Department of Biotechnology
Mohanlal Sukhadia University
Udaipur, Rajasthan

B.Sc. (CBCS) Biotechnology
Syllabus as per the National Education Policy

Biotechnology in B.Sc. Program: Semester wise course types, Course codes, Course title, Delivery type, Workload, Credits, Marks of Examination, and Remarks if any.

Level	Semester	Course Type	Course Code	Course Title	Delivery Type			Total Hours	Credit	Total Credit	Internal Assessment	EoS Exam	M.M.	Remarks
					L	T	P							
5	I	DCC	BIO5000T	Biotechnology-I : Basic Microbiology and Techniques	L	T	-	60	4	6	20	80	100	
			BIO5001P	Biotechnology Lab-I: Basic Microbiology and Techniques	-	-	P	60	2		20	80	100	
		AECC			L	-	-	30	2	2	20	80	100	
	II	DCC	BIO5002T	Biotechnology-II: Animal Biotechnology	L	T	-	60	4	6	20	80	100	
			BIO5003P	Biotechnology Lab-II: Animal Biotechnology	-	-	P	60	2		20	80	100	
		AECC			L	-	-	30	2	2	20	80	100	
Exit with Certificate in Science (After 4 more credits in SEC)														
6	III	DCC	BIO6004T	Biotechnology-III: Plant Biotechnology	L	T	-	60	4	6	20	80	100	
			BIO6005P	Biotechnology Lab-III: Plant Biotechnology	-	-	P	60	2		20	80	100	
		SEC		Communicative English	L	-	-	30	2	2	10	40	50	
	IV	DCC	BIO6006T	Biotechnology-IV: Recombinant DNA Technology	L	T	-	60	4	6	20	80	100	
			BIO6007P	Biotechnology Lab-IV: Recombinant DNA Technology	-	-	P	60	2		20	80	100	
		SEC	SES6300T	Bioinformatics	-	-	T	30	2	2	20	80	100	
Exit with Diploma in Science														

7	V	DSE	BIO710WT	0. Environmental Biotechnology 1. Immunology and Enzyme Technology 2. 3.	L	T	-	60	4	6	20	80	100	
			BIO710XP	4. Elective BIO. Lab-1: Environmental Biotechnology Lab 5. Elective BIO. Lab-2: Immunology and Enzyme Technology Lab 6. 7.	-	-	P	60	2		20	80	100	
		SEC	SES7301P	Basics of Instrumentation	-	-	P	60	2	2	20	80	100	
	VI	DSE	BIO710YT	8. Microbial Technology 9. Agriculture Biotechnology 10. 11.	L	T	-	60	4	6	20	80	100	
			BIO710ZP	12. Elective BIO. Lab-1: Microbial Technology Lab 13. Elective BIO. Lab-2: Agriculture Biotechnology Lab 14. 15.	-	-	P	60	2		20	80	100	
		SEC	SES7302P	Microbial cultivation techniques	-	-	P	60	2	2	20	80	100	
Exit with Graduation Degree in Science (B.Sc.)														

B.Sc. (CBCS) Biotechnology

Total Seats: 60

(All Seats are Self Finance Seats)

Eligibility:

Those students who passed 10+2 school examination (Biology Group) with a minimum of 48% marks. The candidates from outside the state of Rajasthan should possess a minimum of 60% marks to seek admission. Candidates with Agriculture / Horticulture / Biotechnology or any other relevant life sciences subject at 10+2 level will also be considered, provided that they also had Chemistry as an optional subject at 10+2 level.

Note: B.Sc. with Biotechnology course is being offered in combination with Botany and Chemistry. The syllabus for Botany and Chemistry will be adopted from the respective departments.

B. Sc. BIOTECHNOLOGY SEMESTER–I (2023-24)
DCC Course (BIO5000T)

Code of the course: BIO5000T

Title of the course: Biotechnology-I: Basic Microbiology and Techniques

Level of the Course: NHEQF Level 4.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge of basic microbiology learn at School level and lay foundation for further learning of the subject through first course on Basic Microbiology and techniques which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

The student after reading the course will be able to describe general structure of prokaryotic and eukaryotic cell, general structure and diseases caused by microorganisms. Understand the basic principles of sterilization, preparation of media and techniques of cultivation of microorganisms.

Syllabus:

DCC Course (BIO5000T)
Biotechnology-I: Basic Microbiology and Techniques (Theory)
(Credit: 4; Hours: 60)

Unit 1 **12 Credit hours**

Comparison of prokaryotic and eukaryotic cells; general characteristics of microorganisms, Kingdom and Domain classification system, Ultra structure of bacteria: Cell size, shape and arrangement, Cell envelope; cell wall composition, flagella, pilli, cytoplasm, mesosomes, nucleoids and plasmids.

Unit 2 **12 Credit hours**

Virology – virus classification, general features, structure, reproduction; lytic and lysogenic life cycles. Transmission of plant and animal viruses and diseases caused by them. Mycoplasma, Viroids, and prions: general features and diseases caused by them.

Unit 3 **12 Credit hours**

Nutritional requirements of microorganisms -Macronutrients, micronutrients and growth factors. Nutritional types; Autotrophs and heterotrophs, phototrophs and chemotrophs. Culture media: Components of media, synthetic or defined media, complex media, enriched media, selective media and differential media.

Unit 4 **12 Credit hours**

Sterilization-Physical methods: moist heat sterilization; boiling, pasteurization, tyndallization, autoclaving. Dry heat sterilization- Incineration and hot air oven, Filtration- membrane filter and laminar air flows, Radiation- Ionizing radiation and non-ionizing radiation. Chemical methods: Alcohol, aldehydes, phenols, quaternary ammonium compounds and sterilizing gases.

Unit 5 **12 Credit hours**

Pure culture isolation: Streaking, serial dilution and plating methods; cultivation, physical conditions for growth; temperature, pH and oxygen, maintenance and preservation of pure cultures; cultivation of anaerobic bacteria. Morphological and cultural characterization, types of staining.

Recommended Books:

1. Tortora GJ, Funke BR, and Case C.L. (2004). Microbiology: An Introduction. 4th edition. Pearson Education.
2. Atlas RM. (1997). Principles of Microbiology. 2nd edition. WM.T. Brown Publishers.
3. Cappucino J and Sherman N. (2010). Microbiology: A Laboratory Manual. 9th edition. Pearson Education limited.
4. Madigan MT, Martinko JM and Parker J. (2009). Brock Biology of Microorganisms. 12th edition. Pearson/Benjamin Cummings.
5. Pelczar MJ, Chan ECS and Krieg NR. (1993). Microbiology. 5th edition. McGraw Hill Book Company.
6. Dubey, R.C. and Maheshwari, D.K. A Text Book of Microbiology. S. Chand and Company.
7. Prescott, H. and Klein. 2000. Microbiology. McGraw Hill.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–I (2023-24)
DCC Course (BIO5001P)

Code of the course: BIO5001P

Title of the course: Biotechnology Lab-I: Basic Microbiology and Techniques

Level of the Course: NHEQF Level 4.5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge of basic microbiology learn at School level and lay foundation for further learning of the subject through first course on Basic Microbiology and techniques which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DCC Course (BIO5001P)
Biotechnology Lab-I: Basic Microbiology and Techniques (Practical)
(Credit: 2; Hours: 60)

1. Determine quantitatively the number of cells in the given yeast suspension using Neubauer's chamber.
2. Calibrate the ocular micrometer and determine the size of given microscopic structure at 10X and 40X magnification.
3. Prepare suitable smear of the given bacterial cultures and identify them using Gram stain.

4. Prepare suitable smear of the given bacterial culture and demonstrate the presence of bacterial endospores using spore staining.
5. Perform the monochrome staining procedure to identify the morphological shape of bacterial cells.
6. Perform the negative staining procedure to compare morphological shapes and arrangement of bacterial cells using nigrosin stain.
7. Demonstrate the streak/spread/pour plate technique for isolation of bacteria from given sample.
8. Determine the cultural characteristics of the given bacterial colonies.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. TMV
2. pH meter
3. Hot air oven
4. Bacteriophage
5. Filter sterilization unit
6. Laminar air flow bench
7. Compound Microscope
8. Diseased specimen - Citrus canker
   -Yellow vein mosaic of bhindi

Recommended Books:

1. K.R. Aneja (2007) Experiments in Microbiology, Plant pathology and Biotechnology, 4th Edition, New Age International (P) Limited Publishers.
2. R.C. Dubey and D.K. Maheshwari (2012) Practical Microbiology, 3rd Edition, S. Chand and Company Ltd.
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–I (2023-24)

AECC 1

B.Sc. BIOTECHNOLOGY SEMESTER–II (2023-24)
DCC Course (BIO5002T)

Code of the course: BIO5002T

Title of the course: Biotechnology-II: Animal Biotechnology

Level of the Course: NHEQF Level 4.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to animal biotechnology learn at School level and lay foundation for further learning of the subject through this course on Animal Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to illustrate the techniques, procedure and growth patterns of animal cell culture and understand the structure of animal genes and genomes. Understand basic principles and techniques in genetic manipulation and genetic engineering. Understand gene transfer technologies for animals and animal cell lines, Understand the techniques and problems both technical and ethical in animal cloning.

Syllabus:

DCC Course (BIO5002T)
Biotechnology II: Animal Biotechnology (Theory)
(Credit: 4; Hours: 60)

Unit-I **12 Credit hours**

Animal cell culture: History, techniques, methods, culture media (natural and artificial media). Balanced salt solutions and simple growth medium: composition, types and preparation. Role of CO_2, serum and Growth factors in culture media. Serum and protein-free defined media and their applications.

Unit-II **12 Credit hours**

Primary cultures, Secondary cultures. anchorage dependent growth, non-anchorage dependent cells and their growth. Characterization of cultured cells. test of viability, cytotoxicity and measurement of growth.

Unit-III **12 Credit hours**

Animal cell lines: origin, characteristics, nomenclature and maintenance. Transformed animal cells and cell lines, measurement of cell death (apoptosis). Stem cell cultures, scaling-up of animal cell cultures and production of recombinant gene products.

Unit-IV **12 Credit hours**

Organ culture: various techniques, applications and limitations. Whole embryo culture, transfection of animal cells: selectable markers, HAT selection, Somatic cell fusion, hybridoma technology and production of monoclonal antibodies.

Unit-V **12 Credit hours**

Growth kinetics of cells in culture, Applications of animal cell culture. Three-dimensional culture and tissue engineering (artificial skin and artificial cartilage), In vitro fertilization in humans, super ovulation, embryo transfer in humans and livestock.

Recommended Books:

1. Masters, J. Animal Cell Culture. Panima.
2. Freshney, I. Culture of Animal Cell. John Wiley.
3. Martin, C. (Ed). Animal Cell Culture Techniques. Springer.
4. Mather and Barnes. (Ed). Methods in Cell Biology. Vol. 5-7, Animal Cell Culture Method. Academic Press.
5. Paul, J. Animal Tissue Culture.
6. Butler, M. and Dawson, M. Lab Fax : Cell Culture. Bios Scientific Publications.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B.Sc. BIOTECHNOLOGY SEMESTER–II (2023-24)
DCC Course (BIO5003P)

Code of the course: BIO5003P

Title of the course: Biotechnology Lab-II: Animal Biotechnology (Practical)

Level of the Course: NHEQF Level 4.5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to animal biotechnology learn at School level and lay foundation for further learning of the subject through this course on Animal Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DCC Course (BIO5003P)
Biotechnology Lab-II: Animal Biotechnology (Practical)
(Credit: 2; Hours: 60)

1. Prepare single cell suspension of the given animal tissue.
2. Demonstrate the process of lymphocyte separation from blood.
3. Quantify the total number of cells in given suspension.
4. Quantify the total viable cells in given suspension.
5. Perform the mechanical disaggregation of the given tissue and separate the cells.

6. Demonstrate the watch glass method technique for organ culture.
7. Prepare 100 ml Dulbecco's phosphate buffer saline solution A for animal tissue culture.
8. Prepare 100 ml HBSS medium containing 1 gml-1 D-glucose for animal cell culture (pH 6.5).

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. pH meter
2. Defined media
3. Syringe filter
4. CO2 incubator
5. Trypan blue dye
6. Microwave oven
7. Phenol red indicator
8. Inverted microscope

Recommended Books:

1. Freshney, R. I. (2015). Culture of animal cells: a manual of basic technique and specialized applications. John Wiley & Sons.
2. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B.Sc. BIOTECHNOLOGY SEMESTER–II (2023-24)
AECC 2

B. Sc. BIOTECHNOLOGY SEMESTER–III (2023-24)
DCC Course (BIO6004T)

Code of the course: BIO6004T

Title of the course: Plant Biotechnology

Level of the Course: NHEQF Level 5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to plant biotechnology learn at School level and lay foundation for further learning of the subject through this course on Plant Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to learn the principles and technical advances behind the in vitro culture of plant cells and rDNA techniques, Students will learn the applications of plant transformation for improving the productivity and performance of plants under biotic and abiotic stresses, Students will understand the use of antisense technologies for improvement of crop plants.

Syllabus:

DCC Course (BIO6004T)
Biotechnology-III: Plant Biotechnology (Theory)
(Credit: 4; Hours: 60)

Unit-I **12 Credit hours**

Plant tissue culture- History, contribution of Indian Scientists. Concept of cellular totipotancy and differentiation, laboratory facilities and supplies, asepsis and methods of sterilization. Culture medium- composition and methods of preparation. Role of plant growth regulators, vitamins and other adjuvants.

Unit-II **12 Credit hours**

Pathways of micropropagation- axillary bud proliferation, adventitious shoot bud proliferation, Callus organogenesis, Somatic embryogenesis, Steps of micropropagation-management of donor plants, culture establishment, shoot multiplication, rooting, hardening and acclimatization.

Unit-III **12 Credit hours**

Protoplast isolation, culture and Somatic hybridization, production of haploids -Anther and pollen culture, ovary culture. Embryo and endosperm culture. Embryo rescue. Production of synthetic seeds.

Unit-IV **12 Credit hours**

In vitro fertilization, Methods of cryopreservation for germplasm conservation. Somaclonal and gametoclonal variation. Meristem tip culture for elimination of viruses in plants. Commercialization of plant tissue culture- Global scenario and plant tissue culture industries in India.

Unit-V **12 Credit hours**

Cell culture and in vitro production of secondary metabolites. Important alkaloids and factors affecting their production. Hairy root culture, elicitation and biotransformation, Bioreactors – their types, construction and use in secondary metabolite production.

Recommended Books:

1. Robert Smith. Plant tissue culture : Techniques and Experiments. South Asia Edition.
2. Gamborg and Phillip. Plant Cell, Tissue and Organ Culture. Narosa.
3. Dixon and Gonzales. Plant Cell Culture. Panima.
4. Narayanswamy. Plant Cell and Tissue Culture. McGraw Hill.
5. Bhojwani, S.S. and Rajdan, M.K. Plant Tissue Culture: Theory and Practices a revised Edition. Elsevier.
6. Razdan, M.K. Introduction to plant tissue culture. Oxford & IBH Publishers.
7. Chawla, H.S. Introduction to Plant Biotechnology. Oxford & IBH Publishers.
8. Dey, K.K. Plant Tissue Culture.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–III (2023-24)
DCC Course (BIO6005P)

Code of the course: BIO6005P

Title of the course: Biotechnology Lab-III: Plant Biotechnology (Practical)

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to plant biotechnology learn at School level and lay foundation for further learning of the subject through this course on Plant Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DCC Course (BIO6005P)
Biotechnology Lab-III: Plant Biotechnology (Practical)
(Credit: 2; Hours: 60)

1. Preparation of stock solution of MS (Murashige and Skoog, 1962) basal medium and plant growth regulator stocks.
2. Prepare various types of explants and inoculate from the aseptically (in vitro) raised plants.
3. Describe the characteristics of callus on the basis of the following parameters: (a) Color and texture (b) Fresh weight and Dry weight (c) Cell viability test (TTC assay)

4. To provide an introduction to the technique of seed immobilization.
5. Sterilize and inoculate the given seeds for in vitro seed germination on MS media.
6. Prepare, sterilize and inoculate explants (seeds) for callus induction.
7. Prepare suitable media for in vitro shoot multiplication of given material and inoculate shoots for multiplication
8. Prepare, sterilize and inoculate the nodal explants on suitable media for establishment of in vitro shoot cultures.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. Lux Meter
2. Membrane Filter
3. Hair Hygrometer
4. Plant Growth Chamber
5. Stages of micro propagation
6. Questions based on chemicals and stomatal characteristics.
    a. Q1: How does 70% alcohol kills bacteria?
    b. Q2: What is the function of sodium hypochlorite?
    c. Q3: How mercuric chloride kills microbes?
    d. Q4: What factors affect the number of stomata on a leaf?
    e. Q5: What control the opening and closing of stomata?
    f. Q6: Why do stomata closes at night?

Recommended Books:

1. Bhojwani, S. S., & Razdan, M. K. (2003). Plant tissue culture: theory and practice. Elsevier.
2. Chawla, H.S. Introduction to Plant Biotechnology. Oxford & IBH Publishers.
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–III (2023-24)
SEC Course
Communicative English

Code of the course:

Title of the course: Communicative English

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Skill Enhancement Course (SEC) Course for all Discipline/Subject

Delivery Type of the Course: Thirty hours Lecture

Prerequisites:

(1) Courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The purpose of this course is to introduce students to the theory, fundamentals and tools of communication and to develop in them vital communication skills which should be integral to personal, social and professional interactions. One of the critical links among human beings and an important thread that binds society together is the ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. In the context of rapid globalization and increasing recognition of social and cultural pluralities, the significance of clear and effective communication has substantially enhanced.

Course Outcome:

Upon completion of this course, the students will able to learn the basic language and improve communication skills.

Syllabus:

SEC Course
Communicative English (Theory)
(Credit: 2; Hours: 30)

B. Sc. BIOTECHNOLOGY SEMESTER–IV (2023-24)
DCC Course (BIO6006T)

Code of the course: BIO6006T

Title of the course: Recombinant DNA Technology

Level of the Course: NHEQF Level 5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to genetic engineering learn at School level and lay foundation for further learning of the subject through this course on Recombinant DNA Technology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to outline the concept and techniques used in genetic engineering and gene cloning, understand about the different enzymes and vectors used in recombinant DNA technology, learn the techniques used to isolate bio molecules and the principles behind various hybridization and screening techniques.

Syllabus:

DCC Course (BIO6006T)
Biotechnology-IV: Recombinant DNA Technology (Theory)
(Credit: 4; Hours: 60)

Unit-I **12 Credit hours**

Genetic Engineering : definition, scope and importance, molecular tools for genetic engineering. Restriction endonucleases- types, nomenclature, recognition sequences, cleavage pattern. Vectors – general characteristics of vectors, desirable characters such as size, ori site, selection/ markers gene, restriction sites and MCS, cloning and expression vectors.

Unit-II **12 Credit hours**

Plasmid vectors: pBR-322, pUC vectors, Ti-plasmid,. M13 derived pUC vectors, bacteriophage λ vectors, cosmids, YAC and BAC. Creation of recombinant DNA: cloning and selection of individual gene. Transformation techniques: preparation of competent cells of bacteria, physical and chemical methods of gene tranfer in plant and animal cells.

Unit-III **12 Credit hours**

Genomic library and cDNA library, reverse transcriptase, Colony hybridization, screening by DNA hybridization, labelling of DNA, RNA and proteins: use of radioactive isotopes, non-radioactive labelling, relative advantages, in vivo labelling, nick translation, random primer labelling, autoradiography. Blotting techniques southern,northern, western and eastern.

Unit-IV **12 Credit hours**

Protein profiling: SDS PAGE, 2D gel electrophoresis and its significance, gel retardation assay, T-DNA and transposon mediated gene tagging, chloroplast transformation and its utility, DNA microarray.

Unit-V **12 Credit hours**

Antisense RNA technology, Ribozyme: biochemistry, hammerhead, hair pin and other ribozymes, strategies for designing ribozymes, application of antisense and ribozyme technologies.

Recommended Books:

1. Christopher, H.Gene cloning and Manipulation. Cambridge University, Press.
2. Nicholl, D.S.T. An introduction to genetic engineering. Cambridge University Press.
3. Sambrook, Russell and Maniatis. Molecular Cloning : A Laboratory Manual (Vol. I, II and III). Cold Spring Harber Laboratory.
4. Glover, D.M. and Hames, B.D. DNA Cloning : A practical approach. IRL Press. Oxford.
5. Brown, T.A. Gene cloning. Blackwell Publisher.
6. Kreuzar, H. and Massey, A. Recombinant DNA technology. A.S.M. Press, Washington.
7. Llibelli, Lanza and Campbell. Principles of Cloning. Academic Press.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–IV (2023-24)
DCC Course (BIO6007P)

Code of the course: BIO6007P

Title of the course: Biotechnology Lab-IV: Recombinant DNA Technology (Practical)

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to genetic engineering learn at School level and lay foundation for further learning of the subject through this course on Recombinant DNA Technology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DCC Course (BIO6007P)
Biotechnology Lab-IV: Recombinant DNA Technology (Practical)
(Credit: 2; Hours: 60)

1. Demonstrate the loading of given DNA sample to perform agarose gel electrophoresis.
2. Perform agarose gel electrophoresis to study the effect of varying agarose concentration on the mobility of the DNA.
3. Demonstrate the effect of varying voltage on mobility of given DNA samples by Agarose gel electrophoresis.

4. To perform restriction digestion of a given DNA sample and visualize it using agarose gel electrophoresis.
5. Determine the extent of polymorphism in given DNA profile using Jaccard's Coefficient.
6. Quantify the size of unknown DNA comparing with known DNA by semi- logarithmic graph.
7. Study the relation between the quantity and intensity of the given DNA sample using spot assay.
8. To estimate the quantity and purity of the DNA sample by using UV-VIS Spectroscopy.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. SDS-PAGE
2. PCR machine
3. UV transilluminator
4. Electrophoretic apparatus
5. Gel Documentation System
6. Questions based on molecular biology
7. Questions based on solution preparations
8. Role of chemicals: SDS, Chloroform, Isopropanol, NaCl, Lysozyme

Recommended Books:

1. Green, M. R., & Sambrook, J. (2012). Molecular cloning. A Laboratory Manual 4th.
2. Schleif, R. F., & Wensink, P. C. (2012). Practical methods in molecular biology. Springer Science & Business Media.
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–IV (2023-24)
SEC Course (SES6300T)

Code of the course: SES6300T

Title of the course: Bioinformatics

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Skill Enhancement Course (SEC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Thirty hours Lecture

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to basic applications of mathematics and computer science learn at School level and lay foundation for further learning of the subject through this course on bioinformatics which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to gain knowledge and awareness of the basic principles and concepts of biology, computer science and mathematics, existing software effectively to extract information from large databases and to use this information in computer modeling.

Syllabus:

SEC Course (SES6300T)
Bioinformatics (Theory)
(Credit: 2; Hours: 30)

Unit 1: Introduction to Bioinformatics **6 Credit hours**

Introduction, Branches of Bioinformatics, Aim, Scope and Research areas of Bioinformatics. Structural Bioinformatics in Drug Discovery, Quantitative structure-activity relationship (QSAR) techniques in Drug Design, Microbial genome applications, Crop improvement.

Unit 2: Databases in Bioinformatics **6 Credit hours**

Introduction, Biological Databases, Classification format of Biological Databases, Biological Database Retrieval System.

Unit 3 : Biological Sequence Databases **6 Credit hours**

National Center for Biotechnology Information (NCBI): Tools and Databases of NCBI, Database Retrieval Tool, Sequence Submission to NCBI, Basic local alignment search tool (BLAST), Nucleotide Database, Protein Database, Gene Expression Database. Protein Information Resource (PIR): About PIR, Resources of PIR, Databases of PIR, Data Retrieval in PIR. Swiss-Prot: Introduction and Salient Features.

Unit 4: Sequence Alignments **6 Credit hours**

Introduction, Concept of Alignment, Multiple Sequence Alignment (MSA), MSA by CLUSTALW, Scoring Matrices, Per cent Accepted Mutation (PAM), Blocks of Amino Acid Substitution Matrix (BLOSUM).

Unit 5: Molecular Phylogeny **6 Credit hours**

Methods of Phylogeny, Software for Phylogenetic Analyses, Consistency of Molecular Phylogenetic Prediction.

Recommended Books:

1. Ghosh Z. and Bibekanand M. (2008) Bioinformatics: Principles and Applications. Oxford University Press.
2. Pevsner J. (2009) Bioinformatics and Functional Genomics. II Edition. Wiley-Blackwell.
3. Campbell A. M., Heyer L. J. (2006) Discovering Genomics, Proteomics and Bioinformatics. II Edition. Benjamin Cummin
4. Xinong J. Essential Bioinformatics, Cambridge University Press.
5. Mount D.W. Bioinformatics: Sequence and Genome Analysis. Cold Spring Harbor Laboratory Press.
6. Sharma V., Munjal A., Shanker A. A Text Book of Bioinformatics. Rastogi Publications.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–V (2023-24)
DSE Course (BIO7100T)

Code of the course: BIO7100T

Title of the course: Environmental Biotechnology

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)
Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:
The course aims to strengthen the conceptual knowledge related to Environmental science learn at School level and lay foundation for further learning of the subject through this course on Environmental Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:
Upon completion of this course, the students will able to describe factors leading to Environmental degradation, describe different types of biotechnological applications or means through which environmental problems can be solved, explain principles and major processes of bioremediation and phytoremediation, Identify and formulate strategies for the conservation of environment through biotechnological means to achieve goals of sustainable management under the given legislative measures.

Syllabus:

DSE Course (BIO7100T)
Environmental Biotechnology (Theory)
(Credit: 4; Hours: 60)

Unit-I **12 Credit hours**

Natural resources: Energy resources (renewable and non-renewable), conventional and non-conventional sources of energy, forest resources, fish resources, water resources. Conservation of natural resources- ex situ and in situ conservation strategies, wildlife management,

Unit – II **12 Credit hours**

Waste water and its treatment- small scale and large scale sewage treatment, BOD and COD. Ground water remediation, water softening, water demineralization, desalination, ion-exchange and reverse osmosis, disinfection of water; ozonation and chemo-sterilization of water.

Unit – III **12 Credit hours**

Solid waste and their treatment- organic compost and process of composting, vermi-culture technology. Microbial degradation of xenobiotics, microorganism in abatement of heavy metal pollution, aeromicrobiology: aeroallergens and aeroallergy.

Unit – IV **12 Credit hours**

Biogas, biogas production- Solubilization, acetogenesis and methanogenesis, mechanism of methane formation. Microbes and their genetic engineering for degradation of pollutants.

Unit – V **12 Credit hours**

Application of microbes -biofertilizer, biopesticides, microbial leaching, biomining, biohydrometallurgy and biomineralization. Principles and applications of biosensors for detection of pollutants, Oil spills- Causes and recovery, use of super bugs for removal of oil spills.

Recommended Books:

1. Mooray Moo-Young. (Eds). Comprehensive Biotechnology (Vol. I, II, III) Pergamon Press, England.
2. Metcalf and Eddy. Waste water engineering treatment and uses. McGraw Hill.
3. Jogdand, S.N. Environmental Biotechnology. Himalaya Publication House.
4. De, A.K. Environmental Chemistry. Wiley Eastern Ltd.
5. Abbasi and Abbasi. Renewable Energy Sources and their environmental impact. Prentice Hall of India, Pvt. Ltd.
6. Chatterji, A.K. Introduction to Environmental Biotechnology. Prentice Hall of India.
7. Thakur, I. S. Text Book of Environmental Biotechnology. I. K. International Publisher, New Delhi.
8. Mohapatra, P. K. Text Book of Environmental Biotechnology. I. K. International Publisher, New Delhi.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–V (2023-24)
DSE Course (BIO7104P)

Code of the course: BIO7104P

Title of the course: Elective BIO. Lab-1: Environmental Biotechnology Lab (Practical)

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to Environmental science learn at School level and lay foundation for further learning of the subject through this course on Environmental Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DSE Course (BIO7104P)
Elective BIO. Lab-1: Environmental Biotechnology Lab (Practical)
(Credit: 2; Hours: 60)

1. Determine chemical oxygen demand (COD) of given water sample.
2. Determine biological oxygen demand (BOD) of given sewage sample.
3. Determine dissolved oxygen (DO) of given water sample.
4. Determine the total dissolved solids (TDS) in given water sample.
5. Isolate and identify E.coli from the given sewage sample.

