Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

DIT UNIVERSITY

Dehradun

Detailed Course Structure & Syllabus

of

Ph.D. in Chemistry

Approved by the Academic Council at its 17th Meeting held on 24.03.2021

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Core basket for PhD (all courses are compulsory)

Course Category	Course Code	Course Name	Periods			Credits
			L	T	P	
UC	MB901	Research Methodology	4	0	0	4
UC	CPE-RPE	Research Publication and Ethics	2	0	0	2
DC	CH906	Seminar	0	0	2	1
DCE	CH***	Elective-I	4	0	0	4
DCE	CH***	Elective-II	4	0	0	4
		Total				**15**

Electives basket choose any two (min 4 and maximum 8 credits)

Course Category	Course Code	Course Name	Periods			Credits
			L	T	P	
DCE	CH946	Advanced Chromatographic Techniques	4	0	0	4
DCE	CH947	Advanced Spectroscopic Analytical Techniques	4	0	0	4
DCE	CH948	Advanced Organic Synthetic Methodology	4	0	0	4
DCE	CH949	Synthesis and Applications of Nanoparticles	4	0	0	4
DCE	CH956	Natural Product Chemistry	4	0	0	4
DCE	CH957	Biodiversity and conservation	4	0	0	4
DCE	CH958	Physical Environment	3	1	0	4
DCE	CH959	Advanced Glaciology	3	1	0	4

Note:

1. **Above courses are being offered by the department, in case a Research Scholar wants, he may be allowed to take courses (of equivalent credits) offered by other departments from DITU.**
2. **In view of UGC Guidelines, a Research Scholar is also allowed to opt courses from (of equivalent credits) NPTEL/SWAYAM Portals for completion of Pre-Ph.D course work.**

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	MB901	Subject Title	Research Methodology						
LTP	4 0 0	Credit	4	Subject Category	UC	Year	1st	Semester	I / II

UNIT – I

Fundamentals of Research: Defining research, Objectives of research, types, research process, deductive and inductive reasoning;

Identifying and formulating a research problem, Literature review: Search for existing literature (World Wide Web, Online data bases), Review the literature selected (Case studies, review articles and Meta-analysis), Develop a theoretical and conceptual framework, Writing up the review,

Definition of variables: Concepts, indicators and variables, Types of variables, Types of measurement scales, Constructing the Hypothesis- Null(Research) and alternative, one-tailed and two-tailed testing, errors in testing. Ethical and Moral Issues in Research, Plagiarism, tools to avoid plagiarism – Intellectual Property Rights – Copy right laws – Patent rights

UNIT – II

Research Design: Design of Experiments: Research Designs -Exploratory, Descriptive and Experimental, Experimental designs- Types of Experimental Designs

UNIT – III

Sampling, Sampling distribution, and Data Collection: Sampling distribution, Normal and binomial distribution, Reasons for sampling, sampling technique, sampling errors. Sources of Data-Primary Data, Secondary Data, Data Collection methods

UNIT – IV

Statistical Data Analysis: Descriptive and inferential statistical analysis. Testing of hypothesis with Z-test, T-test and its variants, Chi-square test, ANOVA, Correlation, Regression Analysis, Introduction to data analysis data using SPSS20.0

UNIT – V

Research Report: Writing a research report- Developing an outline, Formats of Report writing, Key elements-Objective, Introduction, Design or Rationale of work, Experimental Methods, Procedures, Measurements, Results, Discussion, Conclusion, Referencing and various formats for reference writing of books and research papers, Writing a Research Proposal.

