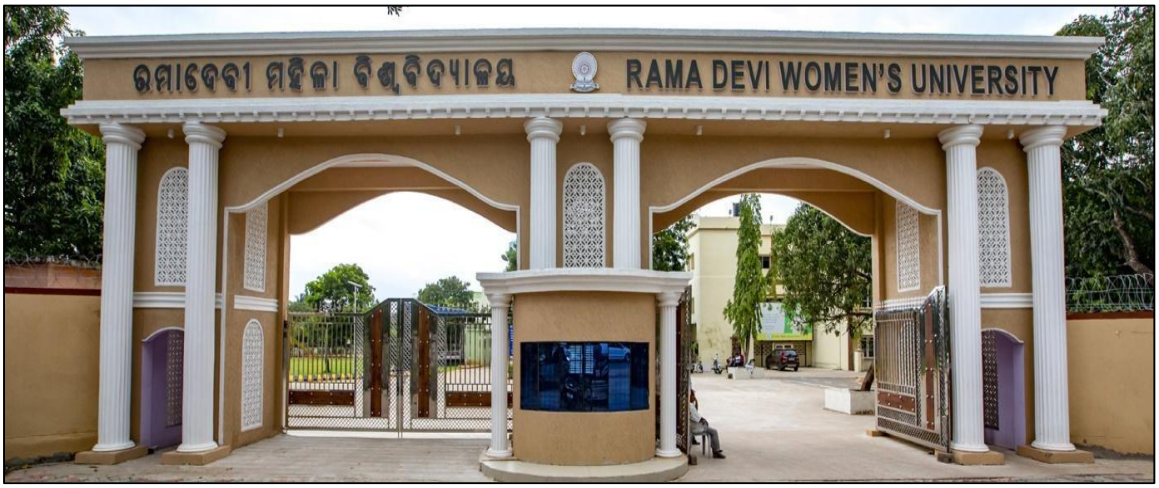
DEPARTMENT OF LIFE SCIENCES

SYLLABUS FOR MASTER OF SCIENCE

IN

INDUSTRIAL MICROBIOLOGY



RAMA DEVI WOMEN'S UNIVERSITY

Vidya Vihar, Bhubaneswar-751022, Odisha

Website: https://rdwu.ac.in

DEPARTMENT OF LIFE SCIENCES

COURSE STRUCTURE AND SYLLABUS

FOR

P.G. in Industrial Microbiology

DEPARTMENT OF LIFE SCIENCES

RAMA DEVI WOMEN'S UNIVERSITY

VIDYA VIHAR, BHUBANESWAR-751022

Industrial Microbiology

PAPER	COURSE CODE	COURSE TITLE	Units	Credits	Mid-sem	End-sem	Total
SEMESTER-I							
Hard Core	HC-101	Introduction to Industrial Microbiology & Microbial Techniques	5	5	30	70	100
Hard Core	HC-102	Immunology and microbial transformation	5	5	30	70	100
Hard Core	HC-103	Bioinstrumentation	5	5	30	70	100
Hard Core	HC- 104	Practical related to paper HC-101, HC-102, HC-103		5	30	70	100
Allied Core	AC-101	Computer application course by e-learning centre	3	3	Mid sem 10 + Practical 10= 20 marks	30	50
TOTAL				**23**	**140**	**310**	**450**
SEMESTER-II							
Hard Core	HC-201	Fermentation Technology	5	5	30	70	100
Hard Core	HC-202	Microbial Physiology and genetics	5	5	30	70	100
Hard Core	HC-203	Food Microbiology	5	5	30	70	100
Hard Core	HC- 204	Practical related to paper HC-201, HC- 202, HC-203 and CE-201A/B		5	30	70	100
Core Elective	CE-201 A/B	A:Recombinant DNA Technology & Bioinformatics B: Bioremediation	5	5	30	70	100
Open Elective	OE-201 A/B	A: Human health & Hygiene B: MOOCs (From SWAYAM/ NPTEL etc.)		4		50	50
TOTAL				**29**	**150**	**400**	**550**
SEMESTER-III							
Hard Core	HC-301	Environmental Microbial Technology	5	5	30	70	100
Hard Core	HC-302	Microbial diseases and their control	5	5	30	70	100