6. Determine total hardness of the given water sample.
7. Determine total alkalinityin given water sample.
8. Determine the chlorine content of given water sample.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. TDS meter
2. Desiccator
3. Water bath
4. Aeroallergens
5. BOD Incubator
6. Water softening
7. Reverse osmosis system
8. Diagram showing Biogas plant

Recommended Books:

1. Patra, J. K., Das, G., Das, S. K., & Thatoi, H. (2020). A Practical Guide to Environmental Biotechnology. Springer.
2. K.R. Aneja (2007) Experiments in Microbiology, Plant pathology and Biotechnology, 4th Edition, New Age International (P) Limited Publishers.
3. Online virtual labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–V (2023-24)
DSE Course (BIO7101T)

Code of the course: BIO7101T

Title of the course: Immunology and Enzyme Technology

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to Immunology and Enzyme biology learn at School level and lay foundation for further learning of the subject through this course on Immunology and Enzyme Technology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to describe fundamental definition of immunity, immunesystem and immune responses, explain different types of immunity and the cellular components involved in the process of immune response, Describe the process of cell-mediated, humeral immunity and other immunity types, Illustrate major principles of antigen-antibody interactions and their role in diagnostic and therapeutic applications, Describe enzymes, enzyme actions and mode of enzyme actions, Illustrate about different types enzymes' classification, Describe principles of major enzymatic reaction occurring in the cells, Identify the relationship between enzyme actions and different cellular processes of metabolism and others.

Syllabus:

DSE Course (BIO7101T)
Immunology and Enzyme Technology (Theory)
(Credit: 4; Hours: 60)

Unit-I **12 Credit hours**

Immune system and immunity; history of immunology; innate and acquired immunity; structure, composition and functions of cells involved in immune system: T cells, B-cells, macrophages,

eosinophils, neutrophils, mast cells and natural killer Cells. Structure, composition and functions of Organs involved in immune system: thymus gland, bone marrow, spleen and lymph nodes.

Unit-II **12 Credit hours**

Antigens – structure and properties, types (iso and alloantigens), haptens, adjuvants; antigen specificity. Immunoglobulins – structure, heterogeneity, types and subtypes, properties (physico-chemical and biological). complement – structure, components, properties and functions of complement; complement pathways and biological consequences of complement activation.

Unit-III **12 Credit hours**

Antigen antibody reactions – agglutination, precipitation, complement fixation, immunofluorescence, immuneoelectrophoresis, Applications of these methods in diagnosis of microbial infections. Major histocompatibility complex – structure and functions of MHC.

Unit-IV **12 Credit hours**

History and introduction to enzymes, Classification of enzymes, IUBMB system of nomenclature, E.C. numbers, Introduction to coenzyme, cofactors and prosthetic groups. Enzyme kinetics (Michaelis-Menten laws), importance and determination of V_{max} and K_m values, catalytic mechanisms of enzymes, acid-base, covalent, metal ion and electrostatic catalysis.

Unit-V **12 Credit hours**

Regulation of enzyme activity: metabolic compartmentation, covalent modification, feedback regulation. Enzyme inhibition: competitive and non competitive. Multienzyme complexes: structure and significance. Isolation and purification of enzymes: salt precipitation, gel filteration, ion exchange and affinity chromatography.

Recommended Books:

1. CoicoR, Sunshine, BenjaminE.Immunology : A short course. John Wiley and Sons.
2. Roitt, Brostoff, Male and Mosby. Immunology.
3. Kuby et al. Immunology. W.H. Freeman and Company.
4. Rao, C.V. An Introduction to Immunology. NarosaPub. House.
5. Coleman, R.M. Fundamental Immunology. McGraw Hill.
6. Paul, W.E. Fundamentals of Immunology. Raven Press New York
7. Palmer, T. Understanding Enzymes.
8. Price and Stevenson. Fundamentals of Enzymology. OxfordUniversity Press.
9. Dixon and Webb. The Enzymes. Academic Press, London.
10. Foster, F.L. The nature of Enzymology. John Wiley and Sons

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–V (2023-24)
DSE Course (BIO7105P)

Code of the course: BIO7105P

Title of the course: Elective BIO. Lab-2: Immunology and Enzyme Technology Lab (Practical)

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to Immunology and Enzyme biology learn at School level and lay foundation for further learning of the subject through this course on Immunology and Enzyme Technology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DSE Course (BIO7105P)
Elective BIO. Lab-2: Immunology and Enzyme Technology Lab (Practical)
(Credit: 2; Hours: 60)

1. Prepare stained blood film and identify different types of blood cells. Draw well labeled diagram of cells observed.
2. Enumerate the total RBC counting in your own blood.
3. Determine the blood group of your own blood.

4. Demonstrate the haemolysis and crenation in RBCs.
5. Prepare a slide of blood showing the formation of haemin crystals. Write the procedure and make the diagram of the crystals seen.
6. Determine the clotting time of your own blood.
7. Demonstrate the enzyme activity of peroxidase in given sample.
8. Demonstrate the enzyme activity of dehydrogenase in given sample.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. Alloantigens
2. Macrophages
3. Heamocytometer
4. Slide of blood cells
5. Heamoglobinometer
6. Multienzyme complexes
7. Blood group detection kit
8. Major histocompatibility complex

Recommended Books:

1. Andreas Hofmann, Samuel Clokie (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 8th edition. Cambridge University Press
2. Frank C. Hay & Olwyn M.R. Westwood (2002). Practical Immunology. Blackwell Science Ltd
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–V (2023-24)
SEC Course (SES7301P)

Code of the course: SES7301P

Title of the course: Basics of Instrumentation

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Skill Enhancement Course (SEC) Course for all Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to basic biological techniques learn at School level and lay foundation for further learning of the subject through this course on Basics of Instrumentations which is a prerequisite for higher courses in Biotechnology. This course will teach the various instrumentations that are used in the analytical laboratories. The students have the basic knowledge on the practical, operation and function of analytical instruments.

Course Outcome:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

SEC Course (SES7301P)
Basics of Instrumentation (Practical)
(Credit: 2; Hours: 30)

1. Verification of Lambert – Beer 's law for KMnO4 using spectrophotometer.
2. Extract and separate pigments from Curcuma longa using Thin Layer Chromatography and calculate their Rf values.
3. Evaluate the effectiveness of moist heat sterilization using linear streak method.
4. Evaluate the effectiveness of dry heat sterilization using linear streak method.
5. Demonstrate the effectiveness of ultra violet radiations using linear streak method.

6. Evaluate the effectiveness of alcohol as a skin antiseptic using thumb impression method.
7. Evaluate the antiseptics (Tincture of iodine and 70% Isopropyl alcohol) by filter paper disk method.
8. Extract and separate photosynthetic pigments by paper chromatography and calculate their Rf values.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. Instruments
    a) Autoclave
    b) Hot air oven
    c) Incubator
    d) Laminar air flow bench
    e) Spectrophotometer
    f) Centrifuge
    g) pH meter
2. Microscopy (principle and applications of Light, phase contrast, SEM,TEM)

Recommended Books:

1. Andreas Hofmann, Samuel Clokie (2018). Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology. 8th edition. Cambridge University Press
2. K.R. Aneja (2007) Experiments in Microbiology, Plant pathology and Biotechnology, 4th Edition, New Age International (P) Limited Publishers.
3. Online virtual labs

Scheme of the Examination:

1.	Major Exercise	20 Marks
2.	Minor Exercise	15 Marks
3.	Minor Exercise	15 Marks
4.	Spots	2 x 5 = 10 Marks
5.	Viva-voce	10 Marks
6.	Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–VI (2023-24)
DSE Course (BIO7108T)

Code of the course: BIO7108T

Title of the course: Microbial Technology

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to Applied Microbiology learn at School level and lay foundation for further learning of the subject through this course on Microbial Technology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

Upon completion of this course, the students will able to throw light on the application of biological and engineering principles in microbial, mammalian, and biological/biochemical systems. Students will gain knowledge on concept of culturing and maintaining industrially important microbes. of significance and activities of microorganisms in food. Students are expected to be able to design a food fermentation process.

Syllabus:

DSE Course (BIO7108T)
Microbial Technology (Theory)
(Credit: 4; Hours: 60)

Unit-I **12 Credit hours**

Introduction to industrial biotechnology, basic principles of fermentation technology, Types of fermentation – solid state, submerged, batch and continuous fermentation. Fermentation media – natural and synthetic media; molasses, corn-steep liquor, sulphite waste liquor, whey, yeast extract and protein hydrolysates.

Unit-II **12 Credit hours**

Fermenters and bioreactors – construction, design and operation, continuous stirred tank, airlift, packed bed, fluidized bed and bubble column bioreactor. Measurement and control of fermentation parameters - pH, temperature, dissolved oxygen, foaming and aeration.

Unit-III **12 Credit hours**

Downstream processing: Cell disruption, filtration, centrifugation, solvent extraction, precipitation, lyophilization and spray drying. Methods of immobilization, advantages and applications of immobilization, large scale applications of immobilized enzymes (glucose isomerase and penicillin acylase).

Unit-IV **12 Credit hours**

Microbial production of industrial products (micro-organisms involved, media, fermentation conditions, downstream processing and uses); Citric acid, ethanol, penicillin, glutamic acid, Vitamin B12 Enzymes (amylase, protease, lipase).

Unit-V **12 Credit hours**

Microbial foods – Single Cell Proteins (SCP), Single Cell Oils (SCO); Techniques of mass culture of Algae-spirulina; Microbial polysaccharides and polyesters; production of xanthan gum and polyhydroxyalkaloides.

Recommended Books:

1. Waites, Morgan, Rockey. Industrial Microbiology. Blackwell Science.
2. Saha, B.D. Fermentation Biotechnology. American Chemical Society.
3. Demain and Davies . Industrial Microbiology and Biotechnology. A.S.M. Press Washington.
4. Glazer, A.N. and Nikaido, H. Microbial Biotechnology : Principle and application of applied microbiology. W.H.Freeman and com.
5. Stanbary, Whitaker and Hall. Principles of Fermentation Technology.
6. Shuler and Kargi. Bioprocess Engineering. Pearson.
7. Mukherji, K.G. Microbial Technology. APH. Pub. Corp.
8. Ray. Fundamental Food Microbiology. CBH Pub.
9. Bell, Neaves and Williams. Food Microbiology and Laboratory Practice. Panima.

E-Resources

1. https://www.khanacademy.org/
2. https://unacademy.com/
3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–VI (2023-24)
DSE Course (BIO71012P)

Code of the course: BIO71012P

Title of the course: Elective BIO. Lab-1: Microbial Technology Lab (Practical)

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to Applied Microbiology learn at School level and lay foundation for further learning of the subject through this course on Microbial Technology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DSE Course (BIO71012P)
Elective BIO. Lab-1: Microbial Technology Lab (Practical)
(Credit: 2; Hours: 60)

1. Perform the negative staining of given the bacterial sample to study morphology and arrangement of bacterial cells
2. To determine the esculin hydrolysis activity for lactobacilli
3. Determine the carbohydrate fermentation pattern of given bacterial sample.
4. To determine the citrate utilization activity of the given bacteria.
5. Perform the Voges–Proskauer test for the given lactobacilli.

6. Isolation of yeast on Sabouraud agar.
7. Determination of titrable acidity of the fermented juice.
8. Identify the acid producing lactobacilli using BCP supplemented MRS medium.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. Cell disruption
2. Negative staining
3. Single Cell Proteins
4. Colony characteristics of yeast
5. Wet mount preparation of yeast
6. Fermented stirred tank bioreactor
7. Composition of MRS, Sabouraud agar
8. Production of Alcohol, Citric acid, Penicillin

Recommended Books:

1. K.R. Aneja (2007) Experiments in Microbiology, Plant pathology and Biotechnology, 4th Edition, New Age International (P) Limited Publishers.
2. R.C. Dubey and D.K. Maheshwari (2012) Practical Microbiology, 3rd Edition, S. Chand and Company Ltd.
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–VI (2023-24)
DSE Course (BIO7109T)

Code of the course: BIO7109T

Title of the course: Agriculture Biotechnology

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Sixty (40 Lectures + 20 tutorial and diagnostic assessment)

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the conceptual knowledge related to Agriculture technology learn at School level and lay foundation for further learning of the subject through this course on Agriculture Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

This course presents the application of biotechnology in agricultural goals. To make the student to understood usage of Plant products and their utilization in Biotechnology. On successful completion of the subject, the student should have understood: Crop development, Callus culture, Biotechnological applications of plants, the principles, practices and applications of plant biotechnology, plant tissue culture, plant genomics, genetic transformation and molecular breeding of plants.

Syllabus:

DSE Course (BIO7109T)
Agriculture Biotechnology (Theory)
(Credit: 4; Hours: 60)

UNIT I **12 Credit hours**

Role of micropropagation in silviculture, horticulture, agriculture, and conservation of biodiversity and threatened plant species. Somatic embryogenesis with special reference to production of synthetic seeds, Application of plant biotechnology in plant pathology with special reference to culture of obligate parasites.

UNIT-II **12 Credit hours**

Screening of germplasm and cell line selection. Application of somaclonal variation with special reference to development of disease resistant cell lines. Applications of plant biotechnology in breeding and crop improvement with special reference to production of haploids and triploids.

UNIT-III **12 Credit hours**

Role of tissue culture in genetic engineering for crop improvement – Agrobacterium mediated gene transfer in plants and development of genetically modified organisms with special reference to drought and salinity, insect and virus resistance.

UNIT-IV **12 Credit hours**

Bioreactors for production of secondary metabolites. Introduction types: stirred-tank type, air-lift type, membrane type bioreactor, packed bed reactor. Modes of culture applied in bioreactors – batch culture, fed-batch culture, semi-continuous culture, continuous culture.

UNIT-V **12 Credit hours**

Secondary products in tissue cultures – production of alkaloids, phenols, steroids, lignins, coumarins, flavonoids, anthroquinones and naphthoquinones, isoprenoids, Plant cell immobilization, gel entrapment, applications of immobilization techniques. Secondary metabolite production using immobilized cells.

Recommended Books:

1. Smyth, S. J., Phillips, P. W., & Castle, D. (Eds.). (2014). Handbook on agriculture, biotechnology and development. Edward Elgar Publishing.
2. Maddela, N. R., & García, L. C. (Eds.). (2021). Innovations in biotechnology for a sustainable future. Springer International Publishing.
3. Shan, G. (2011). Immunoassays in agricultural biotechnology. John Wiley & Sons.
4. Bhojwani, S.S. and Rajdan, M.K. Plant Tissue Culture: Theory and Practices a revised Edition. Elsevier.
5. Razdan, M.K. Introduction to plant tissue culture. Oxford & IBH Publishers.
6. Chawla, H.S. Introduction to Plant Biotechnology. Oxford & IBH Publishers.

E-Resources

1. https://www.khanacademy.org/
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3. https://swayam.gov.in/
4. https://hstalks.com/
5. https://nptel.ac.in/courses

B. Sc. BIOTECHNOLOGY SEMESTER–VI (2023-24)
DSE Course (BIO71013P)

Code of the course: BIO71013P

Title of the course: Elective BIO. Lab-2: Agriculture Biotechnology (Practical)

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to Agriculture technology learn at School level and lay foundation for further learning of the subject through this course on Agriculture Biotechnology which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

DSE Course (BIO71013P)
Elective BIO. Lab-2: Agriculture Biotechnology (Practical)
(Credit: 2; Hours: 60)

1. Prepare suitable explants form the given plant material and demonstrate the process of meristem tip culture for the production of disease free plants.
2. Prepare suitable media for rooting of micro shoot and inoculate it for rooting.
3. Demonstrate the technique of micropropagation by culturing of leaf disc on suitable media.

4. To demonstrate the process of adventitious shoot bud differentiation from leaf of the given plant sample.
5. To isolate the Azotobacter species from soil sample by serial dilution method.
6. To isolate antibiotic producing bacteria from soil.
7. Isolate the fungi from the given soil sample by pour plate method
8. Identification of fungi by wet mount method.
9. Determination of phosphate solubilizing activity in given bacterial culture.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. Bioreactors
2. Silviculture
3. Naphthoquinones
4. Genetic engineering
5. Somaclonal variation
6. Production of haploids
7. Somatic embryogenesis
8. Culture of obligate parasites

Recommended Books:

1. Bhojwani, S. S., & Razdan, M. K. (2003). Plant tissue culture: theory and practice. Elsevier.
2. K.R. Aneja (2007) Experiments in Microbiology, Plant pathology and Biotechnology, 4th Edition, New Age International (P) Limited Publishers.
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

B. Sc. BIOTECHNOLOGY SEMESTER–VI (2023-24)
SEC Course (SES7302P)

Code of the course: SES7302P

Title of the course: Microbial cultivation techniques

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Skill Enhancement Course (SEC) Course for Biotechnology Discipline/Subject

Delivery Type of the Course: Lecture and practical 40+20=60. The 40 lectures for the hands on experiments, observations and record of the data, 10 hours for the experiment, instruments demonstration, lab practices and 10 hours on diagnostic assessment, formative assessment, subject/class activity, problem solving.

Prerequisites:

(1) Life science courses of Central Board of Secondary Education or equivalent.

Objectives of the Course:

The course aims to strengthen the practical knowledge related to isolation and cultivations of microorganisms learn at School level and lay foundation for further learning of the subject through this course on microbial cultivation techniques which is a prerequisite for higher courses in Biotechnology.

Course Outcome:

1. Collect data and update the experimental process insistently.
2. Assess the procedure and outcomes of an experiment qualitatively and quantitatively.
3. Extend the scope of an experiment if or not results are as per expectation
4. Communicate the process and outcomes of an experiment.
5. Perform an experiment collaboratively and ethically

Syllabus:

SEC Course (SES7302P)
Microbial cultivation techniques (Practical)
(Credit: 2; Hours: 60)

1. Preparation of Nutrient agar medium and isolation of bacteria using Streak, Spread and Pour plate method.
2. To study the colony characteristics of bacteria.
3. To perform Gram staining for studying bacterial morphology.
4. To perform catalase test for bacterial identification
5. To perform carbohydrate fermentation test for biochemical identification of bacteria.

6. Preparation of Sabouraud agar for isolation of fungi and to study the colony morphology of isolated colonies.
7. To prepare wet mount of fungi for their identification.
8. To perform slant and stab culture method for storage of bacteria.

Any other experiment can be designed to demonstrate the concepts and phenomenon related to the paper.

SPOTS:

1. Stab and slant culture
2. Streaking four ways
3. Pour plate technique
4. Carbohydrate fermentation
5. Media ingredients and their role: Nutrient agar, Nutrient broth, Sabouraud agar
6. Wet mount of fungi
7. Instruments: Autoclave, Hot air oven, Laminar air flow, pH meter, Centrifuge, Spectrophotometer

Recommended Books:

1. K.R. Aneja (2007) Experiments in Microbiology, Plant pathology and Biotechnology, 4th Edition, New Age International (P) Limited Publishers.
2. R.C. Dubey and D.K. Maheshwari (2012) Practical Microbiology, 3rd Edition, S. Chand and Company Ltd.
3. Online Virtual Labs

Scheme of the Examination:

1. Major Exercise	20 Marks
2. Minor Exercise	15 Marks
3. Minor Exercise	15 Marks
4. Spots	2 x 5 = 10 Marks
5. Viva-voce	10 Marks
6. Record	10 Marks

Department of Botany
Mohanlal Sukhadia University
Udaipur, Rajasthan

B.Sc. Botany Syllabus
[as per the National Education Policy (NEP)]

B.Sc. Course structure

Table 1: CBCS Course structure for B.A./B.Com./B.Sc. (Three Year Program) total credits 120						
	SEM-1	**SEM-II**	**SEM-III**	**SEM-IV**	**SEM-V**	**SEM-VI**
Core Courses	DCC-A1 (6 Cr) DCC-B1 (6 Cr) DCC-C1 (6 Cr)	DCC-A2 (6 Cr) DCC-B2 (6 Cr) DCC-C2 (6 Cr)	DCC-A3 (6 Cr) DCC-B3 (6 Cr) DCC-C3 (6 Cr)	DCC-A4 (6 Cr) DCC-B4 (6 Cr) DCC-C4 (6 Cr)	-	-
DSE / GEC	-	-	-	-	DSE-A1(6 Cr) DSE-B1(6 Cr) DSE-C1(6 Cr)	DSE-A1(6 Cr) DSE-B1(6 Cr) DSE-C1(6 Cr)
AECC	AECC-1 (2Cr)	AECC-2 (2 Cr)	-	-		
SEC			SEC-1(2 Cr) Communicative English	SEC-2 (2 Cr)	- SEC-3 (2Cr)	SEC-4 (2Cr)
	18+0+2+0=20	**18+0+0+2=20**	**18+0+0+2=20**	**18+0+0+2=20**	**0+18+2+0=20**	**0+18+0+2=20**
72(DCC)+36(DSE/GEC)+4(AECC)+8(SEC)=120						

1. Discipline Centric Compulsory Course **(DCC):A, B, and C denote three different disciplines (subjects)**. A student will study 4 papers in each discipline.
2. **Discipline Specific Elective (DSE):**A student will choose DSE courses from the three chosen disciplines (A, B, and C) for semesters V and VI. Any such paper can be Generic Elective Course (GEC) for the students of other disciplines.
3. **Ability Enhancement Compulsory Courses (AECC)** :Modern Indian Languages (MIL), English, Hindi Communication (Odia/Hindi/Telugu/Bangla/……)
4. **Skill Enhancement Courses (SEC):**Communicative English in the 3rd semester and three more subjects from a common pool. Each discipline provide at least one SEC
5. Courses with Practical component: Theory (4 credits) + Practical (2 credits) = 6 credits
6. Non-practical Courses: Theory (5 credits) + Tutorial (1 credit) = 6 credits (Numbers shown in brackets indicate Credits). In some of the disciplines it can be (2L+2P+2T) or (2L+4P)

Table 2: Proposed Botany Courses for CBCS in 3-years B.Sc. Program: Semester wise types, codes, titles, Delivery type, Workload, Credits of the courses, Marks of Examination, and Remarks.

Level	Semester	Course Type	Course Code	Course Title	Delivery type per week			Total hours	Credits	Total Credits	Internal marks	EoSE Marks	Max. Marks	Remarks
					L	T	P							
5	I	DCC	BOT5000T	Botany-I: Diversity of cryptogams, fungi and microbiology	L	T	-	60	4	6	20	80	100	
			BOT5000P	Botany Lab-1: Practicals of cryptogams, fungi and microbiology	-	-	P	60	2		20	80	100	
		AECC			L	T		30	2	2	20	80	100	
	II	DCC	BOT5001T	Botany-II: Biology of phanerogams	L	T	-	60	4	6	20	80	100	
			BOT5001P	Botany Lab-II: Practicals of phanerogams	-	-	P	60	2		20	80	100	
		AECC			L	T		30	2	2	20	80	100	
Exit with Certificate in Science (After 4 more credits in SEC)														
6	III	DCC	BOT6002T	Botany-III: Basics of Cell & Molecular Biology, Genetics, Plant Breeding, Evolution and Biostatistics	L	T	-	60	4	6	20	80	100	
			BOT6002P	Botany Lab-3: Practicals of Cell & Molecular Biology, Genetics, Plant Breeding, Evolution and Biostatistics	-	-	P	60	2		20	80	100	
		SEC	SEA6302T	Communicative English	L		-	30	2	2	20	80	100	
	IV	DCC	BOT6003T	Botany-IV: Plant Biochemistry, Physiology and Biotechnology	L	T	-	60	4	6	20	80	100	
			BOT6003P	Botany Lab-4: Practicals of Plant Biochemistry, Physiology and Biotechnology	-	-	P	60	2		20	80	100	
		SEC	SES6300T	Tools and Techniques in Plant Sciences	L	T	-	30	2	2	20	80	100	

Exit with Diploma in Science														
7	V	Select anyone of the following Discipline specific Elective (DSE) Courses in V and VI semester												
		DSE	BOT7100T	Seed Biology	L	T	-	60	4	6	20	80	100	
			BOT7100P	Elective Botany Lab: Seed Biology	-	-	P	60	2		20	80	100	
			BOT7101T	Cultivation and Commercialization of Medicinal Plants	L	T	-	60	4	6	20	80	100	
			BOT7101P	Elective Botany Lab: Cultivation and Commercialization of Medicinal Plants	-	-	P	60	2		20	80	100	
		SEC	SES7301T	Fundamental of Biostatistics	L	T		30	2	2	20	80	100	
	VI	DSE	BOT7111T	Plant diseases and management	L	T	-	60	4	6	20	80	100	
			BOT7111P	Elective Botany Lab: Plant diseases and management	-	-	P	60	2		20	80	100	
			BOT7112T	Plant Tissue Culture and Commercialization techniques	L	T	-	60	4	6	20	80	100	
			BOT7112P	Elective Botany Lab: Plant Tissue Culture and Commercialization techniques	-	-	P	60	2		20	80	100	
		SEC	SES7302T	Nursery and Gardening	L		-	30	2	2	20	80	100	
Exit with Graduation Degree in Science (B.Sc.)														

DCC- Discipline Centric Compulsory Course (001 to 099); **DSE**- Discipline Specific Core Course (100 to 199)
AECC- Ability Enhancement Compulsory Course (English/Modern Indian Languages/Hindi) (201 to 299); **SEC**- Skill Enhancement Course (300 to 309)
The code has eight places. XYZ (subject name) Level (5/6/7) DCC/DSE/AEC/SEC (3 digits) T/P
If an SEC course is offered by commerce: SE**C**53XXT; Science: SE**S**63XXT; Arts/Humanities/: SE**A**53XXT; Management SE**M**73XXT

B.Sc.
Semester-wise syllabus (Botany)
Semester I

Code of the course	**BOT5000T**
Title of the course	Botany-I: **Diversity of Cryptogams, Fungi and Microbiology**
Level of the Course	NHEQF Level 4.5
Credit of the Course	4
Type of the Course	DCC
Delivery Type of the Course	Lectures and tutorial (40+20=60 hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	(1) Biology courses of Central Board of Secondary Education or equivalent at 10+2 Level (2) Biology courses of Board of Secondary Education Rajasthan or equivalent at 10+2 Level

Objectives of the Course

This course is designed to instill fundamental knowledge about habit, habitat, morphology, anatomy, reproduction and economic importance of various plant groups (Algae, Bryophytes, Pteridophytes) and microorganisms.

Course Learning Outcomes

After the completion of the course the students will be able to:

- Develop critical understanding on habit, classification, reproduction and economic importance of Algae, Bryophytes and Pteridophytes.
- Develop understanding about the classification and diversity of different microbes including Viruses, Fungi, Lichens and their economic importance.
- Learn host –pathogen relationship, important plant diseases caused by fungi, bacteria, viruses and their management.
- Gain Knowledge about the economic values of this lower group of plant community.
- Laboratory sessions following theory will provide easy understanding of external as well as internal structure of selected genus of different plant group.

Syllabus

UNIT-1 (Lecture hours: 12)

Range of thallus organization in Algae, Pigments, Reserve food, Classification of Algae proposed by Fritsch. Life cycle – *Nostoc, Chara, Ectocarpus, Polysiphonia* Economic importance of algae. Introduction to biofuel and biofertilizer.

UNIT- 2 (Lecture hours: 12)

Bryophytes: General characteristics, Classification (up to family), morphology, anatomy and reproduction of *Marchantia, Anthoceros* and *Sphagnum* (Developmental details not to be included). Pteridophytes: General characteristics, Classification (up to family) with examples. Early land plants (*Rhynia*), Heterospory and seed habit, stelar evolution.

UNIT- 3 (Lecture hours: 12)

General characteristics of fungi and classification proposed by Alexopoules (upto class level). Reproduction in fungi (asexual and sexual). Heterothallism and parasexuality. Brief study of life cycle of *Phytophthora, Puccinia, Penicillium, Trichoderma* and *Alternaria.* Mushroom Cultivation, General account and significance of Lichens and Mycorrhiza.