Books Recommended:

1. Ganesan R, Research Methodology for Engineers, MJP Publishers, Chennai. 2011
2. C. R. Kothari, "Research Methodology", 5th edition, New Age Publication,

3. Cooper, "Business Research Methods", 9th edition, Tata McGraw hills publication
4. Walpole R.A., Myers R.H., Myers S.L. and Ye, King: Probability & Statistics for Engineers and Scientists, Pearson Prentice Hall, Pearson Education, Inc. 2007.
5. Anderson B.H., Dursaton, and Poole M.: Thesis and assignment writing, Wiley Eastern 1997.
6. Bordens K.S. and Abbott, B.b.: Research Design and Methods, McGraw Hill, 2008.
7. Morris R Cohen: An Introduction to logic and Scientific Method (Allied Publishers) – P 197-222; 391–403

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CPE-RPE	Subject Title	Research and Publication Ethics						
LTP	2 0 0	Credit	2	Subject Category	DC	Year	1st	Semester	I / II

Course Objective: There are three objectives in research ethics.

1. The first objective is to protect human participants.
2. The second objective is to ensure that research is conducted in a way that serves interests of individuals or society as a whole.
3. The third objective is to examine specific research activities and projects for their ethical soundness, looking at issues such as the management of risk, protection of confidentiality and the process of informed consent. An ethically correct research involving human participants must include the following components.

UNIT-I: Philosophy & Ethics 4

Introduction to Philosophy– Definition, nature & scope, concept, branches

Ethics- Definition, moral Philosophy, nature of moral judgment and reactions

UNIT-II: Scientific Conduct 4

- Ethics with respect to science & research,
- Intellectual honesty and research integrity,
- Scientific Misconduct: Falsification, Fabrication and Plagiarism (FFP),
- Redundant Publications: duplicate & overlapping applications,

Salami slicing, selective reporting & misrepresentation of data

UNIT-III: Publication Ethics 4

Publication Ethics: Definition, introduction & importance

- Best practices/standards settings initiatives & guidelines: COPE, WAME etc.
- Conflicts of interest
- Publication Misconduct: definition, concept, problems that lead to unethical behavior and vice versa type
- Violation of public ethics, authorship and contributor ship
- Identification of publication misconduct, complaints & appeals
- Predatory publishers & journals

UNIT-IV: Open Access Publishing 4

- Open Access publication & initiatives.
- SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies
- Software tool to identify predatory publications developed by SPPU
- Journal finder/journal suggestion tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggested etc.

UNIT-V: Publication Misconduct 4

A. Group Discussion

- Subject specific ethical issues, FFP, authorship

- Conflicts of interest
- Complaints & appeals: examples & fraud from India & Abroad.

B. Software tools

Use of plagiarism software like Turnitin, Urkund and other open source software tools.

UNIT-VI: Databases & Research Metrics

A. Databases

- Indexing databases
- Citation databases: Web of science, Scopus etc.

B. Research Metrics

- Impact factor of journal as per journal citation report, SNIP, SJR, IIP, Cite Score

Metrics: h- Index, g index, i10 index, altmetrics.

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Applicable for Batch: 2021 Onwards

Subject Code	CH946	Subject Title	Advanced Chromatographic Techniques						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1st	Semester	I / II

COURSE OBJECTIVE:

The basic aim of this course is to enhance the capability of research students on hand on experience. They should understand the fundamentals of different techniques and their applications.

UNIT I: Introduction to Separation Techniques **7 Hours**

Separation Techniques, Classification of chromatographic techniques (Retention mode and sample introduction); fundamentals of paper, TLC and HPTLC chromatography-Mobile phases and Stationary Phases, development of Chromatograms; Detection and Quantitation; Applications in qualitative and quantitative analysis

Unit 2: High Performance Liquid Chromatography **8 Hours**

HPLC: Principle, Retention Parameters in HPLC, resolution and retention Time; Instrumentation; Separation Mechanism in HPLC; Stationary phase effects; Role of HPLC and HPTLC in qualitative and quantitative analysis of bioactive metabolites and some approved drugs and application of LC/MS in analysis.

Unit 3: **Gas Chromatography** **8 Hours**

Gas Chromatography: Principle and theories of separation process; GC-columns, gas chromatographic detectors; Recording and analysis; Resolution; Application of GSC and GLC; Applications of GC/Mass and GC/IR analysis; comparison of GC and HPLC.

