, renormalization group approach and its applications to polymeric systems

References:

1. Chaikin P.M. and Lubensky T.C., Principle of Condensed Matter Physics, Cam.Univ.Press, 1998
2. Hansen J.P. and McDonell I.R. Theory of Simple Liquids, Elsevier Inc, 2006.
3. de Gennes P.G. Scaling Concept in Polymer Physics, Cornell Univ Press, 1979.
4. Cloizeanx J.D. and Jannink G., Polymer in Solutions: Their modelling and structure, Oxford Univ. Press, 1990.

5. Singh S. Liquid Crystals: Fundamentals, World Scientific, 2002.
6. Mahan G.D., Many, Particle Physics, Springer, 1990.
7. Goldennfeld Nigel, Lectures on Phase Transitions and the renormalization group, Addison-Wisley, 1992.
8. Puri S. and Wadhawan V.K. Kinetics of Phase Transitions, World Scientific, 2010.