Savitribai Phule Pune University

(Formerly University of Pune)

Two Year Degree Program in Biotechnology

(Faculty of Science & Technology)

Revised Syllabi for

M.Sc. (Biotechnology) Part-II

(For Colleges Affiliated to Savitribai Phule Pune University)

Choice Based Credit System Syllabus
(Based on Guidelines of NEP-2020)

To be implemented from Academic Year 2024-2025

Title of the course: M.Sc. (Biotechnology)

Objectives to be achieved:

- To help the students to build interdisciplinary approach
- To empower students to excel in various research fields of Life Sciences
- To inculcate sense of scientific responsibilities for social and environment awareness.
- To acquaint the students with thrust areas of biotechnology
- To adapt the National Education Policy-2020, that offers opportunities to learn core subjects and to explore additional avenues of learning beyond the core subjects for complete development of an individual.

Course Structure:

M.Sc. Biotechnology (Part-II)

Semester -III

	Course Type	**Credit**	**Theory/ Practical**	**Subject Code**	**Title of Paper**
Semester -III	Major Mandatory (14 Credit)	4	Theory	BT-601-MJ	Physiology
		2	Theory	BT-602-MJ	Plant Biotechnology
		2	Theory	BT-603-MJ	Animal Biotechnology
		2	Theory	BT-604-MJ	Emerging trends in Biotechnology
		2	Practical	BT-605-MJP	Practical in Physiology
		2	Practical	BT-606-MJP	Practical in plant and animal Biotechnology
	Major Elective (4 Credit)	2T+2P	Theory & Practical	BT-610-MJ	Molecular diagnostics
				BT-611-MJP	Practicals in Molecular diagnostics
				BT-612-MJ	Infectious diseases and Vaccine technology
				BT-613-MJP	Practicals in Infectious diseases and Vaccine technology
				BT-614-MJ	Biofuel technology
				BT-615-MJP	Practicals in Biofuel technology
				BT-616-MJ	Biotechnology for sustainable development
				BT-617-MJP	Practicals in Biotechnology for sustainable development
				BT-618-MJ	Biosensor technology
				BT-619-MJP	Practicals in Biosensor technology
				BT-620-MJ	Intellectual Property Right (IPR)
				BT-621-MJP	Practicals in Intellectual Property Right (IPR)
				BT-622-MJ	Biofertilizer and Biopesticide technology
				BT-623-MJP	Practicals in Biofertilizer and Biopesticide technology
				BT-624-MJ	Machine learning and data science
				BT-625-MJP	Practicals in Machine learning and data science
	Research Project (4 Credit)	4	Practical	BT-631-RP	Research Project
Total		22			

Semester -IV

	Course Type	Credit	Theory/ Practical	Subject Code	Title of Paper
Semester -IV	Major Mandatory (12 Credit)	2	Theory	BT-651-MJ	Bioprocess engineering
		2	Theory	BT-652-MJ	Genomics
		2	Theory	BT-653-MJ	Proteomics
		2	Theory	BT-654-MJ	Bioinformatics and structural Biology
		2	Practical	BT-655-MJP	Practical in Bioprocess Engineering
		2	Practical	BT-656-MJP	Practical in Genomics and Proteomics
	Major Elective (4 Credit)	2T+2P	Theory & Practical	BT-660-MJ	System Biology
				BT-661-MJP	Practicals in System Biology
				BT-662-MJ	Synthetic Biology
				BT-663-MJP	Practicals in Synthetic Biology
				BT-664-MJ	Biologics and Biosimilars
				BT-665-MJP	Practicals in Biologics and Biosimilars
				BT-666-MJ	Quality control and Biosafety
				BT-667-MJP	Practicals in Quality control and Biosafety
				BT-668-MJ	Bio-entrepreneurship
				BT-669-MJP	Practicals in Bio-entrepreneurship
				BT-670-MJ	Rational Drug Discovery and Development
				BT-671-MJP	Practicals in Rational Drug Discovery and Development
				BT-672-MJ	Agriculture Biotechnology
				BT-673-MJP	Practicals in Agriculture Biotechnology
				BT-674-MJ	Medical Biotechnology
				BT-675-MJP	Practicals in Medical Biotechnology
	Research Project (6 Credit)	6	Practical	BT-681-RP	Research Project
Total		22			

Semester III

Course Code: BT-601-MJ Physiology 4 Credits

Total Lectures: 60

Course outcomes:

After completion of the course

- Student will develop understanding for the fundamental concepts of physiology of brain and limbic system
- Student will develop understanding of Neuroendocrine physiology
- Student will develop the fundamental concepts of physiology of Control and coordination of Vertebrate Movement
- Familiarize students with Animal Navigation
- Student will develop basic understanding of Phytochrome and light control of Plant Development
- Familiarize students with Responses and adaptations to abiotic Stress

Unit	Syllabus	No. of Lectures
	ANIMAL PHYSIOLOGY	
I	**The Physiology of control:** Cellular organization of neural tissue, ionic basis of membrane potentials, synaptic transmission, neurotransmitters and their types, molecular basis of neurotransmitter release, Sensory processes – mechanoreceptors for touch, vestibular organs and hearing, chemoreception and taste, olfaction, photoreception, visual sensory processing.	8
II	**Neuroendocrine physiology:** Synthesis, storage and release of hormones, Three chemical classes of hormones, endocrine control of – nutrient metabolism in mammals, salt and water balance in vertebrates, Calcium utilization in mammals, mammalian stress response, control and regulation of Hormone release (Pituitary and Hypothalamus), Insect metamorphosis.	8
III	**Control and coordination of Vertebrate Movement:** Skeletal muscle cell, excitation-contraction coupling, neural control of skeletal muscle, smooth (unstriated) muscle, vertebrate cardiac muscle, atrophy, regulating muscle mass.	7
IV	**Animal Navigation:** The adaptive significance of Animal navigation, navigational strategies (Trail following, Piloting, Path integration, deriving compass information from environmental cues, possessing map sense), Magnetoreceptions, Innate and Learned component of navigation.	7
	PLANT PHYSIOLOGY	
V	**Phytochrome and light control of Plant Development:** Characteristics of photochrome induced responses, Structure and functions of phytochrome, phytochrome signaling pathway, ecological functions.	6
VI	**Blue light responses and stomatal movements:** The photo physiology of blue light, blue light photoreceptors, regulation of blue light stimulated responses.	6
VII	**Control of Flowering:** Floral evocation: integrating environmental ques, shoot apex and phase changes, Circadian rhythms – the clock within, photoperiodism, vernalization, long distance signaling involved in flowering, discovery of florigen.	8

VIII	**Responses and adaptations to abiotic Stress:** Adaptation and phenotypic plasticity, water deficit and flooding, imbalances in soil minerals, temperature stress, high light stress, mechanisms that protect plants against environmental extremes.	10

Selected Readings:

1. "Human Physiology: An Integrated Approach" by Dee Unglaub Silverthorn
2. "Anatomy & Physiology For Dummies" by Erin Odya and Maggie Norris
3. "The Human Body Book" by Steve Parker
4. "The Complete Idiot's Guide to Anatomy and Physiology" by Michael J. Vieira
5. Physiology - Guyton
6. Ganong's Physiology Book
7. Fundamentals of Plant Physiology. Second Edition. Lincoln Taiz, Ian Max Møller, Angus Murphy.
8. Plant Physiology Theory and Applications: S. L. Kochhar and Sukhbir Kaur Gujral

Semester III

Course Code: BT-602-MJ Plant Biotechnology 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will 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 learn the concept and applications of transgenic plants.

Unit	Syllabus	No. of Lectures
I	**Plant tissue culture and its applications:** Overview of plant tissue culture Micropropagation- concept, stages of micropropagation (stage 0 to stage 4), Methods/approaches of micropropagation: a) Axillary bud/shoot proliferation, b) Adventitiousbud formation, c) Organogenesis and d) Somatic embryogenesis and artificial seeds Application of micropropagation Somaclonal variations *In vitro* androgenesis and its applications, Protoplast isolation, somatic hybridization, cybridization and their applications Suspension culture: Production of bio active secondary metabolites. Plant tissue culture for production of disease/virus free plants and superior plant varieties (embryorescuing) seedless plants (endosperm culture). Methods and techniques of preservation of plant cultures and its revival	10
II	**Algal and fungal biotechnology:** Qualitative/Quantitative improvement in economically important Algae with one example(Biofuels, Pigments, Single cell proteins) Qualitative/Quantitative improvement in industrially important Fungi like yeast, mushrooms	6
III	**Methods of transformation in plants:** Direct methods of transformation: physical, chemical, In planta methods of plant transformation Indirect Methods of transformation: Agrobacterium mediated gene transfer: Ti plasmid & RiPlasmid vectors, Mechanism of T-DNA transfer to plants, Plant viral vectors Selectable markers, reporter genes and promoters used in plant vectors and their role in genetictransformation	6
IV	**Transgenic plants:** Transgenic plants for biotic (weeds, insects, viruses, fungi and bacteria) and abiotic stress(drought, salt, temperature, and herbicide) tolerance Increase in productivity by manipulation of photosynthesis and nitrogen fixation Concept of synthetic biology for production of bioactive secondary	8

	metabolites Molecular farming (improvement in protein, lipids, carbohydrates), vaccines, antibodies,therapeutic proteins Approaches to marker-free transgenics Debate over GM crops	

Selected Reading:

1. Chawla HC (2004) Introduction to plant biotechnology (Science Publ)
2. Davies K (Ed) (2004) Plant pigments and their manipulation – Annual plant reviews, vol 14 (Blackwell Publ)
3. Altman A, Hasegawa PM (Ed) (2012) – Plant Biotechnology and agriculture. Prospectsfor the 21st century (Academic press).
4. Bhojwani SS. & Razdan MK (1996). - Plant Tissue Culture: Theory & Practice (Elsevier).
5. Slater A, Scott NW, Fowler MR (2008) – Plant Biotechnology: The Genetic Manipulationof plants (Oxford Press)
6. Vasil IK, Thorpe TA (1994) – Plant cell and tissue culture (Springer)
7. H K Das Textbook of Biotechnology 4th edition
8. Reinert J and Yeoman MM (1994) Plant Cell and Tissue Culture: A Laboratory manualSpringer
9. Biotechnology in Crop Improvement, H S Chawla. International Book Distributing Company1998
10. Practical Application of Plant Molecular Biology. RJ Henry. Chapman and Hall 1997

Semester III

Course Code: BT-603-MJ Animal Biotechnology 2Credits

Total Lectures: 30

Course Outcomes:
After completion of the course,

- Students will understand the concept of animal biotechnology that is use of genetically engineer animals in order to improve their suitability for agriculture, industrial, or pharmaceutical applications.
- Students will gain an insight into the concepts and techniques of animal biotechnology and its wide industrial and medicinal applications.
- Students will understand the cell/ tissues culture techniques and their applications
- Students will learn in vitro culturing of organisms and production of transgenic animals.
- Students will be able to apply principles of Biotechnology concepts in veterinary sciences i.e. production of Transgenic animals, Artificial insemination, In-vitro fertilization, Embryo transfer technology.