Unit 4: Ion Exchange Chromatography **8 Hours**

Ion Exchange Chromatography: Theories, use of synthetic ion exchangers in separation, chelating ion exchange resins, liquid ion exchangers, experimental techniques and applications; Affinity chromatography, Affinity separations and SDS-Gel Electrophoresis-applications in Protein purifications.

References:

1) "Unified Separation Science" by J.C. Giddings
2) "Principles and Practice of Modern Chromatographic Methods" by K. Robards, P.R. Haddad and P. E. Jackson.
3) High Performance liquid chromatography: Principles and Methods, Elena D. Katz(John Wiley & Sons Ltd. 2009)
4) Chromatography and Separation Science Satinder Ahuja, (2003), Academic Press

COURSE OUTCOME:

At the end of the course, the student can:

CO1.A solid theoretical understanding of chromatography and mass spectrometry at an advanced level.

CO2. Some experience in addressing complex analytical problems, and acquaintance with tools to solve them.

CO3. Hands-on experience with advanced and diverse chromatographic systems and mass spectrometers.

CO4. New tools for research processes also studied.

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CH947	Subject Title	Advanced Spectroscopic Analytical Techniques						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1st	Semester	I / II

COURSE OBJECTIVE:

The basic aim of this course is to enhance the capability of research students for determination of functional group and spectroscopic analysis of organic compounds in chemistry. They should understand the fundamentals of different techniques and their applications.

Unit 1: UV-Vis & IR Spectroscopy **8 Hours**

Introduction, Types of electronic absorption bands, Theory of electronic spectroscopy, Types of electronic transitions, Transition probability, The Chromophore concept, Auxochrome, Absorption and intensity shifts, Types of absorption bands, Solvent effects, Conjugated dienes, Woodward-Fieser rules for calculating absorption maximum in dienes, UV absorption in α, β-unsaturated carbonyl compounds, Applications of UV spectroscopy, Important features in electronic spectroscopy.

IR spectroscopy: principle of IR spectroscopy, Selection rules, Factors influencing vibrational frequencies, Scanning of IR spectrum and application in interpretation of organic functional groups.

Unit 2: ^{1}H NMR Spectroscopy **8 Hours**

Basic theory – phenomenon of energy absorptions (resonance) and relaxation, chemical shift, shielding and deshielding mechanisms, equivalence and nonequivalence of protons, spin-spin coupling – notation for spin systems, coupling constant and its variation with stereochemistry-Karplus equation. Structural application of 1H NMR, aromaticity, antiaromaticity and homo-aromaticity of organic molecules and related problems.

^{13}C NMR Spectroscopy: Principles; broad band decoupling, DEPT; structural applications of ^{13}C NMR.

Unit 3: **Mass Spectrometry** **8 Hours**

Types of ionization techniques, basic principles of EI. Fragmentation processes and structural analysis; ESI, GC/MS, LC/MS and MS/MS techniques, fragmentation pattern of small molecules and interpretation of spectroscopic (NMR, IR and mass) data, as applied to organic, inorganic and biological systems Problems incorporating spectroscopic data.

Unit 4: Introduction to 2D NMR **8 Hours**

COSY, NOESY, HSQC, HMBC, HETCOR, HOMCOR, INEPT for simple compounds and problem

REFERENCES

1. Spectroscopic identification of organic compounds by Robert M. Silverstein, Francis X. Webster and David J. Kiemle.

2. Introduction to spectroscopy by Donald L. Pavia, Gary M. Lampman and George S. Kriz.

3. Elementary Organic spectroscopy by Y. R. Sharma.

COURSE OUTCOME:

At the end of the course, the student can:

CO1.A solid theoretical understanding of organic compounds by interpretation through spectroscopic and mass spectrometry at an advanced level.

