UPSTREAM PROCESS TECHNOLOGY + LAB		Semester	VII
Course Code	**BBT701**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory/practical		

Course objectives:

- To learn the design and optimisation of biomanufacturing processes
- To learn the basic principles of design of Experiment for process development
- To learn the factors effecting fermentation scale-up and mitigate risks involved with it.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

MODULE-1 (8 HOURS)

PLANT CELL AND TISSUE CULTURE TECHNIQUES

Plant Cell Culture: Introduction, Requirements, Techniques. Media Constituents, Media Selection. Cellular Totipotency characteristics, Practical Applications of Cellular totipotency. Organogenesis: factors affecting organogenesis, importance of organogenesis. Cyto-differentiation. Somatic Embryogenesis: Factors Affecting Somatic embryogenesis. Induction, development and Maturation of Somatic embryos, Large scale Production of somatic Embryos, Synthetic Seeds.

MODULE-2 (8 HOURS)

HAPLOIDS AND TRIPLOID PRODUCTION

Androgenesis and gynogeneis: Techniques for production of haploids, diploidization, production of double haploids, Applications. Triploids production - Endosperm culture and Applications.

IN VITRO SECONDARY METABOLITE PRODUCTION

Secondary metabolite production: strategies for optimizing product yield, culture conditions, selection of high yielding lines, elicitation, immobilization of cultures, hairy root culture and biotransformation. Factors affecting secondary metabolites, Industrial applications of secondary metabolites.

MODULE-3 (8 HOURS)

ANIMAL CELL CULTURE TECHNIQUES

Media for culturing animal cells and tissues; Natural and synthetic media: Preparation, sterilization and storage of Media. Introduction to culture wares Short-term lymphocyte culture, Fibroblast cultures from chick embryo. Development and maintenance of cell lines. In vitro culture of oocytes/embryos. Cell/embryo cryopreservation. Stem cell isolation and culture.

ANTIBODY TECHNOLOGY

Hybridoma technology for monoclonal antibody production. Applications of customised monoclonal antibodies. Bioreactors considerations for animal cell cultures: Monoclonal antibodies and therapeutic proteins.

MODULE-4 (8 HOURS)

MICROBIAL CELL CULTURE TECHNIQUES

Sterilization, media preparation and Culture maintenance. Isolation of pure-colonies. Bacterial titre estimation, Growth curve, Culture characterization. Auxotroph culture isolation. Biochemical characterization. Antibiotic sensitivity. Bacterial recombination, replica plating technique.

MODULE-5 (8 HOURS)

FERMENTATION TECHNOLOGY

Types of fermentation: submerged and solid state fermentation. Modes of fermentation: Batch, continuous and fed-batch. Microbial growth kinetics. Scaling of fermentation process. Optimization of fermentation process: physiological and genetic strategies. Production of primary and secondary metabolites. Strategies to optimize product yield. Instrumentation and control. Preservation of microbial products. Production of antibiotics. Enumeration and screening of novel microbial secondary metabolites, Strain improvement. Microbiology of brewing (Distilled and non-distilled beverages with examples).

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Preparation of media for plant tissue culture.
2	Callus Induction Techniques – Carrot/Beet root/ or any other material.
3	Development of suspension culture from callus.
4	Induction of Secondary metabolite – Anthocyanin/catheranthin.
5	Estimation of Lycopene from tomato fruits.
6	Estimation of Anthocyanin from leaf /callus tissue.
7	Estimation of DNA (by DPA method).
8	Microbial growth kinetic study in a batch culture.
9	Comparison of biomass yield in defined & complex media in shake flask culture.
10	Production and estimation of citric acid from *Aspergillus niger*
11	Isolation of antibiotic produce from soil and microbial inhibition study.
12	Preparation and production of ethanol in fermenter: Study of growth, product formation, and end substrate utilization

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

1. Design and optimize biomanufacturing processes based on measured bioreaction parameters
2. Utilize basic principles of Design of Experiment for process development
3. Identify the main challenges associated with fermentation scale-up and mitigate risks.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.

- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books

- Plant Cell Culture : A Practical Approach by R.A. Dixon & Gonzales, IRL Press.
- Experiments in Plant Tissue Culture by John H. Dodds & Lorin W. Robert.
- Plant tissue Culture : Theory and Practice by S.S. Bhojwani and M.K. Razdan, Elsevier.
- Animal Biotechnology by Murray Moo-Young, Pergamon Press, Oxford.
- Principles of fermentation Technology by P.F. Stanbury and A. Whitaker, Pergamon Press.
- Microbial Biotechnology by Alexander N Glazer, Hiroshi Nikaido, W H Freeman & Company
- Animal Cell Technology by Asok Mukhopadyay, IK Intl. Ltd.
- Plant Tissue Culture by SATHYANARAYANA BN, IK Intl. Publishers
- Plant Molecular biology by D. Grierson & S.N. Covey Blackie, London.
- Animal Cell biotechnology by R.E. Spier and J.B. Griffiths, Academic press.
- Living resources for Biotechnology, Animal cells by A. Doyle, R. Hay and B.E. Kirsop,
- Cambridge University Press.
- Fermentation & Enzyme Technology by D.I.C. Wang et.al., Wiley Eastern.
- Principle of Microbe & Cell Cultivation by SJ Prit, Blackwell Scientific co.
- Experiments in Plant Tissue Culture by John H. Dodds & Lorin W. Robert.
- Plant tissue Culture : Theory and Practice by S.S. Bhojwani and M.K. Razdan,
- Animal cell culture Techniques by Ian Freshney

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://archive.nptel.ac.in/courses/102/105/102105058/

- https://onlinecourses.nptel.ac.in/noc21_bt23/preview
- http://www.digimat.in/nptel/courses/video/102105058/L41.html
- https://archive.nptel.ac.in/courses/102/106/102106080/
- https://archive.nptel.ac.in/courses/102/104/102104059/
- https://www.digimat.in/nptel/courses/video/102106080/L01.html
- https://onlinecourses.nptel.ac.in/noc19_bt33/preview

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Collection of case studies based on research findings
- Model making and Poster presentations on specific case studies.

DOWNSTREAM PROCESS TECHNOLOGY + LAB		Semester	VII
Course Code	**BBT702**	CIE Marks	50
Teaching Hours/Week (L:T:P: S)	3:0:2:0	SEE Marks	50
Total Hours of Pedagogy	40 hours Theory + 8-10 Lab slots	Total Marks	100
Credits	04	Exam Hours	3
Examination nature (SEE)	Theory/Lab		

Course objectives:

- Learn basic requirements of downstream processing for biochemical product recovery
- Learn the effect of change in unit operations and its impact on the process
- Learn applications of emerging technologies in bio chemical product recovery.
- Learn process validation parameters critical for successful large-scale, high-purity bioproduct production.