Unit	Syllabus	No. of Lectures
I	**Introduction to Animal Biotechnology**: Definitions, History, basic concepts and scope of animal biotechnology	2
II	**Animal cell culture and Stem cell biology:** Introduction to Animal cell culture, Culture maintenance and preservation, Types of cultures, Adherent, Suspension Stem cell therapies, induction and differentiation of embryonic, mesenchymal, hematopoietic and pluripotent stem cells, reprogramming of stem cells Somatic and germ line derived stem cells Polyclonal and Monoclonal antibody production and use in animal therapy Vaccines, uses and applications in animal diseases	6
III	**Tissue Engineering and Regenerative Medicine:** Fundamentals and processes in tissue repair and regeneration, cellular interactions, role of extracellular matrix, cell-signaling, cell homeostasis Applications of stem cells in tissue repair and regeneration Biomaterials, nanomaterials, biofabrication, 3D bioprinting, clinical needs and therapeutic solutions Biotechnological application in animal improvements,recombinant therapeutic protein, living medicines,allergenics, molecule drugs and medical devices	8
IV	**Transgenic animals:** Overview of different methods of introduction of a transgene viz. micronuclear injection method, transduction with recombinant viruses, REMI etc. Targeted gene insertion, gene silencing by RNAi, Cre-LoxP recombination for genetic modification CRISPR/Cas9 for targeted genome editing	8

	Transgenic animals: fish, Xenopus, mammals, Concept of Knockout mice, methods and application Mouse models for human genetic disorders, neurodegenerative disorders	
V	**Animal husbandry and reproductive biotechnology:** Overview of livestock breed and their productivity in India Artificial breeding:-Various methods of semen collection, artificial insemination, estrous synchronization, cryopreservation of germ cells, In vitro fertilization and embryo transfer technology Animal cloning: concept and application in conservation	4
VI	Biosafety issues and Bioethics associated with Animal Tissue culture, developing transgenic animals and human cloning	2

Selected Readings:

1. Rangam.m. animal biotechnology. Agrobiosindia limited, 2002
2. Ramadass p, meera rani s. Text book of animal biotechnology. Akshara printers, 1997.
3. Gordon, I. (2005). Reproductive Techniques in Farm Animals. Oxford: CAB International.
4. Levine, M. M. (2004). New Generation Vaccines. New York: M. Dekker.
5. Pörtner, R. (2007). Animal Cell Biotechnology: Methods and Protocols. Totowa, NJ: Humana Press.
6. Primrose SB. 2001. Molecular Biotechnology.Panima.
7. Freshney RI. 2005. Culture of Animal Cells. Wiley Liss. Portner R. 2007. Animal Cell Biotechnology. Humana Press.
8. Animal Cell Culture – Practical Approach Edited by John RW. Masters, Oxford.
9. Animal Cell Culture Techniques edited by Martin Clynes, Springer.

Semester III

Course Code: BT-604-MJ Emerging trends in Biotechnology 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Student will be able to precisely determine the different cell types and subtypes in the given sample.
- Student will learn new technologies, innovative products used as a part of therapy or treatment for a variety of diseases and conditions.
- Student will understand the benefits of genetic engineering in agriculture, food and pharmaceutical fields.
- Student will understand the importance of biotechnology in Sustainable development.
- Student will get an insight of important applications of biotechnology in the field of regenerative medicine and drug testing.

Unit	Syllabus	No. of Lectures
I	Single-cell sequencing - Introduction, Applications, Benefits, and Challenges.	4
II	Cell and Gene therapy - Stem cell and Mesenchymal Stem cell therapy, CAR -T cell therapy, Cell replacement and Adoptive cell Therapy, Gene therapy, Applications, Benefits, and Challenges.	5
III	GMOs, LMOs, Bt-crops, Golden rice, Roundup ready, Flavr Savr tomato, Artic apple, Innate potato, Papaya ring spot virus resistant, Flower colour modified petunias, plants with altered oil composition. GMAs: GloFish, Aqua advantage Salmon, Enviropig, Gene edited cattle. Applications, Benefits, and Challenges faced. Ethical and Regulatory considerations.	5
IV	Microbiomes, factors that alter the microbiome, 16S rRNA sequencing, Microbiome identification workflow and reagents, metagenomics, Applications, Benefits, and Challenges faced.	4
V	3 D Bioprinting of tissue and organs, introduction, bioinks, preparatory phase, printing phase (scaffold, non-scaffold based), post handling phase, bioprinters: inkjet 3D, extrusion, laser assisted, stereo-lithography, 3 D bio printed skin, heart tissue, and Meat as a casestudy, Applications, Benefits, and Challenges faced.	4
VI	Precision medicine, AI, Data Science and ML in data integration analysis, algorithms for disease subtyping and Biomarker discovery, Drug response prediction, Pharmacogenomics, Clinical trials optimization. Applications, Benefits, and Challenges faced.	4
VII	Smart farming using IOT, computer vision, AI, Robots, and drones, vertical farming, hydroponics and urban agriculture. Singapore a developed country as a case study.	4

Selected Readings:

1. Single Cell Methods: Sequencing and Proteomics, Editor: Valentina Proserpio. Springer protocols Methods in Molecular Biology Vol 1979. (2019)

2. A Handbook of Gene and Cell Therapy, Clevio Nobrega, Liliana Mendonca, and Carlos A. Matos, Springer. (2022)
3. 3-D Bioprinting: Principles and Protocols, Editor: Jeremey M. Crook. Springer protocols Methods in Molecular Biology Vol 2140. (2020)
4. Precision Medicine: Editor: Tao Huang, Humana Press, Springer protocols Methods in Molecular Biology Vol 2204. (2020)
5. Smart Plant Factory: The generation vertical indoor farms, Editor: Toyoki Kozai, Springer Publication.

Semester III

Course Code: BT-605-MJP **2 Credits**

No. of Practicals:15

Practical in Physiology

Sr. No.	List of Practicals	No. of Practicals
1	Brain Slice preparation.	1
2	Simple Neuron Model – The Hodgkin -Huxley neuron	1
3	Modelling the resting potential in neurons	1
4	Modelling the action potential	1
5	Voltage current plot	1
6	Study the effect of pharmacological blockers on action potential	2
7	Compare the growth of fenugreek and /or Coriandrum seeds grown in light and dark.	2
8	Study seed germination in dark, red, alternating red and far-red light	2
9	Purify phytochrome from germinating seeds and take its spectra from 340nm to 800nm.	1
10	Study the effect of blue light applied unidirectionally to fenugreek plants.	1
11	Study effect of green, blue, and red light on stomatal aperture.	1
12	Study the morphology of leaf of plants growing in well-watered mild water stress and severe water stressed soil.	1

Semester III

Course Code: BT-606-MJP **2 Credits**

No. of Practicals:15

Practical in Plant and Animal Biotechnology

Sr. No.	List of Practicals	No. of Practicals
1	*Chlorella* or *Spirulina* culture establishments and study of its growth using suitable parameters.	1
2	Biochemical analysis (protein. Pigment) of *Chlorella* or *Spirulina* culture	1
3	Effect of plant growth regulators on in vitro response of explants (induction of callus, somatic embryo, organogenesis, adventitious shoot formation and axillary bud proliferation)	2
4	*In vitro* production of pure lines	1
5	Protoplast isolation and Fusion	1
6	Initiation, maintenance and confirmation of Hairy root culture and sec. metabolite production	1
7	Preparation of culture media with various supplements for animal tissue culture.	1
8	Sub-culture and establishment of Adherent Cell Line	1
9	Initiation of primary culture from chick embryo	1
10	Counting of cells of an animal tissue	1
11	Cell viability by MTT assay and trypan blue dye exclusion method	1
12	Growth curve analysis of cell line	1
13	Chromosome preparations from cultured animal cells.	1
14	Study of animal cell fusion using PEG. / Transfection of Mammalian Cells	1

Semester III

Course Code: BT-610-MJ Molecular diagnostics 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Student will understand the importance of molecular diagnostics
- Student will acquire the knowledge of molecular markers in disease diagnosis
- Student will learn traditional and molecular methods for disease diagnosis
- Student will acquire the knowledge about various molecular diagnostic techniques
- Student will understand applications of molecular diagnostics in human health

Unit	Syllabus	No. of Lectures
I	**Introduction and History of diagnostics:** Rationale and need of early disease diagnosis. Age of molecular diagnostics, importance and scope Development of diagnostic industry in Indian and global perspective Causes and types of Diseases- Genetic, infectious, physiological and metabolic errors, Single gene Disorders (Cystic Fibrosis), Multifactorial disorders (Diabetes) Biomarkers / Genetic markers in disease diagnostics Traditional and molecular methods for the diagnosis of genetic diseases, metabolic disorders and infectious diseases- Advantages and limitations General approach to clinical specimens- types of specimens Sample collection-method of collection, transport and processing of samples Interpretation of results	8
II	**Molecular diagnostic techniques:** ELISA, Western Blotting, PCR, RT-PCR, ARMS-PCR, Multiplex-PCR, RFLP, SSCP, CSGE, DGGE, DHPLC , MALDI-TOF , DNA Sequencing Quality assurance and Quality Control in molecular diagnostics (Pre-analytical, Analytical, Post analytical)	8
III	**Applications of Molecular diagnostics:** Detection of major Metabolic disorders - Diabetes Detection of Genetic disorders- Sickle cell anemia, Duchenne muscular dystrophy, Cystic fibrosis, Retinoblastoma and Sex linked inherited disorders Neonatal and Prenatal disease diagnosis- Amplification of Y chromosome specific Short Tandem Repeats (Y-STR). Analysis of mitochondrial DNA for maternal inheritance. Concept and importance of molecular diagnosis for early detection of cerebral palsy, Down syndrome, other congenital abnormalities Gender identification using amelogenin gene locus. Population screening for genetic disorders Diagnosis of other disorders: Blood disorders, (haemoglobinopathies), Muscle disorders (Muscular dystrophy), Bone disorders (Osteogenesis imperfecta,	10

	Rheumatoid arthritis), Skin disorders (Albinism), Eye disorders (Retinitis pigmentosa) Diagnosis and treatment of Cancer- different types of cancers, Molecular basis of cancer - oncogenes, tumour suppressor genes.	
IV	**Infectious disease diagnosis:** Concept and importance of Polymorphisms and mutations in infectious diseases Detection and identification of microorganisms using molecular techniques Molecular markers in infections (Suitable examples) Early diagnosis and impact on disease outcome	4

Selected Reading:

1. Fundamentals of Molecular Diagnostics (2007). David E. Bruns, Edward R. Ashwood, Carl A. Burtis. Saunders Group.
2. Molecular Diagnostics: Fundamentals, Methods & Clinical applications (2007). Lele Buckingham and Maribeth L. Flaws
3. Molecular Diagnostics for the Clinical Laboratorian 2Ed. 2006, W.B. Coleman. Humana Press.
4. Molecular Microbiology: Diagnostic Principles and Practice David H. Persing, Fred C. Tenover, James Versalovic, Yi-Wei Tang, Elizabeth R. Unger, David A.; Relman, and Thomas J. White, (Eds.) ASM Press 2003 ISBN: 155581221X
5. Molecular Pathology in Clinical Practice (2007). D. G. B. Leonard.
6. Molecular Pathology: The Molecular Basis of Human Disease; William B. Coleman, Gregory J. Tsongalis (Eds.); Academic Press; 1 edition 2009 ISBN 10: 0123744199 ISBN 13: 978- 0123744197
7. Molecular microbiology: diagnostic principles and practice. Persing, D. H., Tenover, F. C., Hayden, R. T., Ieven, M., Miller, M. B., Nolte, F. S., ... & van Belkum, A. (Eds.). (2020). John Wiley & Sons.
8. Expert Review of Molecular Diagnostics

Semester III

Course Code: BT-611-MJP **2 Credits**

No. of Practicals:15

Practicals in Molecular diagnostics

Sr. No.	List of Practicals	No. of Practicals
1	Learn SOP for handling and processing clinical samples	1
2	Detection of antigen/ protein by ELISA (Quantitative test)	2
3	Detection of antigen/ protein by Western blotting	2
4	Extraction and quantification of DNA/ RNA from suitable sample	1
5	Southern / Northern blotting in diagnosis	2
6	Detection of bacterial / viral / fungal pathogens by PCR	1
7	Determination of viral load / genotype by RT PCR	2
8	Polymorphism studies using RFLP	1
9	Detection of genetic disorders (any one)	1
10	Detection of metabolic disorders (any one)	1
11	Understand clinical reporting of diagnostic data	1

Semester III

Course Code: BT-612-MJ Infectious diseases and Vaccine Technology 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Student will understand the concept and importance of infectious diseases
- Student will learn about the etiology and epidemiology of infectious diseases
- Student will acquire knowledge about various approaches used in infectious disease diagnosis
- Student will build an awareness about strategies of infection prevention and control
- Student will understand the importance of vaccines in prevention of infectious diseases

Unit	Syllabus	No. of Lectures
I	**Fundamentals of Infectious diseases:** Definition and types of Infections Sources and mode of transmission Community acquired and Hospital acquired infections Syndromic approach to infectious diseases	2
II	**Etiological agents of Infectious diseases:** Bacterial Diseases Viral Diseases Mycoses Protozoal diseases Helminthic diseases Ectoparasitic diseases	5
III	**Infectious diseases Epidemiology:** Environmental factors in Infectious Diseases Emerging and re-emerging diseases Epidemic alert: Notification and reportable diseases Control strategies for infectious diseases with regard to specific example (levels of prevention, source reduction, vaccination, integrated vector control, diagnosis and treatment) WHO regulations and guidelines Knowledge of the Geo-sentinel network Geographical Information mapping of infectious diseases	6
IV	**Infections in Special Hosts:** Immunocompromised (congenital and acquired) Cancer patients Transplant recipients	3
V	**Laboratory Diagnosis of infectious diseases:** Microscopic techniques, Cultivation of infectious agents, Serological methods, Molecular methods (Suitable examples for each approach)	4
VI	**Prevention of Infection / Infection Control:** Epidemiology and Surveillance Transmission and control of infections Immunization	4