CO2. *Hands-on experience with advanced and diverse spectroscopy, IR, UV-Vis and mass spectrometer*

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CH948	Subject Title	Advanced Organic Synthetic Methodology						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1st	Semester	I / II

COURSE OBJECTIVE:

This course provides an introduction to the synthesis of complex organic molecules. Transformations of C-X to C-C bond-formation, functional group reactivity, chemo-selectivity, regioselectivity, and the strategy of multistep synthesis will be the core topics that are covered. Concepts include strategy/retrosynthesis, advanced aromatic chemistry, protecting groups, stereochemistry, enolates and other carbonyl chemistry, alkene synthesis, reduction/oxidation (introductory), heterocycles, cross-coupling reactions and other modern methods of synthesis

Unit 1: C-C, C-X and C=C bond forming reactions **8 Hours**

Transition metal complexes in organic synthesis; only Pd, Ni, Co, Fe, Cu (Metal mediated C-C and C-X bond formation reactions: Suzuki, Heck, Sonogashira, Stille, Fukuyama, oxo process etc; C=C formation reactions: Wittig, Horner-Wordworth-Emmons, Shapiro reactions, Mc Murry, Julia-Lythgoe and Peterson olefination reactions etc

Unit 2: Multi-component and Ring forming reactions **8 Hours**

Construction of Ring Systems: Different approaches towards the synthesis of four, five and six-membered rings; photochemical approaches for the synthesis of four membered rings, oxetanes and cyclobutanes. Diels-Alder reaction (inter- and intramolecular); specific examples of Mannich reactions, Ugi, Passerini, Pausan-Khand, Bergman and Biginelli Reactions and Diels-Alder reaction; Click chemistry: criterion for click reaction and Sharpless azides cycloadditions.

Unit 3: **Macro cyclic Compounds** **8 Hours**

Principles in the construction of macrocyclic rings and ring closing metathesis, Grubbs 1st and 2nd generation catalyst; Applications of metallic carbenes in organic synthesis. Use of Boron and Silicon in Industrial organic synthesis, applications and other important reactions like; Baylis Hilman, Eschenmoser-Tanabe fragmentation, Mitsunobu reaction, etc

Unit 4: Chemistry of Protective group **8 Hours**

Protecting groups: Protection and de-protection of hydroxy, carboxyl, carbonyl, carboxy amino groups and carbon-carbon multiple bonds; chemo- and regioselective protection and deprotection; illustration of protection and deprotection in synthesis.

REFERENCES

1. Organic chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press)

2. Designing of organic synthesis – S. Warren (Wiley)

3. Some modern methods of organic synthesis – W. Carruthers (Cambridge)

4. Organic synthesis using transition metals-Roderick Bates (Wiley)

5. Organometallics in organic synthesis – J. M. Swan and D. C. Black (Chapman and Hall)

6. Advanced organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007)

COURSE OUTCOME:

At the end of the course, the student can:

CO1.A fundamental and theoretical understanding of organic reactions transformation by mechanistically.

CO2. The knowledge of synthetic organic chemistry is a great demand in pharmacy, medicinal and industrial chemistry.

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CH949	Subject Title	Synthesis and Applications of Nanoparticles						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1st	Semester	I / II

COURSE OBJECTIVE:

This course provides an introduction to the Synthesis of nanoparticles and their application in electronic and magnetic devices

Unit 1. Synthesis of Nanoparticles by Chemical, Physical and Biological routes

Colloids :- Introduction to Colloids and Colloids in Solutions, Effect of Charges on Colloids, Stearic Repulsion, Synthesis of Colloids, Nucleation and Growth of Nanoparticles

Chemical Methods :- Synthesis of Metal Nanoparticles by Colloidal Route, Synthesis of Semiconductor Nanoparticles by Colloidal Route, Langmuir-Blodgett (LB) Method , Microemulsions , Sol-Gel Method, Synthesis Using Micro-reactor or Lab-On-Chip

Physical Methods :- High Energy Ball Milling, Physical Vapour Deposition with Consolidation Ionized Cluster Beam Deposition, Laser Vapourization (Ablation) , Laser Pyrolysis Sputter Deposition, Chemical Vapour Deposition (CVD), Electric Arc Deposition Ion Beam Techniques (Ion Implantation), Molecular Beam Epitaxy (MBE)