UNIT- 4 (Lecture hours: 12)

Bacteria–general characteristics and cell wall structure; reproduction–vegetative, asexual and recombination (conjugation, transformation and transduction); Viruses- structure, replication (general account), General account of Mycoplasma and Phytoplasma.

UNIT- 5 (Lecture hours: 12)

Plant Diseases: Concept, Symptoms, Primary and secondary inoculum, Koch's Postulates. Symptoms, Causal organism, Disease cycle and Control measures of – Early blight of Potato, Black stem rust of wheat, Red rot of Sugarcane, yellow vein mosaic of bhindi; citrus canker, little leaf of Brinjal. Disease management: - Quarantine, Chemical, Biological, Integrated pest disease management.

Suggested Books and References:

- Barsanti, L. and Gualtieri, P. (2014). Algae: Anatomy, Biochemistry and Biotechnology, 2 nd Edition. CRC/ Taylor & Francis, NY.
- Lee, R.E. (2018). Phycology, Fifth Edition. Cambridge University Press, Cambridge.
- Marjorie, Kelly and Cowan, Heidi Smith. (2017). Microbiology: A Systems Approach. McGraw Hill New York, 5th edition.
- Pandey, S.N and Trivedi, P.S. (2015). A text book of Botany Vol.I Vikas publishing House Pvt/ Ltd, New Delhi.
- Parihar, N.S. (1991). An Introduction to Embryophyta Vol. I Bryophyta. Central Book Depot, Allahabad.
- Mehrotra, R.S. and K.R. Aneja. (1999). An Introduction to Mycology. New Age International Publisher.
- PelczarM.J., Chan E.C.S and KreigN.R. (1997). Microbiology. Tata MacGraw Hill.
- Raven, P.H., Johnson, G.B., Losos, J.B., Singer, S.R. (2005). Biology. Tata McGrawHill, Delhi, India.
- Robert Edward Lee. (2018). Phycology. Cambridge University Press, U.K. 5th edition.
- Sethi, I.K. and Walia, S.K. (2011). Text book of Fungi and Their Allies, MacMillan Publishers Pvt. Ltd., Delhi.
- Sharma, O. P. (2011). Algae. Tata McGraw Hill Education Private Limited, U.K. 1st edition.
- Sharma, O.P. (1990). Textbook of Pteridophyta. MacMillan India Ltd. Delhi
- Tortora, G.J., Funke, B.R., Case, C.L. (2011). Microbiology: An Introduction, Pearson Benjamin Cummings, U.S.A. 13th edition.
- Vashishta, P.C., Sinha, A.K., Kumar, A. (2010). Bryophyta, S. Chand. Delhi, India.
- Webster, J. and Weber, R. (2007). Introduction to Fungi. Third Edition. Cambridge UniversityPress. Cambridge and New York.
- Willey, J M., Sherwood, L.M. and Woolverton, C.J. (2017). Prescott's Microbiology, 11th Edition, McGraw-Hill, USA.
- Pandey, B.P. (2010). College Botany Vol II. S. Chand and Company Ltd., New Delhi,India.
- Parihar, N.S. (1976). Biology and Morphology of Pteridophytes. Central Book Depot.

Suggested E-resources

https://community.plantae.org/tags/mooc
https://microbiologyonline.org/file/7926d7789d8a2f7b2075109f68c3175e.pdf
http://allaboutalgae.com/benefits/
https://repository.cimmyt.org/xmlui/bitstream/handle/10883/3219/64331.pdf https://www.mooc-list.com/tags/microbiology
http://www.agrifs.ir/sites/default/files/A%20text%20book%20of%20practical%20botany%201%20%7BAshok%20Bendre%7D%20%5B8171339239%5D%20%281984%29.pdf
https://www.coursera.org/courses?query=plants http://egyankosh.ac.in/handle/123456789/53530
https://www.classcentral.com/tag/microbiology https://www.edx.org/learn/microbiology
https://www.mooc-list.com/tags/microbiology https://www.udemy.com/topic/microbiology/
Suggested equivalent online courses: https://www.anbg.gov.au/bryophyte/what-is-bryophyte.html
https://pteridoportal.org/portal/index.php https://www.conifers.org/zz/gymnosperms.php
http://www.mobot.org/MOBOT/research/APweb/ https://milneorchid.weebly.com/plant-id-for-beginners.html https://www.botany.org/PlantImages/PlantAnatomy.php
http://webapp1.dlib.indiana.edu/inauthors/view?docId=VAC0868&doc.view=print https://palynology.org/
http://www2.estrellamountain.edu/faculty/farabee/biobk/Biobookflowers.html
https://www.sciencelearn.org.nz/resources/100-plant-reproduction https://palaeobotany.org/

Code of the course	BOT5000P
Title of the course	**Botany Lab-1:Practicals of Cryptogams, Fungi and Microbiology**
Level of the Course	NHEQF Level 4.5
Credit of the Course	2
Type of the Course	DCC
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	(1) Biology courses of Central Board of Secondary Education or equivalent at 10+2 Level (2) Biology courses of Board of Secondary Education, Rajasthan or equivalent at 10+2 Level

Objectives of the Course

The objective of the course is to provide students with a comprehensive understanding of various biological organisms and structures through the study of microscopic preparations, specimens, and models. The course focuses on the following key objectives:

- Study of Vegetative and Reproductive Structures: Students will learn about the vegetative and reproductive structures of different organisms including *Nostoc, Oscillatoria, Volvox, Oedogonium, Chara, Ectocarpus, and Polysiphonia*. They will develop skills in preparing temporary preparations, permanent slides, and examining specimens to study the morphology and structure of these organisms.
- Morphology and Microscopic Preparations: Students will explore the external and internal morphology of different taxa including Bryophytes, Pteridophytes, Fungi, and Pathogens. They will learn to examine microscopic preparations of organisms such as *Riccia, Anthoceros, Sphagnum, Selaginella, Equisetum, Penicillium, Alternaria, Puccinia, and Agaricus*, to understand their structures and functions.
- Study of Lichens: Students will examine the growth forms of lichens, including crustose, foliose, and fruticose types. They will understand the symbiotic relationship between fungi and algae in lichens and learn to identify and classify different lichen forms.
- Mycorrhiza: Students will explore mycorrhizal associations, focusing on ectomycorrhiza and endomycorrhiza. They will study photographs and illustrations to understand the mutualistic relationship between fungi and plant roots, and the significance of mycorrhiza in nutrient absorption and plant growth.
- Viruses: Students will study viruses through electron micrographs and models. They will examine the structures and characteristics of T-Phage and TMV (Tobacco Mosaic Virus) and gain an understanding of the lytic and lysogenic cycles of viral replication through line drawings or photographs.
- Gram Staining Technique: Students will learn the principles and techniques of Gram staining, a widely used staining method in microbiology. They will understand the differences in bacterial cell wall composition and the staining process for differentiating Gram-positive and Gram-negative bacteria.

Overall, the course aims to develop students' observational and analytical skills in the study of various biological structures and organisms. It also aims to enhance their understanding of fundamental concepts in microbiology and provide a solid foundation for further studies in the field of biological sciences.

Course Learning Outcomes

By the end of the course, students will be able to identify and analyze the vegetative and reproductive structures of various organisms, understand the morphology of Bryophytes, Pteridophytes, Fungi, and Pathogens, classify lichen growth forms, comprehend mycorrhizal associations, interpret viral structures and cycles, and apply the Gram staining technique in microbiology.

Syllabus (Lecture hours:60)

1. Study of vegetative and reproductive structures of *Nostoc, Oscillatoria, Volvox, Oedogonium, Chara, Ectocarpus* and *Polysiphonia* (or available minimum 3 taxa) through temporary preparations/permanent slides/specimens.
2. Study of external and internal morphology and microscopic preparations of following taxa of Bryophytes, Pteridophytes, Fungi and Pathogens: *Riccia, Anthoceros, Sphagnum, Selaginella*, *Equisetum*, *Penicillium, Alternaria*, *Puccinia*, *Agaricus.*
3. Lichens: Study of growth forms of lichens (crustose, foliose and fruticose).
4. Mycorrhiza: ectomycorrhiza and endomycorrhiza (Photographs).
5. Electron micrographs/Models of viruses – T-Phage and TMV, Line drawing/Photograph of Lytic and Lysogenic Cycle.
6. Gram staining technique

Scheme of Examination

Exercise 1 (Algae)	10
Exercise 2 (Bryophytes)	10
Exercise 3 (Pteridophytes)	10
Exercise 4 (Fungi/ Pathology)	8
Exercise 5 (Microbiology)	6
Spotting (8)	16
Record	10
Viva – Voce.	10
Total	**80**

Suggested Books and References

- Bergey's Manual of Systematic Bacteriology, 2nd ed., vol. 1-3, Springer Verlag, New York, NY.
- Pandey, B.P. (2014). Modern Practical Botany Vol. I. S. Chand and Company Ltd. Ramnagar, New Delhi.
- Purohit, S.D., Kundra, G. K. and Singhvi, A. (2013). Practical Botany (part I). Apex Publishing House Durga Nursery Road Udaipur, Rajasthan.
- Sambamurty, A.V.S.S. (2006). A text book of Algae. I.K International Publishing House,Pvt. Ltd.

Suggested E-resources

Here are some suggested e-resources that can be used for the above course:

1. National Center for Biotechnology Information (NCBI) - This resource provides access to a vast collection of scientific articles, journals, and databases related to various aspects of biology. Students can find relevant research papers and references for their studies.
2. Khan Academy - Khan Academy offers a wide range of educational videos and tutorials on biology topics. Students can find videos on topics like microscopy, fungi, viruses, and staining techniques to supplement their learning.
3. Microbiology Online - This website provides comprehensive information on various microbiology topics, including bacteria, fungi, viruses, and staining techniques. It offers interactive tutorials, virtual lab simulations, and educational resources for students to explore.
4. Virtual Microbiology Classroom - This resource offers virtual microscopy slides and interactive learning modules on microbiology topics. Students can access virtual microscope slides of different organisms, including bacteria, fungi, and algae.
5. OpenStax Biology - OpenStax provides free, open-access textbooks on various subjects, including biology. The Biology textbook covers a wide range of topics, including microbiology, plant anatomy, and ecology. It can serve as a valuable resource for students seeking in-depth knowledge.
6. YouTube - YouTube hosts a plethora of educational channels focused on biology. Channels like CrashCourse, Bozeman Science, and Amoeba Sisters offer engaging video lessons on diverse biological topics, including the ones covered in the course.

It's important to note that the availability of specific resources may vary, and it's recommended to check with your educational institution or library for access to additional e-resources or online databases that may be available to you.

B.Sc.
Semester-wise syllabus (Botany)
Semester II

Code of the course	**BOT5001T**
Title of the course	Botany-II: **Biology of Phanerogams**
Level of the Course	NHEQF Level 4.5
Credit of the Course	4
Type of the Course	DCC
Delivery Type of the Course	Lectures and tutorial (40+20=60hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	(1) Biology courses of Central Board of Secondary Education or equivalent at 10+2 Level (2) Biology courses of Board of Secondary Education Rajasthan or equivalent at 10+2 Level

Objectives of the Course

The course aims to strengthen the basic to applied aspects relevant to higher plants such as concepts of phanerogams, general features to life history of Gymnosperms, taxonomy, external morphology, internal structures of different plant parts and developmental biology of angiosperms, economic and ecological significance of phanerogams learning at the school level and lay a foundation for further learning of the subject through the course on Biology of phanerogams which is a prerequisite for higher courses in Botany.

Course Learning Outcomes

1. Understand about the general characters of phanerogams.
2. Assess terms and concepts related to taxonomy of higher plants and systems of classification and generalize the characters of the families according to various proposed systems of classification.
3. Learn about the various terminology used for description of flower characteristics and plant species
4. The students would be able to understand deep underlying concept of the diagnostic features of various angiosperm families.
5. Learn about the organization of meristem and vascular tissue differentiation.
6. Understand about the anatomical structure of stem and roots and learn the genetic and molecular aspects of flower development.
7. Understand the structure of anther and pollen wall because ultrastructure of pollen grain plays an important role in taxonomy. Evaluate the special structures and types of male and female gametophyte and learn the reproductive process in angiospermic plants.
8. Understand the mechanism of pollination and fertilization and can relate between embryo, endosperm and seed. Comprehend the causes of polyembryony and apomixis with its classification.
9. Learn about the ethnobotanical practices and economic importance of plants. Increase an awareness and appreciation of plants and plant products encountered in everyday life of human usases.

After completion of this course, it will educate students about plant science and inculcate strong fundamentals and classical aspects of Botany on phanerogams and create platform for higher studies in Botany and maintain a high level of scientific excellence in botanical research with specific emphasis on the role of plants thereby facilitating students to take-up successful career in Botany.

Syllabus

Unit I (Lecture hours: 12)

General features and broad classification (up to family) of gymnosperms. Occurrence, structure, life history and economic importance of *Cycas*, *Pinus* and *Ephedra.*

Unit II (Lecture hours: 12)

Taxonomic categories; concept of species, genus and family. Systems of classification of Bentham and Hooker. Diagnostic features and economic importance of Ranunculaceae, Brassicaceae, Malvaceae, Cucurbitaceae, Fabaceae, Asteraceae, Solanaceae, Poaceae.

Unit III (Lecture hours: 12)

Organization of shoot apical meristem and root apical meristem, Tissue and tissue systems; Parenchyma, Collenchyma, Sclerenchyma, Xylem, Phloem. Anatomy of root, stem and leaf.

Unit IV (Lecture hours: 12)

Microsporogenesis and megasporogenesis in Angiosperms. Structure and Development of male and female gametophytes in Angiosperms. Pollination and fertilization in spermatophytes. Types of endosperms and embryo in phanerogams.

Unit V (Lecture hours: 12)

Origin, botany, cultivation, economic importance of Wheat, Maize, Rice, Millets: Pearl millet, Chick pea, *Gossypium*, *Crotalaria*, Sugarcane, ground nut oil. Economic botany of medicinal Plants: *Rauvolfia*, *Papaver*. Introduction to Ethnobotany.

Suggested Books and References

- BhatnagarS.P and MoitraAlok 1996. Gymnosperms. New Age International Pvt. Ltd.Publishers, New Delhi, 470 pp.
- Bhojwani, S.S. and Bhatnagar, S.P. Embryology of Angiosperms (4th Revised and enlarged edition), 2000.
- BierhorstD.W. 1971. Morphology of Vascular Plants. New York and London.
- Cotton, C.M. (1996). Ethnobotany: Principles and Applications. John Willey & Sons, England.
- Cunningham, A.B. (2001). Applied Ethnobotany: Peopple, Wild Plant Uses and Conservation. Earthscan Publication Ltd., London.
- Fahn, A. 1982. Plant Anatomy (3rd Ed.), Pergamon Press, Oxford.
- Gurcharan Singh. 2004. Plant Systematics: Theory and Practice Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.
- Kochhar, S. L. (2016). Economic botany. Cambridge University Press.
- Nautiyal, S. and Kaul A.K. (2003). Non-Timber Forest Products of India. Jyoti Pub, Dehradun, India.
- Nordenstam, B., EIGazaly, G. and Kassas, M. 2000. Plant Systematics for 21st century.
- Sharma O.P. (2017) Plant Taxonomy. McGraw Hill Education.

Suggested E-resources

Here are some suggested e-resources that can be used for the mentioned syllabus:

1. Flora of North America - This online resource provides comprehensive information on the taxonomy and classification of plants in North America. It covers gymnosperms, Ranunculaceae, Brassicaceae, Malvaceae, Cucurbitaceae, Fabaceae, Asteraceae, Solanaceae, and Poaceae, among others.
2. Missouri Botanical Garden - The Missouri Botanical Garden's website offers an extensive botanical database, including information on gymnosperms and various angiosperm families mentioned in the syllabus. It provides detailed descriptions, images, and economic importance of these plant groups.
3. Botanical Society of America - The Botanical Society of America's website features educational resources, articles, and links to journals and databases related to plant anatomy and morphology. It covers topics such as shoot apical meristem, root apical meristem, tissue systems, and the anatomy of root, stem, and leaf.
4. Plant Anatomy Online - This website offers interactive tutorials, virtual slides, and educational resources on plant anatomy. It provides in-depth information on tissue types like parenchyma, collenchyma, sclerenchyma, xylem, and phloem, as well as the anatomy of different plant organs.
5. Angiosperm Phylogeny Website - The Angiosperm Phylogeny Website is a valuable resource for understanding the classification and evolutionary relationships of angiosperms. It provides detailed information on microsporogenesis, megasporogenesis, male and female gametophytes, pollination, and fertilization in angiosperms.
6. Crop Science Society of America - The Crop Science Society of America's website offers information on crop botany, cultivation, and economic importance. It covers crops like wheat, maize, rice, millets, chickpea, sugarcane, groundnut, and provides insights into their botany, cultivation practices, and economic significance.
7. Medicinal Plant Database - Various online databases, such as the Medicinal Plant Database, provide information on medicinal plants, including Rauvolfia and Papaver. These resources offer

details on their botany, distribution, traditional uses, chemical constituents, and potential medicinal applications.

It's important to note that the availability and access to specific e-resources may vary. It's recommended to check with your educational institution or library for access to additional e-resources, such as scholarly journals and databases, that may be available to you.

Code of the course	BOT5001P
Title of the course	**Botany Lab-II: Practicals of Phanerogams**
Level of the Course	NHEQF Level 4.5
Credit of the Course	2
Type of the Course	DCC
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	(1) Biology courses of Central Board of Secondary Education or equivalent at 10+2 Level (2) Biology courses of Board of Secondary Education Rajasthan or equivalent at 10+2 Level

Objectives of the Course

1. Examine and analyze microscopic preparations of male and female cones of Pinus and Ephedra, as well as study the male cone and megasporophyll of Cycas.
2. Identify and classify plant species belonging to different families, such as Ranunculaceae, Brassicaceae, Malvaceae, Leguminosae, Cucurbitaceae, Asteraceae, Solanaceae, and Poaceae.
3. Understand the types of placentation, ovules, and the structure of pollinium through the examination of embryology slides.
4. Study the anatomy of representative stems and roots,
5. Explore the economic importance of plants as outlined in the theory paper, gaining knowledge about their uses and significance.

Course Learning Outcomes

Students will be able to:

- Identify and describe the anatomical structures and features of Pinus, Ephedra, and Cycas.
- Classify and identify representative plant families based on morphological characteristics.
- Understand placentation, types of ovules, and the concept of pollinium in plant embryology.
- Gain knowledge about economically important plants and their uses.

Syllabus (Lecture hours: 60)

1.Temporary, doublestainedmicroscopicpreparations of T.S., T.L.S. and R.L.S. of stem of Pinus and Ephedra and T.S. Leaflet and Rachis of Cycas and needle of Pinus, T.S. of normalandcoralloidroots of *Cycas*. Microscopicpreparations of male cone of *Pinus* and male and female cones of *Ephedra*. Study of male cone and megasporophyll of *Cycas*.

2. TAXONOMY

1. Ranunculaceae : *Ranunculus, Nigella, Delphinium*
2. Brassicaceae : *Brassica, Raphanus, Iberis*
3. Malvaceae : *Hibiscus, Althea*
4. Leguminosae : *Pisum, Crotalaria ; Cassia, Caesalpinia, Bauhinia, Tamarindus ; Acacia, Prosopis, Mimosa.*
5. Cucurbitaceae : *Citrullus, Cucumis*
6. Asteraceae : *Helianthus, Tridax, Launaea, Ageratum.*
7. Solanaceae : *Solanum, Nitotiana, Petunia. Datura*
8. Poaceae : *Triticum.*

Theabovelist of plants is onlysuggestiveandcanbereplaceddependingonlocalavailability.

3. EMBRYOLOGY SLIDES :

1. Placentation : Types
2. Ovules : Types
3. Pollinium (wholemount).

4.Allplants of economicimportance as prescribed in theorypaper

5. ANATOMY

1. Stem : Anyoneortworepresentativelike*Boerhaavia, Achyranthes, Bignonia, Chenopodium, Leptadaenia,Nyctanthes, Salvadora, Dracaena, Triticum, Mirabilis, Aristolochia, Amaranthus, Chenopodium.*
2. Root : Anyoneortworepresentativelike*Tinospora, Ficus.*

Scheme of Examination

Exercise 1 (Gymnosperms)	**10**
Exercise 2 (Taxonomy)	**12**
Exercise 3 (Anatomy)	**12**
Exercise 4 (Embryology)	**5**
Exercise 5 (Economic Botany)	**5**
Spotting (8)	**16**
Record	**10**
Viva–Voce	**10**
Total	**80**

Suggested Books and References

Here are some practical books that cover the topics mentioned in the given syllabus:

1. "A Textbook of Practical Botany" by R.C. Pandey
    - This book provides practical exercises and techniques for studying various aspects of plant morphology, anatomy, and taxonomy. It covers topics such as microscopy, staining techniques, and the study of plant families.
2. "Practical Manual of Plant Anatomy and Embryology" by V. Verma and V. K. Agarwal
    - This book focuses on plant anatomy and embryology, including the study of stem and root anatomy. It provides detailed descriptions of staining techniques, preparation of microscope slides, and the study of various plant organs.
3. "Practical Plant Taxonomy" by S.K. Singh and S.R. Maurya
    - This book specifically focuses on plant taxonomy and provides practical exercises for studying different plant families. It includes information on the identification and classification of plants based on their morphological features.
4. "Practical Manual of Economic Botany" by S.P. Sharma
    - This book covers plants of economic importance and provides practical exercises for studying their morphology, anatomy, and economic uses. It includes detailed descriptions of various plant families and their economic significance.
5. "Practical Handbook of Plant Anatomy" by C.R. Metcalfe and L. Chalk
    - This comprehensive handbook covers plant anatomy and provides practical techniques for the preparation and examination of plant sections. It includes detailed protocols for the study of stem and root anatomy.

Suggested E-resources

Here are some e-resources that you can refer to for the topics mentioned in the syllabus:

1. Plant Anatomy Online (http://plantcellbiology.masters.grkraj.org/)
    - This website provides detailed information on plant anatomy, including stem and root anatomy. It includes interactive tutorials, diagrams, and image galleries that can help you study and understand the anatomy of different plant species.
2. Practical Plant Taxonomy (https://www.sbs.utexas.edu/bio406d/)
    - This online resource offers a comprehensive guide to plant taxonomy. It covers various plant families and provides detailed descriptions, images, and classification information for each family. It also includes practical exercises and quizzes to test your knowledge.
3. Plant Embryology and Embryonic Development (https://www.plantembryology.org/)
4. This website focuses on plant embryology and provides detailed information on placentation, types of ovules, and other aspects of plant embryonic development.
5. Plant Science Image Gallery (https://plantscienceimages.org/)
    - This image gallery, provided by the American Society of Plant Biologists, offers a vast collection of high-quality plant images. You can search for specific plant species or topics related to your syllabus, such as stem anatomy, root anatomy, and different plant families. The images can be a valuable visual resource for studying and identifying plant structures.
6. Digital Library of Economic Plants (https://uses.plantnet-project.org/en/)
    - This online resource provides information on plants of economic importance. It offers a comprehensive database with details on the morphology, anatomy, and uses of various plant species.

B.Sc.
Semester-wise syllabus (Botany)
Semester III

Code of the course	BOT6002T
Title of the course	**Botany-III: Basics of Cell & Molecular Biology, Genetics, Plant Breeding, Evolution and Biostatistics**
Level of the Course	NHEQF Level 5.0
Credit of the Course	4
Type of the Course	DCC
Delivery Type of the Course	Lectures and tutorial (40+20=60hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Intermediate level

Objectives of the Course

1. Understand the fundamental concepts of cell biology, including the cell theory, structure, and functions of prokaryotic and eukaryotic cells, as well as the processes of mitosis and meiosis.
2. Comprehend the structure, types, and functions of DNA and RNA, the central dogma of molecular biology, DNA replication, transcription, and translation, as well as the operon concept of gene regulation.
3. Familiarize with the principles of genetics, including Mendel's laws of inheritance, co-dominance, incomplete dominance, gene interactions, linkage, crossing over, and basics of cytoplasmic inheritance.
4. Gain knowledge of mutations, including spontaneous and induced mutations, physical and chemical mutagens, and the molecular basis of gene mutations.
5. Understand the principles of plant breeding, including centers of origin, selection, hybridization, mutation breeding, and the Green Revolution.
6. Explore the theories of origin and evolution, including Lamarck's theory, Darwin's theory of natural selection, and evidence of evolution.
7. Develop elementary skills in biostatistics, including understanding measures such as mean, mode, median, and standard deviation.

Course Learning Outcomes

1. Understand the fundamental principles of cell biology, including cell structure, organelle functions, and processes of mitosis and meiosis.
2. Comprehend the molecular basis of genetics, including DNA and RNA structure, gene expression, replication, transcription, translation, and gene regulation.
3. Gain knowledge of genetic inheritance patterns, gene interactions, linkage, crossing over, mutations, and basics of cytoplasmic inheritance.
4. Explore the principles of plant breeding, including centers of origin, breeding methods, hybridization, mutation breeding, and the Green Revolution.
5. Develop an understanding of the theories of origin and evolution, including Lamarck's theory, Darwin's theory of natural selection, and evidences of evolution.
6. Acquire basic skills in biostatistics, including the calculation and interpretation of measures such as mean, mode, median, and standard deviation.

Syllabus

Unit-1(Lecture hours: 12)

CellBiology – Celltheory, Structureandfunctions of cell (bothprokaryotesandeukaryotes): Structureandfunctions of plant cellwall, cell membrane andcellorganelles (mitochondria and chloroplast). Chromosomes: Structure of chromatin and chromosomes. Mitosis. Meiosis.

Unit-2 (Lecture hours: 12)

MolecularBiology – Structure, typesandfunctions of DNA & RNA. Modern concept of gene. Concept of central dogma. Basics of DNA replication, transcription of mRNAandtranslation in prokaryotesandeukaryotes. Operonconcept of gene regulation.

Unit-3 (Lecture hours: 12)

Genetics - Mendel'slaws of inheritance, Co-dominanceandincompletedominance, Multiple alleles, Gene gene interactions, Pleiotropy, Lethal alleles, Linkage and crossing over, Basics of cytoplasmicinheritance.

Unit-4 (Lecture hours: 12)

Mutations: Spontaneous and induced mutations, Physical and chemical mutagens. Basics of molecular basis of gene mutations.

Plant breeding - Centres of origin, Principles of plant breeding, Introduction, Selection, Hybridization, Mutationbreeding, Green Revolution.

Unit-5 (Lecture hours: 12)

Origin&Evolution: Origin of life, Evolutionarytheories: Lamarck'stheory, Darwin'stheory (Naturalselcetion), Mutationtheory. Evidences of evolution.

Elementarystudy of biostatistics: Mean, mode, median&standarddeviation.

Suggested Books and References

Here are some books that cover the topics mentioned in the syllabus:

1. "Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, Peter Walter
    - This comprehensive textbook covers cell biology, molecular biology, and genetics. It provides in-depth information on cell structure and functions, DNA replication, transcription, translation, and various genetic concepts.
2. "Principles of Genetics" by Robert H. Tamarin
    - This textbook focuses on the principles of genetics, including Mendelian inheritance, gene interactions, linkage, and mutation. It covers the basics of molecular genetics and provides examples and illustrations to enhance understanding.
3. "Introduction to Genetic Analysis" by Anthony J.F. Griffiths, Susan R. Wessler, Sean B. Carroll, John Doebley
    - This textbook offers an introduction to genetics, covering topics such as Mendelian genetics, gene expression, and genetic analysis techniques. It provides a comprehensive understanding of genetic principles and their applications.
4. "Plant Breeding: Principles and Methods" by B.D. Singh
    - This book specifically focuses on the principles and methods of plant breeding. It covers topics such as centers of origin, principles of breeding, hybridization, mutation breeding, and the Green Revolution. It provides practical insights into plant breeding techniques.
5. "Evolutionary Biology" by Douglas J. Futuyma
    - This textbook explores the principles of evolutionary biology, including theories of origin and evolution, evolutionary processes, and evidence of evolution. It provides a comprehensive understanding of the field of evolutionary biology.
6. "Biostatistics: A Foundation for Analysis in the Health Sciences" by Wayne W. Daniel, Chad L. Cross
    - This book covers the basics of biostatistics, including measures such as mean, mode, median, and standard deviation. It provides an introduction to statistical analysis methods used in the health sciences.