	Disinfection and sterilization Isolation system Regulatory compliance	
VII	**Vaccinology:** Concept of vaccine preventable diseases Importance of Active and Passive immunization Vaccine technology: Classical and Modern approach, Types of vaccines Adjuvants: Classification, properties and role Antibody engineering Vaccine development, preclinical studies and clinical trials Challenges in vaccine development process and ethical considerations	6

Selected Reading:

1. Medical Microbiology (1997), Edited by Greenwood, D, Slack, R and Peutherer, J, ELST Publishers.
2. Ananthanarayan and Paniker's Textbook of Microbiology (2006) Seventh Ed.
3. Parasitology (1997), Chatterjee K.D, Chatterjee Medical Publishers.
4. Bailey & Scott's Diagnostic Microbiology (2002), Betty A. Forbes , Daniel F. Sahm, Alice S. Weissfeld , Ernest A. Trevino, Published by C.V. Mosby
5. Jawetz, Melnick, & Adelberg's Medical Microbiology (2004), Geo F. Brooks, Stephen A. Morse, Janet S. Butel.
6. Henry's Clinical Diagnosis And Management By Laboratory Methods (2007) Mcpherson
7. Molecular Diagnostics: Fundamentals, Methods & Clinical applications (2007). Lele Buckingham and Maribeth L. Flaws

Semester III

Course Code: BT-613-MJP **2 Credits**

No. of Practicals:15

Practicals in Infectious diseases and Vaccine Technology

Sr. No.	List of Practicals	No. of Practicals
1	Isolation of infectious agent (bacteria / yeast / fungi) from community / clinical samples	1
2	Identification of an infectious agent (bacteria) to at least Genus level using the Bergey's Manual	2
3	Determine antibiotic susceptibility of the infectious agent	1
4	Determine MIC /MBC of the antibiotic	1
5	Identification of yeast / fungal pathogens using appropriate techniques	1
6	Identification of protozoa / parasite from human excreta	1
7	Qualitative and quantitative detection of bacterial / viral infection using appropriate Serological diagnosis techniques	2
8	Detection of bacterial / viral infection using molecular diagnostic techniques	2
9	Determine viral load using Real Time-PCR (Demonstration)	1
10	Vaccine antigen preparation	2
11	Antibody production in animal model	1

Semester III

Course Code: BT-614-MJ Biofuel Technology 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Students will become capable to distinguish and critically compare various biofuels in addressing energy needs and environmental concerns.
- Students will acquire theoretical and practical skills for bioethanol and biodiesel production, applying knowledge of feedstock preparation, fermentation/transesterification, and quality control.
- Through life cycle assessment students will be able to evaluate economic feasibility of biofuels, considering factors like carbon footprint, water use, and policy implications.
- Students will become capable to articulate the practical applications and future prospects of biofuel technologies.

Unit	Syllabus	No. of Lectures
I	**Introduction and classification of Biofuels:** Concept of biofuel, Role of biotechnology in biofuel production, History and current status of biofuel development, Advantages and disadvantages of biofuels compared to fossil fuels, Government policies and incentives for biofuel production Classification of biofuel: First-generation, Second-generation, Third-generation. Introduction to various feedstock used for alcohol production. Factors affecting feedstock selection and sustainability	4
II	**Bioethanol Production Technology:** Fermentation process: biochemical mechanisms and factors influencing ethanol production. Fermentation methods and yeast selection: fermentation strategies (e.g., batch, continuous) and selection criteria for efficient yeast strains. Feedstock selection: significance of feedstock choice (molasses, lignocellulose). Molasses-based Bioethanol: Molasses characterization (Composition, grades, storage, Molasses preparation: Dilution practices, water quality and its impact, pre-clarification). Lignocellulose-based Bioethanol: Pretreatment, saccharification (Acid/Enzyme hydrolysis) and liquification Fermentation and downstream processing: Separation, and filtration, distillation methods (pot still, column still). By products of alcohol manufacture – CO_2, fusel oil & yeast sludge	10
III	**Biodiesel and Bio-oil Production:** Transesterification process for biodiesel production Feedstock selection and preparation for biodiesel production Catalyst selection and optimization Purification and quality control of biodiesel Co-production of biodiesel and glycerol	6

	Pyrolysis and gasification processes for bio-oil production Applications of bio-oil and its upgradation options	
IV	**Biogas Production:** Anaerobic digestion process for biogas production Feedstock selection and pretreatment for biogas production Design and operation of biogas digesters Upgradation of biogas to biomethane	5
V	**Environmental and Economic Aspects of Biofuels:** Life cycle assessment of biofuels Carbon footprint and greenhouse gas emissions associated with biofuel production Water use and land use requirements for biofuel production Economic feasibility of biofuel production and use Policy implications and future prospects of biofuel technologies	5

Selected Reading:

1. "Alcohol Textbook" by K. A. Jacques, T. P. Lyons, and D. R. Kelsall
2. "Alcohol Fuel: A Guide to Making and Using Ethanol as a Renewable Fuel" by Richard Freudenberger
3. "Alcohol Can Be a Gas!: Fueling an Ethanol Revolution for the 21st Century" by David Blume
4. "Industrial Alcohol Technology Handbook" by NPCS Board of Consultants & Engineers
5. "Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment" by Henry C. Vogel and Celeste M. Todaro
6. "Distillation: Principles and Practices" by Johann G. Stichlmair
7. "Chemical Process Equipment - Selection and Design" by James R. Couper, W. Roy Penney, James R. Fair, and Stanley M. Walas
8. "Chemical Process Industries" by Shreve's and George T. Austin
9. "Biofuels Engineering Process Technology" by Caye M. Drapcho, Nhuan P. Nghiem, and Terry H. Walker
10. "Introduction to Bioenergy" by Sergio Capareda
11. "Cleaner Combustion and Sustainable World" edited by Samir El-Sharoud
12. "Renewable Energy: Power for a Sustainable Future" by Godfrey Boyle
13. "Alcohol and the Environment" edited by Michael D. Goldsmith
14. "Sustainable Ethanol: Biofuels, Biorefineries, Cellulosic Biomass, Flex-Fuel Vehicles, and Sustainable Farming for Energy Independence" by Jeffrey Goettemoeller and Adrian Goettemoeller
15. "Sustainable Alcohol Production: A Handbook of Energy Efficiency and Renewable Energy Processes" edited by Adalberto Pessoa Jr.
16. "Distilled: From absinthe & brandy to vodka & whisky, the world's finest artisan spirits unearthed, explained & enjoyed" by Neil Ridley and Joel Harrison

Semester III

Course Code: BT-615-MJP **2 Credits**

No. of Practicals: 15

Practicals in Biofuel Technology

Sr. No.	List of Practicals	No. of Practicals
1	Study of raw materials (molasses, lignocellulosic material) used for alcohol production.	1
2	Analysis of fermentable sugars, weighing, dilution and clarification of molasses	1
3	Inoculum development for bioethanol production	1
4	Conduct lab trails of molasses-based fermentation	1
5	Pretreatment (crushing, saccharification-enzyme/acid) of lignocellulosic materials used for alcohol production.	2
6	Determination of the fermentable sugars in the pretreated lignocellulosic materials	1
7	Conduct lab trails of lignocellulosic materials based fermentation	1
8	Microscopic observation of alcoholic fermented broth	1
9	Distillation of molasses and lignocellulosic materials fermented broth	1
10	Estimation of alcohol content from molasses and lignocellulosic based fermentation	1
11	Estimation of residual sugar, total and volatile acidity in fermented broth	2
12	Production of biodiesel in laboratory using non edible/used edible oil.	1
13	Visit to study biogas production (local biogas production unit), and alcohol production (fermentation and distillation processes) at distillery site report writing with photographic evidence	1

Semester III

Course Code: BT-616-MJ Biotechnology for sustainable development 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Students will understand the importance of sustainable development.
- Students will be able to identify the natural resources for the sustainable development of human
- Students understand the importance of preserving natural resources.
- Students will acquire knowledge about the impact of recovery, recycle of the useful resources from the wastes by adopting advanced biological technique
- Students will be able to identify and demonstrate the knowledge to use suitable equipment for abatement and control of air &water and soil pollution.
- Students will acquire the skills for demonstration of sustainable development through Biotechnology
- Students will be able to identify the bio-based industries and their importance.

Unit	Syllabus	No. of Lectures
I	**Definition of sustainability** – environmental, economical and social dimensions of sustainability. Biotechnological approach to sustainable development **Natural Resources:** Types of natural resources, their consumption patterns; Human population explosion and resource degradation and conservation; Factors influencing resource availability, distribution and uses; Current status, management and advances of national and global resources of: Water resources, Marine resources, Energy resources, Forest resources, Mineral resources	4
II	Biotechnology for clean environment- Bioremediation biotechnology to prevent, detect and remedy to environment damage with example Prevention: detection and monitoring; Pollutant assay, Microorganism detection and tracing Bioremediation: Biological treatment of solid wastelandfillinganaerobic digestion of solid; composting Microbially enhanced oil recovery (MEOR), Microbial biopolymers used in recovery Biodegradation of aromatic and chlorinated hydrocarbon and petroleum Microbial removal of metal pollutant from water Bioleaching – bioleaching microorganisms, recovery of metals from mining waste; Extraction of – Copper, uranium, gold Use of Non-conventional Sources of Energy: Recycling/Bioconversion Nanoscience for clean environment and sustainable development	10
III	**Microorganism as constant and alternate source of food, energy and raw material:** microbial production of chemicals, their production process and their uses (acetic acid, citric acid, glycerol, isopropanol, lactic acid, acrylamide) Microbial polymers and plastics – process, production and organisms	10

	involved; Industrial process and clean technology: extraction and supply of raw materials; processing of raw material (eg. Ethanol, Enzymes production from waste,) **Alternative energy sources; Biological energy sources,** Biofuels – generations of biofuels; Combustion of biomass, Biogas, Biodiesel, Ethanol, hydrogen Biofuels from waste: Methods and processes for utilization of waste for production of fuels, Community biogas plant, biogas scheme – scope of rural development,	
IV	**Sustainability in Agriculture:** Biofertilizer: Microorganism involved and role maintaining the fertility of soil Production of biofertilizers and its application Food Security and the Environment: engineering new sustainable pesticides to improve crop yields. GMO as an Environmental and Health Issues, Biosafety Protocol, Genetic engineering in overproduction of agriculture recombinant products, Golden rice, diseases resistant plants, bt-cottan, flaver saver tomato and stress resistant plant	6

Selected Reading:

1. Biotechnological Approaches to Sustainable Development Goals, Springer Cham
2. Devarajan Thangadurai and JeyabalanSangeetha, Industrial Biotechnology: Sustainable Production and Bioresource Utilization, CRC Press.
3. P.K. Chakraborty, Agro & Industrial Biotechnology, Black Prints India Inc., 2014.
4. Elliott JA (2006) An Introduction to Sustainable Development. Routledge
5. Patrick Omoregie Isibor, Paul Akinduti, Solomon U. Oranusi, Jacob O. Popoola (2023) Biotechnological Approaches to Sustainable Development Goals, Springer Cham

Semester III

Course Code: BT-617-MJP **2 Credits**

No. of Practicals:15

Practicals in Biotechnology for sustainable development

Sr. No.	List of Practicals	No. of Practicals
1	Identification of fecal pollution in drinking water	2
2	Preparation of starch-based bio composites	1
3	Preparation of biofertilizer and demonstrate the application of microbial biofertilizer on plant growth.	2
4	Extraction and preparation of natural dyes from beetroot and pomegranate parts and evaluate antioxidant activity	1
5	Preparation of Effective Microorganisms (EM) solution and Evaluating the impact of EM solution on plant growth	2
6	Preparation of plant based biopesticide and its effects	2
7	Production of bioethanol from lignocellulosic biomass	2
8	Preparation of compost using Domestic/Industrial /Commercialwaste	2
9	Visit to vermicomposting/ biofertilizer/ Biopesticideplant	1