Biological Methods:- Synthesis Using Microorganisms, Synthesis Using Plant Extracts Use of Proteins, Templates Like DNA, S-Layers, Synthesis of Nanoparticles Using DNA

Unit 2. Nanomaterials for energy applications

Energy harvesting photodevices, Solar Cells, various types of solar cells, and physics and chemistry of solar cells, nanomaterials in solar cells , Energy storage devices based on nanomaterials, Supercapacitors and batteries, Fuel cells, various types of fuels cells, hydrogen storage using nanomaterials. Energy nanocatalyst including photo-catalyst for water splitting, electro-catalyst. Nanoscale Energy Devices and Thermoelectrics.

Unit 3. Magnetism in bulk and nanostructures:

Behavior of powders of ferromagnetic nanoparticles (Single/individual magnetic nanoparticles); Measurement of super-paramagnetism and blocking temperature; Nanopore containment of magnetic particles; Antiferromagnetic nanoparticles; Rare-earths and Special Oxides (Spinels, Garnets and Perovskites). Magneto-resistance, tunnel magnetoresistance, Definition of spintronics and examples of spintronic devices. Dilute magnetic semiconductors, Magnetic storage and spin valves.

Reference Books:-

1. Nanotechnology: Principles and Practices; Prof. S. K. Kulkarni, Springer Publication

2. Nanomaterials: Synthesis, Properties and Applications; A.S Edelstein and R.C Cammaratra
3. Nanostructures and Nanomaterials: Synthesis, Properties and Applications; Cao & Wang, World Scientific.
4. Nanostructured Materials for Solar Energy Conversion by Tetsuo Soga, Elsevier.
5. Nanomaterials in energy devices by Hieng Kiat Jun, CRC press, Taylor and Francis Group.

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CH956	Subject Title	Natural Product Chemistry						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1st	Semester	I / II

COURSE OBJECTIVE:

This course will provide introduction to natural products chemistry including Synthesis, separation and Characterisation

1. **Introduction to Natural Products:** Primary and Secondary metabolites, use of natural products in traditional medicine, potential of natural products, natural products in drug discovery and development.
2. **Chemistry of natural products:** Introduction, occurrence, classification, extraction, isolation, separation, purification, synthesis, and biosynthesis of alkaloids, flavonoids, phenolics, saponins, steroids, and terpenoids.
3. **Extraction:** Maceration, percolation, reflux extraction, Soxhlet extraction, liquid-liquid extraction, counter-current extraction, supercritical fluid extraction, ultrasound and microwave assisted extraction, pulsed electric field and enzyme assisted extraction.
4. **Separation Methods:** Theory and techniques of distillation, fractional distillation, steam distillation, vacuum distillation, theory of action of drying agents, fractionation by evaporation, working of rotary film evaporator and crystallization.
5. **Chromatographic Techniques:** Principle and applications of adsorption (TLC, paper chromatography, column chromatography, gas chromatography, HPTLC, HPLC, Gel permeation chromatography, flash chromatography and super critical fluid chromatography, ion-exchange chromatography) with suitable example and chromatogram. Extraction-distribution law. Preparative GC. Multi-dimensional chromatographic separation (3D Prep GC, TWO-3D Prep GC)

Reference Books

1. New trends in natural product chemistry, Atta-ur-Rahman and MI Choudhary, Harwood Academic Publishers.
2. Natural products: Chemistry and biological significance, J Mann, RS Davidson, JB Hobbs, DV Banthrope and JB Harborne, Longman, Essex.
3. Chemistry, biological and pharmacological properties of medicinal plants from the Americas, ed. Kurt Hostettmann, MP Gupta and A Marston, Harwood Academic Publishers.
4. Organic chemistry, vol. 2, IL Finar, ELBS.