Hard Core	HC-303	Practical related to paper HC-301, HC-302 and CE-301 A/B, CE-302 A/B	-	5	30	70	100
Core Elective	CE-301 A/B	A: Microbes, Bio fertilizer and Bioinsecticides B: Virology	5	5	30	70	100
Core Elective	CE-302 A/B	A: Research Methodology B: Waste Management	5	5	30	70	100
Field Internship	FI- 301	Field Internship		3		50	50
TOTAL				**28**	**150**	**400**	**550**
SEMESTER-IV							
Hard Core	HC-401	Subject Overview	-	5	-	100	100
Hard Core	HC-402	Seminar	-	5	-	100	100
Hard Core	HC-403	Dissertation	-	5	-	100	100
Core Elective	CE-401	Dissertation Evaluation	-	5	-	100	100
Allied Core	AC-401	Theory : 'Women and Society' (For All PG Subjects/Programs)	03	03	15	35	50
TOTAL				**23**	**15**	**435**	**450**

Summary

HC-HardCore	14 x100	1400
CE-CoreElective	4 x100	400
OE-OpenElective	1x50	50
AC-AlliedCore	2x50	100
FI-FieldInternship	1x50	50
TotalMarks:		**2000**

Summary

	Credits	**TotalMarks**
Sem-I	23	450
Sem-II	29	550
Sem-III	28	550
Sem-IV	23	450
TOTAL	**103**	**2000**

Program Outcomes (POs):

PO 1: Develop an understanding of microbial diversity and their application, demonstrate practical knowledge & skills using bio instruments in industrial domain.

PO 2: Describe the microbial nutrition & growth and explain various culture, sterilization techniques in microbiology.

PO 3: To demonstrate the basic knowledge of immunological processes at cellular and molecular level.

PO 4: Describe the design and application of fermenter and bioreactors, explain the media requirement for fermentation process.

PO 5: Explain the microbial physiology, regulation of gene expression and understand the basics of RDT, bioinformatics and their applications.

PO 6: Develop an understanding of various microbial diseases and their management; the pathogens and spoilage microbes with respect to food and dairy processing and the bioremediation approaches for treatment of contaminated water and soil.

PO 7: Emergence of new microbial pathogens, basic concepts of epidemiology of infectious disease, pathogenicity of microorganisms, antimicrobial chemotherapy, mechanism of antibiotic resistance. Concept of biopesticides and biofertilizers.

PO 8: Learning the basic concepts of waste management, applications for its processing, characterization and its management in various places.

PO 9: Finding innovative idea in research topic to contribute for mankind following the research ethics, develop experimental and practical knowledge in lab and field research work and carry out efficient research using various instruments.

PO 10: To develop mental flexibility, sequential compilation of data, preparation of concise and comprehensible presentation and public speaking.

Program Specific Outcomes (PSOs):

PSO-1 Develop deeper understanding of advanced techniques in biology such as ELISA, RDT, PCR, HPLC, SEM, TEM.

PSO-2 Have a brief idea about application of fermenter, bioreactors and bioinformatics.

PSO-3 Acquired practical learning from internship, field visit, industrial visit and research projects.

PSO-4 To develop innovative idea in research topic, mental flexibility, sequential compilation of data, preparation of concise and comprehensible presentation and public speaking.

HC-101: Introduction to Industrial Microbiology and Microbial Techniques

Course Outcome:

After reading this paper, students should have:

1. Deeper understanding of developments in Industrial Microbiology.
2. Knowledge regarding microbial diversity and ecology.
3. Hands on practice on culture techniques in Microbiology.
4. Deeper understanding of sterilization techniques and their effectiveness.
5. A brief knowledge on microbial nutrition and growth.

SEMESTER I

HC-101	Introduction to Industrial Microbiology and Microbial Techniques	5CH	100 MARKS

Unit 1 Discovery of microorganisms and development of Industrial microbiology, Origin and evolution of microorganisms.Scope and relevance of Microbiology- Future of microbiology.Microorganisms in Marine and Freshwater Environments, Microorganisms in Terrestrial Environments.

Unit 2 Introduction to microbiology diversity and ecology: Extremophiles: Thermophiles, Psychrophiles, Acidophiles, Alkalophiles and Barophiles. Biogeochemical cycling- Carbon cycle, Nitrogen cycle, Iron cycle, Sulphur cycle.