Semester III

Course Code: BT-618-MJ Biosensor Technology 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Student will understand different classes of biosensors and their functioning principles
- Student will be able to apply principles and concepts of biology to design biosensors
- Student will be able to recognize different types of transducers, and their application in biosensor design
- Student will understand the use of biomolecues as recognition elements for detection of a particular analyte
- Student will acquire knowledge of applications of biosensors in various fields of life sciences

Unit	Syllabus	No. of Lectures
I	**Introduction to biosensors:** Components of biosensors, Generations of biosensors Biosensor classification- Biocatalysis based biosensors, Bioaffinity based biosensors, Inhibition based biosensors, Cell-based biosensors, Biologically active material and analyte, Biochips and biosensor arrays Types of membranes used in biosensor constructions Biosensors- Advantages and limitations Properties of ideal materials for biosensors Classes of materials for biosensors- polymers, material containing metal complex, sol-gel materials, nanomaterials, composite materials, metal oxides, photonic crystals, and zeolite materials	8
II	**Biological Recognition Systems:** tissue, cell, DNA, enzyme, antibody, antigen, protein, peptide, aptamer	4
III	**Transducers in Biosensors:** Types of transducers, principles and applications of Calorimetric, Optical, Potentiometric / Amperometric, Conductometric / Resistometric, Piezoelectric, acoustic wave, Semiconductor, Impedimetric and Chemiluminiscene - based Biosensors.	6
IV	**Basics of detection methods:** Fluorescence Spectroscopy, UV-Vis Absorption and Emission, Surface Plasmon Resonance, Magnetic labelling Introduction to electrochemical detection methods, redox processes, and electron transfer	6
V	**Application of Biosensors:** In clinical chemistry, medicine and health care Detection of viruses and bacteria, clinical diagnostics Biosensors for veterinary, agriculture and food Biosensor in industrial processes for online monitoring, environmental	6

	monitoring. Application of enzyme electrodes as biosensors in industry, healthcare, food and environment.	

Selected Reading:

1. Biosensors an Introduction, Brian R Eggins, First edition, John Wiley & Sons Publishers, 1996.
2. Biosensors Principles and Applications, Loic J Blum, Pierre R Coulet. First edition, Marcel Dekker,Inc, 1991.
3. Biosensors Theory and Applications, Donald G. Buerk. First Edition Technomic Publishing. Co, Inc, 19931.
4. Biosensors, Elizabeth A Hall. First Edition, Open University, Milton Keynes, 1990.
5. Biosensors and modern bio-specific analytical techniques, L. Gorton (ed) Volume XLIV Elsevier 2005.
6. Advances in biosensors, B. D. Malhotra & A. P. F. Turner (eds), Volume 5, Elsevier science 2003. R

Semester III

Course Code: BT-619-MJP **2 Credits**

No. of Practicals: 15

Practicals in Biosensor Technology

Sr. No.	List of Practicals	No. of Practicals
1	Enzyme Immobilization using any two techniques	3
2	Cell Immobilization / Entrapment	2
3	Determine important characteristics of different types of biosensors: a) Sensitivity b) Selectivity c) Stability d) Limit of detection e) Reproduciblity f) Response time g) Linearity	8
4	Demonstration of application and functioning of various types of biosensors	2

Semester III

Course Code: BT-620-MJ Intellectual Property Right (IPR) 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Student will understand the concept and importance of intellectual property rights
- Student will acquire knowledge about various tools of IP
- Student will understand the significance of practice and procedure of Patents
- Student will learn the procedure of obtaining Patents and Copyrights
- Student will get an insight for importance and need for protection of biotechnology inventions

Unit	Syllabus	No. of Lectures
I	**General Regime of Intellectual Property Rights:** Overview and Historical Perspectives Intellectual Property as an Instrument of Development, IP and Innovation Need for Protecting Intellectual Property National Perspectives and International demands TRIPS (Trade Related Intellectual Property Rights) Agreement and International Treaties related to IPR Tools of IPR	6
II	**Patents:** Criteria of Patentability; Types of patents Patent applications: Types, provisional and complete specifications. Patent Specification Drafting Procedure for Filing Patent Applications, Patent Granting Procedure; Revocation of patent Patent Infringement and Remedies; Commercialization of patented innovations; licensing and transfer of patents, royalty Indian Patent Law	8
III	**Copyright -** Conceptual Framework, Copyright works, Ownership, transfer and duration of Copyright, Renewal and Termination of Copyright, Neighbouring Rights Infringement of copyrights and remedies; Examples and Case study Indian Copyright act	5
IV	**Protection of Plant Varieties:** Importance and need for Protection of Plant Varieties, Plant Breeders' Rights and Farmers' Rights, Authority and Registry Registration of Plant Varieties and Essentially derived variety, Duration, Effect of Registration and Benefit Sharing; Examples and Case study	4
V	**Patents of Microorganisms and genes:** Meaning and Definition, Budapest Treaty, International Depositary Authority, Criteria of novelty for patenting Microorganisms Case Study: Diamond V/S Chakrabarty Relevant Provisions of the Biological Diversity Act, 2002	4
VI	**Trade mark, Trade Secrets and Industrial Designs:** Need and Importance in Biotechnology, Examples	3

Selected Reading:

1. Karki, M S, Intellectual property rights: basic concepts (2009) M Atlantic Publishers & Distributors, New Delhi
2. Wadehra, B.L. Law Relating To Intellectual Property, (2011), Fifth Edition, Universal Law Publishing Co.Pvt. Ltd.
3. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata
4. National IPR Policy, Department of Industrial Policy & Promotion, Ministry ofCommerce, GoI
5. Complete Reference to Intellectual Property Rights Laws. (2007).Snow White Publication Oct.
6. TIFAC 2002 Some questions and answers on Patents an d Copyrights
7. Hirvani R, Patents in Plant Breeding: Guarding the Green Gold-,Biotech News, (2009),vol 4.,
8. GanguliPrabuddh, Intellectual Property Rights , (2001), Tata McGraw-Hill Publishing Company Ltd. 13. Narayanan,P, Law of copyright and Industrial Designs,(2010), Eastern Law House, Delhi
9. Office of the Controller General Of Patents, Designs & Trade,(CGPDTM): Manual of Patents/Manual of Industrial Design/Draft Manual of Trademarks
10. Website: World Trade Organisation. http://www.wto.org
11. Website:World Intellectual Property Organisation. http://www.wipo.int
12. Office of the Controller General of Patents, Design & Trademarks; Department of Industrial Policy & Promotion; Ministry of Commerce & Industry; Governmentof India. http://www.ipindia.nic.in/
13. International Union for the Protection of New Varieties of Plants. http://www.upov.int

Semester III

Course Code: BT-621-MJP **2 Credits**

No. of Practicals:15

Practicals in Intellectual Property Right (IPR)

Sr. No.	List of Practicals	No. of Practicals
1	Exercise Prior Art Search for patent	2
2	Visit IPO / Copyright office website / NIPAM	2
3	Visit WIPO website	1
4	Study Copyright registration procedure	2
5	Patent Specification Drafting Exercise	2
6	Study Patent Application filing procedure in India	2
7	Trademark public search	2
8	Study Trademark registration process	1
9	Case study of revocation of patent	1

Semester III

Course Code: BT-622-MJ Biofertilizer and Biopesticide technology 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- Students will apply knowledge of biofertilizer and biopesticide principles to enhance crop yield and reduce chemical dependence.
- Students will acquire theoretical knowledge and practical skills for formulation of biofertilizers and biopesticides.
- Students will be able to evaluate the quality control parameters and efficacy of biofertilizers/biopesticides.
- Students will promote potential of biotechnologies for environmentally friendly/sustainable agricultural practices.

Unit	Syllabus	No. of Lectures
I	**Introduction to biofertilizers and biopesticides** Agriculturally important beneficial Microorganisms, Introduction and scope of biofertilizers Types and classification of biofertilizers. Present status of biofertilizer market, Government policies and future scenario. History and concept of Insect pathogens and biopesticides. Introduction, importance, scope and potential of biopesticides. Definitions, concepts and classification of biopesticides viz. pathogens, botanical pesticides, and bio-rationals.	6
II	**Microbes as biofertilizers** Nitrogen biofertilizers-Symbiotic and non-Symbiotic nitrogen fixation. Nodule formation, Competitiveness, quantification of nitrogen fixed, associative and free-living nitrogen fixation, cyanobacterial biofertilizers. Phosphate solubilizing bacteria and fungi, mechanism and solubilization of phosphorus, phosphate mobilizing microorganisms. Calcium, Potassium and Zinc Biofertilizers. Plant Growth Promoting rhizobacteria (PGPR). Vesicular Arbuscular Mycorrhiza (VAM) and its significance.	6
III	**Biofertilizer production technology** Strain selection/development, Sterilization, Growth and Fermentation. Mass scale production of different carrier and liquid based biofertilizers FCO specifications and quality control of biofertilizers. Storage, shelf life and marketing. Factors influencing the efficacy of biofertilizers. Application technology for seeds, seedlings, tubers, sets biofertilizers – Microbes beneficial for recycling of organic wastes and composting. Bio remediators and its related microbes.	6
IV	**Biopesticides production technology** Types of Biopesticides: Microbial Biopesticides (Viruses, Bacteria, Fungi, Virulence, pathogenicity and symptoms of entomopathogenic organisms. Botanical and other Bio-rational Pesticides: Plant extracts, Biofumigants, Other natural pest control agents.	12

	Production and Applications: Importance of Biopesticides in Sustainable Agriculture, Role in organic farming, Benefits for ecofriendly agriculture. Mass Production of Bioagents: Trichogramma, Cryptolaemus, Chrysoperla, NPV, Entomofungal pathogens, Scaling up production for different categories. Application Methods and Precautions: Effective delivery methods, Precautionary measures for safe handling and usage. Quality Control and Challenges, Quality Control Techniques, Methods for assessing biopesticide efficacy, Standards and parameters as per CIB specifications. Constraints and Solutions, Production and usage challenges, Potential solutions and future directions. Regulations and Marketing, Registration Procedures, Strategies for CIB and organic farming institute registration. Marketing and Commercialization, Case studies of successful biopesticide businesses	

Selected Reading:

1. Leo, M.L. Nollet, Hamirsingh Rathore. Bio Pesticide Handbook. CRC Press Tayler & Francis group, Newyork. 1-29 pp.
2. Md. Arshad Anwer. 2017. Bio Pesticides and Bio Agents e book CRC Press Taylor & Francis group Newyork. 1-365 pp.
3. Dwijendra Singh.2014. Advances in Plant Bio Pesticides. Publisher Springer 1-401 pp.
4. Ghayur Alam. 2000. A Study of Bio Pesticides and Bio Fertilisers in Haryana, India. International Institute for Environment and Development 3 Endsleigh Street London 1-24 pp.
5. Vibrant Gujarath. 2017. Setting up a Bio-Fertilizers and Bio-Pesticides Unit Biotechnology Government of Gujarat. Gujarat State Biotechnology Mission. 1-23 pp. 199
6. Salma Mazid, Ratul Ch. Rajkhowa, Jogen Ch. Kalita (2011). A review on the use of Bio Pesticides in Insect Pest Management. International Journal of Science and Advanced Technology, Volume 1 No 7, 169-178 pp.
7. Muhammad Nawaz, Juma Ibrahim Mabubu and Hongxia Hua. 2016. Current status and advancement of Bio Pesticides: Microbial and Botanical Pesticides.Journal of Entomology and Zoology Studies, Volume 4(2): 241-246 pp.
8. S. Ezhil Vendan. 2016. Current Scenario of Bio pesticides and eco-friendly insect pestmanagementinIndia. South Indian Journal of Biological Sciences 2(2); 268-271pp.
9. Opender Koul.2011. Microbial Bio Pesticides: Opportunities and Challenges. CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources Vol 6, No. 56. 1-26 pp.
10. Vaishali Kandpal 2014. Bio Pesticides.International Journal of Environmental Research and Development. 4(2), 191-196 pp. Page16
11. Subrata Datta. 2012. Bio Pesticides and Fertilizers: Novel Substitutes of their Chemical Alternates.Journal of Environmental Research and Development, 6 (3A), 773-777 pp.
12. Biofertilisers in Agriculture by N. S. Subba Rao.

13. Recent Trends in Biofertilisers by Pati Bikasir and Mandal Santi, M.

14. The complete technology book on Biofertiliser and Organic Farming (2nd revised edition) by Niir Board. 2012 published.