Teaching-Learning Process (General Instructions)

These are sample Strategies; that teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

MODULE-1 (8 HOURS)

DOWNSTREAM PROCESS TECHNOLOGY: AN OVERVIEW

Role and importance of downstream processing in biotechnological processes, Problems and requirements of byproduct purification, Economics of downstream processing in Biotechnology, Cost cutting strategies, Characteristics of biological mixtures, Process design criteria for various classes of byproducts (high volume, low value products and low volume, high value products), Physico-chemical basis of different bio-separation processes.

MODULE-2 (8 HOURS)

REMOVAL OF INSOLUBLES

Cell Disruption Techniques: Brief introduction of types of cells, location of the Products Inside the Cells and Product Release Kinetics, Mechanical cell disruption methods and non-mechanical cell disruption methods. Clarification techniques: basic principle and methods of Filtration (Depth Filters, Plate and Frame Filters, Pressure Leaf Filters and Continuous Rotary Drum Filters), Centrifugation(Tubular-bowel Centrifuge, Disc-bowel Centrifuge, and Basket Centrifuge), Basic Principle and methods of flocculation and sedimentation.

MODULE-3 (8 HOURS)

PRODUCT SEPARATION TECHNIQUES

Distillation: Principle, types (Batch and continuous distillation) and methods of Distillation (Extractive Distillation, Steam distillation, and Vacuum distillation). Liquid-Liquid Extraction: Principle and methods of Liquid–liquid Extraction, Aqueous Polymer Two-phase Extraction, Supercritical Fluid Extraction. Adsorption: Principle and types of Adsorption Process (Adsorption in a Continuous Stirred Tank, Adsorption in a Fixed Bed). Evaporation: Principle of Evaporation, Factors Influencing the Rate of Evaporation, Types of Evaporators (Short Tube Evaporator, Long Tube Vertical Evaporator, Falling Film Evaporator)

MODULE-4 (8 HOURS)

PRODUCT PURIFICATION

Precipitation: Structure of Typical Globular, Protein Precipitation Methods (Protein Precipitation by Solvent Property Modification, Protein Precipitation by Solute Property Modification), Industrial Scale Precipitation. Membrane Based Separation Process: Types of Membrane, Membrane based Separation Theory (Solution-diffusion Model, Capillary Flow Model), Types of Membrane Processing (Reverse Osmosis, Ultrafiltration, Microfiltration, Electrodialysis), Application of Membrane Based Separation techniques. Chromatography: General

Chromatography Theory, Large Scale Chromatography (Fixed-bed Chromatography, Moving-bed, Simulated Moving-bed Chromatography, Stacked Columns, Radial Flow Column), Types of (Ion Exchange , Affinity Chromatography, Reverse Phase and Hydrophobic Interaction Chromatography)

MODULE-5 (8 HOURS)

PRODUCT RESOLUTION

Crystallization: Crystallization Theory, Nucleation, Crystal Growth, Mixed Product Removal Crystallizer with Mixed Suspension, Process Crystallization. Freeze Drying: Freeze Drying Principle, Freeze Drying Process (Freezing, Primary Drying, and Secondary Drying), Applications of Freeze drying.

PRACTICAL COMPONENT OF IPCC

Sl.NO	Experiments
1	Cell disruption techniques.
2	Solid-liquid separation methods: Filtration
3	Solid-liquid separation methods: Sedimentation.
4	Solid-liquid separation methods: Centrifugation.
5	Product enrichment operations: Precipitation – $(NH_4)_2SO_4$ fractionation of a protein.
6	Product enrichment operations: Two – phase aqueous extraction.
7	Product drying techniques.
8	Estimation of % of ethanol from fermented broth.
9	Estimation of Citric acid from fermented broth.
10	Separation of proteins by molecular sieving / Ion exchange chromatography.
11	Native PAGE versus SDS PAGE (using BSA).
12	Separation of Amino acids / Carbohydrates by TLC.

Course outcomes (Course Skill Set):

At the end of the course, the student will be able to:

1. Describe the basic requirements of downstream processing for biochemical product recovery
2. Identify and summarize the effect of change in unit's operations and its impact on the process
3. Illustrate how emerging technologies would benefit the bio chemical product recovery and show the likely benefits it would have over the traditional operations.
4. Analysing both analytical and process validation issues that are critical to successful manufacturing.
5. Outline the processes involving large-scale, high-purity protein production.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

CIE for the theory component of the IPCC (maximum marks 50)

- IPCC means practical portion integrated with the theory of the course.
- CIE marks for the theory component are **25 marks** and that for the practical component is **25 marks**.
- 25 marks for the theory component are split into **15 marks** for two Internal Assessment Tests (Two Tests, each of 15 Marks with 01-hour duration, are to be conducted) and **10 marks** for other assessment methods mentioned in 22OB4.2. The first test at the end of 40-50% coverage of the syllabus and the second test after covering 85-90% of the syllabus.
- Scaled-down marks of the sum of two tests and other assessment methods will be CIE marks for the theory component of IPCC (that is for **25 marks)**.

- The student has to secure 40% of 25 marks to qualify in the CIE of the theory component of IPCC.

CIE for the practical component of the IPCC

- **15 marks** for the conduction of the experiment and preparation of laboratory record, and **10 marks** for the test to be conducted after the completion of all the laboratory sessions.
- On completion of every experiment/program in the laboratory, the students shall be evaluated including viva-voce and marks shall be awarded on the same day.
- The CIE marks awarded in the case of the Practical component shall be based on the continuous evaluation of the laboratory report. Each experiment report can be evaluated for 10 marks. Marks of all experiments' write-ups are added and scaled down to **15 marks**.
- The laboratory test **(duration 02/03 hours)** after completion of all the experiments shall be conducted for 50 marks and scaled down to **10 marks.**
- Scaled-down marks of write-up evaluations and tests added will be CIE marks for the laboratory component of IPCC for **25 marks**.
- The student has to secure 40% of 25 marks to qualify in the CIE of the practical component of the IPCC.

SEE for IPCC

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours**)

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored by the student shall be proportionally scaled down to 50 Marks

The theory portion of the IPCC shall be for both CIE and SEE, whereas the practical portion will have a CIE component only. Questions mentioned in the SEE paper may include questions from the practical component.