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CH957	Subject Title	Biodiversity and Conservation						
LTP	4 0 0	Credit	4	Subject Category	DC	Year	1st	Semester	I / II

COURSE OBJECTIVE: This Course is an introductory course on biodiversity and its conservation, where biodiversity will be taught from genetics to ecosystem level. Advanced techniques related to Biodiversity conservation will be discussed

1. Biodiversity: the concept and levels of biodiversity: Genetic, species, community and

Ecosystem

2. Biodiversity and ecosystem functions & Services: Concepts and models, Auto-ecology & Synecology, Ecological efficiency & productivity, Homeostasis, Productive, Consumptive, Ethical, Aesthetic, Research & option and Ecological services of Biodiversity.

3. Magnitude and distribution: Diversity gradients and related hypotheses, Advanced methods for biodiversity monitoring, megadiversity zones and hot spots, Significance of endemism

4. Threats to biodiversity: human population growth and its implications on

Biodiversity, Causes of biodiversity loss, species extinction, vulnerability of

species to extinction, IUCN threat categories, Red data book, biodiversity prospecting.

5. Strategies for biodiversity conservation: Principles of biodiversity conservation, in-situ

and ex-situ conservation strategies; Advanced techniques for biodiversity conservation, Biodiversity act of India, International convention on biodiversity, Biodiversity legislations in India.

Suggested Readings:

1. Global Biodiversity Assessment, VH Heywood & RT Watson (1995), UNEP, Cambridge
2. University Press.
3. Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring, D Hill, M
4. Fasham & P Shaw (2005), Cambridge University Press.
5. Ecological Diversity and Its Measurement, AE Magurran (1988), Princeton University
6. Press, Princeton, New Jersey.
7. Conservation Biology: Foundations, Concepts, Applications, Van Dyke Fred (2008), 2nd
8. edition, McGraw Hill, New York, USA
9. Biodiversity and Conservation, Peter J. Bryant (2009), University of California, Irvine,
10. USA

Course Structure & Syllabus of Ph.D. Chemistry

Applicable for Batch: 2021 Onwards

Subject Code	CH358	Subject Title	Physical Environment						
L T P	3 1 0	Credit	4	Subject Category	DCE	Year	1st	Semester	I / II

Course Objective

The objective of the course is to acquaint the student with a basic understanding of the concept and structure of Environment. The global environmental issues and disasters posed by the Cryospheric Environment will also be introduced to the students through the course. The course will help the student to develop the understanding about the introduction of Remote sensing, application of Remote Sensing in various domains of environmental sciences, natural hazards assessment and disaster management.

UNIT-I: Basics in Environmental Sciences **(07 Hours)**

Definition, scope and importance of environmental studies, Structure of Earth and its spheres, Monsoon System in Indian subcontinent, Radiative and turbulent heat fluxes, Mountain Hydro-meteorology, Mountain and valley winds

UNIT-II: Environmental Pollution and Degradation (08 Hours)

Environmental Pollution and its type, Factors Governing air, water and noise Pollution, Green House Effect, Air and water quality standards, Gaseous and particulate matters, Waste Disposal techniques, Global Warming and its consequences

UNIT-III: Principles of Remote Sensing (13 Hours)

Introduction, Definition and Scope, Stages of Remote Sensing data acquisition, Type of Remote Sensing, Advantages and Limitations of Remote Sensing, Platforms – Types and their characteristics; Satellites and their characteristics – Geostationary and sun-synchronous; Earth Resources Satellites, Satellite Image Interpretation.

UNIT-IV: Natural hazards and Disaster Management (04 Hours)

Cloud Burst, Torrential Rainfall, Avalanches, Flash Floods, Lake Outburst Flood, Landslide, Forest fire, Drought

Reference Books:

1. Introduction to Environmental Engineering and Science (3rd Edition) - Masters G.M. andEla W.P., Prentice Hall, OCLC Number: 747648756, 2008.
2. Environmental Science (16th Edition) - Miller T.G. & Spoolman S., Cengage Learning,ISBN-10: 9781337569613, 2018.
3. Fundamentals of Remote Sensing (2nd Edition) – George Joseph, Universities Press,ISBN: 9788173715358, 2005.
4. Remote Sensing and GIS (2nd Edition) – Basudeb Bhatta, Oxford, ISBN-10: 0198072392,2011.