Suggested E-resources

Here are some e-resources that you can refer to for the topics mentioned in the syllabus:

1. Khan Academy (https://www.khanacademy.org/)
    - Khan Academy offers free online courses and resources covering a wide range of subjects, including cell biology, molecular biology, genetics, and statistics. It provides video lessons, practice exercises, and quizzes to help you learn and understand the topics.

2. National Center for Biotechnology Information (https://www.ncbi.nlm.nih.gov/)
    - The NCBI website provides access to a vast collection of scientific articles, research papers, and databases related to molecular biology, genetics, and evolutionary biology.

You can search for specific topics, browse through publications, and access resources like the GenBank database for genetic information.

3. Coursera (https://www.coursera.org/)
    - Coursera offers online courses from top universities and institutions. You can search for courses related to cell biology, molecular biology, genetics, and statistics. These courses often provide video lectures, assignments, and quizzes to help you grasp the concepts and deepen your understanding.
4. National Human Genome Research Institute (https://www.genome.gov/)
    - The NHGRI website provides resources and information on genomics, genetics, and related topics. It offers educational materials, interactive tools, and databases that can be helpful for studying genetics, DNA sequencing, and molecular biology.
5. BioInteractive by Howard Hughes Medical Institute (https://www.biointeractive.org/)
    - BioInteractive offers a collection of multimedia resources, including videos, animations, and virtual labs, on various biological topics. It covers subjects like cell biology, genetics, and evolutionary biology. The resources provide interactive learning experiences and can enhance your understanding of the topics.

Code of the course	BOT6002P
Title of the course	**Botany Lab-III: Practicals of Cell & Molecular Biology, Genetics, Plant Breeding, Evolution and Biostatistics**
Level of the Course	NHEQF Level 5.0
Credit of the Course	2
Type of the Course	DCC
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	Intermediate level

Objectives of the Course

1. Prepare smear preparations of root tips and onion buds to observe and analyze different stages of mitosis and meiosis.
2. Solve problems related to genetics, including concepts of inheritance, genetic crosses, and test crosses.
3. Understand the techniques of emasculation, crossing, and bagging in crop plants for controlled breeding.
4. Apply statistical measures such as mean, mode, median, and standard deviation to analyze data in genetics experiments.
5. Demonstrate monohybrid and dihybrid crosses and test cross to understand inheritance patterns.
6. Study cell organelles through electron microphotographs/models to comprehend their structure and function.
7. Perform rapid DNA isolation using the spooling method for genetic analysis and experimentation.

Course Learning Outcomes

1. Demonstrate practical skills in preparing and analyzing microscopic slides, conducting genetics experiments, applying statistical measures, and performing DNA isolation methods.
2. Understand fundamental concepts in cell biology, genetics, plant breeding, and statistical analysis relevant to the syllabus topics.

Syllabus (Lecture hours: 60)

- Smearpreparation of root tipsandonionbudfor different stages of mitosisandmeiosis.
- Problems related to genetics.
- Emasculation, crossing and bagging in crop plants.
- Mean, Mode, Median, Standard Deviation.
- Demonstration of MonohybridandDihybridcrossesandtestcross.
- Study of cellorganellethroughelectronmicrophotograhs/models
- Rapid DNA isolationmethod (spoolingmethod).

Scheme of Examination

Exercise 1 (Cell and Molecular Biology)	16
Exercise 2 (Genetics)	12
Exercise 3 (Plant Breeding)	8
Exercise 4 (Biostatistics)	8
Spotting (8)	16
Record	10
Viva–Voce	10
Total	**80**

Suggested Books and References

Here are some practical books that cover the topics mentioned in the syllabus:

1. "Laboratory Manual in Biology" by V. Satyanarayana and Dr. C. Lakshmi Saraswathi
   - This practical manual provides detailed instructions and protocols for various biology experiments, including smear preparations, genetics problems, plant breeding techniques, statistical analysis, and DNA isolation methods.
2. "Practical Cell Biology" by Jennifer L. Anderson and Wolfgang Stein
   - This book focuses on practical techniques and experiments in cell biology. It covers topics such as preparing smear preparations, studying cell organelles, and conducting

molecular biology experiments. It includes step-by-step protocols and explanations.

3. "Experiments in Molecular Genetics" by Jeffrey H. Miller, Michael L. Gergen, and Karen M. Fossett
    - This practical guide is specifically tailored to molecular genetics experiments. It covers topics like DNA isolation, genetic crosses, and analysis of genetic data. It provides detailed protocols, background information, and troubleshooting tips.
4. "Practical Statistics for Field Biology" by Jim Fowler, Lou Cohen, and Phil Jarvis
    - This book focuses on the practical application of statistical methods in biology. It covers topics such as calculating means, modes, medians, and standard deviations. It provides guidance on data analysis and interpretation in the context of biological experiments.
5. "Practical Genetics for the Laboratory Investigator" by Svetlana Dzakpasu
    - This practical guide offers hands-on experiments and protocols in genetics. It covers topics such as genetic crosses, test crosses, and analyzing genetic inheritance patterns. It provides clear instructions and explanations for each experiment.

Suggested E-resources

1. National Center for Biotechnology Information (NCBI) - https://www.ncbi.nlm.nih.gov/
2. Khan Academy - https://www.khanacademy.org/
3. National Human Genome Research Institute (NHGRI) - https://www.genome.gov/
4. Coursera - https://www.coursera.org/
5. BioInteractive by Howard Hughes Medical Institute - https://www.biointeractive.org/
6. OpenStax Biology - https://openstax.org/subjects/science/biology
7. Biology Online - https://www.biology-online.org/
8. NCERT Biology Textbook - http://ncert.nic.in/textbook.php?lemh1=1-14

B.Sc.
Semester-wise syllabus (Botany)
Semester IV

Code of the course	**BOT6003T**
Title of the course	**Botany-IV: Plant Biochemistry, Physiology and Biotechnology**
Level of the Course	NHEQF Level 5.0
Credit of the Course	4
Type of the Course	DCC
Delivery Type of the Course	Lectures and tutorial (40+20=60hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Intermediate level

Objectives of the Course

The main objective of this course is to provide the basic theoretical knowledge to undergraduate students about the various important topics of plant biochemistry, physiology and biotechnology.

Course Learning Outcomes

The course will definitely enrich the theoretical knowledge of various important topics of plant biochemistry, physiology and biotechnology and will also help in qualifying various competitive examinations (Civil Services, School Education etc).

Syllabus

Unit-1 (Lecture hours: 12)

Biomolecules: structures and classifications of carbohydrates, protein and lipids; Enzymes: general characteristics, classification and mode of action. Water potential and Transpiration: osmosis, plasmolysis, diffusion pressure deficit.

Unit-II (Lecture hours: 12)

Guttation and transpiration, stomatal movement; Photosynthesis: plant pigments, light reaction, Photophosphorylation, mechanism of CO_2 fixation in C3, C4 and CAM plants.

Unit-III (Lecture hours: 12)

Respiration: glycolysis, citric acid cycle and oxidative phosphorylation; Photoperiodism and Vernalization; Structure and physiological functions of plant growth regulators (auxins, cytokinins, gibberellins, and ethylene).

Unit-IV (Lecture hours: 12)

Plant Tissue culture: cellular totipotency, nutrient media, explants, differentiation, organogenesis, micropropagation, hardening, applications of plant tissue culture technique.

Unit-V (Lecture hours: 12)

Recombinant DNA Technology: restriction endonucleases, cloning vectors, basics of plant transformation methods (*Agrobacterium tumefaciens*, Particle gun, microinjection electroporation), applications of transgenic plants.

Suggested Books and References

- Jain,J.L., Jain S. and Jain N. (2016), Fundamentals Of Biochemistry, S. Chand Publication (ISBN-13: *978-8121924535).*
- Gupta, S.N. (2010), A Textbook of Biochemistry, Rastogi Publication ((ISBN-13:978-8171339389).
- Salisbury, F.B. and Ross, C.W. (2004, Plant Physiology, Wadsworth *Publishing* Company (ISBN: 9788131501658).
- Gupta, P.K. (2009), Elements of Biotechnology, Rastogi Publication (ISBN-13: 978-8171339372.
- Jain, S.K. (2000), Textbook of Biotechnology (Fundamentals of Molecular Biology), CBS Publishers and Distributors PVt Ltd (ISBN-13: 978-8171339372).

- Joshi, N. and Purohit. S.D. (2007,) Molecular Biology & Biotechnology, Apex Publishing House (ISBN-13: 978-8130100401).
- Singh, B.D. (2015), Plant Biotechnology, Kalyani Publishers (ISBN-13: 978-9327256390).

Suggested E-resources

- E-notes on Biochemistry: https://www.studystack.com/Biochemistry
- E-notes on Plant Physiology: http://www.eagri.org/eagri50/PPHY261/index.html
- E-notes on Plant Biotechnology: https://epgp.inflibnet.ac.in/

Code of the course	BOT6003P
Title of the course	**Botany Lab-IV: Practicals of Plant Biochemistry, Physiology and Biotechnology**
Level of the Course	NHEQF Level 5.0
Credit of the Course	2
Type of the Course	DCC
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	Intermediate level

Objectives of the Course

This course aims to provide practical knowledge of plant biochemistry, physiology and biotechnology. It includes several classroom experiments to improve practical skills in plant biochemistry, physiology and biotechnology.

Course Learning Outcomes

Practical knowledge of plant biochemistry, physiology and biotechnology will definitely improve the in depth knowledge and understanding about the subjects.

Syllabus (Lecture hours: 60)

- Demonstration of pH meter, Laminar Air Flow Bench, Spectrophotometer, Autoclave and centrifuge.
- Phytochemical tests of starch, cellulose, sucrose, fats and proteins.
- Demonstration of opening and closing of stomata.
- Demonstration of phenomenon of osmosis by potato osmoscope.
- Demonstration of separation of plant pigments using thin layer chromatography.
- Preparation of Murashige and Skoog`s medium for plant tissue culture

Scheme of Examination

Exercise 1 Major (Physiology and Biochemistry)	16
Exercise 2 Minor (Physiology and Biochemistry)	6
Exercise 3 Major (Biotechnology)	16
Exercise 4 Minor (Biotechnology)	6
Spotting (8)	16
Record	10
Viva–Voce	10
Total	**80**

Suggested Books and References

- Gour, L., Sharma, R. and Rama Krishnan R.S. (2020), Fundamental of Plant Biochemistry and Biotechnology-A Practical Book, Akinik Publications.
- Bala, M. (2020), Practicals in Plant Physiology and Biochemistry, Scientific Publishers (ISBN: 9789386102638).
- Gupta, N.K., Sangha,M.K., Bala, M. and Gupta, S. (2016), Practicals in Plant Physiology and Biochemistry, Scientific Publishers (ISBN: 978-9386102638).
- Inam, A. (2012), A Laboratory Manual of Plant, Physiology, Biochemistry and Ecology, Agrobios Publisher (ISBN: 9788177544589).
- Purohit, S.S. (2021),A Laboratory Manual of Plant Biotechnology, Agrobios Publisher (ISBN: 9788177542226).
- Shivakumar, R. (2015), Practical Plant Physiology, Narendra Publishing House (ISBN: 9789384337247).

Suggested E-resources

- Biochemistry virtual Lab. https://vlab.amrita.edu/?sub=3&brch=63
- Online Plant Physiology Experiments https://biology4isc.weebly.com/plant-physiology-experiments.html
- Basic Plant Physiology https://study.com/academy/topic/basic-plant-physiology.html
- Plant Biotechnology Information Center https://plantbiotech.bg/en/i-want-to-know/plant-tissue-culture-and-micropropagation/

Code of the Course	SES6300T
Title of the Course	**Tools and Techniques in Plant Sciences**
Level of the Course	NHEQF Level 5.0
Credit of the Course	2
Type of the Course	SEC
Delivery Type of the Course	Lectures and tutorials (20+10=30hours). The 20hours lectures for content delivery and 10 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Intermediate level

Objectives of the Course

The objective of this syllabus is to provide students with a thorough understanding of laboratory etiquette, safety practices, and maintenance of lab equipment. It aims to develop students' skills in preparing solutions, calculating molecular formula weight, and calibrating equipment. The syllabus further aims to familiarize students with basic equipment used in plant sciences, principles and applications of centrifugation and microscopy techniques, chromatographic techniques (paper, thin layer, column, and gel chromatography), spectrophotometry principles and applications, as well as the principle and applications of PCR.

Course Learning Outcomes

Upon completion of the course covering the mentioned syllabus, students will be able to:

1. Demonstrate an understanding of laboratory etiquette and safety protocols, adhering to good laboratory practices to ensure a safe working environment.
2. Apply proper maintenance techniques to ensure the functionality and longevity of lab equipment used in plant sciences, such as autoclaves, weighing balances, pH meters, laminar flow benches, hot air ovens, and microtomes.
3. Prepare solutions of specific molarity, percentage, or concentration accurately, and calculate molecular formula weights for various compounds.
4. Calibrate and operate laboratory equipment effectively, understanding the principles and procedures involved in calibration.
5. Explain the principles and applications of centrifugation, including different types of centrifuges and their appropriate applications, as well as ultra-centrifugation techniques.
6. Utilize various microscopy techniques, including optical, phase contrast, fluorescence, and confocal microscopy, to observe and analyze biological samples effectively.
7. Understand the principles and methodologies of different chromatographic techniques, such as paper, thin layer, column, and gel chromatography, and apply them to separate and analyze complex mixtures.
8. Comprehend the principles of spectrophotometry, including UV-Vis spectrophotometry, colorimeter usage, and its applications in quantifying substances in samples.
9. Describe the principle and applications of Polymerase Chain Reaction (PCR) and its significance in various fields, including molecular biology, genetics, and diagnostics.
10. Apply the knowledge gained from the course to design and conduct experiments, analyze data, and draw conclusions using the techniques and instruments covered in the syllabus.

These learning outcomes aim to equip students with theoretical knowledge and practical skills in laboratory practices, equipment handling, solution preparation, analysis techniques, and application of various technologies to conduct scientific research or experiments in the field of plant sciences and related areas.

Syllabus

UNIT-1 (Lecture hours: 6)

Laboratory etiquette and safety. Good laboratory practices, maintenance of lab equipment. Making solutions, molecular formula weight. Calibration of equipment.

UNIT- 2 (Lecture hours: 6)

Basic equipment used in plant sciences: Autoclave, Weighing balance, pH meter, Laminar flow, Hot air oven, Microtomy

UNIT- 3 (Lecture hours: 6)

Centrifugation: Principle; types, application. Ultra-centrifugation.

Microscopy: Optical, phase contrast, Fluorescence microscopy, Confocal microscopy.

UNIT- 4 (Lecture hours: 6)

Spectrophotometry-Principle, and applications, Colorimeter, UV-Vis Spectrophotometry, AAS, NMR. Principle of PCR and its applications.

UNIT- 5 (Lecture hours: 6)

Chromatography: Principle and methodology of chromatographic techniques: Paper, Thin Layer, Column chromatography and types (gel exclusion, ion exchange, affinity, HPLC, GCMS, LCMS).

Suggested Books and References

"Laboratory Safety for Chemistry Students" by Robert H. Hill Jr. and David C. Finster.
"Experimental Organic Chemistry: A Miniscale and Microscale Approach" by John C. Gilbert and Stephen F. Martin.
"Plant Physiology and Development" by Lincoln Taiz, Eduardo Zeiger, Ian M. Møller, and Angus Murphy.
"Plant Physiology" by Frank B. Salisbury and Cleon W. Ross.
"Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter.
"Molecular Cell Biology" by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, HiddePloegh, and Paul Matsudaira.
"Principles and Practice of Chromatography" by Raymond P.W. Scott.
"Introduction to Modern Liquid Chromatography" by Lloyd R. Snyder, Joseph J. Kirkland, and John W. Dolan.
"Spectrophotometry: Principles, Instrumentation, and Applications" by James N. Butler.
"Principles of Instrumental Analysis" by Douglas A. Skoog, F. James Holler, and Stanley R. Crouch.

Suggested E-resources

1. Laboratory etiquette and safety, good laboratory practices, maintenance of lab equipment, making solutions, molecular formula weight, and calibration of equipment:

- URL: https://www.labmanager.com/
- Description: Lab Manager provides articles, guides, and webinars on laboratory management, safety protocols, and maintenance of lab equipment. It covers topics such as calibration techniques and best practices for making solutions.

2. Basic equipment used in plant sciences (autoclave, weighing balance, pH meter, laminar flow, hot air oven, microtomy):

- URL: https://www.plantmethods.com/
- Description: Plant Methods is an open-access journal that publishes research articles on methods and techniques used in plant sciences. It can be a valuable resource to learn about the operation and usage of basic equipment in plant sciences.

3. Centrifugation (principle, types, application, ultra-centrifugation):

- URL: https://www.thermofisher.com/centrifuge-resource-center
- Description: Thermo Fisher Scientific's Centrifuge Resource Center provides a comprehensive collection of resources, including articles, application notes, and videos, covering various aspects of centrifugation, including principles, types, applications, and ultra-centrifugation.

4. Microscopy (optical, phase contrast, fluorescence, confocal microscopy):

- URL: https://www.microscopy.org/
- Description: The Microscopy Society of America (MSA) website offers educational resources on various microscopy techniques. It provides articles, webinars, and links to online courses and tutorials for understanding the principles and applications of optical, phase contrast, fluorescence, and confocal microscopy.

5. Chromatography (principle and methodology of chromatographic techniques - paper, thin layer, column, gel chromatography):

- URL: https://www.chromatographyonline.com/
- Description: Chromatography Online provides articles, tutorials, and application notes explaining the principles and methodologies of various chromatography techniques, including paper, thin-layer, column, and gel chromatography.

6. Spectrophotometry (principle, applications, colorimeter, UV-Vis spectrophotometry) and principle of PCR and its applications:

- URL: https://www.thermofisher.com/spectrophotometry-resource-center
- Description: Thermo Fisher Scientific's Spectrophotometry Resource Center offers a wide range of resources on spectrophotometry, including articles, application notes, and technical guides. It covers principles, applications, colorimeters, UV-Vis spectrophotometry, as well as the principle and applications of PCR.

B.Sc.
Semester-wise syllabus (Botany)
Semester V

Code of the course	**BOT7100T**
Title of the course	**Seed Biology**
Level of the Course	NHEQF Level 5.5
Credit of the Course	4
Type of the Course	DSE
Delivery Type of the Course	Lectures and tutorial (40+20=60hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Advance Course

Objectives of the Course

The objectives for the given syllabus are as follows:

1. Understand the physiology of seed development and maturation, including the chemical composition, synthesis, and accumulation of seed reserves, and the hormonal regulation of seed development.
2. Explore the factors influencing seed germination, such as embryonic axis, growth hormones, enzyme activities, seed age, size, and position, and the physiological processes during germination.
3. Study seed dormancy, including its types, significance, mechanisms, and the role of phytochrome and plant growth regulators in dormancy regulation.
4. Examine seed viability, longevity, and factors affecting viability, including pre and post-harvest considerations. Understand the physiology of seed deterioration, including lipid peroxidation and viability theories.
5. Learn about seed vigour, including its concept, test methods, factors affecting vigour, and its physiological basis in relation to crop performance and yield. Understand seed invigoration and its physiological control.

Course Learning Outcomes

1. Gain a comprehensive understanding of the physiological processes involved in seed development, maturation, germination, dormancy, viability, and vigour.
2. Acquire knowledge of the factors influencing these processes and their significance in plant growth, performance, and crop yield.

Syllabus

Unit – 1 (Lecture hours: 12)

Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.

Unit – 2 (Lecture hours: 12)

Seed germination; factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization.

Unit – 3 (Lecture hours: 12)

Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR.

Unit – 4 (Lecture hours: 12)

Seed viability and longevity, pre and post-harvest factors affecting seed viability; seed ageing; physiology of seed deterioration; lipid peroxidation and other viability theories; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.

Unit – 5 (Lecture hours: 12)

Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed

vigour in relation to crop performance and yield. Seed invigoration and its physiological control.

Suggested Books and References

1. AgrawalPK&Dadlani M. (Eds.). 1992. Techniques in Seed Science and Technology. South Asian Publ.
2. Agrawal, P.K. & M. Dadlani, 1995. Techniques In Seed Science And Technology (2nd Ed.) South Asian Publ. New Delhi.
3. Baskin CC & Baskin JM. 1998. Seeds: Ecology, Biogeography and Evolution of Dormancy and Germination. Academic Press. Basra AS. 2006. Handbook of Seed Science and Technology. Food Product Press.
4. Bench ALR& Sanchez RA. 2004. Handbook of Seed Physiology. Food Product Press.
5. Bewley JD & Black M. 1982. Physiology and Biochemistry of Seeds in Relation to Germination. Vols. I, II. Springer Verlag.
6. Bewley JD & Black M. 1985. Seed: Physiology of Seed Development and Germination. Plenum Press.
7. Copeland LO &Mc Donald MB. 1995. Principles of Seed Science and Technology. 3rd Ed. Chapman & Hall.
8. Khan AA. 1977. Physiology and Biochemistry of Seed Dormancy and Germination. North Holland Co.
9. Kigel J &Galili G. (Eds.). Seed Development and Germination. Marcel Dekker.
10. Murray DR. 1984. Seed Physiology. Vols. I, II. Academic Press. Sadasivam S &Manickam A. 1996. Biochemical Methods. 2nd Ed. New Age.

Suggested E-resources

Here are some e-resources that cover the topics mentioned in the syllabus:

1. Plant Physiology Online - http://plantphys.info/
2. National Center for Biotechnology Information (NCBI) - https://www.ncbi.nlm.nih.gov/
3. Khan Academy - https://www.khanacademy.org/
4. OpenStax Biology - https://openstax.org/subjects/science/biology
5. Coursera - https://www.coursera.org/
6. BioInteractive by Howard Hughes Medical Institute - https://www.biointeractive.org/
7. National Human Genome Research Institute (NHGRI) - https://www.genome.gov/
8. Online lectures and materials from reputable universities offering courses in plant physiology, such as MIT OpenCourseWare (https://ocw.mit.edu/index.htm) or Stanford Online (https://online.stanford.edu/).
9.

These e-resources provide a wealth of information, including articles, lectures, videos, interactive modules, and course materials related to plant physiology, seed development, germination, dormancy, viability, and vigour.

Code of the course	BOT7100P
Title of the course	**Elective Botany Lab: Seed Biology**
Level of the Course	NHEQF Level 5.5
Credit of the Course	2
Type of the Course	DSE
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	Advance Course

Objectives of the Course

1. Develop skills in seed sampling and testing, including assessing physical purity, germination, viability, and other relevant parameters.
2. Gain proficiency in conducting different germination tests using paper towel and petri dish methods.
3. Understand and apply methods for breaking seed dormancy.
4. Learn and perform vigour tests such as the brick gravel and paper piercing methods.
5. Acquire knowledge and practice seed viability tests.
6. Study and analyze different seed qualities, including size, shape, color, purity, viability, and germination.

Course Learning Outcomes

1. Develop practical skills in seed sampling, testing, and analysis, including assessing physical purity, germination, viability, and seed qualities.
2. Acquire proficiency in conducting various germination tests, breaking seed dormancy, and performing vigour and viability tests.

Understand the importance of seed quality evaluation and its significance in seed industry, agriculture, and crop production.

Syllabus (Lecture hours: 60)

- Seed sampling and testing: Physical purity, germination, viability, etc.
- Different germination tests (Paper towel and petridish method)
- Methods of Breaking seed dormancy
- Vigour Tests (Brick gravel, Paper piercing)
- Seed viability Tests
- Study of different qualities of seeds in respect of size, shape colour, purity, viability germination.

Scheme of Examination

Exercise 1 Major	16
Exercise 2 Minor	6
Exercise 3 Major	16
Exercise 4 Minor	6
Spotting (8)	16
Record	10
Viva–Voce	10
Total	**80**

Suggested Books and References

1. "Seed Testing: Principles and Practices" by A.A. Desai
2. "Handbook of Seed Testing" by K.R. Reddy and K.V. Krishna Rao
3. "Seed Science and Technology" by R.S. Dhiman
4. "Principles of Seed Science and Technology" by Lawrence O. Copeland and Miller M. McDonald
5. "Seed Technology and Seed Testing" by A.K. Choudhary and V.P. Singh

Suggested E-resources

1. International Seed Testing Association (ISTA) - https://www.seedtest.org/
2. The Association of Official Seed Analysts (AOSA) - https://www.aosaseed.com/
3. The International Seed Testing Association (ISTA) Online Seed Testing Training Course -

https://www.seedtest.org/en/training-and-education/online-seed-testing-training-course.html

4. United States Department of Agriculture (USDA) Seed Testing Laboratory - https://www.ams.usda.gov/services/seed-testing
5. Crop Science Society of America (CSSA) Seed Testing and Quality Resource - https://www.crops.org/education/classroom/lesson-plans/seed-testing
6. Online seed testing protocols and guidelines provided by reputable seed testing laboratories and institutions, such as state agricultural universities and research institutes.

Code of the course	BOT7101T
Title of the course	**Cultivation and Commercialization of Medicinal Plants**
Level of the Course	NHEQF Level 5.5
Credit of the Course	4
Type of the Course	DSE
Delivery Type of the Course	Lectures and tutorials (40+20=60 hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Advance Course

Objectives of the Course

1. Develop theorical understanding in conventional propagation and maintenance of medicinal plants, including *Aloe, Chlorophytum, Withania, Commiphora*, and *Papaver*.
2. Acquire knowledge of post-harvesting and processing methods, such as harvesting, drying, storage, and prevention of microbial contamination in herbal products.
3. Gain proficiency in extraction and analysis methods, including distillation, solvent extraction, chromatographic and spectroscopic techniques for identifying and characterizing active principles.
4. Understand the practices of storage, preservation, packaging, and herbal formulations, along with techniques for enhancing shelf-life and value addition of aromatic compounds.
5. Analyze the Indian market scenario and entrepreneurship opportunities in the herbal product processing and export industry, with a focus on the business environment and industrial case studies.

Course Learning Outcomes

1. Develop a comprehensive understanding of the propagation, post-harvesting, and processing methods of medicinal plants, including harvesting, drying, storage, and prevention of microbial contamination.
2. Acquire proficiency in extraction and analysis techniques for identifying and characterizing active principles using advanced chromatographic and spectroscopic methods.
3. Gain practical skills in storage, preservation, packaging, and herbal formulations to enhance shelf-life and value addition of aromatic compounds.
4. Analyze the Indian market scenario and entrepreneurship opportunities in the herbal product industry, evaluating the overall business environment and industrial case studies.

Syllabus

UNIT-1(Lecture hours: 12)

Medicinal Plants and their uses, Conventional propagation and maintenance of medicinal plants like- *Aloe, Chlorophytum*(Safedmusli)*, Withania* (Ashwagandha)*, Commiphora*(Guggal)*, Papaver*.National Medicinal Plants Board (NMPB) and its role in promoting the cultivation of medicinal plants, Medicinal plant database of India

UNIT-2(Lecture hours: 12)

Post harvesting and processing methods: Methods of harvesting, drying and storage. Microbial contamination of stored herbal product. Influence of temperature, time and season on active principles.

UNIT-3 (Lecture hours: 12)

Extraction and analysis methods: Distillation, solvent extraction, separation, purification, identification and characterization of active principles from medicinal plants using advanced chromatographic and spectroscopic techniques like- TLC/HPLC/GC-MS/LC-MS/FTIR/NMR.

UNIT-4 (Lecture hours: 12)

Practices of storage, preservation, packaging, herbal formulations (decoction, infusion, aromatic waters, herbal tea, dried powder). Enhancement of shelf- life, and value addition of aromatic compounds.

UNIT-5 (Lecture hours: 12)

Indian market scenario and Entrepreneurship: Assessing overall business environment in the Indian economy, Characteristics of Indian herbal product processing and export industry. Industrial case studies (Herbal products and companies).