Suggested Learning Resources:

Books

- Downstream Process Technology – A new horizon in Biotechnology by Nooralabettu Krishna Prasad, PHI Learning Private Limited.
- Bioseparation – Downstream processing for biotechnology by Belter P.A., Cussier E. and Wei Shan Hu., Wiley Interscience Pub.
- Separation Processes in Biotechnology by Asenjo J. et al., Marcel Dekker Publications.
- Bioseparations by Belter P.A. and Cussier E., Wiley.
- Product Recovery in Bioprocess Technology - BIOTOL Series,VCH.
- Fermentation & Enzyme Technology by D.I.C. Wang et.al., Wiley Eastern.
- Purifying Proteins for Proteomics by Richard J Simpson, IK International.
- Bioseparations: Science and Engineering By Roger G Harrison, Oxford Publications.
- Rate controlled separations by Wankat P.C., Elsevier.
- Bioprocess Engineering by Shule and Kargi, Prentice Hall.
- Bioprocess Engineering – Kinetics, Mass Transport, Reactors and Gene Expression by Wolf
- R. Vieth, Wiley – Interscience Publication.
- Rate controlled separations by Wankat P.C., Elsevier.
- Bioseparations by Belter P.A. and Cussier E., Wiley.
- Product Recovery in Bioprocess Technology - BIOTOL Series, VCH.
- Separation processes in Biotechnology by Asenjo J. and Dekker M.

Web links and Video Lectures (e-Resources):
VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://archive.nptel.ac.in/courses/102/106/102106022/
- https://archive.nptel.ac.in/courses/102/106/102106048/
- https://archive.nptel.ac.in/courses/102/105/102105058/
- http://www.digimat.in/nptel/courses/video/103103163/L27.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Collection of case studies based on research findings
- Model making and Poster presentations on specific case studies.

BIOETHICS , BIOSAFETY AND REGULATORY AFFAIRS		Semester	VII
Course Code	**BBT703**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	4:0:0:0	SEE Marks	50
Total Hours of Pedagogy	50	Total Marks	100
Credits	04	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To understand the ethical and biosafety concepts in biotechnology
- To emphasize on regulatory requirement of biotech industries

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (10 Hours)

BIOTECHNOLOGY AND SOCIETY:

Introduction to science, technology, society and environment, Issues of access-Case studies/experiences from developing and developed countries. Ownership, monopoly, traditional knowledge, biodiversity, benefit sharing, environmental sustainability, public vs. private funding, biotechnology in international relations, globalization and development divide. Public acceptance issues for biotechnology: Biotechnology and hunger: Challenges for the Indian Biotechnological research and industries

Module-2 (10 Hours)

BIOETHICS & LEGAL ISSUES:

Principles of bioethics: Legality, morality and ethics, autonomy, human rights, beneficence, privacy, justice, equity etc. The expanding scope of ethics from biomedical practice to biotechnology, bioethics vs. business ethics, ethical dimensions of IPR, technology transfer and other global biotech issues. The legal, institutional and socioeconomic impacts of biotechnology; biotechnology and social responsibility, Public education to increase the awareness of bioethics with regard to generating new forms of life for informed decision making – with case studies.

Module-3 (10 Hours)

BIOSAFETY CONCEPTS AND ISSUES:

Ethical conflicts in biotechnology - interference with nature, fear of unknown, unequal distribution of risks and benefits of biotechnology, Rational vs. subjective perceptions of risks and benefits, relationship between risk, hazard, exposure and safeguards, Biotechnology and biosafety concerns at the level of individuals, institutions, society, region, country and the world. The Cartagena protocol on biosafety. Biosafety management. Ethical implications of biotechnological products and techniques

Module-4 (10 Hours)

VALIDATION

Validation and Regulatory Affairs in Bio (Pharmaceutical) Manufacturing: An Introduction to FDA Operations & Industry Compliance Regulations, The Fundamentals of Regulatory Compliance with respect to Good Clinical Practice (GCP), Good Manufacturing Practice (GMP) & Good Laboratory Practice (GLP). An Introduction to the Basic Concepts of Process Validation & how it Differs from Qualification (IQ, OQ & PQ) Procedures, A Review of Prospective, Concurrent, Retrospective Validation & Revalidation.

Module-5 (10 Hours)

REGULATIONS AND STANDARDS

Biosafety regulations and national and international guidelines with regard to recombinant DNA technology. Guidelines for research in transgenic plants. National and international regulations for food and pharma products. Introduction to ISO 9000 series of standards: format of ISO 9000 changed from older version to latest version of ISO 9000 series. Components of ISO 9001:2000: Management Responsibility, Resource Management, Product Realisation, and Measurement Analysis & Improvement. ISO-14001, Environmental Management Systems.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Outline the importance of the bioethics and biosafety in the biotech industry.
2. Comprehend the various regulatory requirements and the organizations governing the same

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Biotechnology and Safety Assessment by Thomas, J.A., Fuch, R.L, Academic Press.
- Biological safety Principles and practices by Fleming, D.A., Hunt, D.L, ASM Press.
- Biotechnology - A comprehensive treatise. Legal economic and ethical dimensions VCH.
- Bioethics by Ben Mepham, Oxford University Press.
- Bioethics & Biosafety by R Rallapalli & Geetha Bali, APH Publication.
- Bioethics & Biosaftey by SATEESH MK, IK Publishers
- Pharmaceutical Process Validation, Robert Nash and Alfred Wachter, Marcel Dekker, New York :

Marcel Dekker, 2003.
- Good Manufacturing Practices for Pharmaceuticals: A Plan for Total Quality Control from Manufacturer to Consumer Sidney J. Willig, Marcel Dekker New York : Marcel Dekker, 2001

Web links and Video Lectures (e-Resources):

- https://www.youtube.com/watch?v=rETwCJv0lpA
- https://www.coursera.org/lecture/promote-ethical-data-driven-technologies/bioethics-Igc7q
- https://archive.nptel.ac.in/noc/courses/noc21/SEM1/noc21-ge14/
- http://www.digimat.in/nptel/courses/video/127106137/L21.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies based on research findings
  Poster presentations on specific case studies.

CLINICAL RESEARCH		Semester	VII
Course Code	**BBT714A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

The main objective of this course is to

- Develop experts or skilled professionals to handle large clinical data procedure with correct guidelines, rules and orientation of clinical research.
- Acquire a basic understanding of the concepts and practices of clinical trials in CRO and Pharmaceutical industry.
- Enable participants to understand issues surrounding the risks and benefits of drugs used in humans including the cause, manifestations and consequences of adverse drug effects.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

CLINICAL RESEARCH OVERVIEW:

Introduction To Clinical Research, The Historical Prospective Of Clinical Research, Introduction To Clinical Pharmacology and Drug Development Process.

MOLECULAR MECHANISM OF DRUG ACTION: Introduction, history, drug target types, Receptor mediated mechanisms, Cancer pharmacology

Module-2 (8 Hours)

PRECLINICAL EVALUATION DRUGS:

Introduction And Drug Discovery Process, Bioassays: Basic Principles Of Bioassays, Principles Of Toxicology, Guidelines And Regulatory Agencies

REGULATION AND ETHICS IN CLINICAL RESEARCH:

Ethics committee & ethical issues in clinical research, Guidelines in clinical research, Clinical trial regulations, Clinical research regulatory submission & approval process

Module-3 (8 Hours)

PHARMACOVIGILANCE

Introduction To pharmacovigilance, Guidelines on pharmacovigilance for medicinal product, Regulatory aspects of medical devices, Pharma regulatory affairs, drug reactions and case processing.