5. Remote Sensing and Image Interpretation (6th Edition) – Lillesand, Kiefer, Chipman,Wiley, ISBN-10: 8126532238, 2011.

6. Remote Sensing of the Environment: An Earth Resource Perspective (2nd Edition) – John R. Jensen, Pearson Education India, ISBN-10: 9789332518940, 2013

Course Outcome

At the end of this course the student will be able to understand -

CO1. Significance of environmental science as a Research discipline.

CO2. Important environmental issues and the factors responsible for their cause.

CO3. Basic phenomenon and principles of remote sensing.

CO4. Applications of remote sensing to various domains of environmental sciences.

Course Structure & Syllabus of Ph.D. Chemistry
Applicable for Batch: 2021 Onwards

Subject Code	CH959	Subject Title	Advanced Glaciology						
L T P	3 1 0	Credit	4	Subject Category	DCE	Year	1st	Semester	I / II

Course Objective

The course will help the student to develop the understanding about significance of Glaciological science as a research discipline. The course will help student to understand glacier monitoring and modelling techniques.

UNIT-I: Introduction to Glacier **(07 Hours)**

Glaciations, Transformation of snow to ice, Physical properties and classification, Glacier Distribution, Glacier-climate interaction, Erosional and Depositional feature, Surface morphology, Glaciofluvial landforms

UNIT-II: Glacier Dynamics (07 Hours)

Components of glacier, Thermodynamics process, Geometrical changes, Snout Fluctuation, Flow of Glaciers, Glacier Mass Balance, case studies

UNIT-III: Glaciological Measurements (09 Hours)

In-situ Measurements: Monitoring systems for Hydro-meteorology; Field based Scientific Equipment, Space-Based Measurement: Snow cover, Vegetation cover, Glacier geometry, Trend Analysis, Correlation, Regression Analysis

UNIT-IV: Glaciological Modelling (09 Hours)

T-index modelling, Energy-Mass balance modelling, Semi-Distributed conceptual hydrological modelling of streamflow, case studies

Reference Books:

1. Climatology - D.S. Lal, Sharda Pustak Bhawan, ISBN: 9788186204122, 2011.
2. Atmosphere, Weather and Climate - Barry R.G. & Chorley R.J., Routledge, Taylor &Francis, ISBN-10: 9781138294073, 2010.
3. The Physics of Glaciers (4th Edition) - Cuffey, K.M. and Paterson, W.S.B., Butterworth-Heinemann, USA. 2010.
4. Glacier Atlas of India - Raina, V.K. and Srivastava, D., Geological Society of India,Bangalore, ISBN: 81-85867-80-9, 316 pp., 2008.
5. Principles of Glacier Mechanics - Roger LeB. Hooke, Cambridge University Press, OnlineISBN: 9780511614231, 2005, DOI: https://doi.org/10.1017/CBO9780511614231
6. Ice Composition and Glacier Dynamics - Roland A. Souchez & Reginald D. Lorrain,Springer-Verlag Berlin Heidelberg, ISBN: 978-3-642-63497-0, 1991

7. Introduction to the Physics of the Cryosphere- Melody Sandells & Daniela Flocco, Morgan & Claypool Publishers, ISBN: 978-1-6270-5302-0, 2014.
8. The Cryosphere- Shawn J. Marshall, Princeton University Press, ISBN: 9780691145266,2012
9. Remote Sensing of the Cryosphere - Marco Tedesco, Wiley, ISBN: 978-1-118-36885-5,2014.

Course Outcome

On completion of the course, the students will be able to understand -

CO1. Basic phenomenon and principles of glaciology.

CO2. Applications of remote in glaciological sciences.

CO3. Glacier Monitoring and Modelling Techniques Satellites and their characteristics.