Suggested Books and References

1. Chadha, K.L. ICAR, 2001. Hand Book of Horticulture. Directorate of Information and Publications of Agriculture, Pusa, New Delhi.
2. Azhar Ali Farooqui and Sreeramu, B.S. 2001. Cultivation of medicinal and aromatic plants. United Press Limited.
3. Atal, E.K. and Kapur, B. 1982. Cultivation and Utilization of Medicinal and Aromatic plants. CSIR, New Delhi.
4. Kumar, N. J.B.M. Md. Abdul Khaddar, RangaSwamy, P. and Irulappan, I. 1997. Introduction to Spices, Plantation Crops Medicinal and Aromatic Plants.Oxford&IBH, New Delhi.
5. Jain, S.K. 1968. Medicinal Plants .National Book Trust New Delhi. Oxford &IBH, New Delhi.
6. Dastur, J.F. 1982. Medicinal plants of India Pakistan Taraprevalasoms and co-private Ltd.
7. Dharmvir, H. 2007. Bioactive medicinal plants, Gene Tech Books.
8. Farooqu, A.A., and Khan, M.M. and Vasundhara, M. 2001. Production technology of medicinal plantsand aromatic crops. Natural Remedies Pvt. Ltd.
9. Panda, H. 2007. Medicinal plants, cultivation and their use. Asia Pacific Business Press.
10. Masoda, Y. 1986. Analysis of essential oil by GC-MS, John Wiley and Sons.
11. Paine, F.A. 1987. Modern processing, packaging and distribution systems for food, AVI Publication.
12. SudhirK.P. and Indira V. B. 2008. Post harvest technology of horticultural crops, Horticulture Science Series. New India Publication Agency.
13. Ramawat K.G. and Merillon J-M. 2013. Natural Products. Phytochemistry, botany and metabolism of alkaloids, phenolics and terpenes, Springer.

Suggested E-resources

1. National Medicinal Plants Board (NMPB) - http://www.nmpb.nic.in/
2. International Union for Conservation of Nature (IUCN) - Medicinal Plant Specialist Group - https://www.iucn.org/commissions/medicinal-plants-specialist-group
3. Indian Council of Medical Research (ICMR) - http://icmr.nic.in/
4. National Institute of Ayurveda (NIA) - https://www.nia.nic.in/
5. National Medicinal Plants Board (NMPB) e-Library - http://nmpb.nic.in/en/e-library

These e-resources provide information on medicinal plants, their propagation, post-harvesting and processing methods, extraction and analysis techniques, storage and preservation practices, packaging, herbal formulations, and the Indian market scenario and entrepreneurship opportunities in the herbal product industry.

Code of the course	BOT7101P
Title of the course	**Elective Botany Lab: Cultivation and Commercialization of Medicinal Plants**
Level of the Course	NHEQF Level 5.5
Credit of the Course	2
Type of the Course	DSE
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	Advance Course

Objectives of the Course

1. Develop skills in identifying and documenting selected medicinal plants, including their morphological characteristics and medicinal properties.
2. Gain proficiency in various propagation methods for establishing plantations of medicinal plants.
3. Learn proper techniques for harvesting, drying, storing, and packing medicinal plant parts to ensure their quality and efficacy.
4. Acquire knowledge and practical experience in processing and grinding medicinal plant parts for further utilization.
5. Understand different extraction methods for extracting active ingredients from medicinal plants and their applications in herbal preparations.
6. Learn the principles and techniques of paper chromatography and thin-layer chromatography (TLC) for the separation and identification of active ingredients in medicinal plants.

Course Learning Outcomes

1. Develop proficiency in identifying and documenting medicinal plants, including their morphological characteristics and medicinal properties.
2. Acquire practical skills in plantation, propagation, harvesting, drying, storage, and packing techniques for medicinal plant parts.
3. Gain knowledge and hands-on experience in processing and grinding medicinal plant parts for various applications.
4. Understand different extraction methods for obtaining active ingredients from medicinal plants and their use in herbal preparations.
5. Learn and apply separation techniques such as paper chromatography and thin-layer chromatography (TLC) for the analysis of active ingredients in medicinal plants.

Develop an understanding of the importance of quality control, standardization, and preservation of medicinal plants throughout the processing and formulation stages.

Syllabus (Lecture hours: 60)

1. Identification and documentation of selected medicinal plants
2. Plantation using various propagation methods
3. Harvesting, drying, storage and packing techniques for medicinal plant parts
4. Processing and grinding of medicinal plant parts.
5. Different extraction methods for active ingredients
6. Separation of active ingredients using Paper chromatography/TLC

Scheme of Examination

Exercise 1 Major	16
Exercise 2 Minor	6
Exercise 3 Major	16
Exercise 4 Minor	6
Spotting (8)	16
Record	10
Viva–Voce	10
Total	**80**

Suggested Books and References

1. "Medicinal Plants: A Beginner's Guide to Learning the Hidden Powers of Plants" by Timothy Myers
2. "Practical Herbalism: Ordinary Plants with Extraordinary Powers" by Philip Fritchey
3. "The Medicinal Plant Guide: A Practical Reference to Herbal Remedies" by Richard Craze
4. "Herbal Medicine: A Practical Guide for Medical Students and Healthcare Professionals" by Philip F. Builders
5. "The Herbal Apothecary: 100 Medicinal Herbs and How to Use Them" by JJPursell
6. "Practical Handbook of Medicinal Plants and Herbal Medicine" by Stephen Harrod Buhner

Suggested E-resources

1. National Medicinal Plants Board (NMPB) - http://www.nmpb.nic.in/
2. World Health Organization (WHO) - Traditional Medicine - https://www.who.int/medicines/areas/traditional/en/
3. HerbalGram - American Botanical Council (ABC) - https://www.herbalgram.org/
4. PubMed - https://pubmed.ncbi.nlm.nih.gov/
5. ResearchGate - https://www.researchgate.net/
6. ScienceDirect - https://www.sciencedirect.com/

Code of the course	SES7301T
Title of the course	**Fundamental of Biostatistics**
Level of the Course	NHEQF Level 5.5
Credit of the Course	2
Type of the Course	SEC
Delivery Type of the Course	Lectures and tutorial (20+10=30hours). The 20hours lectures for content delivery and 10 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Advance Course

Objectives of the Course

Understand control and treatment, replicates, sampling, experimental design, standard curve. Analyze measures of central tendency. Learn standard deviation, skewness, kurtosis. Grasp correlation, regression, Chi-square test basics. Recognize error types, degrees of freedom, null and alternative hypotheses, p-value. Interpret single-factor ANOVA, comprehend post-hoc analysis.

Course Learning Outcomes

The course learning outcomes are as follows:

1. Understand the concept of control and treatment, and apply them in experimental settings to design and analyze experiments effectively.
2. Gain knowledge of replicates and sampling techniques to ensure reliable and representative data collection.
3. Comprehend the principles of experimental design and apply appropriate designs based on research objectives.
4. Learn how to construct and utilize standard curves, and differentiate between the blank of a standard curve and the control of an experiment.
5. Analyze and interpret measures of central tendency (mean, median, and mode) to describe and summarize data distributions.
6. Understand the concepts of standard deviation, standard errors, skewness, and kurtosis, and their significance in analyzing data variability and distribution shape.
7. Grasp the basics of correlation and regression analysis and their application in examining relationships between variables.
8. Learn the Chi-square test and its use in analyzing categorical data, testing for independence or association between variables.
9. Recognize different types of errors (Type I and Type II) and understand their implications in hypothesis testing.
10. Comprehend the concept of degrees of freedom, null and alternate hypotheses, level of significance, and the interpretation of p-values.
11. Gain knowledge of analysis of variance (ANOVA) for single-factor analysis and learn how to interpret the results.
12. Understand the concept of post-hoc analysis and its importance in identifying significant differences among multiple treatment groups.

These course learning outcomes aim to equip students with the necessary knowledge and skills to design and conduct experiments, analyze data using appropriate statistical techniques, and interpret the results effectively in various research and scientific contexts.

Syllabus

UNIT-1 (Lecture hours: 6)

Concept of control and treatment, replicates, sampling, experimental design, standard curve, difference between blank of standard curve and control of experiment.

UNIT- 2 (Lecture hours: 6)

Measures of central tendency: Mean, Median and Mode.

UNIT- 3 (Lecture hours: 6)

Standard deviation and standard errors; skewness and kurtosis. Basics of Correlation and Regression.

UNIT- 4 (Lecture hours: 6)

Chi-square test, Types of error (Type I and II error), concept of degree of freedom, null and alternate hypothesis, level of significance, meaning of *p*-value.

UNIT- 5 (Lecture hours: 6)

Analysis of variance (single factor analysis), its interpretation. Concept of Post-Hoc analysis.

Suggested Books and References

1. Sokal, R. R., &Rohlf, F. J. (2012). Biometry: The principles and practice of statistics in biological research (4th ed.). W.H. Freeman.
2. Zar, J. H. (2010). Biostatistical analysis (5th ed.). Pearson.
3. Field, A., Miles, J., & Field, Z. (2012). Discovering statistics using R. SAGE Publications Ltd.
4. Agresti, A., & Franklin, C. A. (2018). Statistics: The art and science of learning from data (4th ed.). Pearson.
5. Dancey, C. P., & Reidy, J. (2017). Statistics without maths for psychology: Using SPSS for Windows (8th ed.). Pearson.

Suggested E-resources

1. Khan Academy: Statistics and probability - https://www.khanacademy.org/math/statistics-probability
2. Stat Trek: Online Tutorials - https://stattrek.com/tutorials/statistics-tutorial.aspx
3. Laerd Statistics: Statistical Tutorials and Learning Resources - https://statistics.laerd.com/
4. UCLA Institute for Digital Research and Education: Statistics Guides - https://stats.idre.ucla.edu/
5. Social Research Methods: Statistical Analysis –https://www.socialresearchmethods.net/kb/statanal.php
6. StatSoft Electronic Statistics Textbook - https://www.statsoft.com/Textbook
7. NCSS Statistical Software: Online Help Documentation - https://www.ncss.com/help/
8. Statistical Consulting Group at UCLA: Online Resources - https://stats.idre.ucla.edu/other/mult-pkg/whatstat/

B.Sc.
Semester-wise syllabus (Botany)
Semester VI

Code of the course	**BOT7111T**
Title of the course	**Plant Diseases and Management**
Level of the Course	NHEQF Level 5.5
Credit of the Course	4
Type of the Course	DSE
Delivery Type of the Course	Lectures and tutorials (40+20=60hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Advance Course

Objectives of the Course

1. Understand the concept of disease and its classification, including factors that influence plant diseases and the study of epidemics and epiphytotics.
2. Learn the methods of isolating and identifying plant pathogens, including the application of Koch's Postulates.
3. Gain knowledge about the structural and biochemical defense mechanisms of plants against diseases.
4. Recognize the symptoms and study the etiology and management of important fungal, bacterial, phytoplasma, spiroplasma, virus, and viroid diseases affecting various plants.
5. Comprehend the principles and practices of plant disease management, including prophylactic approaches, eradication, prevention, and chemical control methods.
6. Explore the concept of biological control and understand the role of biological control agents (BCA) in managing plant diseases.
7. Familiarize oneself with the different types of interactions contributing to biological control and the importance and basic principles of Integrated Disease Management (IDM).

Course Learning Outcomes

By the end of this course, students will be able to understand and classify different types of plant diseases, identify common plant pathogens, analyze disease symptoms, apply appropriate disease management strategies, and comprehend the principles of biological control and integrated disease management.

Syllabus

Unit – 1 (Lecture hours: 12)

Disease: Concept of disease. Types and classification of diseases, factors affecting plant diseases, study of epidemics and epiphytotics, Isolation and identification of plant pathogens, Koch's Postulates. Basics of structural and biochemical defense mechanism.

Unit – 2 (Lecture hours: 12)

Plant disease: Symptoms, study of etiology and management of following important plant diseases; **Fungal diseases**: downy mildew of maize, green ear disease of bajra**,** rust of wheat, black smut, brown spot of rice, tikka disease of groundnut.

Unit – 3 (Lecture hours: 12)

Study of etiology and management of following important plant diseases. **Bacterial diseases:** Citrus canker, blight of bean, Soft rots of fruits, ratoon stunting of sugarcane. **Phytoplasma and spiroplasma diseases:** Symptoms and disease cycle of little leaf of brinjal, Grassy shoot of sugarcane **Viruses and Viroid diseases**: Papaya leaf curl, Bunchy top of Banana

Unit – 4 (Lecture hours: 12)

Plant disease management: Concept: Principles and practice, Prophylactic approach, Eradication, Prevention. Chemical control; classification and types of formulations, additives, application, storage and disposals.

Unit –5 (Lecture hours: 12)

Biological control: Definition, Concept, biological control agents (BCA). Types of interactions contributing to biological control. Integrated Disease Management (IDM) (importance and basic principles).

Suggested Books and References

1. Principles of Plant Pathology, R.S. Singh, 3 rd Ed., Oxford & IBH Co., New Delhi. 1988.
2. Plant Pathology, R.S. Mehrotra,. Tata McGraw Hill Publishing Company, New Delhi. 1989.
3. Diseases of Crop Plants in India, G. Rangaswami and A. Mahadevan, Printice Hall of India Publications. 1999.
4. Essential Plant Pathology, Gail L. Schumann and Cleora J. D'Arcy C H Dickinson , J A Lucas, 2006.
5. A Text books of Modern Plant Pathology, K. S. Bilgrami and H. C. Dube, Vikas Publishing House Pvt. Ltd., 1996.
6. Plant Tumors, Arun Mishra, Today and Tomorrow's Printer and Publishers, India, 1985.
7. Plant Disease: An Advance Treatise, James G. Horsfall and Ellis B. Cowling, Second Edition, Academic Press, London, 1977

Suggested E-resources

1. Plant-wise Knowledge Bank (https://www.plantwise.org/knowledgebank/): This online platform provides access to a wealth of information on plant health, including articles, diagnostic tools, and management recommendations for various plant diseases.
2. Crop Protection Compendium (https://www.cabi.org/cpc/): This comprehensive online resource offers information on plant diseases, pests, and weeds, including their biology, identification, and management strategies.
3. American Phytopathological Society (APS) Journals (https://www.apsnet.org/publications/journals): APS publishes several journals focused on plant pathology, such as Phytopathology, Plant Disease, and Molecular Plant-Microbe Interactions. These journals provide access to research articles and scientific studies related to plant diseases.
4. eXtension (https://extension.org/): eXtension is an online platform that hosts resources developed by extension professionals and subject matter experts. It covers a wide range of topics, including plant diseases, and provides access to articles, webinars, and educational materials.
5. ResearchGate (https://www.researchgate.net/): ResearchGate is a social networking platform for researchers, offering access to scientific publications, research papers, and collaboration opportunities. You can search for specific topics related to plant diseases and find relevant research articles and studies.
6. Open Access Journals: Explore open access journals such as PLOS ONE, Frontiers in Plant Science, and BMC Plant Biology. These journals provide free access to research articles on various aspects of plant pathology and disease management.

Code of the course	**BOT7111P**
Title of the course	**Elective Botany Lab: Plant diseases and management**
Level of the Course	NHEQF Level 5.5
Credit of the Course	2
Type of the Course	DSE
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	Advance Course

Objectives of the Course

1. Acquire the skills to prepare culture media, such as Potato Dextrose Agar (PDA) and Czapek'sDox Agar, for the cultivation of fungal cultures.
2. Develop proficiency in measuring fungal dimensions, including spore size and mycelium width, using appropriate techniques and instruments.
3. Understand the relationship between diseases, their respective hosts, causal organisms, and symptomatology.
4. Master the techniques of isolating plant pathogenic fungi and bacteria, and cultivating them in pure cultures for further analysis.
5. Gain the ability to identify plant pathogenic fungi and bacteria using morphological, cultural, and biochemical characteristics, as well as diagnostic techniques.

Course Learning Outcomes

By the end of this course, students will be able to prepare culture media for fungal culture, measure fungal dimensions accurately, identify and study plant diseases with respect to host and causal organism, isolate and develop pure cultures of plant pathogenic fungi and bacteria, and effectively identify plant pathogenic microorganisms using appropriate techniques.

Syllabus (Lecture hours: 60)

1. Preparation of culture media; PDA and CzapeksDox Agar for fungal culture.
2. Measurement of fungal dimensions (Measurement of spore size, Mycelium width etc.)
3. Study of diseases with respect to host, casual organism, symptoms.
4. Isolation and pure culture development of plant pathogenic fungi and bacteria.
5. Identification of plant pathogenic fungi and bacteria.

Scheme of Examination

Exercise 1 Major	16
Exercise 2 Minor	6
Exercise 3 Major	16
Exercise 4 Minor	6
Spotting (8)	16
Record	10
Viva–Voce	10
Total	**80**

Suggested Books and References

1. "Laboratory Manual of Plant Pathology" by R.K. Thakur - This comprehensive manual provides step-by-step procedures for preparing culture media, measuring fungal dimensions, isolating and identifying plant pathogenic microorganisms, and studying diseases and symptoms.
2. "Principles of Plant Pathology Laboratory Manual" by Robert D. Raabe - This manual focuses on laboratory techniques used in plant pathology, including culture media preparation, isolation, and identification of plant pathogens, and the study of diseases and symptoms.
3. "Methods in Plant Pathology" edited by P. Narayanasamy - This book covers a wide range of laboratory methods and techniques used in plant pathology, including culture media preparation, isolation, identification, and characterization of plant pathogens, and disease study.

4. "Laboratory Guide for Plant Pathology" by J. R. Paula and S. D. Sharma - This guidebook provides practical guidance on laboratory techniques for plant pathology, including culture media preparation, microscopic measurement, isolation, identification, and disease study.
5. "Identification of Plant Pathogenic Bacteria" by N. W. Schaad et al. - This book specifically focuses on the identification and characterization of plant pathogenic bacteria, providing detailed protocols and descriptions of diagnostic tests and techniques.

Suggested E-resources

1. American Phytopathological Society (APS) Phytobiomes Journal (https://apsjournals.apsnet.org/loi/phyto): This journal publishes research articles and methods papers related to plant-microbe interactions, including laboratory techniques for studying plant pathogens and diseases.
2. Open Plant Pathology (https://openplantpathology.org/): This online platform provides open-access resources and protocols for plant pathology research, including laboratory techniques, culture media preparation, and identification of plant pathogens.
3. Molecular Plant Pathology (https://onlinelibrary.wiley.com/journal/13653059): This journal covers a wide range of topics in plant pathology, including laboratory techniques, methods, and protocols for studying plant pathogens at the molecular level.
4. Plant Disease Management Reports (https://apsjournals.apsnet.org/loi/pdmr): This resource provides practical reports and articles on the management of plant diseases, including laboratory techniques for isolating, identifying, and studying plant pathogens.
5. ResearchGate (https://www.researchgate.net/): ResearchGate is a social networking platform for researchers that offers access to scientific publications, research articles, and protocols. You can search for specific topics related to laboratory techniques in plant pathology and find relevant resources shared by researchers in the field.
6. Protocol Exchange (https://protocolexchange.researchsquare.com/): This platform hosts a collection of protocols and methods shared by scientists across various research disciplines, including plant pathology. You can search for specific laboratory techniques and find detailed protocols and procedures.

Code of the course	BOT7112T
Title of the course	**Plant Tissue Culture and Commercialization Techniques**
Level of the Course	NHEQF Level 5.5
Credit of the Course	4
Type of the Course	DSE
Delivery Type of the Course	Lectures and tutorials (40+20=60hours). The 40hours lectures for content delivery and 20 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Advance Course

Objectives of the Course

1. Understand the scope and applications of plant tissue culture and its historical development, including the contributions of key researchers.
2. Grasp the concepts of cell totipotency, cellular differentiation, and morphogenesis in the context of plant tissue culture.
3. 3. Gain knowledge of asepsis and sterilization methods, as well as the principles, construction, and operation of instruments used in plant tissue culture.
4. Learn the selection, preparation, and initiation of cultures, including callus and suspension cultures, single-cell cultures, and measurement of growth characteristics.
5. 5. Explore different pathways of micropropagation, such as enhanced axillary branching, de novo shoot bud differentiation, somatic embryogenesis, and callus organogenesis, along with their practical applications.
6. Understand the stages involved in the process of micropropagation and the production, function, and uses of secondary plant metabolites in cell cultures.
7. Familiarize oneself with available technologies for micropropagation of ornamental and fruit plants.
8. Gain knowledge of costing tissue culture raised plants, quality control measures, packaging, transport, and shipment. Learn about greenhouse technology, virus indexing, quarantine, and health aspects.
9. 9. Acquire entrepreneurial skills related to setting up a micropropagation-based industry, including conducting SWOT analysis, understanding capital and operational costs, conducting market surveys, and assessing product acceptance.
10. Learn about technology demonstration, preparation of project reports, accessing financial institutions and support, developing marketing strategies, and exploring export potential in the field of micropropagation.

Course Learning Outcomes

By the end of this course, students will be able to comprehend the historical development and scope of plant tissue culture, acquire skills in tools and techniques, demonstrate proficiency in in vitro regeneration pathways, understand applications and entrepreneurship aspects, and apply gained knowledge in the field

Syllabus

Unit-I (Lecture hours: 12)

History: Scope and applications, Historical account of development of plant tissue culture; Contributions of P. R. White, R. J. Gauthret, J. Reinert, F. C. Steward, G. Morel, E. C. Cocking, P. Maheshwari, B. M. Johri, I. K. Vasil, VimlaVasil, S. C. Maheshwari, Sipra-Guha Mukherjee. Concept of cell totipotency, cellular differentiation and morphogenesis.

Unit-II (Lecture hours: 12)

Tools and techniques: Concept of asepsis and methods of sterilization, Principle, construction and operation of instruments used in plant tissue culture- pH meter,Laminar Flow Clean Air Bench, Autoclave, Glassbead sterilizer, Lux meter, Magnetic stirrer etc. Explant selection, preparation and initiation of cultures, callus and suspension cultures, single cell culture, measurement of growth characteristics.

Unit-III (Lecture hours: 12)

***In vitro* regeneration of plants:** Different pathways of micropropagation (Enhanced axillary branching, *de novo* shoot bud differentiation, somatic embryogenesis and callus organogenesis) and their applications. Stages of micropropagation. **Secondary plant metabolites:** Production by use of cell culture

technology. Production, function and uses of Alkaloids, phenols, tannins in cultures.

Unit-IV (Lecture hours: 12)

Applications: Available technologies for micropropagation of ornamentals, fruit plants Costing of tissue culture raised plants, quality control, packaging, transport and shipment. Green house technology, Virus indexing, quarantine and health.

Unit-V (Lecture hours: 12)

Entrepreneurship: Setting-up of a micropropagation based industry- SWOT analysis, capital and operational cost, market survey and product acceptance, technology demonstration, preparation of project report, financial institutions and supports, marketing strategies, Export potential.

Suggested Books and References

1. Bhojwani S.S. and Razdan M.K. (1983). Plant Tissue Culture: Theory and Practice. Elsevier, Amsterdam.
2. RazdanM.K., 2002. Introduction to Plant Tissue Culture. Oxford & IBH.
3. Reinert J. andBajaj Y.P.S.1977. Plant Cell Tissue and Organ Culture. Springer Verlag.
4. Bhojwani S.S. 1990. Plant Tissue Culture: Application and Limitations. Elseiver.
5. Narayanswamy. 1994. Plant Cell and Tissue Culture. East-West Press.
6. Singh, B.D. (2005). Plant Breeding: Principles and Methods. Kalyani Publishers. 7thedition.
7. Ramawat KG and Arora JA (2021) Molecular Biology and plant Biotechnology, Himanshu Publications, New Delhi

Suggested E-resources

1. Plant Tissue Culture: Concepts and Laboratory Exercises (https://link.springer.com/book/10.1007/978-1-4939-6640-4): This book provides a comprehensive overview of plant tissue culture techniques, including historical development, tools and techniques, in vitro regeneration of plants, applications, and entrepreneurship aspects.
2. Plant Tissue Culture: Techniques and Experiments (https://www.taylorandfrancis.com/books/plant-tissue-culture-techniques-and-experiments): This book offers practical guidance on various aspects of plant tissue culture, including tools, techniques, in vitro regeneration pathways, secondary plant metabolites, applications, and practical exercises.
3. Plant Tissue Culture Protocols (https://www.springer.com/gp/book/9781617792629): This book provides a collection of detailed protocols and methods for various techniques used in plant tissue culture, including sterilization, explant selection, initiation of cultures, measurement of growth characteristics, and in vitro regeneration pathways.
4. National Center for Biotechnology Information (NCBI) - PubMed (https://pubmed.ncbi.nlm.nih.gov/): This database provides access to a wide range of research articles and scientific studies related to plant tissue culture. You can search for specific topics, authors, or keywords and find relevant literature.
5. ResearchGate (https://www.researchgate.net/): ResearchGate is a social networking platform for researchers, offering access to scientific publications, research papers, and protocols. You can search for specific topics related to plant tissue culture and find relevant resources shared by researchers in the field.
6. Online courses and lectures: Platforms like Coursera (https://www.coursera.org/) and edX (https://www.edx.org/) offer online courses on plant tissue culture and related topics. You can explore these platforms for courses taught by experts in the field.

Code of the course	BOT7112P
Title of the course	**Elective Botany Lab: Plant Tissue Culture and Commercialization Techniques**
Level of the Course	NHEQF Level 5.5
Credit of the Course	2
Type of the Course	DSE
Delivery Type of the Course	Practical- 60 hours (Hands-on, demo, virtual, pictorial, video observations, with main emphasis on concept, principle)
Prerequisites	Advance Course

Objectives of the Course

1. Demonstrate proficiency in explant preparation.
2. Master the skills of medium preparation for plant tissue culture.
3. Perform shoot culture technique and successfully achieve regeneration of shoots.
4. Acquire knowledge and practical experience in rooting and hardening of plantlets.
5. Conduct paper chromatography/TLC for the separation and identification of plant pigments or colored food additives.
6. Apply column chromatography techniques to effectively separate secondary metabolites.
7.

Course Learning Outcomes

By the end of this course, students will be able to demonstrate proficiency in practical techniques of plant tissue culture, including explant preparation, medium preparation, shoot culture and regeneration, rooting and hardening, as well as chromatography procedures for separation and identification of plant pigments and secondary metabolites.

Syllabus (Lecture hours: 60)

Demonstration of

1. Explant preparation.
2. Medium preparation.
3. Shoot culture technique and regeneration.
4. Rooting and hardening of plantlets
5. Paper Chromatography/TLC of plant pigment/ colored food additives (Anthocyanin/ curcuma).
6. Column chromatography procedure for separation of secondary metabolites.

Scheme of Examination

Exercise 1 Major	16
Exercise 2 Minor	6
Exercise 3 Major	16
Exercise 4 Minor	6
Spotting (8)	16
Record	10
Viva–Voce	10
Total	**80**

Suggested Books and References

1. Plant Tissue Culture Techniques and Experiments by Roberta H. Smith: This book provides detailed explanations of various plant tissue culture techniques and includes step-by-step protocols for practical experiments.
2. Plant Tissue Culture: Concepts and Laboratory Exercises by Robert N. Trigiano and Dennis J. Gray: This book covers a wide range of topics in plant tissue culture, including explant preparation, medium preparation, regeneration techniques, rooting, and practical exercises.
3. Practical Plant Tissue Culture by Colin W. Archer: This practical guidebook offers a comprehensive overview of plant tissue culture techniques and provides practical protocols for different experiments in plant tissue culture.
4. Plant Tissue Culture: An Introductory Text by Sant Saran Bhojwani and M.K. Razdan: This book provides a comprehensive introduction to the principles and practices of plant tissue

culture, including detailed protocols for various techniques and experiments.

5. Plant Tissue Culture: Techniques and Experiments by Robert M. Larkin: This book offers a practical approach to plant tissue culture, providing clear explanations and protocols for techniques such as explant preparation, medium preparation, shoot culture, rooting, and chromatography.