CLINICAL TRIAL MANAGEMENT

Overview, A sponsor's perspective, An investigator's perspective, Service providers / vendors perspective, Case studies, Essential documentation.

Module-4 (8 Hours)

GCP, GMP GUIDELINES

Good clinical practice (GCP guidelines)–general overview, Ethics committee composition & function –GCP, Good laboratory practices (GLP), Good manufacturing practices (GMP)

MEDICAL WRITING AND PHARMACOLOGY

Introduction to medical writing, Regulations and ethics in medical writing, Types of medical writing methodology, Documentation in medical writing, Chemotherapeutic drug, Toxicology

Module-5 (8 Hours)

CLINICAL DATA MANAGEMENT

Introduction To Clinical Data Management, Start Up Phase In Clinical Data Management, Conduct And Study Wrap Up In Clinical Data Management, And Standards In Clinical Data Management.

CLINICAL PROGRAMMING

Introduction to Clinical Programming, Design CRF, SQL (Basics), SAS, R Programming, Python, Application of AI and ML in Clinical Research.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. To understand the study design and the concept of Clinical Trials.
2. To learn the Processes of Development of Drug.
3. To understand the regulatory perspectives and ethics on clinical research trials activities.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Fundamentals of Clinical Trials, Lawrence M. Friedman, Curt Furberg, David L. DeMets, Springer, 1998
- Principles and Practice of Clinical Research, Frederick P Ognibene, John I. Gallin, 2011.
- Designing Clinical Research, Stephen B. Hulley, Steven R. Cummings, Warren S. Browner, Deborah G. Grady, Thomas B. Newman, Wolters Kluwer Health, 2011
- Practical Guide to Clinical Data Management, Susanne Prokscha, CRC Press, 2011
- Drug Discovery and Clinical Research, SK Gupta, Jaypee Brothers Medical Publishers Pvt. Limited, 2011

Web links and Video Lectures (e-Resources):

- https://onlinecourses.nptel.ac.in/noc21_ge14/preview
- https://archive.nptel.ac.in/courses/127/106/127106009/
- https://onlinecourses.nptel.ac.in/noc20_ge13/preview
- https://archive.nptel.ac.in/courses/127/106/127106137/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Visit to hospital where clinical research is conducted.

ENVIRONMENTAL BIOTECHNOLOGY		Semester	VII
Course Code	**BBT714B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- Learn to find and implement scientific, technological, economic and political solutions to environmental problems.
- Learn to analyse the interrelationship between living organism and environment.
- Learn the importance of environment by assessing its impact on the human world
- Learn to integrated themes and biodiversity, natural resources, pollution control and waste management.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION TO ENVIRONMENTAL POLLUTANTS:

Water, Soil and Air: their sources and effects. Removal of Specific Pollutants: Sources of Heavy Metal Pollution, Microbial Systems for Heavy Metal Accumulation, Biosorption& detoxification mechanisms

Module-2 (8 Hours)

MICROBIOLOGY AND BIOCHEMISTRY OF WASTE WATER TREATMENT:

Biological Treatment of anaerobic and aerobic; methanogenesis, methanogenic, acetogenic, and fermentative bacteria- technical process and conditions; Use of Genetically Engineered Organisms. emerging biotechnological processes in waste - water treatment; Applications include treatment of municipal and industrial wastewaters.

Module-3 (8 Hours)

SOCIAL ISSUES AND THE ENVIRONMENT:

From unsustainable to sustainable development – urban problems related to energy –3 water conservation, Water conservation, rain water harvesting, watershed management, resettlement and rehabilitation of people; its problems and concerns, case studies – role of non-governmental organization- environmental ethics: Issues and possible solutions – climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies. – wasteland reclamation – consumerism and waste products. Different Environmental Acts and policies.

Module-4 (8 Hours)

NATURAL RESOURCES:

Forest resources: Use and over-exploitation, deforestation, case studies- timber extraction, mining,

dams and their effects on forests and tribal people, Food resources: World food problems, changes caused by agriculture and overgrazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity, case studies – Energy resources: Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. case studies – Land resources: Land as a resource, land degradation, man induced landslides, soil erosion and desertification – role of an individual in conservation of natural resources – Equitable use of resources for sustainable lifestyles. Field study of local area to document environmental assets – river / forest / grassland / hill / mountain. Non Timer Forest Products. Biofuels.

Module-5 (8 Hours)

BIO LEACHING:

Biooxidation – Direct and Indirect Mechanisms – Biooxidation Kinetics; Bacterial oxidation of Sphalerite, Chalcopyrite and Pyrite.; Extraction of metals from ores; Recovery of metals from solutions; Microbes in petroleum extraction; Microbial desulfurization of coal, gene closing - use of genetically altered microorganisms for field biodegradation of hazardous materials.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. To gain knowledge on the importance of environmental education and ecosystem.
2. To acquire knowledge about environmental pollution- sources, effects and control measures of environmental pollution.
3. To understand the treatment of wastewater and solid waste management.
4. To acquire knowledge with respect to biodiversity, its threats and its conservation and appreciate the concept of interdependence.
5. To be aware of the national and international concern for environment for protecting the environment.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.

2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Environmental Microbiology, W.D. Grant & P.E. Long, Blakie Glassgow and London, 1981.
- Microbial Gene Technology, H. Polasa (ED.), South Asian Publishers, New Delhi, 1991.
- Environmental Biotechnology: Principles and Applications,Bruce Rittmann and Perry McCarty Tata McGraw-Hill Education, 2012
- Introduction to Environmental Engineering and Science, Gilbert M.Masters, Pearson Education 2nd edition, 2004
- Environmental Science and Engineering, Benny Joseph, Tata McGraw-Hill, New Delhi, 2004
- Biotreatment Systems, D. L. Wise (Ed.), CRC Press, INC.1988
- Standard Methods for the Examination of Water and Waste Water, American Public Health Association, APHA, 1985
- Textbook of Environmental Studies, ErachBharucha, Universities Press(I) Pvt. Ltd., Hyderabad, 2015
- Environmental Studies-From Crisis to Cure, Rajagopalan R, Oxford University Press, 2005
- Environmental Science, G. Tyler Miller and Scott E. Spoolman, Cengage Learning India PVT, LTD, Delhi, 2014

Web links and Video Lectures (e-Resources):

- https://archive.nptel.ac.in/courses/102/105/102105088/
- https://www.classcentral.com/course/swayam-environmental-biotechnology-43592

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered

BIOLOGICAL DATA MANAGEMENT		Semester	VII
Course Code	**BBT714C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

The main objective of this course is to

- To understand the types of databases and their data formats.
- To study the importance of various Omics experiments, data generation techniques, data management strategies and their effective utilization.
- To comprehend the nature of Clinical Data, its Management and related basic operations.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

DATABASES OVERVIEW:

PubMed, GenBank, EMBL, DDBJ, Swiss Prot, Uniprot, TrEMBL, PDB, EST, SCOP, Pfam, SMART; Interaction Databases, (BIND, STRING), Pathway Databases, (KEGG), Signal Transduction database (STKE), Organism Specific database (Yeast, OMIM, HGNC, Flybase, wormbase), Genome databases (GOLD), Pathogen database (PATRIC), About the January Issue of Nucleic Acids Research journal and the catalog of biological databases. Data Models: Relational, Object Oriented. Hierarchical, Semi-structured, Unstructured (e.g.Text),Model of Querying: SQL ,Information Integration ,Data Mining for various applications.