15. Hand book of Microbial Biofertilisers by Mahendra Rai. Published in 2006 by CRC Press.

16. Biofertiliser in Sustainable Agriculture by A. C. Guar. Published by ICAR.

17. Biofertilisers Technology by S. Kannaiyan, K. Kumar and Govindarajan published by Scientific Publishers (India) 2004

Semester III

Course Code: BT-623-MJP **2 Credits**

No. of Practicals:15

Practicals in Biofertilizer and Biopesticide technology

Sr. No.	List of Practicals	No. of Practicals
1	Isolation of N_2 fixing (symbiotic, free living) microorganisms and its preservation	2
2	Isolation of Phosphate solubilizing, Calcium solubilizing, Zinc solubilizing, microorganisms and its preservation.	2
3	Isolation of hormone producing microorganisms and its preservation.	2
4	Isolation of siderophore producing microorganisms and its preservation.	2
5	Formulation and preparation of biofertilizer (Bacterial and Fungal) using suitable carrier material.	1
6	Isolation of potent biopesticide producer (Trichogramma/ Cryptolaemus/ Chrysoperla/ NPV/ Entomofungal pathogens)	2
7	Formulation and preparation of biopesticide using suitable carrier material.	1
8	Checking efficiency of biofertilizer/biopesticide using suitable assay	2
9	Visit to agriculture university/ biofertilizer / biopesticide production unit, report writing and photo documentation	1

Semester III

Course Code: BT-624-MJ Machine learning and data science 2 Credits

Total Lectures: 30

Course Outcomes

After completion of the course

- The student will be able to understand the foundational concepts of machine learning.
- The student will be able to develop computational pipelines for biological and healthcare data.
- The student will be able to develop machine-learning models for classification and regression tasks required in healthcare applications.
- The student will be able to apply machine-learning models for better performance and application in healthcare.

Unit	Syllabus	No. of Lectures
I	**Introduction to Machine Learning** Introduction: What is Machine Learning, Definitions and Real-life applications, Comparison ofMachine learning with traditional programming, ML vs AI vs Data Science. Learning Paradigms: Learning Tasks- Descriptive and Predictive Tasks, The Brain and the Neuron , Design a Learning System, Perspectives and Issues in Machine Learning, Types of Machine Learning : Supervised, Unsupervised,Semi-supervised and Reinforcement Learnings. Applications of machine learning in healthcare and biotechnology. Ethical considerations in biotechnological applications of ML	10
II	**Data Preprocessing and Understanding:** Data preprocessing and visualization: Types of data, dealing with missing data, data visualization: Scatter Plot, histogram, group plots, box plots etc., dimensionality reduction. Data preparation/annotation,Feature Selection and Extraction: Importance of feature engineering in biotechnological data Feature Transformation: Dimensionality reduction techniques- PCA and LDA	10
III	**Applications of Machine Learning in Biotechnology:** Applications in Biotechnology: Image analysis (microscopy, bio-imaging), Sequence analysis (DNA, RNA), Applications of machine learning in drug design, Case studies on successful drug discovery projects. Personalized treatment strategies using machine learning.	10

Selected Reading:

1. Jiawei Han, MichelineKamber, and Jian Pie, “Data Mining: Concepts and Techniques”, ElsevierPublishers Third Edition, ISBN: 9780123814791, 9780123814807
2. EthemAlpaydin, “Introduction to Machine Learning”, Publisher: The MIT Press,2014
3. Peter Flach: “Machine Learning: The Art and Science of Algorithms that Make Sense of Data”, Cambridge University Press, Edition 2012

4. Ian H Witten, Eibe Frank, Mark A Hall, “Data Mining, Practical Machine Learning Tools and Techniques”, Elsevier, 3rd Edition
5. Shalev-Shwartz, Shai, and Shai Ben-David, “Understanding machine learning: From theory to algorithms”, Cambridge university press, 2014
6. McKinney, “Python for Data Analysis O' Reilly media, ISBN : 978-1-449- 31979-3

Semester III

Course Code: BT-625-MJP **2 Credits**

No. of Practicals:15

Practicals in Machine learning and data science

Sr. No.	List of Practicals	No. of Practicals
1	Download healthcare data from Kaggle and perform preprocessing techniques	3
2	Download healthcare data from Kaggle and draw scatter plot, box plots	3
3	Implement Decision Tree algorithm	3
4	Implement Naïve Bayes Algorithm	3
5	Write a program to implement Unsupervised Learning using K-means Clustering Students can perform the above programs using Weka Tool\python programming	3

Semester III

Course Code: BT-631-RP **4Credits**

Research Project

Project work, Thesis Submission and Presentation

- Project work / Thesis / Dissertation shall be carried out under the supervision of a qualified teacher in the concerned Department / Research Institute / Industry.
- Project work / Thesis / Dissertation shall be pursued for a minimum of 12 weeks during the semester, following the preliminary plan of work carried out in the semester.
- The Project Report / Thesis / Dissertation report is to be prepared as per standard scientific research methodology and duly signed by the supervisor(s) and the Head of the Department shall be submitted to the concerned department.
- The assessment (Internal and external) of the project work will be as per SPPU guidelines.

Semester IV

Course Code: BT-651-MJ Bioprocess Engineering 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will upgrade the knowledge, understanding and skills of microbial growth and product recovery in the Biopharmaceutical industry.
- Students will be able to understand and explain the definition of bioprocess techniques and their position in the scientific tree,
- Students will be able to analyze and present the principles of bioprocess engineering.

Unit	Syllabus	No. of Lectures
I	**Introduction to bioprocess engineering:** Introduction to bioprocess engineering; Concept of Bioprocess and bioprocess Engineering Outline of an integrated bioprocess and the various (upstream and downstream) unit operations involved in bioprocesses Material and Energy Balance Computations; **Types of Fermentations:** Solid state fermentation, Dual/Multiple, Aerobic, Anaerobic, batch, fed-batch, continuous **Kinetics of microbial growth:** Phases of cell growth in batch cultures; Unstructured & simple structured kinetic models for microbial growth; Monod model; Growth of filamentous organisms. **Microbial growth and product formation:** Growth associated (primary) and non-growth associated (secondary) product formation kinetics, **Isolation, screening and maintenance** industrially important microbes **Strain Improvement:** Product formation and inhibition pathways and their regulations, Strain improvement by: Mutation, Protoplast fusion, parasexual cycle and genetic engineering; Isolation of mutants with altered permeability, auxotrophic mutants, analogue resistant **Bioreactor Design:** Construction material used, surface treatment of the material **Different designs of bioreactors**: continuous stirred tank bioreactor,bubble column fermenter, Air Lift (internal and external loop), Packed Bed reactor, Fluidized bed reactor	8
II	**Media for industrial fermentations:** Medium requirements for fermentation processes, carbon, nitrogen, minerals, vitamins and other complex nutrients, oxygen requirements, Buffering agents, Chelators, Water, Precursors, Inhibitors, Inducers Antifoams Concept of Medium Optimization: Medium formulation (Statistical design) of optimal growth and product formation, Ingredients for mammalian cell culture and plant cell culture. **Sterilization of media and air**: Thermal death kinetics of microorganisms, Del factor, design organism, Design of sterilization process (batch and continuous), sterilization of bioreactor& feed	7

	Sterilization of air, exhaust air, theory of depth filter, designing of depth filters. **Monitoring of process variables:** Types of sensors, Measurement and control of various parameters (pH, Temperature, dissolved oxygen, microbial biomass, fluid flow, Pressure, Foam) P.I. D. control, Computer control of variables. **Scale Up and Scale Down:** Importance, parameters involved	
III	**Mass transfer, Heat transfer, Oxygen transport to cells and agitation of fermentation broth:** Mass transfer: Concept of mass transfer, Molecular diffusion and role in bioprocess, Two–film theory, Convective mass transfer, volumetric mass transfer, Liquid-Solid, Liquid-liquid and Gas- liquid mass transfer equations and significance in bioprocess. Heat Transfer: Various modes of heat transfer, viz., conduction convection and radiation. Design Equations for Heat Transfer Systems – Energy Balance, Calculation of Heat-Transfer Coefficients. Relationship between heat transfer, cell concentration and stirring conditions Oxygen transfer: Oxygen Uptake in cell cultures, Oxygen transfer from Gas bubble to Cell. Gas hold up, KLa importance, Measurement of KLa, Determination of KLa, Factors affecting KLa. Agitation: Type of impellors. Fermentation Broth rheology–Newtonian and NonNewtonian fluids, Factors affecting broth rheology, Power requirement for mixing Power number, Reynolds number, Flow regimes in fermentation tank (Laminar, turbulent and transition),	8
IV	**Downstream Processing:** Economics of downstream processing in Biotechnology. Cost cutting strategies, characteristics of biological mixtures, process design criteria for various classes of bioproducts (high volume-low value products and low volume- high value products), physicochemical basis of bio separation processes. **Recovery Process:** Solid liquid separation: filtration, centrifugation, sedimentation, flocculation; Cell disruption methods (Physical, Chemical and enzymatic methods); Precipitation methods - Precipitation with salts, organic solvents & polymers Extraction (Liquid-liquid, Aqueous two phase, Supercritical fluid); Batch extractions, staged extractions-cross current, co current, counter current extractions. Distillation. **Purification:** Purification by chromatographic techniques; – gel filtration, ion-exchange Reverse osmosis and ultra-filtration; dialysis, electro dialysis, Isoelectric focusing. Adsorption Drying; Crystallization, Whole Broth Processing	**7**

Selected Readings:

1. Doran, Pauline M. (1995). Bioprocess engineering principles / Pauline M. Doran. London; San Diego :Academic Press,
2. Stanbury, P. F., Whittaker, A. and Hall, S., (2016) Principles of Fermentation technology, Springer, Third edition

3. Peppler, H. J.,D. Perlman (1979), Microbial Technology, Vol I and II, Academic Press, Second edition (E book by Elsevier)
4. Casida, L. E., (1984), Industrial Microbiology, Wiley Easterbs, New Delhi
5. Prescott. S.C and Dunn, C. G., (2004) Industrial Microbiology, CBS Publishers and Distributors, Fourth Edition.
6. A.H. Patel. (2011), Industrial Microbiology, Macmillan India Ltd., Second Edition.
7. Crueger, W. and Crueger, A. (2005) A Text Book of Industrial Biotechnology, Panima,
8. John Villadsen, Jens Nielsen, Gunnar Lidén. (2011) Bioreaction Engineering Principles, 3rd Edition. Springer Science & Business Media.

Semester IV

Course Code: BT-652-MJ **Genomics** **2 Credits**

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will gain thorough knowledge in genetics and molecular biology, including in-depth understanding of expression and organization genomes.
- Students will acquire strong competences in computer programming, biostatistics, multiscale modelling and computational simulations as well as theoretical modelling and algorithms applicable to quantitative biology.
- Students will possess advanced biocomputing skills for gene-bank data mining, annotation, and management, as well as theoretical knowledge and practical skills for the analysis of biological communities, cell populations and complex systems.