Suggested E-resources

1. Protocol Online (https://www.protocol-online.org/): This online resource provides a collection of protocols and methods for various techniques used in plant tissue culture. You can search for specific protocols related to explant preparation, medium preparation, regeneration techniques, rooting, and chromatography.
2. Plant Methods (https://plantmethods.biomedcentral.com/): Plant Methods is an open-access journal that publishes research articles and protocols related to plant biology and techniques, including plant tissue culture. You can search for specific articles and protocols relevant to your practical syllabus.
3. In Vitro Cellular & Developmental Biology - Plant (https://www.springer.com/journal/11627): This journal covers research and protocols related to plant tissue culture, regeneration techniques, and other aspects of in vitro plant development. You can access articles and protocols through your institution's library or individual subscription.
4. ResearchGate (https://www.researchgate.net/): ResearchGate is a social networking platform for researchers, offering access to scientific publications, research papers, and protocols. You can search for specific topics related to plant tissue culture and find relevant protocols shared by researchers in the field.
5. YouTube tutorials: YouTube hosts a variety of video tutorials related to plant tissue culture techniques. You can search for specific techniques like explant preparation, medium preparation, shoot culture, rooting, and chromatography, and find practical demonstrations and step-by-step instructions.

Code of the course	**SES7302T**
Title of the course	**Nursery and Gardening**
Level of the Course	NHEQF Level 5.5
Credit of the Course	2
Type of the Course	SEC
Delivery Type of the Course	Lectures and tutorial (20+10=30hours). The 20hours lectures for content delivery and 10 hours on diagnostic assessment, formative assessment, and subject/class activity, problem solving.
Prerequisites	Advance Course

Objectives of the Course

1. Understand the concepts, objectives, and infrastructure requirements of a nursery.
2. Gain knowledge about planting techniques, seed structure and types, seed collection and care, storage, and methods to promote seed germination.
3. Learn various methods of vegetative propagation, including selection of propagating material, rooting medium, planting methods, and hardening of plants.
4. Comprehend the definition, objectives, and scope of gardening, and identify suitable plants and pots for different types of gardens.
5. Develop practical skills in gardening operations, such as soil preparation, sowing, manuring, watering, garden maintenance, and management of pests and diseases.

Course Learning Outcomes

1. Understand the principles and practices of nursery management, including site selection, plant and soil types, and seasonal activities.
2. Acquire knowledge of seed structure, collection, storage, and methods to promote seed germination.
3. Demonstrate proficiency in vegetative propagation methods, including selection of propagating material, rooting, and planting techniques.
4. Apply concepts of gardening, including garden types, suitable plants, and pots for different settings.
5. Develop practical skills in gardening operations, such as soil preparation, sowing, plant maintenance, and management of pests and diseases.

Syllabus

Unit I(Lecture hours: 6)

Nursery - Definition, Objective, Infrastructure Required, Other Requirements Selection of Right Site, Plants and Soil Types, Planning And Making a Calendar For The Seasonal Activity, SWOT Analysis.

Unit II (Lecture hours: 6)

Planting, Seed Structure and Types, Collection of Seeds, Care of Seeds, Seed Storage, Seed Dormancy Methods to Promote Seed Germination, Seed Testing and Certification.

Unit III(Lecture hours: 6)

Propagation Methods of Vegetative Propagules, Selection of Season and Plant, Treatments to Be Given to The Propagating Material, Rooting Medium, and Methods of Planting of Propagules, Hardening of Plants

Unit IV(Lecture hours: 6)

Gardening - Definition, Objectives and Scope, Types of Gardens, Pots and Plants Suitable For Different Types of Gardens, Home, Terrace and Kitchen Gardens.

Unit V(Lecture hours: 6)

Gardening Operations; Soil Laying, Sowing of Plants In Garden Soil and Pots, Manuring, Watering Maintainence of The Garden, Management of Pests and Diseases.

Suggested Books and References

1. The Well-Tempered Garden by Christopher Lloyd: This classic gardening book provides insights into various aspects of gardening, including garden design, plant selection, soil management, and garden maintenance.
2. The Complete Book of Plant Propagation by Graham Clarke and Alan Toogood: This comprehensive guide covers all aspects of plant propagation, including seed propagation, vegetative propagation, and nursery management.
3. The Well-Designed Mixed Garden: Building Beds and Borders with Trees, Shrubs, Perennials, Annuals, and Bulbs by Tracy DiSabato-Aust: This book focuses on garden design principles and offers practical advice on creating mixed gardens with a variety of plant types.
4. The New Organic Grower, 3rd Edition: A Master's Manual of Tools and Techniques for the Home and Market Gardener by Eliot Coleman: This book provides valuable insights into organic gardening practices, including soil management, crop rotation, pest and disease management, and season extension techniques.
5. The Complete Idiot's Guide to Seed Saving and Starting by Sheri Ann Richerson: This beginner-friendly guide covers the basics of seed saving, starting seeds, and plant propagation, providing step-by-step instructions and tips for successful gardening.

Suggested E-resources

1. The Royal Horticultural Society (RHS) website: The RHS website (https://www.rhs.org.uk/) offers a wealth of information on gardening, plant selection, gardening techniques, and nursery management. It provides articles, guides, and resources for both beginners and experienced gardeners.
2. University extension websites: Many universities and agricultural extensions have online resources dedicated to gardening and nursery management. Examples include the Cooperative Extension System (https://extension.org/) in the United States and the Gardening Australia website (https://www.abc.net.au/gardening/) for Australian gardeners.
3. Gardening forums and communities: Online gardening forums and communities, such as GardenWeb (https://forums.gardenweb.com/), Gardeners' World Forum (https://www.gardenersworld.com/forum/), and Reddit's r/gardening (https://www.reddit.com/r/gardening/), provide opportunities to connect with experienced gardeners, ask questions, and share insights.
4. YouTube channels: YouTube hosts numerous gardening channels that offer instructional videos, gardening tips, and demonstrations. Channels like "Garden Answer" (https://www.youtube.com/user/gardenanswer), "Epic Gardening" (https://www.youtube.com/c/EpicGardening), and "Gardener's World" (https://www.youtube.com/c/GardenersWorld) provide valuable content for gardeners.
5. Online gardening courses: Platforms like Udemy (https://www.udemy.com/), Coursera (https://www.coursera.org/), and Skillshare (https://www.skillshare.com/) offer online courses on gardening and nursery management. These courses provide structured learning with video lessons, assignments, and quizzes.

Table 1: Proposed Chemistry Courses for CBCS in B.Sc. Program: Semester wise course types, Course codes, Course title, Delivery type, Workload, Credits, Marks of Examination, and Remarks if any.

Level	Semester	Course Type	Course Code	Course Title	Delivery type per week			Total hours	Credits	Total Credits	Internal marks	EoSE Marks	Max. Marks	Remarks
					L	T	P							
5	I	DCC	CHE5000T	Chemistry-I: Atomic Structure, Chemical Bonding and Stereochemistry	L	T	-	60	4	6	20	80	100	
			CHE5000P	Chemistry Lab-1: Chemical Analysis Lab-I	-	-	P	60	2		20	80	100	
		AECC	AES5200T		L	T		30	2	2	20	80	100	
	II	DCC	CHE5001T	Chemistry-II: Thermodynamics, Hydrocarbons and Halides	L	T	-	60	4	6	20	80	100	
			CHE5001P	Chemistry Lab-2: Chemical Analysis Lab-II	-	-	P	60	2		20	80	100	
		AECC	AES5201T		L	T		30	2	2	20	80	100	
Exit with Certificate in Science														
6	III	DCC	CHE6002T	Chemistry-III: s, p, d, f block elements, Coordination Chemistry and Organic Compounds of Oxygen	L	T	-	60	4	6	20	80	100	
			CHE6002P	Chemistry Lab-3: Chemical Analysis Lab-III	-	-	P	60	2		20	80	100	
		SEC-1		Communicative English	L	T		30	2	2	20	80	100	
	IV	DCC	CHE6003T	Chemistry-IV: Chemical kinetics, Electrochemistry, Organic Compounds of Nitrogen, Heterocycles	L	T	-	60	4	6	20	80	100	
			CHE6003P	Chemistry Lab-4:Chemical Analysis Lab-IV	-	-	P	60	2		20	80	100	
		SEC-2	SES5320T	Chemistry Laboratory Preparations	L	T		30	2	2	20	80	100	

Exit with Diploma in Science														
7	V	**Select anyone of the following Discipline specific Elective (DSE) Courses in V and VI semester**												
		DSE	CHE7300T	1. Spectroscopy and Instrumental Techniques	L	T	-	60	4	6	20	80	100	
			CHE7300P	1. Elective Chemistry Lab-I	-	-	P	60	2		20	80	100	
		DSE	CHE7301T	2. Green and Sustainable Chemistry	L	T	-	60	4	6	20	80	100	
			CHE7301P	2. Elective Chemistry Lab-II		-	P	60	2		20	80	100	
		DSE	CHE7302T	3. Polymer Chemistry	L	T	-	60	4	6	20	80	100	
			CHE7302P	3. Elective Chemistry Lab-III	-	-	P	60	2		20	80	100	
		SEC-3	SES5321T	Food Preservation and Adulteration	L	T		30	2	2	20	80	100	
	VI	DSE	CHE7303T	4. Organometallic Chemistry and Catalysis	L	T	-	90	6 (5+1)	6	20	80	100	
		DSE	CHE7304T	5. Molecules of Life	L	T	-	90	6 (5+1)	6	20	80	100	
		DSE	CHE7305T	6. Advanced Physical Chemistry	L	T		90	6 (5+1)	6	20	80	100	
		SEC-4	SES5322P	Water Pollution and Analysis			P	30	2	2	20	80	100	
Exit with Graduation Degree in Science (B.Sc.)														

DCC- Discipline Centric Compulsory Course (001 to 099); **DSE**- Discipline Specific Core Course (100 to 199)

AECC- Ability Enhancement Compulsory Course (English/MIL Communication/ Environmental Science) (201 to 299); **SEC**- Skill Enhancement Course (301 to 399)

The code has eight places. XYZ(subject name)Level(5/6/7)DCC/DSE/AEC/SEC(3 digits)T/P

If an AECC course is offered by commerce: AEC5201T; If an AECC course is offered by Science: AES5201T; If an AECC course is offered by Arts/Humanities/…..: AEA5201T

If an SEC course is offered by commerce: SEC53XXT; If an SEC course is offered by Science: SES63XXT; If an SEC course is offered by Arts/Humanities/…..: SEA53XXT

Semester I

DCC Chemistry I: CHE5000T

Atomic Structure, Chemical Bonding and Stereochemistry

Code of the Course: CHE5000T

Title of the Course: Atomic Structure, Chemical Bonding and Stereochemistry

Level of the Course: NHEQF Level 4.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Chemistry courses of Central Board of Secondary Education (CBSE) or 10+2 level.

Objective of the Course: This course provides an introduction to the fundamental concepts of atomic structure, chemical bonding, and organic chemistry. It covers topics such as atomic models, covalent bonding, metallic bonding, ionic bonding, and organic chemistry and stereochemistry basics. The course aims to develop student's understanding of the fundamental principles underlying chemical bonding and the structure of atoms and molecules.

Learning Outcomes: By the end of this course, students will be able to -

1. Understand the fundamental principles of atomic structure, including the arrangement of subatomic particles and the organization of electrons within an atom.
2. Describe and explain the different types of chemical bonds, including covalent, metallic, and ionic bonds, and understand the factors that influence their formation.
3. Understand the atomic structure and chemical bonding knowledge to predict the properties and behaviors of different elements and compounds.
4. Understand the basics of organic chemistry, including the structure, nomenclature, and properties of organic compounds.
5. Describe the principles of stereochemistry, including the three-dimensional arrangement of atoms in molecules and the effects of stereochemistry on chemical reactivity.
6. Apply stereochemical concepts to predict the behavior of chiral molecules and their interactions with other compounds.
7. Develop critical thinking and problem-solving skills through the application of theoretical concepts to real-world examples and chemical experiments.
   Overall, the course aims to provide students with a solid foundation in atomic structure, chemical bonding, and organic chemistry, preparing them for further studies in chemistry and related disciplines.

Syllabus:

UNIT I

Atomic structure: Bohr's theory and its limitations, dual behavior of matter and radiation, de Broglie's relation, Heisenberg's uncertainty principle, hydrogen atom spectra, radial and angular wave functions, probability distribution curves, shapes of s, p, d orbitals, nodal planes time independent Schrodinger equation, significance of ψ and ψ^2, Schrödinger equation for hydrogen atom.Significance of quantum numbers, orbital angular momentum, quantum numbers, rules for filling electrons in various orbitals, electronic configurations of the atoms, stability of half-filled and fully filled orbitals, concept of exchange energy, relative energies of atomic orbitals, anomalous electronic configurations.

(12 Lecture hours)

UNIT II

Covalent Bond: Valance bond approach of covalent bond, shapes of some inorganic molecules and ions on the basis of VSEPR theory, the concept of hybridization with suitable examples of linear, trigonal planar, tetrahedral, trigonal pyramidal, trigonal bipyramidal, octahedral, and square planar arrangements. Concept of resonance and resonating structures in various inorganic compounds.

Metallic bond: Introduction, free electron theory, concept of band theory, importance of metallic bond, properties of semiconductors, insulators with examples.

(12 Lecture hours)

UNIT III

Ionic Bonding: General characteristics of ionic bonding, energy considerations in ionic bonding, lattice energy, solvation energy, their importance in the context of stability and solubility of ionic compounds, statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power, and polarizability, Fajan's rules, ionic character in covalent compounds, dipole moment and percentage ionic character.

Weak Chemical Interactions: van der Waals forces, ion-dipole forces, dipole-dipole interactions, instantaneous dipole-induced dipole interactions, induced dipole interactions, repulsive forces, hydrogen bonding, theories of inter- and intra-molecular hydrogen bonding, valence bond treatment, effects of chemical forces on melting point, boiling point and solubility.

(12 Lecture hours)

UNIT IV

Fundamentals of Organic Chemistry: Covalent bond, hybridization and shapes of molecules, geometry and structure of sp^3, $sp^2$and sp hybridized orbitals, influence of hybridization on bond properties.

Electronic displacements: Inductive, electromeric, resonance and field effect. Hyperconjugation, concept of dipole moment, homolytic and heterolytic fission, curved arrow notation, electrophiles and nucleophiles, types of organic reactions.

Types of reactive intermediates: Generation, shape and relative stability of different reactive intermediates namely carbocation, carbanion, free radicals, nitrene, carbene and benzyne.

Aromaticity: Introduction, Electronic structure and Huckel's rule, aromaticity in carbocyclic, heterocyclic, benzenoid, non-benzenoid, anti-aromatic and non-aromatic compounds.

(12 Lecture hours)

UNIT V

Stereochemistry: Concept and significance of isomerism, structural isomersim and stereoisomerism, types of stereoisomerism, geometrical and optical isomerism.

Chirality: Concept of chirality (chirality upto two carbon atoms), stereogenic centre, optical activity, Cahn-Ingold-Prelog (CIP) rules and priority assignments, enantiomers, diastereomers and meso compounds.

Nomenclature systems: Cis-trans nomenclature, E/Z nomenclature, R/S nomenclature (up to two chiral carbon atoms), threo and erythro, D and L nomenclature

Conformational isomerism: Conformations with respect to ethane, butane and cyclohexane.Interconversion of Wedge formula, Newmann, Sawhorse and Fischer representations.

(12 Lecture hours)

E-resources:

1. https://www.britannica.com/science/atom
2. https://www.youtube.com/watch?v=OH-aSu-rWgk
3. https://collegedunia.com/exams/metallic-bonds-properties-examples-and-importance chemistry-articleid-1747

4. https://byjus.com/jee/covalent-bond/
5. https://ncert.nic.in/textbook/pdf/kech104.pdf
6. https://bio.libretexts.org/Bookshelves/Microbiology/Microbiology_(Boundless)/02%3A_Chemistry/2.02%3A_Chemical_Bonds/2.2.02%3A_Colvalent_Bonds_and_Other_Bonds_and_Interaction
7. https://gtu.ge/Agro-Lib/McMurry%20J.E.%20-%20Fundamentals%20of%20Organic%20Chemistry,%207th%20ed.%20-%202010.pdf
8. https://faculty.ksu.edu.sa/sites/default/files/1-chem_109_introduction_modified_0.pdf
9. https://www.uou.ac.in/lecturenotes/science/MSCCH-17/CHEMISTRY%20LN%201%20STERIOCHEMISTRY.pdf

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
4. Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
5. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in InorganicChemistry*, John Wiley & Sons.
6. Huheey, J.E., Keiter, E.A., Keiter, R.L. &Medhi, O.K. *Inorganic Chemistry:Principles of Structure and Reactivity*, Pearson Education India, 2006.
7. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, JohnWiley & Sons (2014).
8. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning IndiaEdition, 2013.
9. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, NewDelhi (1988).
10. Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education,2000.
11. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
12. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
13. Bahl, A. &Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

Semester I

Chemistry Lab1: CHE500P

Chemical Analysis Lab-I

Code of the Course: CHE500P

Title of the Course: Chemical Analysis Lab-I

Level of the Course: NHEQF Level 4.5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. Inorganic Chemistry **40 Marks**

Inorganic salts analysis: Semi-micro qualitative analysis using H_2S of mixtures - not more than four ionic species (two anions and two cations and excluding insoluble salts) out of the following:

Cations: NH_4^+, Pb^{2+}, Ag^+, Bi^{3+}, Cu^{2+}, Cd^{2+}, Sn^{2+}, Fe^{3+}, Al^{3+}, Co^{2+}, Cr^{3+}, Ni^{2+}, Mn^{2+}, Zn^{2+},Ba^{2+}, $Sr^{2+,}$ Ca^{2+}

Anions: CO_3^{2-}, S^{2-}, SO_3^{2-}, $S_2O_3^{2-}$, NO_3^-, CH_3COO^-, Cl^-, Br^-, I^-, NO_2^-,SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, $C_2O_4^{2}$, F^-(Spot tests should be carried out wherever feasible)

2. Organic Chemistry: Purification of organic compounds: **20 Marks**

a) **Crystallization:**

- Phthalic acid from hot water
- Acetanilide from boiling water
- Benzoic acid from water
- Decolourisation and crystallization using charcoal
- Decolorisation and crystallization of impure naphthalene (100g of naphthalene mixed with 0.3 g of Congo Red using 1 g decolorising carbon) from ethanol.

b) **Sublimation**:

- Camphor, Naphthalene, Phthalic acid and succinic acid
- Mixed melting point determination

- Urea-Cinnamic acid mixture of various compositions (1:4, 1:1, 4:1)

c). Identification of functional group in given organic compounds *i.e.* Carboxylic acid, Phenols, Alcohols, Carbohydrates, Aldehydes, Ketones, Nitro compounds, Amino compounds, Anilides, Amides, Esters, Thioamides, Hydrocarbons and halogen containing compounds

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. https://byjus.com/chemistry/salt-analysis/
2. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXII/chemistry/lelm107.pdf
3. https://byjus.com/chemistry/crystallization/
4. https://chem.libretexts.org/Courses/Los_Medanos_College/Chemistry_6_and_Chemistry_7_Combined_Laboratory_Manual/Experiment_727_Organic_Compound_Functional_Groups__1_2_0
5. https://pubs.acs.org/doi/10.1021/ac60052a036

Reference Books:

1. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
2. Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.
5. Advanced Practical Physical Chemistry; Eighteenth Edition J.B.Yadav; Goel Publishing House, Meerut, 2015.
6. Practical Chemistry,Ameta, Punjabi &Ameta, Himanshu Publications, New Delhi, 2020.

Semester II

DCC Chemistry II: CHE5001T

Thermodynamics, Hydrocarbons and Halides

Code of the Course: CHE5001T

Title of the Course: Thermodynamics, Hydrocarbons and Halides

Level of the Course: NHEQF Level 4.5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) course for chemistry discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Chemistry courses of central board of secondary education or equivalent.

Objective of the Course: To learn the basic principles involved in energetic of chemical reactions, role of enthalpy in chemical reactions and the behaviour of electrolytes in solution with the concepts of pH measurements. This course also provides knowledge about alkanes, alkenes, alkynes, alkyl and aryl halides.

Learning Outcomes: By the end of this course, students will be able to-

1. Understand the principles and definitions of thermochemistry, first law of thermodynamics and Joule's law.
2. Calculate standard enthalpies of formation and understand the concept of a standard state. Calculate bond energy, bond dissociation energy, and resonance energy using thermochemical data.
3. Understand the second law of thermodynamics and its different statements; Carnot cycle and its efficiency; entropy.
4. Comprehend the concepts of free energy and work function and analyze their variations with pressure, volume, and temperature. Apply the Clausius-Clapeyron equation and its applications.
5. Differentiate between strong, moderate, and weak electrolytes. Determine the degree of ionization and factors affecting, ionization constants and ionic product of water.
6. Analyze the ionization of weak acids and bases and understand the pH scale. Apply the common ion effect and calculate hydrolysis constants and pH for different salts. Understand buffer solutions and solve problems related to solubility and solubility product.
7. Understand the functional group approach for the preparation and reactions of alkanes, alkenes, and alkynes. Identify various methods for the preparation of alkanes, alkenes, and alkynes.
8. Explain the mechanisms and outcomes of various reactions in aliphatic hydrocarbons.
9. Understand the preparation methods for alkyl halides from alkenes and alcohols.

10. Analyze the reactions of aryl halides, including aromatic nucleophilic substitution and the effect of nitro substituents. Differentiate between different types of nucleophilic substitution reactions (S_N1, S_N2 and S_Ni).

Syllabus:

UNIT I

Chemical Energetics-I: Review of thermodynamics and firstlaw of thermodynamics, Joule'slaw, Joule-Thomson coefficient and inversion temperature, important principles and definitions of thermochemistry,concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution,calculation of bond energy, bond dissociation energy and resonance energy fromthermo-chemical data,variation of enthalpy of a reaction with temperature - Kirchhoff's equation.

(12 Lecture hours)

UNIT II

Chemical Energetics-II: Second law of thermodynamics, different statements of the law, Carnot cycle and its efficiency, Carnot theorem, Concept of entropy, entropy as a state function, entropy as a function of V & T, entropy as a function of P & T, entropy change in physical processes, third law of thermodynamics, calculation of absolute entropies of substances,free energy(G), work function(A), variation of G and A with P,V and T. Reaction isotherm and reaction isochore, Clausius-Claperyron equation and applications.

(12 Lecture hours)

UNIT III

Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water,ionization of weak acids and bases, pH scale, common ion effect,salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts,buffer solutions,solubility and solubility product of sparingly soluble salts and its applications.

(12 Lecture hours)

UNIT IV

Alkanes: Preparation, physical properties and chemical reactions, mechanism of free radical substitution with reference to halogenation, orientation, reactivity and selectivity.

Cycloalkanes: Nomenclature, preparation, chemical reactions, Baeyer strain theory and its limitation, ring strain in small rings (cyclopropane and cyclobutane), theory of strainless rings, banana bond in cyclopropane.

Alkene: Introduction of alkenes, preparation, physical properties and relative studies of alkenes, their preparation with reference to mechanisms of dehydration of alcohols and dehydrohalogenation of alkyl halides, regioselectivity in alcohol dehydration, Saytzeff's rule, Hofmann elimination. Chemical reactions of alkenes-mechanisms involved in hydrogenation, electrophilic and free radical additions, Markownikoff's rule, hydroboration-oxidation, oxymecuration-demercuration, epoxidation, ozonolysis, hydration, hydroxylation, oxidation with $KMnO_4$, polymerization of alkenes, substitution at the allylic and vinylic positions of alkene, industrial applications of ethylene and propene.

Dienes: Nomenclature, classification, isolated, conjugated and cumulated dienes, structure of allenes and butadiene, preparation, chemical reactions- polymerization, 1,2- and 1,4- additions, Diels-Alder reaction.

Alkynes: Nomenclature, preparation, physical properties and chemical reactions, mechanism of electrophilic and nucleophilic addition reactions, hydroboration, metal ammonia reductions, oxidation and polymerization.

(12 Lecture hours)

UNIT V

Alkyl and Aryl Halides: Nomenclature and classification of alkyl halides, preparation, physical propertiesand chemical reactions, mechanismof nucleophilic substitution (S_N1, S_N2 and S_Ni)reactions, hydrolysis, nitrite and nitro formation, nitrile and isonitrile formation. Williamson'sether synthesis, haloform reaction, freons.Preparation of aryl halides, nuclear and side chain reactions, addition-elimination and elimination-addition reactions, mechanism of nucleophilic aromatic substitution reactions.Relative reactivities of alkyl halides v/s allyl, vinyl, and aryl halides, synthesis and uses of DDT and BHC.

(12 Lecture hours)

E-resources:

1. https://byjus.com/physics/thermodynamics/
2. https://www.chemguide.co.uk/physical/energetics/basic.html
3. https://chem.libretexts.org/Courses/University_of_South_Carolina__Upstate/USC_Upstate%3A_CHEM_U109__Chemistry_of_Living_Things_(Mueller)/07%3A_Energy_and_Chemical_Processes/7.6%3A_Energetics_and_Kinetics
4. https://wou.edu/chemistry/courses/online-chemistry-textbooks/ch105-consumer-chemistry/ch105-chapter-8/

5. https://byjus.com/chemistry/preparation-alkyl-halides/#:~:text=The%20key%20difference%20between%20alkyl,between%20carbon%20atoms%20forming%20rings).

Reference Books:

1. A Text Book of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2002.
2. The Elements of Physical Chemistry; P.W. Atkins; Oxford University Press, 1996.
3. Physical Chemistry; Seventh Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 1987.
4. Physical Chemistry Through Problems S.K. Dogra and S.Dogra; Wiley Eastern Ltd, New Delhi, 2001.
5. Physical Chemistry, Suresh Ameta, RakshitAmeta, Hemleta; Himanshu Publications, New Delhi, 2020
6. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
7. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
8. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
9. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
10. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
11. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.

Semester II

Chemistry Lab-2: CHE5001P

Chemical Analysis Lab-II

Code of the Course: CHE5001P

Title of the Course: Chemical Analysis Lab-II

Level of the Course: NHEQF Level 4.5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. **Potentiometric & Conductometric titrations** **40 Marks**
   a) Titration of acetic acid against NaOH potentiometrically.
   b) Determination of solubility and solubility product of a sparingly soluble salt (leadsulfate/ barium sulfate/ silver chloride/ calcium sulfate/ lead chromate) by conductance measurement.

   Thermochemistry
   a) Determination of solubility of benzoic acid at different temperatures and determine ΔH of the dissolution process.
   b) Determine enthalpy of neutralization of a weak acid/weak base vs strong base / strong acid.
   c) Determine the enthalpy of the solution of solid $CaCl_2$ and calculate the lattice energy using Born-Haber Cycle.

   Preparation of buffer solutions:
   a) Sodium acetate-acetic acid
   b) Ammonium chloride-ammonium hydroxide
   c) Measurement of the pH of buffer solutions and comparison of the values withtheoretical values.
2. **Identification of organic compounds through functional group analysis and preparation of their derivatives:** **20 Marks**
   a) Hydrocarbons: Benzene, Toluene, Naphthalene, Anthracene

b) Carboxylic acid: Oxalic, Tartaric, Citric, Benzoic, Succinic, Cinnamic, Salicylic, Phthalic acids

c) Alcohols: Methyl, Ethyl, Propyl, Isopropyl, *n*-butyl, isobutyl, tertbutyl alcohols

d) Phenols: Phenol, Resorcinol, Hydroquinone, *p*-Cresol, α-Naphthol, β-Naphthol

e) Carbohydrates: Glucose, Fructose, Cane sugar, Starch

f) Aldehydes: Formaldehyde, Acetaldehyde, Benzaldehyde

g) Ketones: Acetone, Ethyl methyl ketone, Acetophenone, Benzophenone

h) Esters: Methyl acetate, Ethyl acetate

i) Halogen Containing Compounds: Chloroform, Chloral hydrate, Iodoform, Chlorobenzene, *p*-Dichlorobenzene, *p*-Dibromobenzene

j) Nitro compounds: Nitrobenzene, *p*-Nitrotoluene, *m*-Dinitrobenzene

k) Amino compounds: Aniline, *o*-, *m*- and *p*-Toluidine, α-Naphthylamine and β-Naphthylamine

l) Anilides: Acetanilide and Benzanilide

m) Amides: Acetamide, Benzamide, Urea

n) Thioamide: Thiourea

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. **https://chem.libretexts.org/Courses/Los_Medanos_College/Chemistry_6_and_Chemistry_7_Combined_Laboratory_Manual/Experiment_727_Organic_Compound_Functional_Groups__1_2_0**
2. **https://pubs.acs.org/doi/10.1021/ac60052a036**
3. **https://byjus.com/jee/buffer-solutions/**
4. **https://www.youtube.com/watch?v=Bfo6vccc0KY**
5. **https://www.youtube.com/watch?v=VzMiTg0Qz3g**

Reference Books:

1. Advanced Practical Physical Chemistry; Eighteenth Edition J.B.Yadav; Goel Publishing House, Meerut, 2015.
2. Practical Chemistry,Ameta, Punjabi &Ameta, Himanshu Publications, New Delhi, 2020.