Module-2 (8 Hours)

MICROARRAY DATA ANALYSIS:

Why are MicroArray Important? What is a DNA MicroArray?, Designing a MicroArray Experiment-The Basic steps, Types of MicroArray. NCBI and MicroArray Data Management, GEO (Gene Expression Omnibus), MAML, The benefits of GEO and MAML, The Promise of MicroArray Technology in Treating Disease. MicroArray Data Pre-processing, Data normalization, Measuring Dissimilarity of Expression Pattern-Distance Motifs and Dissimilarity measures, Visualizing MicroArray Data. Principal Component Analysis, MicroArray Data. NCBI and MicroArray Data Management, GEO (Gene Expression Omnibus), MAML, The benefits of GEO and MAML, The Promise of MicroArray Technology in Treating Diseases. Data Mining for specific applications

Module-3 (8 Hours)

NGS DATA ALAYSIS:

Importance of Omic Technologies, NGS data collection and Bioinformatics principles. Data standards for Omic data: the basis of data sharing and reuse. Omic data management and annotation. Data and knowledge management in cross omics research projects. Statistical analysis principles for omic data. Statistical methods and models for bridging Omics data levels. Analysis of time course omic datasets. The use and abuse of Omes. Computational analysis of High Throughput Sequencing Data Analysis of SNP in case control studies. Bioinformatics for RNomics. The ENCODE project consortium. Data Mining for specific applications.

Module-4 (8 Hours)
OMICS DATAMANAGEMENT: Qualitative and Quantitative Proteomics. Bioinformatics for Mass spectrometry and 2D gels. Concepts of Metabolomics, Transcriptomics and Interactomics. Computational Analysis Workflows for Protein Array Data Interpretation. Integration, Warehousing, and Analysis Strategies of Data. Integration. Data for signaling pathways, interactome reconstruction and functional analysis. Network Inference from Time Dependent data. Omics- Bioinformatics in the context of diseases, Omics-Based Identification of Pathophysiological Processes. Data Mining Methods in Omics-Based Biomarker Discovery.
Module-5 (8 Hours)
CLINICAL DATA ANALYTICS: Overview of Clinical Data Management plan, CRF design consideration, Data cleaning issues and Data processing issues, Database design consideration: Making design decisions, Operating procedures for database design, Dealing with problem data, modifying data, Quality control through database audits, Identifying and managing discrepancies, Quality control and assurance, Managing laboratory data, Storing lab data, Creating report and transferring data, Clinical data management systems, Electronic data capture systems, System Validation, Migrating, data integration and archiving data. Data Normalization and Querying Techniques. Data Mining for desired applications.
Course outcome (Course Skill Set) At the end of the course, the student will be able to : 1. Decipher the differences in the types of data bases and their data formats. 2. Apply the knowledge of various Omics experiments, data generation techniques, data management concepts. 3. Data mining strategies and their effective utilization. 4. Comprehend the aspects of Clinical Data, data integration, data Management, data mining for defined applications.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.

2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Bioinformatics Database Systems by Byron et al., CRC Press, 2017.
- Data Mining in Bioinformatics by Wang et al.(eds), Springer, 2005.
- Computational Biology and Genome Informatics by Wang et al.(eds) World Scientific, 2003.
- Pattern Discovery in Biomolecular Data: Tools, Techniques and Applications by Wang et al.(eds)Oxford University Press, 1999.
- Microarray Technology and Its Applications Uwe R. Muller, DanV. Nicolau Springer, 2005.
- Microarray Bioinformatics by Dov Stekel, Cambridge University Press, 2003.

Web links and Video Lectures (e-Resources):

- https://www.udemy.com/topic/clinical-research/?
- https://www.coursary.com/search?
- https://www.coursera.org/learn/clinical-data-management
- https://www.udemy.com/course/clinical-data-management-cdm-online-course/

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- Group Discussions
- Lab exercises

AGRICULTURAL BIOTECHNOLOGY		Semester	VII
Course Code	**BBT714D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

The main objective of this course is to

- Understand the fundamental concepts and principles of agricultural biotechnology.
- Identify and evaluate the various applications of biotechnology in agriculture.
- Analyze the ethical, social, and environmental implications of agricultural biotechnology.
- Apply biotechnological techniques and tools in solving agricultural problems.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

PLANT TISSUE CULTURE AND MICROPROPAGATION:

Cellular totipotency, Tissue Culture Media, Callus and Suspension Cultures, Somatic Embryogenesis, Haploid Culture, Protoplast isolation & Somatic hybridization techniques, Meristem and Embryo culture; Synthetic seeds. In vitro germplasm conservation, hardening and acclimatization. Cryopreservation. Applications of plant tissue culture in Agriculture**.**

Module-2 (8 Hours)

GENETIC ENGINEERING AND EMERGING TRENDS IN AGRICULTURAL BIOTECHNOLOGY:

Plant Transformation methods and gene transfer techniques; Genetically modified organisms (GMOs) in agriculture (Bt cotton, Golden rice, Herbicide resistance); Marker-assisted selection and plant breeding techniques. Genome editing techniques (CRISPR-Cas9, TALENs): RNA interference (RNAi) and gene silencing; Synthetic biology and its applications in agriculture.

Module-3 (8 Hours)

MOLECULAR FARMING AND NITROGEN FIXATION:

Molecular farming for the production of industrial enzymes, biodegradable plastics, polyhydroxybutyrate, antibodies, edible vaccines; Use of mutants in crop improvement and polyploidy; Metabolic engineering of plants for the production of fatty acids, industrial oils, flavonoids etc., Engineering of carotenoid and provitamin biosynthetic pathways. Nitrogen fixation and biofertilizers-Diazotrophic microorganisms, nitrogen fixation genes.