Unit	Syllabus	No. of Lectures
I	Definition and scope of genomics Historical perspective and milestones in Genomics	4
II	a. Chromosome structure and organization, techniques used – FISH (Chromosome mapping, detecting chromosomal abnormalities and Gene Localization); Chromosome Conformation Capture (3C) and Derivatives (4C, 5C, Hi-C) - Studying long-range chromatin interactions, understanding genome organization. Microscopy Techniques (Confocal Microscopy, Super-resolution Microscopy): Detailed visualization of chromosomal structure, studying chromosome dynamics during cell division. b. Epigenetics and Chromatin Modification: Chromatin Immunoprecipitation (ChIP) and ChIP-Seq (Mapping histone modifications, studying transcription factor binding sites, identifying active and repressed chromatin regions) DNA Methylation Analysis: Bisulfite Sequencing, Studying DNA methylation patterns, understanding the role of DNA methylation in gene regulation. Histone Modification Analysis: Mass Spectrometry, WesternBlotting (Profiling histone modification patterns, studying the impact of histone modifications on gene expression). RNA Sequencing (RNA-Seq) for Non-Coding RNAs (Studying the regulatory roles of non-coding RNAs in epigenetic processes.	10
III	DNA Sequencing: Sanger sequencing, Next-generation sequencing (NGS) technologies	4
IV	Genomic Data Analysis, Bioinformatics tools and databases Genome assembly and annotation, Comparative genomics, FunctionalGenomics, Gene expression analysis (microarrays, RNA-seq), Proteomics and metabolomics, Functional annotation of genes	8
V	Genomic Technologies and Applications: Genomic Medicine, Personalized genomics, Pharmacogenomics,Toxicogenomic, Genetic testing and counseling	2

VI	Ethical, Legal, and Social Issues in Genomics - Ethical considerations ingenetic research, Genetic privacy and consent, Genetic discrimination and social implications	2

Selected Readings:

1. Introduction to Genomics
2. Bioinformatics and Functional Genomics: Jonathan Pevsner
3. The Selfish Gene by Richard Dawkins
4. The Ancestor's Tale, by Richard Dawkins
5. The Origins of Genome Architecture, by Michael Lynch
6. Evolutionary Genomics and Proteomics, by Mark Pagel and Andrew Pomiankowski
7. Rosalind Franklin: The Dark Lady of DNA by Brenda Maddox
8. The Human Genome: Book of Essential Knowledge, by John Quackenbush
9. The Signature in the Cell, by Stephen C. Meyer
10. The Immortal Life of Henrietta Lacks, by Rebecca Skloot
11. Genetics: Analysis and Principles, by Robert Booker
12. Principles of Genetics by Gardner
13. Human Genetics concepts and application by Ricki Lewis
14. Genetics: A Molecular Approach by T. A. Brown
15. Concept of Genetics by Klug
16. Genetics: A conceptual Approach by Pierce
17. An introduction to Genetic Analysis by Griffiths
18. Theory and Problems of Genetics by Stansfield.
19. Genetics: Analysis of Genes and Genomes by Hartl and Rubolo
20. Genetics by Fletcher and Hickey.
21. Genes by Lewin

Semester IV

Course Code: BT-653-MJ **Proteomics** **2 Credits**

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will have better understanding of the structure and function of the organism.
- Student will acquire the knowledge about common workflows for the large-scale analysis of proteins
- Student will get an insight into the analysis of post-translational modifications and protein-protein interactions.
- Student will understand in depth working of high throughput techniques.

Unit	Syllabus	No. of Lectures
I	Definitions, Proteomics Origins, Genome Information, Why Proteomics? Annotation of the genome, Protein expression studies, Protein function, Protein modifications, Protein localization and compartmentalization, Protein-protein interactions, Types of Proteomics, Protein expression proteomics Structural proteomics, Functional proteomics.	6
II	Separation and Isolation of Proteins, One- and two-dimensional gel electrophoresis, Alternatives to electrophoresis, Acquisition of Protein Structure Information, Edman sequencing, ESI, RPHPLC, Mass spectrometry, MALDI. (i)Sample preparation (ii)Sample ionization (iii)Mass analysis (iv)Types of mass spectrometers (v)Peptide fragmentation (vi)Our approach to mass spectrometry, Database Utilization, Peptide mass fingerprinting, database searching, Amino acid sequence database searching, De novo peptide sequence information, Uninterrupted MS/MS data searching	8
III	Identifying gene and its homolog (SEQUEST), Sequencing database searching with GAPPED-BLAST and PSI – BLAST, predicting protein structure and Function, matching proteins to pathways and identifying the cellular roles of protein.	8
IV	Characterization of Protein Complexes, Protein Expression Profiling, Expression profiling by two-dimensional electrophoresis, Isotope-coded affinity tags, Protein arrays, Proteomics Approach to Protein Phosphorylation, Phosphoprotein enrichment, Phosphorylation site determination by Edman degradation, Phosphorylation site determination by mass spectrometry: (i) Phosphopeptide sequencing by MS/MS (ii) Analysis of phosphopeptides by MALDI-TOF, Yeast Genomics and Proteomics, Proteome Mining Challenges for Proteomics.	8

Selected Readings:

1. Daniel C. Liebler, Introduction to Proteomics. Humana Press. (2000).
2. Twyman RM, Principle of Proteomics. BIOS Scientific Publishers. (2004).
3. Hubert Rehn. Protein Biochemistry and Proteomics, Academic Press. (2006).
4. Liebler Humana. Introduction to proteomics: Tools for new Biology, W.CBS Pub.,(2002).
5. Apweiler R. Protein sequence databases, Adv. Protein Chem. 54: 31-7,1 (2000).

Semester IV

Course Code: BT-654-MJ Bioinformatics and structural Biology 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Student will understand the concept of biomolecular structure and organization.
- Student will acquire the knowledge of methods of biomolecular structure determination.
- Student will be able to use the main databases at the NCBI and other resources.
- Student will be able to extract data from specific databases.
- Student will learn to use selected tools for gene and protein structure prediction.

Unit	Syllabus	No. of Lectures
I	Principles of Biomolecular structure and organisation (types of bonds, atomic interactions, secondary, tertiary str etc)- Proteins, Nucleic Acids, Carbohydrate, Lipids	5
II	Experimental methods of structure determination (X-ray, NMR, EM)	3
III	Computational methods of protein structure prediction (secondary and Tertiary), Integrative Modeling, Validation Checks - Ramachandran Plots, Energy Profiles etc	5
IV	Structural Alignments of proteins	3
V	Binding pocket prediction on protein structure	4
VI	Protein structure based function prediction	5
VII	Computational methods of RNA structure prediction (Secondary and Tertiary)	5

Selected Readings:

1. Introduction to Bioinformatics – Teresa Atwood and David J.Parry, Pearson smith publication (2003)
2. Introduction to Bioinformatics – lesk, Oxford press (2003)
3. Fundamental Concepts of Bioinformatics - Dan E. Krane, Michael L. Raymer, Pearson education (2004)
4. Sequence structure and Database – Des Higgins, Willice Taylor, oxford press (2003)
5. Bioinformatics: Sequence and Genome analysis by David W. Mount CBS Publishers & Distributors, 2004 reprint
6. Bioinformatics Concepts, Skills & Application. S.C.Rastogi, Namita Mendiratta and Parag Rastogi
7. Bioinformatics: Sequence, Structure and Databanks A Practical Approach, Higgins, ISBN: 0195667530, I.K. International Publishing House Pvt. Ltd
8. Essential Bioinformatics. Jin Xiong
9. Bioinformatics and Functional Genomics. Jonathan Pevsner

Semester IV

Course Code: BT-655-MJP **2 Credits**

No. of Practicals:15

Practicals in Bioprocess Engineering

Sr. No.	List of Practicals	No. of Practicals
1	Screening and identification (Genus Level) of a production strain (enzyme /antibiotic) from soil samples	2
2	Medium optimization for laboratory scale production of enzyme/antibiotics	1
3	Study of Working of lab bench fermenter (with production of enzyme or antibiotic using screened organism)	2
4	Laboratory scale production, recovery and estimation (bioassay or enzyme assay) of primary metabolite (Citric acid or glutamic acid or any vitamin)	3
5	Laboratory scale production, recovery and estimation (bioassay or enzyme assay) of secondary metabolite (antibiotic)	2
6	Production of wine and chemical analysis (alcohol, Total acidity, reducing sugar pH etc)	2
7	Solid state fermentation: Lab scale production of a product.	2
8	Visit to fermentation industry and Report writing	1

Semester IV

Course Code: BT-656-MJP **2 Credits**

No. of Practicals: 15

Practicals in Genomics and Proteomics

Sr. No.	List of Practicals	No. of Practicals
1	Visit and use various databases on world wide web for Genomics (NCBI) and Proteomics (Expasy)	1
2	Attempt to solve the queries based on biological databases a. Retrieve the gene sequence in FASTA format b. To determine the Post Translational Modifications (PTM) in any one of the gene/protein sequences and to determine the residues involved in PTM. c. Retrieve any one FASTA sequence of any one protein in Human, mouse, pig, chick, and zebra fish.	1
3	Gene prediction using GENSCAN	1
4	Finding the official Symbol, alias name, chromosome number and ID for gene using NCBI	1
5	Retrieval and analysis of a protein sequence from protein database Primary structure analysis of a protein, Secondary structure analysis of a protein, Tertiary protein structure analysis using RASMOL	1
6	Pair-wise and multiple sequence alignment using ClustalW	1
7	Pair-wise and multiple sequence alignment using BLAST	1
8	Protein precipitation–organic solvent Acetone, ethanol,and10%TCA	1
9	Fractional precipitation by ammonium sulphate and dialysis	1
10	Native-PAGE of proteins and silver staining	1
11	Zymography of amylase and/or urease	1
12	SDS-PAGE of the protein sample and determine its molecular weight of unknown protein by plotting a graph of relative mobility Vs log of molecular weight.	2
13	Demonstration of HPLC and 2-D PAGE	1
14	Visit to Laboratory equipped with Mass Spectrometer	1

Semester IV

Course Code: BT-660-MJ **System Biology** **2 Credits**

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will be able to describe methods essential for the representation of a system using some fundamental Systems Biology approaches.
- Students will be able to explain the theory behind the statistical methods commonly used within Systems Biology, and reflect on their applicability to different biological contexts.
- Students will apply achieved methodological knowledge to biologically relevant problems.
- Students can interpret the results from commonly used Systems Biology methods.
- Students will be able to design and justify the processing of omics data for the interpretation within Systems Biology.

Unit	Syllabus	No. of Lectures
I	Introduction – Mathematical Modeling, MATLAB basics,	2
II	Introduction to networks, network biology, network perturbations, Community detection, Motifs, Lab: Cytoscape, Lab: network models perturbations. Reconstruction of gene regulatory network, protein network, signaling network	4
III	Introduction to dynamic modeling, solving ODEs in MATLAB, Parameter estimation, methods of parameter estimation, direct search method	4
IV	Genetic algorithms, PyGMO, Modeling in drug development.	6
V	Constrain based modeling metabolic networks, Flux balance analysis, FBA based MATLAB	6
VI	Perturbations to Metabolic Networks: Deletions, Lab: COBRA Toolbox, Metabolic Flux Analysis using Mass Spectrometry	4
VII	Computational Modelling of Host--Pathogen Interactions, Robustness in Biological Systems: Mechanisms, organizing principles, tradeoffs	4

Selected Reading:

1. "An Introduction to Systems Biology: Design Principles of Biological Circuits" by Alon U
2. "Mathematical Biology: An Introduction" by Murray J
3. "An Introduction to Mathematical Biology" by Linda J S Allen
4. "Introduction to Systems Biology" by Sangdun Choi
5. "Life: An Introduction to Complex Systems Biology" by Kaneko Kunihiko

Semester IV

Course Code: BT-661-MJP **2 Credits**

No. of Practicals: 15

Practicals in System Biolology

Sr. No.	List of Practicals	No. of Practicals
1	Introduction to The Systems Biology Markup Language (SBML), Cell Designer, and its plugin SBML squeezer and SBML2LaTeX	2
2	Introduction to more software: Copasi, Cytoscape, and its plugin BiNoM, MATLAB, SBMLtoolbox for MATLAB,	3
3	Introduction to databases: KEGG, EcoCyc, ExPASy Proteomics Server, BRENDA, EzCatDB, SABIO, BioNumbers BioModels, Reactome, Orenza, BiGG, ChemSpider, HMDB	4
4	Perform Sensitivity Analysis Tutorial using SimLab	1
5	Perform Mathematical modelling of biochemical reactions; the law of mass action; and a discussion on ultrasensitivity, cooperativity, and Hill numbers.	5

Semester IV

Course Code: BT-662-MJ Synthetic Biology 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Student will understand the basic principles of synthetic biology and its distinction from traditional genetic engineering.
- Student will apply engineering principles to design synthetic biological systems.
- Student will utilize bioinformatics tools for DNA design and analysis.
- Student will conduct basic laboratory techniques used in synthetic biology research.
- Student will analyze ethical, safety, and societal implications of synthetic biology.