Semester-III

DCC Chemistry III: CHE6002T

s, p, d, f Block Elements, Coordination Chemistry and Organic Compounds of Oxygen

Code of the Course: CHE6002T

Title of the Course: s, p, d, f Block Elements, Coordination Chemistry and Organic Compounds of Oxygen

Level of the Course: NHEQF Level 5

Credit of the Course: 04

Type of the Course: DCC

Delivery type of the course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Foundation and introductory courses of inorganic and organic chemistry

Objective of the course: This course is mainly focuses on basic facts and concepts of chemical bonding, theories of covalent bonding including VBT and MOT. Basics of ionic solids, its structures, lattice defects, metallic bond and weak interactions, coordination bond theories of coordination bond (VBT and CFT). General properties of s-block elements, p-block elements, 3d transition metals and their important chemical reactions. This course also comprises classification, nomenclature, preparation and important chemical reactions of alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives, with special emphasis on naming reactions.

Learning outcomes: By the end of this course, students will be able to:

1. Understand various properties of s-block elements, complexation and solvation tendencies of s-block elements and their role in biological systems.
2. Know about basic chemistry, physical and chemical properties of p-block elements and preparation and structure of compounds of p-block elements.
3. Understand the facts of 3d transition elements covering general properties and important chemical reactions.
4. Understand the facts of lanthanides and actinides covering general properties and important chemical reactions and their separation.
5. Explain the concept of coordination bond, nomenclature, isomerism in coordination compounds, valance bond theory, hybridization, crystal field theory, magnetic proprieties and colour of the complexes.
6. Explain the preparation and chemical reactions of alcohols, phenols, aldehydes and ketones, carboxylic acid and their derivatives

7. Explain the naming reactions like; Fries rearrangement, Clasien rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer Manasse reaction, Reimer-Tiemann reaction, Benzoin, Aldol, Perkin and Knoevenagel condensations, Wittig reaction, Mannichreaction, Cannizzaro reaction. Baeyer-Villigeroxidation, Meerwein-Ponndorf-Verley, Clemmenson, Wolff-Kishner, reductions, Hell-Volhard-Zelinsky reaction, Hofmann-bromamide reaction.

Syllabus:

UNIT I

s-block elements: General characteristics, diagonal relationships and anomalous behavior of first member of each group. Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water, common features of hydrides, oxides, carbonates, nitrates, sulphates of alkali and alkaline earth metal compounds, complex formation tendency and solutions of alkali metals in liquid ammonia.

p-block elements: Periodicity in properties of p-block elements with special reference to atomic and ionic radii, ionization energies, electron-affinity, electronegativity, allotropy, inert pair effect, catenation including diagonal relationship. Structure, bonding and properties of hydrides of group 13, oxides of phosphorus and sulphur, oxoacids of phosphorus, halides of silicon and phosphorus, borazine, silicates, silicones.

(12 Lecture hours)

UNIT II

Transition elements (3d series): General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states.

Lanthanides and actinides: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides and actinides (ion exchange method only).

(12 Lecture hours)

UNIT III

Coordination chemistry: Introduction, classification of ligands, chelation, polynuclear complexes, Werner's coordination theory, IUPAC nomenclature of coordination compounds and structural and stereoisomerism in complexes with coordination numbers 4 and 6.Valence bond theory (VBT), Inner and outer orbital complexes of 3d series and limitations of VBT.

Crystal field theory: Main postulates, crystal field splitting of d-orbitals in octahedral and tetrahedral complexes and square planner complexes, factors affecting the magnitude of Δ_o, calculation of crystal field stabilization energy, strong field and weak field ligands, spectrochemical series, distortion of octahedral complexes and Jahn-Teller theorem.

(12 Lecture hours)

UNIT IV

Alcohols: Classification, nomenclature, preparation and important chemical reactions of monohydric, dihydric (glycol) and trihydric (glycerol) alcohols.

Phenols: Nomenclature, structure and bonding, preparation of phenols, physical properties, acidic character, comparative acidic strength of alcohols and phenols and stability of phenoxide ion. Reactions of phenol-electrophilic aromatic substitution(acylation and carboxylation), Fries rearrangement, Clasien rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Lederer Manasse reaction and Reimer-Tiemann reaction with their mechanism.

Aromatic aldehydes and ketones: Preparation,physical propertiesand chemical reactions of aromatic aldehydes and ketones. Mechanism of nucleophilic addition to carbonyl group with particular emphasis on Benzoin, Aldol, Perkin and Knoevenagel condensations, condensation with ammonia and its derivatives, Wittig reaction, Mannich reaction, Cannizzaro reaction, Baeyer-Villiger oxidation, Meerwein-Ponndorf-Verley, Clemmenson, Wolff-Kishner, $LiAlH_4$, and $NaBH_4$ reductions, halogenation of enolizable ketones.

(12 Lecture hours)

UNIT V

Carboxylic acids: Nomenclature, structure and bonding, acidity of carboxylic acids, effects, substituents on acid strength. Preparation, physical properties and chemical reactions of monocarboxylic, dicarboxylic acids (oxalic, malonic, succinic and phthalic acid), substituted acids (halo acids), hydroxy acids (lactic, malic, salicyclic, tartaric and citric acid), unsaturated acids (acrylic and cinnamic acid).

Carboxylic acids derivatives: Preparation, properties and uses of acid halides, amides, anhydrides and esters, interconversion of acid derivatives by nucleophilic acyl substitution, mechanism of Hell-Volhard-Zelinsky reaction, Hofmann-bromamide reaction and ester hydrolysis.

(12 Lecture hours)

E-resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. https://www.accessscience.com/content/book/9780071811118/chapter/chapter16
3. https://www.angelo.edu/faculty/kboudrea/index_2353/Chapter_03_2SPP.pdf
4. https://www.egyankosh.ac.in/bitstream/123456789/59594/1/Unit19.pdf
5. https://www.geo.utexas.edu/courses/376m/coord_chem.htm

Reference Books:

1. Lee, J.D. *Concise Inorganic Chemistry* ELBS, 1991.
2. Cotton, F.A., Wilkinson, G. &Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.
3. Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
4. Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
5. Graham Solomon, T.W., Fryhle, C.B. &Dnyder, S.A. *Organic Chemistry*, John Wiley & Sons (2014).
6. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.
7. Sykes, P. *A Guidebook to Mechanism in Organic Chemistry*, Orient Longman, New Delhi (1988).
8. Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
9. Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
10. Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry*, S. Chand, 2010.
11. Barrow, G.M. *Physical Chemistry* Tata McGraw-Hill (2007).
12. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
13. Kotz, J.C., Treichel, P.M. & Townsend, J.R. *General Chemistry* Cengage Learning India Pvt. Ltd., New Delhi (2009).
14. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
15. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
16. Shriver, D.F. & Atkins, P.W. *Inorganic Chemistry*, Oxford University Press.
17. Wulfsberg, G. *Inorganic Chemistry*, Viva Books Pvt. Ltd.
18. Rodgers, G.E. *Inorganic & Solid State Chemistry*, Cengage Learning India Ltd., 2008.

Semester III

Chemistry Lab 3: CHE6002P

Chemical Analysis Lab-III

Code of the Course: CHE6002P

Title of the Course: Chemical Analysis Lab-III

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. **Binary mixtures** **30 Marks**

   Separation and identification of organic compounds in solid-solid binary mixture

2. **Surface tension and viscosity measurement** (organic solvents excluded). **30 Marks**

   a) Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer.

   b) Study of the variation of surface tension of a detergent solution with concentration.

   c) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.

   Volumetric analysis

   a) Estimation of Cu (II) ions iodometrically using $Na_2S_2O_3$.

   b) Estimation of (i) Mg^{2+} or (ii) Zn^{2+} by complexometric titrations using EDTA.

   c) Estimation of total hardness of a given sample of water by complexometric titration.

   d) Determination of the strength of ferrous ammonium sulphate (Mohr's salt) solution.

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. https://soe.unipune.ac.in/studymaterial/ashwiniWadegaonkarOnline/mixturechartfinalwatermark.pdf
2. https://www.youtube.com/watch?v=cPdRGbD31-A

3. https://davjalandhar.com/dbt/chemistry/SOP%20LabManuals/B.Sc.%20BT%20SEM%20III.pdf
4. https://pdfkeys.com/download/2588723-A%20Volumetric%20Analysis%20Complexometric%20Titration%20Of.pdf

Reference Books:

1. Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011)
2. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, Pearson Education, 2012.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., *Textbook of Practical Organic Chemistry*, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry* Orient-Longman, 1960.

Semester IV

DCC Chemistry IV: CHE6003T

Chemical Kinetics, Electrochemistry, Organic Compounds of Nitrogen, Heterocycles

Code of the course: CHE6003T

Title of the course: Chemical kinetics, Electrochemistry, Organic Compounds of Nitrogen, Heterocycles

Level of the Course: NHEQF Level 5

Credit of the Course: 4

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline/Subject

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Foundation and introductory courses

Objective of the Course: To know about rate of reaction, factors affecting, theories of chemical kinetics, conductance, its types, theory of weak and strong electrolytes, electrode potential, cell EMF, electrochemical cells, etc. This course also provides the knowledge aboutnitro compounds, amines (Aliphatic and Aromatic), diazzonium salts, heterocyclic compounds (furan, thiophene, pyrrole, and pyridine) and their characteristic reactions.

Learning Outcomes: By the end of this course, students will be able to-

1. Understand the scope of chemical kinetics, factors affecting rate of reaction, integrated rate law for different order reactions, theories of chemical kinetics
2. Conductance, applications of conductivity measurements, Conductometric titrations.
3. Electrolytic and electrochemical cell, electrochemical series, standard electrode potential.
4. Preparation and chemical reactions of aliphatic and aromatic nitro compounds, amines, and diazonium compounds
5. Introduction and basic Nomenclature of heterocyclic compounds, method of synthesis, mechanistic view of various reactions of pyrrole, furan, thiophene and pyridine

Syllabus:

UNIT I

Chemical Kinetics: Introduction and its scope, rate of a reaction, factors influencing rate of reaction; mathematical characteristics of simple chemical reactions- zero order, first order, second order, pseudo order, half life and mean life, determination of the order of reaction-differential, integration, half life period and isolation methods, radioactive decay as a first order phenomenon. Theories of chemical kinetics- Arrhenius equation and activation energy,

collision theory and transition state theory, introduction and type of catalysis, specificity and selectivity, enzyme catalysis and Michalis-Menten mechanism.

UNIT II

Electrochemistry-I: Charge transport, conductance in metals and electrolyte solutions, specific conductance and equivalent conductance, measurement of equivalent conductance, variation of equivalent and specific conductance with dilution and temperature. Migration of ions and Kohlrausch law, Arrhenius theory of electrolytic dissociation, Ostwald dilution law, Debye-Huckel-Onsager equation for strong electrolytes (elementary treatment only).

Applications of conductivity measurements- determination of degree of dissociation, acid dissociation constant (K_a), solubility product of sparingly soluble salts, conductometric titrations.

UNIT III

Electrochemistry-II: Types of reversible electrodes – gas-metal ion, metal-metal ion, metal insoluble salt-anion and redox electrodes, electrode reactions, Nernst equation-derivation of cell E.M.F,single electrode potential,standard hydrogen electrode,reference electrodes, standard electrode potential, electrochemical chemical series and its significance.

Electrochemical Cells: Electrolytic and Galvanic cells- reversible and irreversible cells, conventional representation of electrochemical cells.EMF of a cell and its measurements, computation of cell EMF,calculation of thermodynamic quantities of cell reactions (ΔG, ΔH & K) and overpotential.

UNIT IV

Nitro compounds: Preparation of nitro compounds (Aliphatic and Aromatic), reactivity of nitro substituted arenes,chemical reactions and uses of primary nitro compounds and nitrobenzene.

Amines: Preparation and chemical reactions of amines (Aliphatic and Aromatic), properties and uses of primary amino compounds, aniline, acetanilide, nitroanilines.

Basic strength of amines - similarities and differences between aliphatic and aromatic amines

Diazonium Salts: Preparation, properties and synthetic uses of benzene diazonium salt, diazo coupling and its mechanism.

UNIT V

Heterocyclic Compounds: Introduction and basic nomenclature, molecular orbital picture and aromatic characteristics of pyrrole, furan, thiophene and pyridine, preparation and chemical reactions with particular emphasis on the mechanism of electrophilic substitution, mechanism of nucleophilic substitution reactions in pyridine derivatives, comparison of basicity of pyridine, piperidine and pyrrole.

E-resources:

1. https://www.vssut.ac.in/lecture_notes/lecture1425072667.pdf
2. https://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000005CH/P000661/M019105/ET/1515648331CHE_P6_M25_e-Text.pdf
3. https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/heterocy.htm
4. https://www.lkouniv.ac.in/site/writereaddata/siteContent/202003291608409191arun_sethi_Diazonium_compounds.pdf
5. https://uou.ac.in/sites/default/files/slm/BSCCH-202.pdf

Reference books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. A Text Book of Physical Chemistry; A.S. Negi, S.C. Anand; New Age International (P) Limited, New Delhi, 2002.
4. The Elements of Physical Chemistry; P.W. Atkins; Oxford University Press, 1996.
5. Physical Chemistry; Seventh Edition; R.A. Alberty; Wiley Eastern Ltd., Singapore, 1987
6. Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Wiley Eastern Ltd, New Delhi, 2001.

Semester IV

Chemistry Lab 4: CHE6003P

Chemical Analysis Lab-IV

Code of the course: CHE6003P

Title of the course: Chemical Analysis Lab-IV

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Discipline Centric Compulsory (DCC) Course for Chemistry Discipline/Subject

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

Syllabus:

1. Synthesis of Inorganic complexes and organic compounds 20 Marks

Inorganic Complexes

(a) Preparation of sodium trisoxalato ferrate (III)

(b) Preparation of Ni-DMG complex.

(c) Preparation of cis-and trans-bisoxalatodiaquo chromate (III) ion.

(d) Cuprous chloride

(e) Sodium thiosulphate

(f) Ferrous sulphate from Kipp's waste

(g) Mercury tetrathiocyanate

Organic Synthesis

(a) Acetylation of salicylic acid, aniline, glucose and hydroquinone, benzoylation of aniline and phenol.

(b) Aliphatic electrophilic substitution: Preparation of iodoform from ethanol and acetone.

(c) Aromatic electrophillic substitution-

Preparation of m-dinitrobenzene from nitrobenzene.

Preparation of p-nitroacetanilide from acetanilide.

Preparation of p-bromoaccetanilide from acetanilide.

Preparation of 2,4,6-tribromophenol from phenol.

(d) Diazotization/coupling - Preparation of methyl orange and methyl red.

(e) Oxidation: Preparation of benzoic acid from toluene

(f) Reduction: Preparation of aniline from nitrobenezene.

2. Thin Layer Chromatography : 10 Marks

Determination of Rf values and identification of organic compounds.

(a) Separation of green leaf pigments (spinach leaves may be used)

(b) Separation of a mixture of dyes using cyclohexane and ethyl acetate (8.5:1.5)

Paper Chromatography: Determination of Rf values and identification of organic compounds in a mixture of amino acids / monosaccharides.

3. Physical Chemistry: 30 Marks

(a) First order reaction kinetics: Acid hydrolysis of an ester
(b) Second order reaction kinetics: base hydrolysis of an ester (saponification)
(c) Determination of cell constant of a given cell.
(d) Determination of specific and equivalent conductance of the given electrolyte (NaCl) at different dilutions
(e) Conductometric titrations of Strong Acid-Strong Base, Strong Acid-Weak Base, Weak Acid-Strong Base, Weak Acid-Weak Base.

4. Viva-Voce 10 Marks

5. Evaluation of record book of experiments performed in semester. 10 Marks

E-resources

1. https://mobiroderic.uv.es/bitstream/handle/10550/77746/Handout%20LQI_II_revised.pdf?sequence=1&isAllowed=y
2. https://www.youtube.com/watch?v=DdGToO-qbY8
3. https://lab-training.com/thin-layer-chromatography-tlc/
4. https://www.chm.uri.edu/mmcgregor/chm114/chm114exp2.pdf
5. https://www.youtube.com/watch?v=QfS1DSOw3Og

References:

1. Vogel's Textbook of Quantitative Chemical Analysis; Sixth Edition; M. Thomas, B. Sivasankar, J. Mendham, R.C. Denney, J. D. Barnes; Pearson Education, New Delhi, 2009.
2. Advanced Practical Physical Chemistry; Eighteenth Edition; J.B.Yadav; Goel Publishing House, Meerut, 2015.

Semester V

DSE-1 :CHE7300T

Spectroscopy and Instrumental Techniques

Code of the Course: CHE7300T

Title of the Course: Spectroscopy and Instrumental Techniques

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) course for chemistry discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Intermediate level courses.

Objectives of the Course: This course focuses on the principles and applications of various instrumental techniques used in chemistry. It covers topics such as electromagnetic radiation, UV-Visible, AAS (Atomic Absorption Spectroscopy), and IR (Infrared) spectroscopy, mass spectrometry, chromatography, NMR (Nuclear Magnetic Resonance) spectroscopy, potentiometry, voltammetry, and flame photometry. The course provides a comprehensive understanding of these analytical techniques and their role in chemical analysis and characterization.

Learning Outcomes: By the end of this course, students will be able to-

1. Understand the electromagnetic radiation, interaction of light with matter and the determination of absorption spectra, principles, instrumentation and applications of UV-Visible, AAS, FT-IR spectroscopy.
2. Explain the principles of mass spectrometry and its applications in determining molecular mass, molecular structure, and isotopic composition.
3. Understand the principles and various types of chromatography, including gas chromatography, liquid chromatography, and thin-layer chromatography, and apply these techniques to separate and analyze complex mixtures.
4. Interpret NMR spectra to determine the structure and composition of organic compounds, including the identification of functional groups and stereochemistry.
5. Explain the principles and applications of potentiometric analysis including voltammetry, cyclic voltammetry, flame photometry and its applications.

Overall, the course aims to equip students with a strong foundation in analytical techniques

used in chemistry, enabling them to apply these techniques effectively in various scientific and industrial settings.

Syllabus:

UNIT I

Introduction to spectroscopic methods of analysis: Origin of spectra, interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, Beer-Lambert's law, classification of analytical methods and the types of instrumental methods, consideration of electromagnetic radiation.

UV-Visible Spectroscopy: Basic principle, molar absorbtivity, types of electronic transitions, effect of conjugation and solvents, instrumentation (choice of source, monochromator and detector) for single and double beam instruments, and applications of UV-Vis spectroscopy.

Atomic Absorption Spectroscopy (AAS): Introduction, principle, sample atomization, flame atomizer, types of flames, factors affecting atomization efficiency, radiation sources-HCL, EDL and instrumentation for AAS, standard addition, internal standard method of analysis and applications of AAS.

(12 Lecture hours)

UNIT II

Infrared spectroscopy: Basic principle, Hooke's law, mode of molecular vibrations, finger print and functional group region, structural illustration through interpretation of data (common functional groups), instrumentation (choice of source, monochromator & detector), sampling techniques and applications of IR spectroscopy.

Mass spectrometry: Basic principle, fragmentation methods (EI, CI, electrospray, ED, LD, FAB), fragmentation of simple organic molecules, base peak, molecule ion peak, and brief idea about instrumentation, and applications of mass spectrometry.

(12 Lecture hours)

UNIT III

Chromatography: Classification, basic principle, mechanism of separation- adsorption, partition and ion exchange, development of chromatograms-frontal, elution and displacement methods, qualitative and quantitative aspects of chromatographic methods of analysis- paper chromatography, TLC (Thin Layer Chromatography), HPLC (High-Performance

Chromatography) and GLC (Gas Liquid Chromatography).

(12 Lecture hours)

UNIT IV

Nuclear Magnetic Resonance Spectroscopy: Introduction, basic principle, instrumentation, nuclear shielding and deshielding, chemical shift, factors affecting chemical shift, spin-spin interaction, coupling constant, area of signals, interpretation of PMR spectra of organic molecules such as ethyl bromide, ethanol, acetaldehyde, 1,1,2-tribromoethane, ethyl acetate, toluene and acetophenone.

(12 Lecture hours)

UNIT V

Potentiometry: Basic principle, instrumentation, ion-selective electrodes,applications of ion-selective electrodes.

Voltammetry: Basic principle, instrumentation, classification (cyclic voltammetry, linear sweep voltammetry, and pulse voltammetry), and applications.

Flame Photometry: Basic principles, instrumentation, and applications.

(12 Lecture hours)

E-resources:

1. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_ug/110
2. https://swayam.gov.in/explorer
3. https://swayamprabha.gov.in/index.php/search
4. https://swayamprabha.gov.in/index.php/module_details
5. http://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

Reference Books:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. Vogel's Textbook ofQuantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of analysis, 7thEd. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
3. Christian, G.D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.

6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles
8. Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
9. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974.
10. Donald L. Pavia, Thompson. Introduction to Spectroscopy: 2009.

Semester V

DSE Lab-1 :CHE7300P

Elective Chemistry Lab-I

Code of the Course: CHE7300P

Title of the Course: Elective Chemistry Lab-I

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

1. Colorimetric analysis **30 Marks**

a) To verify Beer-lambert law for $KMnO_4$/ $CoCl_2$ using colorimetric analysis.

b) Job's Method

c) Mole-ratio Method

2. Potentiometric analysis **30 Marks**

a) To titrate the given ferrous ammonium sulphate (FAS) solution using $KMnO_4$ as titrant and calculate the redox potential of Fe^{2+}/Fe^{+3} system on hydrogen scale.

b) To determine the strength of HCl/CH_3COOH by titrating with NaOH solution potentiometrically.

Spectroscopy

To elucidate the structure of organic compounds with the help of UV, IR and NMR spectra.

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-resources:

1. https://chemistlibrary.files.wordpress.com/2015/05/practical-inorganic-chemistry-1984-vorobyova-dunaeva-ippolitova-tamm.pdf
2. https://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf
3. https://www.youtube.com/watch?v=9WO9ggFEtp8
4. https://www.youtube.com/watch?v=WDx4lQUYBUk&t=111s

Reference Books:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative*

Chemical Analysis, John Wiley & Sons, 1989.

2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA,1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York,2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
7. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, EllesHarwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
8. Ditts, R.V. *Analytical Chemistry; Methods of Separation*, van Nostrand, 1974.

Semester V

DSE 2: CHE7301T

Green and Sustainable Chemistry

Code of the Course: CHE7301T

Title of the Course: Green and Sustainable Chemistry

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: DSE

Delivery type of the course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Intermediate level courses.

Objectives of the course: This course collectively aims to advance the adoption of green chemistry principles, hazardous waste, explore sustainable alternatives in solvents and reagents, understand environmental chemistry, and develop expertise in pollution analysis to foster a greener and more sustainable chemical industry.

Learning Outcomes: By the end of this course, students will be able to -

1. Understand and explain the importance of using environmentally friendly practices in chemistry.
2. Identify and assess the use of eco-friendly solvents in chemical processes to reduce harm to the environment.
3. Use safer and greener reagents to design and improve chemical reactions.
4. Analyze and understand how pollutants behave in the environment and develop solutions to prevent and remediate pollution.
5. Learn and apply techniques to measure and evaluate pollution levels in different environments.
6. Propose innovative solutions to environmental challenges in the chemical industry.
7. Effectively communicate scientific concepts and findings related to environmental issues.
8. Consider the ethical and social impact of chemical processes and suggest sustainable alternatives.
9. Work well in teams to address environmental problems in chemistry.
10. Stay updated on new developments and continue learning about green chemistry and environmental practices.

Syllabus:

UNIT I

Green Chemistry: Introduction, definition, principles, atom economy, calculation of atom economy of the rearrangement, addition, substitution and elimination reactions, reducing

toxicity.

Hazardous Waste-: Introduction, production, problems and preventions problem caused by waste, source of waste, waste minimization techniques.

(12 Lecture hours)

UNIT II

Green solvents: Supercritical fluids, water as a solvent for organic reactions, organic solvents, solvent-free systems, dry synthesis.

Green reagents: Introduction, toxic functional groups, examples of greener reagents and other polymer supported regents, solid state polymerization.

(12 Lecture hours)

UNIT-III

Green synthesis: Classification and applications of green synthesis including microwave assisted synthesis and ultrasound assisted synthesis, green synthesis of polycarbonates, paracetamol, ibuprofen, citral, adipic acid, urethane, styrene, phase transfer catalyst.

(12 Lecture hours)

UNIT-IV

Environmental chemistry: Oxygen and ozone chemistry, greenhouse gases and effect, sewage treatment, smoke formation acid rains, a brief idea of toxicological effects of arsenic, lead, cadmium, and pesticides.

(12 Lecture hours)

UNIT-V

Analysis of pollution: Sampling and monitoring of air and water, determination of total dissolved solids (TDS), conductivity, acidity, alkalinity, hardness, sulphate, chloride, DO, BOD, COD, water pollution laws and standards.

(12 Lecture hours)

E-Resources:

1. https://www.asdlib.org/onlineArticles/ecourseware/Manahan/GreenChem-2.pdf
2. https://www.youtube.com/watch?v=EvoN6vmiCfI&list=PLKSeO-scpOo33zdDN0i2uw1Xh3zh_UfGO

Reference Books:

1. Green Chemistry: An Introductory Text, Mike Lancaster, Royal Society of Chemicals, Cambridge, 2002.
2. Green Chemistry: Frontiers in Benign Chemical Synthesis and Processes, Edited by Paul T. Anastas & Tracy C. Williamson, Oxford University Press.
3. Green Chemical Syntheses and Processes: Edited by Paul T. Anastas, Lauren G. Heine & Tracy C. Williamson, ACS Symposium Series.
4. Green Chemistry: Environment Friendly Alternatives, Edited by Rashmi Sanghi, M. M. Srivastava, Narosa Publishing House, New Delhi.
5. Green Chemistry: Microwave Synthesis, K. R. Desai, Himalaya Publishing House.
6. Green Chemistry: A Teaching Resource, Dorothy Warren, Royal Society of Chemicals, 2001.
7. Green Chemistry: Williams, Charlotte.
8. Environmental Chemistry, S. E. Manahan, Lewis Publishers.
9. Environmental Chemistry, Sharma & Kaur, Krishna Publishers.
10. Environmental Chemistry, A. K. De, Wiley Eastern.
11. Environmental Pollution Analysis, S.M. Khopkar, Wiley Eastern
12. Environmental Toxicology, Ed. J. Rose, Gordon and Breach Science Publication.

Semester V

DSE Lab-2: CHE7301P

Elective Chemistry Lab-II

Code of the Course: CHE7301P

Title of the Course: Elective Chemistry Lab-II

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

1. **Green Synthesis** **30 Marks**
   a) Preparation of acetanilide
   b) Diels-Alder reaction between furan and maleic acid
   c) Benzil-benzilic acid rearrangement
   d) Nitration of phenol
   e) Synthesis of dibenzalpropanone
   f) Synthesis of adipic acid
   g) Bromination of acetanilide
2. **Use of enzymes as catalysts** **30 Marks**
   a) Biocatalysts (lipase, amylase, citrus fruit, yeast, etc) catalyzed reactions.
   b) Benzoin condensation using thiamine hydrochloride as a catalyst instead of cyanide.

   Alternative sources of energy
   a) Microwave-assisted synthesis of chalcones
   b) Photo-reduction of benzophenone to benzopinacol in the presence of sunlight.