Module-4 (8 Hours)

APPLICATIONS OF BIOTECHNOLOGY IN LIVESTOCK PRODUCTION:

Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, in vitro fertilization, culture of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic animal technology, animal viral vectors, marker assisted breeding of livestock.

Module-5 (8 Hours)

ENVIRONMENTAL AND ETHICAL CONSIDERATIONS: BIOTECHNOLOGY & HUNGER.

Ethical issues associated with labelling and consumption of GM foods. Public perception of GM technology. Biosafety management. Cartagena protocol on biosafety. Ethical implication of BT products, public education, Biosafety regulations, experimental protocol approvals, guidelines for research, environmental aspects of BT applications.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Apply the knowledge of plant tissue culture and genetic engineering for mass propagation and crop improvement.
2. Identify and evaluate the various applications of biotechnology in agriculture.
3. Analyze the ethical, social, and environmental implications of agricultural biotechnology.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks.

Suggested Learning Resources:

Books

- Elements of Biotechnology by Gupta PK, Rastogi Publ. 1997.
- An Introduction to Recombinant DNA Technology: Basic Experiments in Gene Manipulation by Hackett PB, Fuchs JA & Messing JW2nd Ed. Benjamin Publ. Co., 1988.
- Molecular Biology & Genetic Engineering by L M Narayanan, A. Mani, A.M Selvaraj, N Arumugam, Padmalatha Singh, Saras Publication. 2014
- Plant Biotechnology: Principles and Applications" by Channapatna S. Prakash and Hugh D. Spence
- Agricultural Biotechnology: Challenges and Prospects" edited by A. Kundu and S. Kumar

Web links and Video Lectures (e-Resources):
• https://www.classcentral.com/course/food-production-agricultural-technology-plant-bio-14399 • https://www.futurelearn.com/courses/food-production-agricultural-technology-plant-biotechnology • https://www.mooc-list.com/tags/plant-biotechnology
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning • Class Presentations and discussions of research articles from publications. • Online tools for surprise quizzes. • Collection of case studies via Newspapers/Journal articles, on topics covered. • Group discussions on recent advancements and case studies.

BIOMATERIALS AND MEDICAL IMPLANTS		Semester	VII
Course Code	**BBT755A**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To Provide graduate-level foundation on biomaterial principles.
- To Discuss the concepts of surfaces & interfaces in biomaterial interactions.
- To Discuss cellular and molecular aspects of host responses to biomaterials.
- To understand the concepts related to Design and development of biomedical implants.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION TO BIOMATERIALS:

Historical developments, definition and classification of biomaterials, impact of biomaterials, mechanical properties, wound healing process, tissue response to implants, safety and efficiency testing, bio-compatibility. Metallic and Ceramic Biomaterials: Stainless steel, cobalt chromium alloys, titanium-based alloys, nitinol, metallic corrosion, medical applications, biological tolerance of implant metals. Case studies.

Module-2 (8 Hours)

SYNTHETIC POLYMERS:

Relatively bioinert bioceramics, biodegradable ceramics, surface reactive or bioactive ceramics, composites, analysis of ceramic surfaces, deterioration of ceramics, medical applications, Nano-composites. Synthetic and Biopolymers: Polymers in biomedical use, biodegradable synthetic polymers, silicone rubber, plasma polymerization, microorganism in polymeric implants, bio polymers, polymer sterilization. Case studies.

Module-3 (8 Hours)

BIOCOMPATIBILITY:

Wound healing process-bone healing, tendon healing. Material response: Function and Degradation of materials in vivo. Host response: Tissue response to biomaterials, Testing of bone implants: Methods of test for biological performance- In vitro implant tests, Qualification of implant materials. Case studies.

Module-4 (8 Hours)

CARDIOVASCULAR BIOMATERIALS:

Tissue properties of blood vessels, Treatments of atherosclerosis; Biomechanical design issues pertaining to stents, balloon angioplasty, and pacemakers. Soft Tissue Reconstruction; Natural and Synthetic. Wound healing. Tissue ingrowths: Stability; Biofixation, Foreign Body response, Soft implants. Case Studies. Tissue Engineering: Current issues and Future Directions. Case studies.

Module-5 (8 Hours)

IMPLANTABLE DEVICES:

Implantable Cardiovascular Assist Devices, Artificial RBC Substitutes, Orthopedic Applications, Dental Implants, Adhesives and Sealants, Ophthalmological Applications (Various types of contact lenses, Intra Ocular Lens Implant), Cochlear Prostheses. Case studies.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. Express a range of potential biomaterial and implants as specific treatments options.
2. Outline all parameters needed to optimize the design of implants and devices.
3. Identify the advantages and disadvantages of materials in terms of its compatibilities, biological responses, and degradation.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- An Introduction to Biomaterials byJ. B. Park and R. S. Lakes, Springer, 2007.
- Biological Performance of materials byJ. Black, Taylor &Francis, 2005.
- Biomaterials Science: An Introduction to Materials in Medicine by Buddy D. Ratner, Elsevier, 2004.
- Essential Biomaterials: Cambridge Texts in Biomedical Engineering by David Williams, 2014.
- Polymeric Biomaterials by Piskin and A S Hoffmann, MartinusNijhoff Springer, 1986.
- Wearable And Implantable Medical Devices by Dey Nilanjan, Acad Press, 2019
- Biopolymers for Medical Applications, By Juan M. Ruso and Paula V. Messina, CRC Pressm 2017
- Biointegration of Medical Implant Materials: Science & Design by Chandra P. Sharma, Elsevier, 2019

Web links and Video Lectures (e-Resources):
VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource • https://www.udemy.com/course/draft/3729862/ • https://www.edx.org/learn/biomaterials • https://onlinecourses.nptel.ac.in/noc20_bt12/preview • https://www.mooc-list.com/tags/biomaterials • https://www.coursera.org/lecture/industrial-biotech/biomaterials-engineering-cell-niches-hydrogels-p5lVD • https://onlinecourses.nptel.ac.in/noc20_bt12/preview • https://www.edx.org/course/biofabrication • https://ocw.mit.edu/courses/20-441j-biomaterials-tissue-interactions-fall-2009/ • https://engineering.purdue.edu/online/courses/introduction-biomaterials
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning • AV presentation by students (on topics as per choice of the teacher) • Online tools for surprise quizzes • Collection of case studies via newspaper on topics covered • Discussion on recent advancements and case studies

PUBLIC HEALTH AND COMMUNITY MEDICINE		Semester	VII
Course Code	**BBT755B**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To make the students aware of environmental, social, financial, personal, occupational issues of the public health.
- To learn techniques of prevention at Individual, National and International level for various health issues.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

MAN AND MEDICINE

Changing concepts in public health. Concept of health and disease: Dimensions and determinants of Health, Indicators of Health, Natural history of disease.