Unit	Syllabus	No. of Lectures
I	**Introduction to Synthetic Biology:** Overview of synthetic biology History and development, Key concepts and terminology	2
II	**DNA as a Programming Language:** DNA structure and function Genetic circuits and logic gates Promoters, ribosome binding sites, and terminators	3
III	**Tools and Techniques in Synthetic Biology:** PCR, restriction enzymes, and ligation CRISPR-Cas9 technology DNA synthesis and assembly methods	3
IV	**Bioinformatics for Synthetic Biology:** DNA sequence analysis and design tools Genome editing software Databases and resources	5
V	**Genetic Circuits and Network Design:** Principles of genetic circuit design Toggle switches and oscillators Case studies: Synthetic gene networks	2
VI	**Metabolic Engineering:** Pathway construction and optimization Synthetic pathways for biofuel and pharmaceutical production Flux balance analysis	3
VII	**Synthetic Biology in Medicine:** Synthetic biology for diagnostics and therapeutics Gene therapy and engineered immune cells Case studies: CAR-T cells, synthetic vaccines	3
VIII	**Synthetic Biology in Industry:** Industrial applications: biofuels, bioplastics, and chemicals Startups and biotech companies Case studies: Commercial synthetic biology products	2
IX	**Laboratory Techniques and Safety:** Laboratory safety and Standard laboratory protocols in synthetic biology	2
X	**Ethical, Legal, and Social Implications:** Ethical considerations in synthetic biology	2

	Biosafety and biosecurity Public perception and policy	
XI	**Advanced Topics in Synthetic Biology:** Synthetic genomics and minimal genomes Whole-cell biosensors Artificial life and xenobiology Emerging trends and future directions in synthetic biology	3

Selected Readings:

1. "Synthetic Biology: A Primer" by Paul S. Freemont and Richard I. Kitney
2. "Biodesign: The Process of Innovating Medical Technologies" by Stefanos Zenios et al.

Semester IV

Course Code: BT-663-MJP **2 Credits**

No. of Practicals: 15

Practicals in Synthetic Biology

Sr. No.	List of Practicals	No. of Practicals
1	Isolation of Plasmid DNA and analysis by agarose gel electrophoresis	2
2	Recombination in the plasmid DNA	1
3	Preparation of competent cells and transformation	2
4	Setting up the PCR and product analysis	1
5	Colony PCR	1
6	Inverse PCR mutagenesis (Demonstration)	1
7	Genetic modifications using Restriction enzymes and Ligation	2
8	Introduction to Gibson assembly	1
9	Primer design using appropriate tools	1
10	Introduction to BioBrick Assembly	1
11	Introduction to Genome-Editing Technologies - CRISPR-Cas9, TALE nucleases, and zinc-finger nucleases	1
12	Case studies on potential societal and ethical impact of synthetic biology	1

Semester IV

Course Code: BT-664-MJ Biologics and Biosimilars 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Student will acquire the knowledge of potential of herbal medicines
- The student will review the intricate scientific process used to produce biopharmaceutical agents and compare it with the process used to create traditional chemical drug products traditional chemical drug products.
- The student will review the key information that will be needed to evaluate biosimilars.
- To arouse interest of student to participate in an innovative field of medical biotechnology.

Unit	Syllabus	No. of Lectures
I	The basics of Biologics and biosimilars, biosimilars are not same as generic drugs. Biomimics and Biobetters (the second-generation biologics). Major classes of Biotherapeutics.	4
II	Naming the biosimilars – challenges. Economics, High cost and promises of lowering the cost. Biologics licence application (BLA) and Regulatory Pathways and Guidelines, globally (FDA, EMA, ICH). India – the quiet Leader.	6
III	Drug targets for Biologics, Cell culture and fermentation, production, downstream processing and purification techniques, formulation and drug product development.	6
IV	Pharmacokinetics, Pharmacogenomics of Biologics, Pharmacovigilance of new Biologic and/or Biosimilar	6
V	New emerging Biotherapies and their case studies. Approved Bispecific, CAR-T Cell therapy, Immune checkpoint antagonism	5
VI	Who will benefit from Biologics and their compliance with ethical standards	3

Selected Readings:

1. Biologics, Biosimilars, and Biobetters: An Introduction for Pharmacists, Physicians, and Other Health Practitioners; Editor: Iqbal Ramzan, John Wiley & Sons, Inc. 2021
2. Biologics and Biosimilars: Drug Discovery and Clinical Applications; Xiaodong Feng, Hong-Guang Xie, Ashim Malhotra, Catherine F. Young, Tylor and Francis Group. 2022
3. Introduction to Biologic and Biosimilar Product Development and Analysis: AAPS Introductions in the Pharmaceutical Sciences; Author: Karen M. Nagel, AAPS, Springer. 2018

Semester IV

Course Code: BT-665-MJP **2 Credits**

No. of Practicals: 15

Practicals in Biologics and Biosimilars

Sr. No.	List of Practicals	No. of Practicals
1	Using computer, compare the structure, Molecular weight and conformation of Generic and Biosimilar: a. Aspirin b. Insulin c. Erythropoietin d. Monoclonal antibody	3
2	Using computer, prepare the loss of exclusivity (LOE) and entry time line biologics	2
3	Using internet, prepare the safety data, efficacy data, post marketing data and clinical studies of biologics used for the treatment of cancer (monoclonal antibodies), diabetes (insulin) erythropoiesis (erythropoietin), Inflammation (Chimeric MAB)	10

Semester IV

Course Code: BT-666-MJ Quality control and Biosafety 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will understand the cGMP aspects in a pharmaceutical industry
- Importance of documentation
- Scope of quality certifications applicable to Pharmaceutical industries
- Responsibilities of QA & QC
- Students can prepare HACCP based SOP
- Students will understand the concept and importance of Biosafety
- Students will learn biosafety guidelines and risk management

Unit	Syllabus	No. of Lectures
	Quality Control	
I	**Quality Standard & Quality assurances**: Concept of quality Assurance & Quality control their function and advantage Quality assurance and quality management in Biotech Industry Testing and Calibration Procedures, Total Quality Assurance, Quality Control, Quality Planning Laboratory Management Procedure, Lab Information Management System, Validation of Equipment and Safety Protocols Types of validation in pharma & food industry, Importance of validation Elements of validation (IQ,OQ, PQ,DQ) Food safety: Hazard Analysis Critical Control Point (HACCP) pre-requites, principles and its implementation.HACCP based SOPs. Export, Import of product, Rules & Regulations for start-up companies GMP, cGMP	8
II	**Essential Documents & Regulatory Submission, Compliance and Audits:** Quality Audit Definition, Types of Audit - Internal Audit and External Audit, Need of Audit, Importance of Audit and Forensic Significance. Preparation, production and quality control of regulatory documents, creating editorial timelines and work flow specifications, SOP Scheduling and tracking documents, writing and proofreading. Development and updates on specifications for the design, tracking of regulatory documents and artwork used in regulatory document Regulatory requirements for Biotech/pharma/food product development	7
	Biosafety	
III	**Introduction:** Biosafety in Laboratory and Institution, Laboratory associated infections and other hazards. Introduction to Biological Safety Cabinets, Primary Containment for	10

	Biohazards Biosafety Levels, Biosafety Levels of Specific Microorganisms, Recommended Biosafety Levels for Infectious Agents and Infected animals Safety considerations in clinical trials Safety and hazards: Chemical and radiation hazards Control of exposure to radiation, Fire prevention methods Industrial Hygiene and toxicology: Introduction, evaluation & control, Personal protective equipment	
IV	**Biosafety guidelines**– Guideline & regulations (National and International) GMOs & LMOs Guidelines of India Environmental release issues of GMOs Risk Analysis and assessment, risk management and communication Roles of Institutional Biosafety Committee RCGM, GEAC etc. Regulation of clinical trials	5

Selected Readings:

1. The training manual for Food Safety Regulators. (2011) Vol.III, Food Safety regulations and food safety management. Food Safety and Standards Authority of India. New Delhi.
2. Gazette of Food Safety and Standards Act, (2006) Food Safety regulations and food safety management. Food Safety and Standards Authority of India. New Delhi
3. Helferich, W., and Winter, C.K. (2007) Food Toxicology, CRC Press, LLC. Boca Raton, FL
4. Mortimre, S., and Wallace, C., (2005) HACCP: A practical approach, 2nd Ed, Aspen Publication
5. Pelczar, M.I., and Reid, R.D. (2009) Microbiology, 5th Ed., McGraw Hill Inc., New York.
6. James, M.J. (2007) Modern Food Microbiology, 2nd Ed., CBS Publisher, New Delhi
7. Adams, M.R., and Moss, M.G., (2005) Food Microbiology, 1st Ed., New Age International (P) Ltd., New Delhi.
8. Frazier, W.C. (2008) Food Microbiology, 4th Ed., McGraw Hill Inc., New York.
9. Doyle, P., Bonehat, L.R. and Mantville, T.J. (2007) Food Microbiology, Fundamentals and Frontiers, ASM Press, Washington DC
10. Andres Vasconcellos J. 2005. Quality Assurance for the Food industry - A practical approach. CRC press. 2. Inteaz Alli. 2004. Food quality assurance - Principles & practices. CRC Press. New York. 3. Sara Mortimore and Carol Wallace. 2013. HACCP - A practical approach. Third edition. Chapman and Hall, London
11. M K Sateesh. Bioethics and Biosafety. Jeffrey M. Gimble, Academia to Biotechnology, Elsevier Academic Press.
12. RajmohanJoshi(Ed.).2006.BiosafetyandBioethics.IshaBooks,Delhi.
13. SenthilKumar, Sadasivam, and Mohammed Jaabir M.S.(2008).IPR, Biosafety and Biotechnology Management, Jasen Publications, Ind

Semester IV

Course Code: BT-667-MJP **2 Credits**

No. of Practicals: 15

Practicals in Quality control and Biosafety

Sr. No.	List of Practicals	No. of Practicals
1	Calibration of pipettes, scales and dispensers	1
2	Estimation of mycotoxins from food samples	1
3	Enumeration of microorganisms: a. Direct count b. Total aerobic count c. Selective media	2
4	Detection and quantification of pesticides	1
5	Detection and quantification of food additives	1
6	Preparation of HACCP based SOP for any agri-based food product	1
7	Handling and disposal of Hazardous chemicals	2
8	Handling and disposal of pathogens	2
9	Safety measures during instrument operations	2
10	Risk management in the laboratory	1
11	Use of various Personal protective equipments	1

Semester IV

Course Code: BT-668-MJ **Bio entrepreneurship** **2 Credits**

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will understand the importance of innovation and creativity in entrepreneurship.
- Students will learn to manage resources efficiently and effectively.
- Students will communicate effectively in a business context.
- Students will recognize the importance of sustainable business practices.
- To understand the role of financial and government agencies in supporting start-ups.

Unit	Syllabus	No. of Lectures
I	**Introduction to Entrepreneurship:** Concept, history, need and importance of entrepreneurship Skills and characteristic of successful entrepreneurs Role of entrepreneurship in economic development Evolution and growth of entrepreneurship in India Concept of business, industry and commerce and their inter-relationship in today's environment Opportunity search, Opportunity selection, Divergent thinking mode: concept, objectives Tools and Techniques: Environmental scanning for business opportunity identification Convergent thinking mode: concept, objectives	10
II	**Entrepreneurship in Biotechnology:** Integration of Science, technology and business Conceptual framework and characteristics for being an entrepreneur in biotechnology. Case studies of successful bio-entrepreneurs Biotechnology Entrepreneurship: Emerging industries with examples from GMOs, Environmental biotechnology, Agriculture, Drug development, DNA chip technology, Stem cell research/Tissue engineering. Contract Research Organization, marketing consultancy, bio-learning module	10
III	**Business Development in Biotechnology:** Factors affecting biotech business: finance, infrastructure, equipment, manpower, resources, project location, end product, quality issues, etc. Identification and evaluation of market potential of various bio-entrepreneur sectors Role of government and schemes, financial institutions in fostering bio-entrepreneurship	10

	Ethics and IPR in biotech-industries: Fundamentals of ethics in business, Ethical dilemmas in biotech industry, IPR- Introduction, Forms of IPR	

Selected Readings:

1. The BioEntrepreneur Handbook: How to Start and Grow a Successful Life Sciences Venture by Russell D. Kolodziej (2010, John Wiley & Sons)
2. Biotechnology Entrepreneurship: Starting and Growing a Biotech Company by Robert A. Friesen (2014, John Wiley & Sons)
3. The Startup Owner's Manual: The Step-by-Step Guide for Building a Great Company by Steve Blank and Bob Dorf (2020, The Startup Owner's Manual Publishing, Inc.)
4. Venture Deals: Be Smart About Investments, Terms, and People by David M. Belasco (2014, Harvard Business Review Press).
5. Bioentrepreneurship in India: Exploring Opportunities and Challenges by Rishi Biotech (2007, Rishi Biotech)
6. Biotechnology: A Game Changer for India by Confederation of Indian Industry (CII) (2016, Confederation of Indian Industry)
7. Biotechnology Entrepreneurship in India: Trends and Challenges by National Research Council (NRC) (2011, National Academies Press)
8. BIRAC Annual Reports: https://birac.nic.in/desc_new.php?id=111
9. Startup India website: https://www.startupindia.gov.in/content/sih/en/about_startup_portal.html
10. BioSpectrum's Bio-Entrepreneur Awards case studies: https://www.biospectrumasia.com/bsa-awards
11. BIRAC success stories:

    https://birac.nic.in/webcontent/BIRAC_Success_Story_15_12_2016.pdf or https://birac.nic.in/
12. BioSpectrum's Bio-Entrepreneur Awards case studies: https://en.wikipedia.org/wiki/National_Bioscience_Award_for_Career_Development