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-Resources:

1. https://ia800206.us.archive.org/19/items/TextbookOfPracticalOrganicChemistry5thEd/VogelPracticalOrganicChemistry5thEditionnewfoundV_text.pdf
2. https://www.youtube.com/watch?v=OXPBuwatqco

3. https://www.youtube.com/watch?v=Y48UgKi33Ps
4. https://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf

Reference Books:

1. Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistry experiment*. American Chemical Society, Washington DC (2002).
2. Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry,* American Chemical Society (2008).
3. Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry,* American Chemical Society (2008).
4. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition, 2010.
5. Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to OrganicLaboratory Techniques: A Microscale and Macro Scale Approach,* W.B.Saunders, 1995.
6. Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. Green Chemistry Experiment: A monograph International Publishing House Pvt Ltd. New Delhi. Bangalore CISBN 978-93-81141-55-7 (2013).

Semester V

DSE 3: CHE7302T

Polymer Chemistry

Code of the course: CHE7302T

Title of the course: Polymer Chemistry

Level of the Course: NHEQF Level 5.5

Credit of the Course: 4

Type of the Course: Discipline Specific Elective (DSE) course for chemistry discipline

Delivery Type of the Course: Sixty hrs (40 hrs for lectures and 20 hrs for diagnostic and formative assessment during lecture hours.

Prerequisites: Intermediate level courses of polymers, their structure and polymerization process.

Objectives of the Course: The course aims to strengthen the conceptual knowledge of polymers learn at school level and lay foundation for further learning of the subject through first course on polymers which is a prerequisite for higher courses in polymer chemistry.

Learning Outcomes:

1. It helps the students to invent, design, make and use materials for products, processes and services.
2. They deploy these activities based on an in-depth understanding of polymer processing, the structure of polymer and their properties, including the intricate relationships between them.
3. The general knowledge about the synthesis and mechanism of different polymers will be valuable in polymer and pharmaceutical industries.
4. Course helps to create skilled professionals who can operate in the design, fabrication, and testing of engineering materials.

Syllabus:

UNIT I

Polymeric materials: Introduction, history, classification, nomenclature, molecular forces and chemical bonding, texture of polymers.

Functionality and its importance: Formation of **s**ynthetic polymer, classification of polymerization processes, relationships between functionalities, extent of reaction and degree of polymerization, bifunctional systems, poly-functional systems.

(12 Lecture hours)

UNIT II

Type of polymerization: Condensation, addition polymerization, and their mechanism.

Kinetics of polymerization: Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic) and coordination polymerizations, Mechanism and kinetics of copolymerization, polymerization techniques.

(12 Lecture hours)

UNIT III

Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, morphology of crystalline polymers, factors affecting crystalline melting point.

Nature and structure of polymers- Structure Property relationships.

Determination of molecular weight of polymers (Mn, Mw, *etc.*) by end group analysis, viscometry, light scattering and osmotic pressure methods, molecular weight distribution and its significance, polydispersity index.

(12 Lecture hours)

UNIT IV

Glass transition temperature (Tg)**:** Introduction and its determination, free volume theory, WLF (Williams-Landel-Ferry) equation, factors affecting glass transition temperature (Tg).

Polymer Solution: Criteria for polymer solubility, solubility parameter, thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymers solutions, Flory- Huggins theory, lower and upper critical solution temperatures.

(12 Lecture hours)

UNIT V

Synthetic Polymers: Preparation, structure, properties (physical, thermal, Flow & Mechanical) and application of the following polymers- polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and poly(vinyl acetate), acrylic polymers, fluoro polymers, polyamides. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, polycarbonates, conducting polymers [polyacetylene, polyaniline, poly(p-phenylenesulphidepolypyrrole, polythiophene)].

(12 Lecture hours)

E-Resources:

1. https://www.vssut.ac.in/lecture_notes/lecture1541230922.pdf
2. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SCY1616.pdf

Reference Books:

1. Seymour, R.B. &Carraher, C.E. *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
2. Odian, G. *Principles of Polymerization*, 4th Ed. Wiley, 2004.

3. Billmeyer, F.W. *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
4. Ghosh, P. *Polymer Science & Technology*, Tata McGraw-Hill Education, 1991.
5. Lenz, R.W. *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers.

Semester V

DSE Lab3:CHE7302P

Elective Chemistry Lab-III

Code of the Course: CHE7302P

Title of the Course: Elective Chemistry Lab-III

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: 60 hrs (40 hrs for the hands on experiments, observations and the record of the data and 10 hrs for the experiment, instruments demonstration, lab practices and 10 hrs on diagnostic assessment, formative assessment, subject/ class activity, problem solving).

1. S**ynthesis of Resins** **30 Marks**

a) Urea-formaldehyde resin
b) Phenol-formaldehyde resin
c) Novalac resin/resold resin

S**ynthesis of Polymers**

a) Preparation of nylon 66 or nylon 6
b) Preparation and purification of IPC (isophthaloyl chloride)
c) Preparation of polyester from (IPC) and phenolphthalein
d) Redox polymerization of acrylamide
e) Precipitation polymerization of acrylonitrile
f) Preparation of polyacrylamide and its electrophoresis

2. **Characterization and Analysis of Polymers** **30 Marks**

a) Determination of molecular weight by viscometry-
Polyacrylamide-aq.$NaNO_2$ solution and
Polyvinyl propylidine (PVP) in water
b) Determination of the viscosity-average molecular weight of poly(vinyl alcohol)(PVOH) and the fraction of “head-to-head” monomer linkages in the polymer.
c) Determination of molecular weight by end group analysis: Polyethylene glycol (PEG)(OH group).
d) Testing of mechanical properties of polymers.

e) Determination of hydroxyl number of a polymer using colorimetric method.

f) IR studies of polymers

3. Viva-Voce **10 Marks**

4. Evaluation of record book of experiments performed in semester. **10 Marks**

E-Resources:

1. https://ia800206.us.archive.org/19/items/TextbookOfPracticalOrganicChemistry5thEd/VogelPracticalOrganicChemistry5thEditionnewfoundV_text.pdf
2. https://nie.lk/pdffiles/other/eALOM%20Chemistry%20Practical%20Handbook.pdf

Reference Books:

1. M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press, 1999.
2. H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry*, 3rd ed.Prentice- Hall (2003)
3. F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)
4. J.R. Fried, *Polymer Science and Technology*, 2nd ed. Prentice-Hall (2003)
5. P. Munk& T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. JohnWiley & Sons (2002)
6. L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley &Sons(2005)
7. M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press(2005).
8. Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).

Semester VI

DSE 4: CHE7303T

Organometallic Chemistry and Catalysis

Code of the Course: CHE7303T

Title of the Course: Organometallic Chemistry and Catalysis

Level of the Course: NHEQF Level 5.5

Credit of the Course: 6 (5+1)

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: Ninety hrs (75 hrs for lectures and 15 hrs tutorials).

Prerequisites: Intermediate level courses.

Objectives of the Course: This course provides an introduction to the fundamental concepts of organometallic compounds, metal alkyls, metal carbonyls, catalysis and organometallic catalysis. It covers topics such as nature of metal-carbon bond,multicenter bonding in metal alkyls, concept of aromaticity, structure, bonding and properties of metal carbonyls, homogenous catalysis and heterogenous catalysis. It also covers the basics of organometallic catalysis. The course aims to develop student's understanding of the fundamental principles underlying organometallic compounds and their applications in catalysis.

Learning Outcomes: By the end of this course, students will be able to:

1. Understand the fundamentals of organometallic compounds, concept of the hapticity of organic ligands, EAN rule. Basics of Π-bonded organometallics such as alkene and alkyne complexes.
2. Describe and explain structure and bonding in methyl lithium (tetramer) and trialkyl aluminium (dimer), multicenter bonding in these compounds.
3. Explain structure and synthesis of ferrocene and learn its comparison with benzene.
4. To know the preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals, p-acceptor behaviour of carbon monoxide.
5. It covers the various aspects of catalysis, homogenous and heterogenous catalysis and their industrial applications.
6. Describe the General reaction involved in organometallic catalysis like oxidative addition, migratory insertion, and reductive elimination, isomerization and rearrangement.
7. Alkene metathesis, hydroboration, hydroamination, hydrosilation, hydrogenation, carbonylation, and the idea of C-C bond coupling.

Overall, the course aims to provide students with fundamentals about organometallic compounds, metal alkyls, metal carbonyls, catalysis, organometallic catalysis.

Syllabus:

UNIT I

Organometallic Compounds: Definition, nomenclature and classification of organometallic compounds on the basis nature of metal-carbon bond (ionic, s, p and multicentre bonds). Concept of hapticity of organic ligands, EAN rule. Structure and bonding of Π-bonded organometallics such as alkene and alkyne complexes.

(12 Lecture hours)

UNIT II

Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkylaluminium (dimer), concept of multicentre bonding in these compounds.Ferrocene- Preparation and reactions (acetylation, alkylation, metallation, MannichCondensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

(12 Lecture hours)

UNIT III

Metal carbonyls: Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. pi-acceptor behavior of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies)

(12 Lecture hours)

UNIT IV

Catalysis: General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts.

(12 Lecture hours)

UNIT V

Organometallic catalysis: General reaction involved in organometallic catalysis like oxidative addition, migratory insertion, and reductive elimination, isomerization and rearrangement. Alkene metathesis, hydroboration, hydroamination, hydrosilation, hydrogenation, carbonylation, C-C coupling reactions.

(12 Lecture hours)

E-Resources:

1. https://www.swayamprabha.gov.in/index.php/search

Reference Books:

1. Mehrotra R.C. and Singh, A. Organometallic Chemistry, New Age International Publishers, 2nd Ed, 2000.
2. Gupta B. D. and Elias A. J., Basic organometallic Chemistry, 2nd Ed., University Press(2013).
3. Crabtree, R. H. The Organometallic Chemistry of the Transition Metals. New York, NY: John Wiley, 2000.
4. Powell, P. Principles of Organometallic Chemistry, Chapman and Hall, 1988.
5. Collman, J. P. et al. Principles and Applications of Organo-transition Metal Chemistry. Mill Valley, CA: University Science Books, 1987.
6. Huheey J. E., Keiter E. A. and Keiter R. L., Inorganic Chemistry – Principles of structure and reactivity, Pearson Education, 4th Ed. 2002.
7. Shriver D. E., Atkins P. W., Inorganic Chemistry, Oxford University Press, 5th Ed.
8. Das Asim K., Fundamentals of Inorganic Chemistry, Vol. II, CBS Publications, 2nd Ed.2010.
9. Mallick, Madan and Tuli, Selected Topic in Inorganic Chemistry, S. Chand Publisher.17th Ed. 2010.
10. Puri, Sharma, Kalia, Principles of Inorganic Chemistry, Vishal Pub. Co., 33rd ed., 2017.
11. Cotton, F.A., Wilkinson, G., Murrillo, C. A., Bochmann, M., Advanced Inorganic Chemistry 6thEd. 1999.Wiley.
12. Boy Cornils, Wolfgang A. Herrmann, et al., Applied Homogeneous Catalysis with Organometallic Compounds: A Comprehensive Handbook in Four Volumes 3rd, 2017, Wiley.
13. R.D. Adams, Comprehensive Organometallic Chemistry II, Volume 10: Heteronuclear Metal and Metal Bonds 1st Ed., 2004 Pergamon.

Semester VI
DSE 5: CHE7304T

Molecules of Life

Code of the course: CHE7304T

Title of the course: Molecules of Life

Level of the Course: NHEQF Level 5.5

Credit of the Course: 6

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline

Delivery Type of the Course: Ninety hrs (75 hrs for lectures and 15 hrs tutorials).

Prerequisites: Intermediate level courses of biomolecules (carbohydrates, amino acids, lipids, fats) and their structure.

Objectives of the Course: The course aims to strengthen the conceptual knowledge of biomolecules, and lay the foundation for further learning of the subject through the first course on Biomolecules of life. It also focuses on comprehending the relationship between structure and function as well as nucleic acid structure and properties of lipids.

Learning Outcomes: By the end of this course, students will be able to:

1. To offer detailed knowledge of biomolecules for living systems.
2. To understand sugars from monosaccharides to polysaccharides.
3. To provide basic concepts of structural organization and characterization of proteins.
4. To acquire knowledge on physicochemical properties and characterization of lipids.
5. To understand the structure of DNA and RNA and their types.

Syllabus:

UNIT I

Carbohydrates: Classification of carbohydrates, reducing and non-reducing sugars, general properties of glucose and fructose, their open chain structure.Epimers, mutarotation and anomers.Determination of configuration of glucose (Fischer proof), cyclic structure of glucose and fructose, Haworthprojections.Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) andpolysacharrides (starch and cellulose) excluding their structure elucidation.

(12 Lecture hours)

UNIT II

Amino Acids, Peptides and Proteins: Classification of amino acids, Zwitter ion structure and isoelectric point. Overview of primary, secondary, tertiary and quaternary structure of proteins, determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme).Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyl oxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

(12 Lecture hours)

UNIT III

Enzymes: Introduction, mechanism of enzyme action, factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action(including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition(competitive and noncompetitive inhibition including allosteric inhibition).

(12 Lecture hours)

UNIT IV

Nucleic Acids: Components of nucleic acids-adenine, guanine, thymine, cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides, structure of DNA (Watson-Crick model) and RNA (**types of RNA**), genetic code, biological roles of DNA and RNA-replication, transcription and translation.

(12 Lecture hours)

UNIT V

Lipids: Introduction to lipids, classification, oils and fats-common fatty acids present in oils and fats, omega fatty acids, trans fats, hydrogenation, saponification value, iodine number, iodine value, acid value. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol).

(12 Lecture hours)

E-resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

Reference Books:

1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
4. Nelson, D. L. & Cox, M. M. *Lehninger's Principles of Biochemistry 7th Ed.,* W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. *Biochemistry*, W.H. Freeman, 2002.

Semester VI

DSE-6: CHE7305T

Advanced Physical Chemistry

Code of the course: CHE7305T

Title of the course: Advanced Physical Chemistry

Level of the Course: NHEQF Level 5.5

Credit of the Course: 6 (5+1)

Type of the Course: Discipline Specific Elective (DSE) Course for Chemistry Discipline/Subject

Delivery Type of the Course: Ninety hrs (75 hrs for lectures and 15 hrs tutorials).

Prerequisites: Intermediate level courses of physical chemistry

Objectives of the Course: To learn the basic principles involved in quantum chemistry, surface chemistry, solid state, phase rule, nuclear and radiochemistry, and macromolecules.

Learning Outcomes: After studying this paper, students will be able to:

1. Contextualise the connection between quantum mechanics and thermodynamics.
2. Describe the different ensembles and the fundamental aspects of chemistry.
3. Understand the electric double layer (edl) structure.
4. General concepts, principles, kinetics and methodology of polymerization and kinetics of chain growth and step growth polymerization.
5. Properties and applications of polymers.
6. Demonstrate an ability to describe, with confidence, the features of the most common crystalline structures.
7. Crystalline structure with the bonding to predict materials properties.
8. Different defect structures in the solid state and its effects on the materials properties.
9. Band theory to describe the operation of modern semiconductor devices.

Syllabus:

UNIT I

Quantum Chemistry: Introduction, Black-body radiation, photoelectric effect, Planck's radiation law, the heat capacity of solids, Bohr's model of hydrogen atom (no derivation) and

its defects, Compton effect, de-Broglie hypothesis, Heisenberg's uncertainty principle, Sinusoidal wave equation, Schrodinger wave equation and its importance, postulates of quantum mechanics, operators, Hamiltonian operator, Eigen function and Eigenvalues, physical interpretation of the wave function.

Applications of quantum mechanics: Particle in the one-dimensional and two-dimensional box, Schrodinger wave equation for H-atom, separation into three equations (without derivation), quantum numbers and their importance, hydrogen-like wave functions, radial and angular wave functions, selection rule and spectra of the hydrogen atom.

(15 Lecture hours)

UNIT II

Macromolecules: Nomenclature, Classification, properties of the polymer, mass of macromolecules, number average and weight average molecular mass, determination of molecular weight by osmotic pressure, viscosity and light scattering and sedimentation (ultra centrifuge) method.

Surface Chemistry: Surface tension, measurement of surface tension, factors affecting surface tension, sorption of surfaces, physical and chemical adsorption, factors effecting adsorption, applications of adsorption, Freundlich, Langmuir and Gibbs adsorption isotherms and their derivation, Streaming Potential electrophoresis and Electro-osmosis.

(15 Lecture hours)

UNIT III

Solid State: Definition of space lattice, unit cell, Bravias lattices, laws of crystallography- law of constancy of interfacial angles, law of rationality of indices, Weiss and Miller indices, law of symmetry, symmetry elements in crystals, classification of crystals, X-ray diffraction by crystals, derivation of Bragg equation, determination of crystal structure of NaCl, KCl and CsCl (Laue's method and powder method).

(15 Lecture hours)

UNIT IV

Heterogeneous Equilibria: Introduction to phase rule, component and degree of freedom, derivation of Gibbs phase rule, phase equilibria of one component system-water, CO_2 and sulfur system, Phase equilibria of two-component system-solid-liquid equilibria, simple eutectic – Bi-Cd, Pb-Ag systems, desilverization of lead.

Solid solutions: compound formation with congruent melting point (Mg-Zn), ($FeCl_3$ – H_2O)

and incongruent melting point (NaCl-H_2O) and ($CuSO_4$ – H_2O) system, freezing mixtures.

(15 Lecture hours)

UNIT- V

Nuclear and Radiochemistry: Elementary idea of the nucleus, nuclear forces, packing fraction, mass defect and binding energy, nuclear fission and fusion reactions, calculation of Q - values of nuclear reactions, liquid drop and shell models of nucleus, theory of radioactivity, G. M. counter, half-life period, average life, radioactive disintegration, radioactive steady state, group displacement law, radioactive series, separation and identification of isotopes, application of radioactivity and radioactive tracers.

(15 Lecture hours)

E-Resources:

1. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
2. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA==

Reference Books:

1. A Text Book of Physical Chemistry; A.S. Negi, S.C.Anand; New Age International (P) Limited, New Delhi, 2002.
2. Quantum Chemistry Including Molecular Spectroscopy; B.K. Sen; Tata McGraw-Hill, Publishing Company Ltd, New Delhi, 1996.
3. Introductory Quantum Chemistry; A.K. Chandra; Tata McGraw Hill Publishing Company Limited. New Delhi, 1998
4. Quantum Chemistry; R.K. Prasad; New Age International (P) Ltd., New Delhi, 2003.
5. Physical Chemistry Through Problems; S.K. Dogra and S.Dogra; Wiley Eastern Ltd, New Delhi, 2001.
6. Exploring Chemistry with Electronic Structure Methods- by James B. Frishman and A. Frisel, Gaussian, Inc. Pittsburge, PA
7. Principles of Physical Chemistry: B. R. Puri and L.R. Sharma.
8. Physical Chemistry, Pt. I & II: C.M. Gupta, J.K. Saxena and M. C. Purohit.
9. Physical Chemistry (Hindi Ed.): Suresh Ameta, R.C. Khandelwal, R. Ameta & J. Vardia, Himanshu Pub.

Semester IV

Skill Course 2: SES5320T

Chemical Laboratory Preparation

Code of the Course: SES5320T

Title of the Course: Chemical Laboratory Preparation

Level of the Course: NHEQF Level 5

Credit of the Course: 2

Type of the Course: Skill Course

Delivery Type of the Course: Thirty Lectures (20 hrs for content delivery and 10 hrs on diagnostic and formative assessment and subject/ class activity, problem solving)

Prerequisites: Chemistry of XII standard

Objective of the Course: Laboratory training is a frequently used skill to develop advanced study or research and also minimize the risk of injury or illness to laboratory workers.

Learning outcomes: After studying this course-

1. Students will have a firm foundation in the fundamentals and application of current chemical and scientific theories including those in Analytical, Inorganic, Organic and Physical Chemistries. Majors to be certified by the American Chemical Society will have extensive laboratory work.
2. Students will be able to design and carry out scientific experiments as well as accurately record and analyze the results of such experiments.
3. Students will be skilled in problem-solving, critical thinking, and analytical reasoning as applied to scientific problems.
4. Students will be able to explore new areas of research in both chemistry and allied fields of science and technology.
5. Students will appreciate the central role of chemistry in our society and use this as a basis for ethical behaviour in issues facing chemists including an understanding of the safe handling of chemicals, environmental issues and key issues facing our society in energy, health and medicine.
6. Students will be able to function as a member of an interdisciplinary problem-solving team.

Syllabus:

UNIT I

Chemistry Laboratory: General introduction to chemistry lab, safety rules and precautions in the chemistry laboratory, storage, ventilation, lighting, fumes, cupboard, hazards, precautions, maintenance of laboratory, cleaning of laboratory, apparatus and preparation room.

6 Lecture hours

UNIT II

Laboratory Apparatus: Basic idea about equipment/apparatus, (glass apparatus, Heating apparatus, Stirrer, Oven, Melting point apparatus, Kipp's apparatus).

6 Lecture hours

UNIT III

Laboratory Reagents and Solvents: Reagents-classification of reagents according to their action (i) acids (ii) bases (iii) salts (iv) complexing agents (v) oxidizing and reducing agents (vi) precipitating agents (vii) chelating agents.

6 Lecture hours

UNIT IV

Concentration Terms – Percentage (Mass, Volume, Mass-Volume), Mole percent, Mole fraction, Mass ppm, ppb, g/L, molarity, normality, molality,

6 Lecture hours

UNIT V

Solution Preparation: Solutions, components of a solution, types of solution, solubility, calculation of masses and volumes for preparation of solutions and their practical approach

6 Lecture hours

E-Resources:

1. https://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm201.pdfhttps://ncert.nic.in/pdf/publication/sciencelaboratorymanuals/classXI/chemistry/kelm201.pdf
2. https://www.acs.org/education/policies/middle-and-high-school chemistry/laboratory.html
3. https://link.springer.com/referenceworkentry/10.1007/978-3-642-41609-5_39-1

References Books:

1. Vogel, Arthur I: A Textbook of Quantitative Inorganic Analysis (Rev. by GH Jeffery and others) 5th Ed. The English Language Book Society of Longman
2. Willard, Hobert H. et. al: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. New York-John Willy, 2004.
4. Harris, Daniel C, Quantitative Chemical Analysis, 3rd Edition, W.H. Freeman and

Company, New York, 2001.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry New Age, International Publisher, 2009.

Semester V

Skill Course 3: SES5321T

Food Preservation and Adulteration

Code of the Course: SES5321T

Title of the Course: Food Preservation and Adulteration

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Skill Course

Delivery Type of the Course: Thirty Lectures (20 hrs for content delivery and 10 hrs on diagnostic and formative assessment and subject/ class activity, problem solving)

Prerequisites: Chemistry of XII standard

Objective of the Course: Enable students to understand the types of adulterants in food, the effect of adulteration and the detection of adulterants in food. Develop awareness among students to prevent adulteration.

Learning outcomes: After studying the concept, students will be able to:

1. Understand how microorganisms spoil food.
2. Recall food preservatives examples and explain how they are used to preserve foods.
3. Know about chemical food preservatives.
4. Understand what is canning, drying and freezing food preservation.
5. Know what pickle is and how various types of foods are preserved as pickles.
6. Understand what pasteurization is and why pasteurized milk is better for consumption.

Syllabus:

UNIT I

Food Preservation: Introduction, techniques of food preservation, physical and chemical methods, the importance of food preservation, food preservatives and food packing.

6 Lecture hours

UNIT II

Adulterants in Food Products: Introduction, definition, types of food adulteration, methods of food adulteration, effect of food adulteration.

6 Lecture hours

UNIT III

Adulterants in milk and milk products, oil, fats, mustard oil and, sweetening agents (natural and artificial).

6 Lecture hours

UNIT IV

Adulteration in spices and pulses: Turmeric powder, coriander powder, Chili Powder, food grains and their products, (gram flour etc.).

6 Lecture hours

UNIT V

Detection and prevention of food adulteration, sugar in honey, rhodamine B in ragi, differentiation between iodized and common salts, food safety and regulatory authorities in India

6 Lecture hours

E-Resources:

1. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9818512/
2. https://www.fssai.gov.in/upload/media/FSSAI_News_Adulteration_Express_05_08_2020.pdf

References Books:

1. G. SubbuLakshmi, S. A. Udipi and P. S. Ghugre, Food Processing and Preservation, New Age International Publisher New Delhi, second edition, 2021.
2. N. N. Potter and J. H. Hotchkiss, Food Science, 5th edition, CBS Publishers India, 2007.
3. Shalini Sehgal, A Laboratory Manual of Food Analysis, Dreamtech (Wiley) Publishers, 2020.
4. Sahay Devina, Aahar Vigyan, New Age International Publisher New Delhi, first edition, 2019.

Semester VI

Skill Course 4: SES5322P

Water Pollution and Analysis

Code of the Course: SES5322P

Title of the Course: Water Pollution and Analysis

Level of the Course: NHEQF Level 5.5

Credit of the Course: 2

Type of the Course: Skill Course

Delivery Type of the Course: Thirty practical hours (20 hrs for the hands on experiments, observations and the record of the data and 10 hrs on diagnostic and formative assessment and subject/ class activity, problem solving)

Prerequisites: Chemistry of XII standard

Objective of the Course: Enable students to understand environmental problems, looking at causal linkages between pollution sources, exposure pathways, and impacts on environmental quality and human health.

Learning outcomes: After studying the concept:

1. Students will be able to describe the processes of and importance of groundwater flow and aquifer systems.
2. Students will be able to compare chemical interactions that occur in various hydrologic settings and their importance to water resources, geological and biological systems, and water/wastewater treatment.
3. Students will be able to describe the role water plays in atmospheric systems and the climate system.
4. Students will be able to describe the interactions between water systems and ecosystems.
5. Students will be able to describe the challenges of maintaining surface and groundwater quality.
6. Students will apply their knowledge base and research skills to current issues pertaining to water resources, management, and remediation, with emphasis on related economic, social, and public policy dimensions.

Syllabus:

1. **Pollution:** Definition, history, types of pollutants, pollution control and measures, types of chemical pollution with examples, impact on ecosystem, e-waste and its toxic effects.
   Water Analysis: Chemistry of water, physical and chemical properties, water resources, water pollution.
2. Important water quality parameters and methods for their determination, turbidity, color,

taste, pH, acidity, alkalinity, metals, hardness, dissolved oxygen, standard for drinking water as per WHO specifications.

Determination of BOD, COD, DO, alkalinity, total hardness of drinking water.

3. **Soil Analysis:** Introduction, characteristics of soil (soil texture and structure), composition of soil (inorganic, organic components, water and air in soil), soil organisms, soil profile, soil reactions (cation and anion exchange reactions), essential elements (macronutrients and micronutrients).

Scheme of Examination

i) Experiment (Any Two)	**60 Marks**
ii) Viva-Voce	**10 Marks**
iii) Evaluation of record book of experiments performed in semester.	**10 Marks**

E-Resources:

1. https://www.nrdc.org/stories/water-pollution-everything-you-need-know
2. https://home.iitk.ac.in/~anubha/WQ.pdf
3. https://in.video.search.yahoo.com/search/video;_ylt=AwrPqgVRWPhk2boPgsi7HAx.;_ylu=Y29sbwNzZzMEcG9zAzEEdnRpZAMEc2VjA3BpdnM-?p=Determination+of+BOD%2C+COD%2C+DO%2C+alkalinity%2C+total+hardness+of+drinking+water.&fr2=piv-web&type=E210IN1485G0&fr=mcafee#id=1&vid=3981992b1b957a4483620e9c1c8c63f2&action=view
4. http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/chemistry/environmental_c hemistry/14.soil_composition,_micro_and_macronutrients/et/4781_et_et.pdf https://youtu.be/w1D_wqesJqU
5. https://youtu.be/h1qSFZ9aw94

Reference Books:

1. P.K. Goel, Water pollution causes, effects and control,
2. W. K . Berry, Water pollution, CBS Publisher, 2017.
3. A. K. De, Environmental Chemistry, New Age International Publisher New Delhi, first edition, 2016.
4. M. N. Rao, Wastewater treatment, 3rd edition, Oxford & IBH Publishing, 2020.