Module-2 (8 Hours)

ENVIRONMENT AND HEALTH

Water, Air, Light, Ventilation, Noise, Meteorological environment, Humidity, Housing, Disposal of waste, Excreta disposal, Medical entomology &Insecticides, Rodents & related Disease, Radiation, Zoonosis.

Module-3 (8 Hours)

MEDICINE AND SOCIAL SCIENCE

Concepts in Sociology, Psychology, Social Psychology, Family in health and disease, Cultural factors in health and disease, Hospital Sociology, Art of Interviewing, Social Problems, Economics, Social security

Module-4 (8 Hours)

NUTRITION AND HEALTH:

Introduction to nutrition, Vitamins, Minerals, Nutritional problems of public health importance, Nutritional requirements, Assessment of nutritional status, Nutritional surveillance and social aspects of nutrition, Food hygiene and Food borne disease, Prevention of food adulteration act, Community nutrition programs.

Module-5 (8 Hours)

EPIDEMIOLOGY:

Aims and Approaches of Epidemiology, Rates, ratios and measurement of morbidity and mortality, Epidemiological methods – Descriptive, Analytical and experimental, Association and causation, Uses of epidemiology, Infectious disease epidemiology – Dynamics of disease transmission, Immunity and immunizing agent, Disease prevention and control, Disinfection, Investigation of an epidemic Including Filed survey.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Comprehend common health problems and emergencies at individual, family and community levels keeping in mind the existing health care resources and prevailing socio cultural beliefs
2. Recognise the principles and components of primary health care and the national health policies to achieve the goal of "Health for all"

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Parks text book of preventive & social medicine – K Park, Bhanot Publication
- Text Book of Community Medicine with Recent Advances- JP Suiryakatha,
- Text Book of Community Medicine- Sunderlal & others
- A Treatise on Health Management- SC Mohapatra, M Mohapatra & V Mohapatra, JP Brothers Publication Pvt Ltd
- Applied Statistics in Health Sciences – NSN Rao & NS Murthy, JP Brothers Publication
- Text Book of Epidemiology—Leon Gordis
- Sathya Swaroop, Introduction to Health Statistics. Latest edition – E & S Living Stone Ltd., Edinburgh, London.
- Nutritive value of Indian foods – C. Gopalan, NIN Publication

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource • https://www.himsr.co.in/department/community-medicine/ • https://www.youtube.com/watch?v=9kDUHs7l9TI
Activity Based Learning (Suggested Activities in Class)/ Practical Based learning • Family Visit & Socio Clinical Case Study • Group Discussion on Primary Health Care.

TRADITIONAL MEDICINE AND HEALTH MANAGEMENT		Semester	VII
Course Code	**BBT755C**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To provide foundation for understanding the causes, mechanisms, clinical features and diagnosis of disease as understood by traditional medicine.
- Understanding of common diseases and the principles of management using Ayurvedic concepts.

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

HUMAN SCIENCES AND NUTRITION

Brief introduction of structure and functions of the cells, tissues and biomolecules. Brief introduction of Metabolism and control of carbohydrates, lipids and proteins. Brief introduction of Structure and functions of the human organ system. Brief introduction of structural characteristics and function of a range of key macronutrients and micronutrients. Brief description of processes involved in the catabolism of food components.

Module-2 (8 Hours)

CLINICAL SCIENCES

Causes and mechanisms of disease, describing diseases, the principles of differential diagnosis. Disorders of cells and response to disorders. Infectious diseases and circulatory disorders. Symptoms and signs related to diseases of the various body systems and diseases of control systems.

Module-3 (8 Hours)

PLANT CHEMISTRY & PHARMACOLOGY

The chemical and physical structure, properties and functions of the main classes of secondary plant chemicals. The dynamics and kinetics of medicinal substances upon the human body – remedy absorption, distribution, metabolism, excretion, and sensitivity. The toxicology of commonly used medicinal plants: side effects, cautions and contraindications

Module-4 (8 Hours)

PHARMACOGNOSY & DISPENSING

Processes and issues of Quality Assurance in relation to herbal and traditional medicines. Characteristics of commonly used herbal and traditional medicines. Dispensary skills. Legislation relating to the sourcing, purchasing, storage, labelling and dispensing of herbal and traditional medicine. Forms of administration of herbal and traditional medicine.

Module-5 (8 Hours)

AYURVEDIC MEDICINE

Ayurvedic Fundamental Principles: Padartha Vijnana and Rachana & Kriya Sharira. Ayurvedic Pharmacology and Pharmacy: principles of pharmacology, pharmacodynamics, and physiochemical and medicinal properties of raw materials used in Ayurvedic medicine. Ayurvedic Pathology and Therapeutics: Swasthavrtta and Yoga, Roga vijnana and Vikruti Vijnana, Textual study of Charaka Samhita, Introduction to Kayachikitsa. Ayurvedic Internal Medicine: Advanced Kayachikitsa, Pañcakarma, Rasayana and Vajikarna, Manasa Roga and Vedic Healing. Ayurvedic Specialist Medicine: Prasuti Tantra, Stree Roga, Kaumarabhritya, and Shalya-Shalakya

Course outcome (Course Skill Set)

At the end of the course, the student will be able to:

1. Comprehend causes, mechanisms, clinical features and diagnosis of disease as understood by traditional medicine.
2. Apply Ayurvedic concepts to understanding of common diseases and the manage human diseases and disorders.

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

Continuous Internal Evaluation:

- For the Assignment component of the CIE, there are 25 marks and for the Internal Assessment Test component, there are 25 marks.
- The first test will be administered after 40-50% of the syllabus has been covered, and the second test will be administered after 85-90% of the syllabus has been covered
- Any two assignment methods mentioned in the 22OB2.4, if an assignment is project-based then only one assignment for the course shall be planned. The teacher should not conduct two assignments at the end of the semester if two assignments are planned.
- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Principles of Anatomy and Physiology, Tortora, Gerard J. et al., Rom. John Wiley and Sons, 11th edition, 2006.
- Nutrition: Principles and Clinical Practice, Hunt, S.M et al, John Wiley and Sons, 1980.
- Clinical Medicine Guide - a holistic perspective, Gascoigne, Stephen, Jigme Press, 2001.
- Herb Contra-indications and Drug Interactions, Brinker, Francis, Sandy, Oregon: Eclectic Medical Publications, 3rd edition, 2001.
- Indian Medicine, Jolly, Julius, Munshiram Manoharlal Publishers, New Delhi: 1994.
- Reflectons on the basic concepts of Indian pharmacology. Studies on Indian medical History, edited by G. Meulenbeld and D. Wujastyk Groningin, The Netherlands: Egbert Forsten, 1987.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.digimat.in/nptel/courses/video/121106003/L05.html
- https://amrita.digimat.in/nptel/courses/video/127106233/L10.html

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Discussion on recent advancements and case studies

BIOREMEDIATION TECHNIQUES		Semester	VII
Course Code	**BBT755D**	CIE Marks	50
Teaching Hours/Week (L: T:P: S)	3:0:0:0	SEE Marks	50
Total Hours of Pedagogy	40	Total Marks	100
Credits	03	Exam Hours	3
Examination type (SEE)	Theory		

Course objectives:

- To Demonstrate an understanding of the nature and importance of bioremediation for real world applications.
- To Understand the influence of site characteristics: hydraulic conductivity, soil type, microbial presence, and groundwater properties.
- To Understand the influence of contaminant characteristics to bioremediation (e.g. chemical structure, toxicity, and solubility).