Semester IV

Course Code: BT-669-MJP **2 Credits**

No. of Practicals: 15

Practicals in Bio entrepreneurship

Sr. No.	List of Practicals	No. of Practicals
1	Define your business idea/goal	1
2	Collect data by conducting market research	1
3	Compilation of the information from financial agencies that will help to set up business enterprise and report writing.	2
4	Compilation of the information from the government agencies that will help set up business enterprise.	2
5	Preparation of a business plan for the start-up venture.	3
6	Study the various funding schemes for the start-up venture.	2
7	Preparation of financial feasibility report for the start-up venture.	2
8	Study the business registration procedure	1
9	Visit to an incubation center / startup	1

Semester IV

Course Code: BT-670-MJ Rational Drug Discovery and Development 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- The students will acquire the knowledge of the process of drug development
- The students will understand the concept of drug targets and ADMET
- The students will acquire the knowledge of databases of drugs
- The students will gain an understanding of drugs, their approvals, various methods for identifying drugs
- The students will be equipped to be able to carry about preliminary research on drug design

Unit	Syllabus	No. of Lectures
I	History of Drug Discovery and Development, Emergence of pharmaceutical companies and regulatory agencies Types of drugs: Biologics and Small Molecules, Databases of drugs	3
II	Drug targets: Identification and Validation, Properties of successful targets, Druggability, Polypharmacology	3
III	Representation of small molecules (1D, 2D, 3D), small molecule databases with activities such as PubChem, ChEMBL, Commercial collections, structure comparison, Structure properties, Rules of drug Likeness	4
IV	Structure based design: Docking, Virtual screening, Scoring, Free energy calculations	4
V	Ligand based design: QSAR, QSPR, AI/ML for predictive modeling Pharmacophore design for structure and ligand based drug design Predictive ADMET	6
VI	High-Throughput Screening (HTS) and Assay Development (In-vitro, In-vivo), Animal studies, Clinical Trials, Drug Approval and Post-Marketing Surveillance, IPR	6
VII	Drug Repurposing Personalized Medicine	4

Selected Readings:

1. Drug Discovery and Development: Technology in Transition Paperback – 28 Aug. 2021 by Raymond G Hill (Editor), Duncan Richards (Editor)
2. The Evolution of Drug Discovery: From Traditional Medicines to Modern Drugs Hardcover – 18 Mar. 2011 by Enrique Ravina (Author)
3. Textbook of Drug Design and Discovery, Fourth Edition Hardcover – 13 Oct. 2009 by Kristian Stromgaard (Editor), Povl Krogsgaard-Larsen (Editor), Ulf Madsen (Editor)

Semester IV

Course Code: BT-671-MJP **2 Credits**

No. of Practicals: 15

Practicals in Rational Drug Discovery and Development

Sr. No.	List of Practicals	No. of Practicals
1	Browsing database of small molecules, drugs and drug targets	3
2	Introduction to molecular modeling software	2
3	Exercises on docking and virtual screening	3
4	Exercises on QSAR/ Predictive modeling	3
5	Exercises on Predictive ADMET	4

Semester IV

Course Code: BT-672-MJ Agriculture Biotechnology 2 Credits

Total Lectures: 30

Course outcomes:

After completion of the course,

- Students will understand the integration of biotechnology with various agricultural disciplines for sustainable food production.
- Students could critically assess the benefits and limitations of genetically modified crops and biotechnologies.
- Students will gain practical skills of bio-inoculant preparation and biofertilizer production.
- Students will learn practical applications of molecular techniques for plant identification and breeding programs.

Unit	Syllabus	No. of Lectures
I	**Introduction to agricultural Biotechnology:** Importance of agriculture in national economy, Agricultural biotechnology and agribusiness, opportunities in the agriculture biotechnology Biotechnology in Agriculture: *In-Vitro* plant propagation (Micropropagation)**.** Case study of any commercially propagated plant (e.g. Banana, ornamental plants), Constraints in use of bioreactors in plant production and scale up for commercialization, Virus indexing and production of virus free plants. Plant Tissue culture technology for crop improvement: Pureline/homozygous plant production, embryo rescue & embryo culture in rearing viable hybrid embryos, endosperm culture & production of triploids, induced polyembryony, somaclonal and gametoclonal variations, somatic hybridization.	12
II	**rDNA technology and Agricultural Biotechnology:** Improvement of crop quality (FlavrSavr tomato, Golden rice, Terminator gene technology), Chloroplast manipulations for yield enhancement, production of therapeutic proteins, vaccines, antibodies.	10
III	**Microbes in Agriculture:** Beneficial microorganisms in agriculture: Biofertilizer (bacterial, cyanobacterial and fungal), microbial bio insecticides, major pest and diseases of horticultural crops and their control by biotechnological methods. Development, formulation (with various carrier materials) of bio-inoculant for better productivity.	8

Selected Readings:

1. Plant molecular breeding, 2009, New bury HJ, John Wiley and Sons, USA.

2. Chawla H.C., 2004, Introduction to plant biotechnology(Science Publication)
3. Kumar A., Shekhawat N. S. 2009, Plant tissue culture and molecular Markers: their rolein improving crop productivity (IK International)
4. Das HK, 2010, Biotechnology, 4th edition, Wiley India Pvt. Limited, India
5. Slater A, Scott NW, 2008, Plant Biotechnology: the genetic manipulation of plants Oxford Press.
6. Fowler M R, Green M R & Sambrook J., 2014, Molecular Cloning: A Laboratory Manual. 4th Ed. Vol. I, II& III. Cold Spring Harbor Laboratory Press.
7. Grierson D. 2012, Plant Genetic Engineering, Springer Netherlands.
8. Primose SB & Twyman RM. 2006, Principles of Gene Manipulation and Genomics 7th Ed. Blackwell Publishing.
9. Sambrook J. and Russel D, 2001, Molecular Cloning: A Laboratory Manual 3rd Ed Cold Spring Harbor Laboratory Press.
10. Philips C.L. and Wetter L.R., 1995, Plant cell tissue and organ culture: fundamental methods, National Research council, Canada, PRL, Saskatoon.

Semester IV

Course Code: BT-673-MJP **2 Credits**

No. of Practicals: 15

Practicals in Agriculture Biotechnology

Sr. No.	List of Practicals	No. of Practicals
1	Organization of commercial plant tissue culture laboratory	1
2	Virus indexing using ELISA/PCR	2
3	Study of embryo rescuing and embryo culture.	1
4	Micropropagation of commercially propagated plant (e.g. Banana/ornamental plants) (organogenesis/ somatic embryogenesis/ axillary bud/ adventitious bud formation)	3
5	Pure line production for plant breeding	1
6	Endosperm culture for production of triploid/seedless plants.	1
7	Demonstration of non-gel techniques for plant genotyping and CRISPR based technology (using web resources)	1
8	Isolation of N_2 fixing (symbiotic, free living) microorganisms and its preservation	1
9	Isolation of Phosphate solubilizing, Calcium solubilizing, Zinc solubilizing, microorganisms and its preservation.	1
10	Isolation of hormone producing microorganisms and its preservation.	1
11	Preparation of biofertilizer using suitable carrier material.	1
12	Visit to commercial PTC and biofertilizer production unit.	1

Semester IV

Course Code: BT-674-MJ **Medical Biotechnology** **2 Credits**

Total Lectures: 30

Course outcomes:

After completion of the course,

- The students will understand the molecular basis of various diseases.
- The students will learn the disease diagnostic techniques.
- The students will understand the concept of therapeutic approaches for various diseases.
- The students will acquire the knowledge of Stem cell and regenerative medicine.
- The students will apply the knowledge to the emerging field of regenerative medicine.

Unit	Syllabus	No. of Lectures
I	**Introduction to molecular basis of Disease :** Introduction, Worldwide market in medical biotechnology, Revolution in diagnostics and therapy. Introduction to Chromosomal Disorders and Structural Disorders with examples Classifications of Genetic diseases Single Gene disorders- Sickle cell anemia and Thalassemia, polygenic diseases e.g. Type I diabetes, Alzheimer Disease Infectious diseases and disorders	8
II	**Diagnostic tools and techniques:** Diagnosis using protein and enzyme markers: Enzyme probes Glucose oxidase, Monoamine oxidase. Diagnosis using Monoclonal antibodies – hormonal disorders and infectious diseases DNA/RNA based Diagnosis: PCR based and Use of Nucleic acid probes Biosensors in clinical diagnosis Microarray Technology for disease diagnosis Genetic Counseling	7
III	**Therapies:** Gene Therapy: ex-vivo and in-vivo gene therapy Strategies of Gene therapy: Gene augmentation, antisense therapy, ribozymes. Vectors used in gene therapy, synthetic vectors Gene therapy trials: ADA deficiency, Cystic fibrosis, HIV Enzyme therapy: Gaucher disease Hormone replacement therapy: Diabetes Modern Vaccine technology: Advantages and limitations (suitable example)	8
IV	**Stem Cell Therapy and Nanotechnology:** Stem cells in therapy -embryonic and adult stem cells, Characteristics and properties of stem cells. Potential use of stem cells Cell and Tissue engineering Bio-artificial organs (liver, Blood cells, skin)	7

	Nanotechnology in diagnosis	

Selected Readings:

1. Introduction to Human Molecular genetics- J J Pasternak, John willey Publications
2. Human Molecular genetics – McConkey
3. Medical Biotechnology-PratibhaNallari V Venugopal Rao Oxford Press
4. Medical Biotechnology-1 st edition- Juditpongracz,Mary Keen
5. Medical Biotechnology-by Bernald Glick, Terry L Delovitch, Cheryl L Pattern ASM press 2014.
6. Molecular Biotechnology- Principles and Applications of Recombinant DNA, 4th Edition by Bernald Glick Cheryl L Pattern
7. Medical Biotechnology first edition by Trivedi P C Avishkar Publisher
8. Medical Biotechnology Principle and Applications by Kun L Y world Science Publications.
9. Methods of Biotechnology and Bioengineering by Vyas CBS publications 2004
10. Stem Cell technology by Marshak et al CSHL publications

Semester IV

Course Code: BT-675-MJP **2 Credits**

No. of Practicals: 15

Practicals in Medical Biotechnology

Sr. No.	List of Practicals	No. of Practicals
1	Blood film preparation and identification of normal and abnormal cells	1
2	Estimation of chemical marker from suitable clinical sample (glucose / urea / uric acid / bilirubin etc.)	1
3	Diagnosis of disease using suitable protein marker (Qualitative test)	1
4	Diagnosis of disease using suitable enzyme marker (Quantitative determination)	1
5	Disease diagnosis using Biosensor based device	1
6	Hemoglobinopathaties screening	1
7	Isolation of DNA / RNA from suitable sample for molecular diagnosis	1
8	PCR based diagnosis of genetic / infectious diseases	2
9	Use of Nucleic acid probes for quantitative determination of genetic / infectious diseases	2
10	Disease diagnosis using Monoclonal antibodies (Qualitative and Quantitative)	2
11	Estimation of HbA1C by HPLC	1
12	Use of Bioinformatics for genetic disorder determination	1

Semester IV

Course Code: BT-681-RP **6 Credits**

Research Project

Project work, Thesis Submission and Presentation

- Project work / Thesis / Dissertation shall be carried out under the supervision of a qualified teacher in the concerned Department / Research Institute / Industry.
- Project work / Thesis / Dissertation shall be pursued for a minimum of 12 weeks during the final semester, following the preliminary plan of work carried out in the previous semester.
- The Project Report / Thesis / Dissertation report is to be prepared as per standard scientific research methodology and duly signed by the supervisor(s) and the Head of the Department shall be submitted to the concerned department.
- The assessment (Internal and external) of the project work will be as per SPPU guidelines.