Teaching-Learning Process (General Instructions)

These are sample Strategies, which teachers can use to accelerate the attainment of the various course outcomes.

- Explanation via real life problem, situation modelling, and deliberation of solutions, hands-on sessions, reflective and questioning /inquiry-based teaching.
- Instructions with interactions in classroom lectures (physical/hybrid).
- Use of ICT tools, including YouTube videos, related MOOCs, AR/VR/MR tools.
- Flipped classroom sessions (~10% of the classes).
- Industrial visits, Guests talks and competitions for learning beyond the syllabus.
- Students' participation through audio-video based content creation for the syllabus (as assignments).
- Use of gamification tools (in both physical/hybrid classes) for creative learning outcomes.
- Students' seminars (in solo or group) /oral presentations.

Module-1 (8 Hours)

INTRODUCTION:

Process of bioremediation; Bioremediation of synthetic compounds, petrochemicals, inorganic wastes; Bioremediation strategies, Bioremediation techniques in situ, Bioremediation techniques ex situ, Phytoremediation and Phytotechnology, bioremediation of Metals, Gaseous bioremediation.

Module-2 (8 Hours)

BIOREMEDIATION:

Advantages of Bioremediation, types of bioremediations. Monitoring the efficacy of Bioremediation. Bioaugmentation, biomagnifications and Biotransformation. Bioventing. Bioremediation for controlling oil spills.

Module-3 (8 Hours)

BIOSORPTION:

Use of bacteria and fungi, Bioreaction for biosorption. Problems associated with disposal of xenobiotic compounds, Hazardous wastes. Biodegradation of xenobiotics: Persistent compounds, Degradation mechanisms, naphthalene, benzene, phenol, PCB's, propanil (Herbicide), urea. Biodegradation of petrochemical effluents.

Module-4 (8 Hours)

BIOTECHNOLOGICAL METHODS TO CONTROL POLLUTION:

Biofilters, Bioremediation, Biotransformation Biodegradation and Phytoremediation: In situ and Ex situ bioremediation; Evaluating Bioremediation; Bioremediation of VOCs. Factors affecting process of biodegradation; Biotechnological solutions for Global environment problems like Greenhouse effect, Ozone depletion, UV radiation, Acid rain.

Module-5 (8 Hours)

METHODS IN DETERMINING BIODEGRADABILITY:

Contaminant availability for biodegradation; Use of microbes (bacteria and fungi) and plants in

biodegradation and Biotransformation; Phytoremediation: Waste water treatment using aquatic plants; Root zone treatment.

Course outcome (Course Skill Set)

At the end of the course, the student will be able to :

1. Demonstrate an understanding of the nature and importance of bioremediation for real life problems.
2. Analyze the influence of site characteristics like hydraulic conductivity, soil type, microbial presence, and groundwater properties.
3. Analyze the influence of contaminant characteristics to bioremediation (e.g. chemical structure, toxicity, and solubility).

Assessment Details (both CIE and SEE)

The weightage of Continuous Internal Evaluation (CIE) is 50% and for Semester End Exam (SEE) is 50%. The minimum passing mark for the CIE is 40% of the maximum marks (20 marks out of 50) and for the SEE minimum passing mark is 35% of the maximum marks (18 out of 50 marks). A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures a minimum of 40% (40 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

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- For the course, CIE marks will be based on a scaled-down sum of two tests and other methods of assessment.

Internal Assessment Test question paper is designed to attain the different levels of Bloom's taxonomy as per the outcome defined for the course.

Semester-End Examination:

Theory SEE will be conducted by University as per the scheduled timetable, with common question papers for the course (**duration 03 hours).**

1. The question paper will have ten questions. Each question is set for 20 marks.
2. There will be 2 questions from each module. Each of the two questions under a module (with a maximum of 3 sub-questions), **should have a mix of topics** under that module.
3. The students have to answer 5 full questions, selecting one full question from each module.
4. Marks scored shall be proportionally reduced to 50 marks

Suggested Learning Resources:

Books

- Bioremediation Principles by Eweis JB, Ergas SJ, Chang DPY, and Schroeder ED, McGraw-Hill Companies, Inc., 1998.
- Environmental Biotechnology: Principles and Applications, by B.E. Rittmann and P.L. McCarty, McGraw-Hill, Inc., New York, 2001.
- Environmental Biotechnology: Theory and Application, by G.M. Evans and J.C. Furlong, John Wiley & Sons, Ltd., Chichester, England, 2003.
- Bioremediation, by K.H. Baker and D.S. Herson, McGraw-Hill, Inc., New York, 1994.
- Bioremediation: A Desk Manual for the Environmental Professional, by D.R. Schneider and R.J. Billingsley, Cahners Publishing Company, Des Plaines, IL, 1990.

- Environmental Biotechnology for Waste Treatment, by G.S. Saylor, R. Fox and J.W. Blackburn (eds.), Plenum Press, New York, NY. 1990.
- Hydrocarbon Bioremediation by R.E. Hinchee, B.C. Alleman, R.E. Hoeppel, and R.N. Miller (eds.), Lewis Publishers, Boca Raton, FL. 1994.
- Emerging Technology for Bioremediation of Metals by J.L. Means and R.E. Hinchee (eds.), Lewis Publishers, Boca Raton, FL. 1994.
- Microbial Transformation and Degradation of Toxic Organic Chemicals, by L.Y. Young and C.E. Cerniglia (eds.), Wiley-Liss, Inc., New York, NY. 1995.

Web links and Video Lectures (e-Resources):

VTU EDUSAT / SWAYAM / NPTEL / MOOCS / Coursera / MIT-open learning resource

- https://www.mooc-list.com/tags/bioremediation
- https://onlinecourses.nptel.ac.in/noc21_bt41/preview
- http://learnbioremediation.weebly.com/course-overview.html
- https://www.classcentral.com/course/swayam-applied-environmental-microbiology-10083

Activity Based Learning (Suggested Activities in Class)/ Practical Based learning

- AV presentation by students (on topics as per choice of the teacher)
- Online tools for surprise quizzes
- Collection of case studies via newspaper on topics covered
- Discussion on recent advancements and case studies