Unit 3 Microbial World; Types of Microorganisms, cellular and acellular microorganisms, General characters of archae bacteria, eubacteria, mycoplasma, fungi, viruses and micro algae

Unit 4 Culture Technique: Culture media- synthetic, defined and complex media. Methods for studying microorganisms: Isolation of pure culture, streak plate, pour plate, spread plate. Methods of sterilization – Heat, Low temperature, Filtration, Radiation, Use of chemicals as sterilizing agents. Effectiveness of sterilizing agents,

Unit 5 Microbial nutrition: Nutritional requirements, Nutritional types among microorganisms, Microbial growth, phases of growth, conditions of growth, mathematics of growth., Factors affecting microbial growth.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	2	2	4	2	4	2	2	4	4
CO2	5	4	5	5	5	2	5	4	5	2
CO3	5	4	5	4	5	2	4	4	4	4
CO4	5	2	4	4	4	4	2	5	2	2
CO5	5	4	4	2	4	4	4	2	2	2

HC-102: Immunology and Microbial Transformation
Course Outcome:

After reading this paper, students should have:

1. Basic knowledge of immunological processes at a cellular and molecular level.
2. In-depth knowledge on cell types and organs present in the immune response.
3. Idea on various mechanisms that regulate immune responses and their mechanisms
4. Brief knowledge regarding microbial transformation of steroids.
5. The ability to work on various techniques involved in diagnosis of immune disorders.

HC- 102	Immunology and Microbial Transformation	5CH	100rks

1. Unit 1 Cells and organs involved in immune system and immune response. Concept of haptens and antigens. Concept of innate and adaptive immunity,T- cell and B-cell biology. Cell mediated and Humoral immune response (Primary and secondary immune response).

2. Unit 2 Concept of Antigen, Haptens, adjuvants. Immunoglobulins: Structure and properties of immunoglobulin classes, Production of Polyclonal antibodies, dose and route of antigen administration, collection of sera, purification of antibodies. Hy

3. bridoma technology - production and applications of monoclonal antibodies for diagnosis and pharmaceutical industries.

4. Unit 3 Hypersensitivity, Immunoassay procedures ELISA, SDS PAGE, Immunodetection, Western blotting, Immunodiffusion, Immunoelectrophoresis, chromatography etc. their uses in diagnostics.

5. Unit 4 Cancer, Immunodiagnostics and Immunosurvillance, Immunodisorders, B Cell, immuno disorder, T cell immunodisorder, SCID (Severe combined immunodisorder).

6. Unit 5 Steroids, Types of steroids, Function of steroid. Microbial transformation of steroids, its application.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	2	2	4	2	4	2	2	4	4
CO2	4	4	5	5	5	2	5	4	2	2
CO3	4	4	5	2	5	4	2	5	4	4
CO4	5	5	4	4	4	4	2	5	2	4
CO5	5	4	4	2	4	4	4	2	2	4

HC-103: Bioinstrumentation

Course Outcome:

After reading this paper, students should have:

1. Kowledge on working principles of basic instruments in laboratory..
2. Brief understand about the working principles of advanced instruments in Life Sciences.
3. Hands on working experience of different instruments.
4. Idea to perform the techniques involved in molecular biology and diagnosis of diseases.
5. An updated current knowledge regarding biomedical engineering involving new methods and the instrumentation.

HC- 103	Bioinstrumentation	5CH	100 MARKS

UNIT - I: Basic Instruments**:** Digital Balance, pH meter, pH calibration, Autoclave and its principle. Hot air oven, Laminar air flow and its function, HEPA filters, Membrane filters, Separation of biomass, Filtration and types of Filtrations and their applications.

UNIT-II-Instrumentation I: Microscopy- Principle of light transmission, Types of Microscope- Simple, Compound, Fluroscence, Electron (SEM, TEM), Centrifugation: principles of centrifugation, types and applications, differential and density gradient centrifugation.

Unit III: Instrumentation II: Electrophoresis: Principles, Types- Agarose, polyacrylamide gel, 2-D Electrophoresis, Pulsed Field Gel Electrophoresis; working applications,
Chromatography: Principles, types and applications-gel filtration chromatography, paper chromatography, TLC, GLC, Ion exchange and affinity chromatography, HPLC.

Unit IV: Instrumentation III: Spectrophotometry: Principle, Beer-Lamberts Law, Components, Working mechanism and applications of UV-Vis spectrophotometer, Atomic Absorption spectrophotometer, Fourier Transform Infrared Spectroscopy

Unit V: Advanced Techniques in Biology: Polymerace Chain Reaction (PCR) and its variants. Application of PCR in biology, ELISA- Types and Applications, Radio Immuno Assay, Blotting techniques and their application, DNA sequencing. Geiger Muller Counter - Principles and uses. XRay diffraction

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	5	2	4	2	5	2	2	4	4
CO2	5	4	5	5	5	2	5	4	5	2
CO3	5	4	4	2	5	5	4	4	4	4
CO4	5	2	4	2	4	4	2	5	4	4
CO5	5	4	4	5	4	4	4	4	2	2

HC-104: PRACTICAL BASED ON PAPERS HC 101, HC 102, HC 103
Course Outcome:

After reading this paper, students should have:

1. Knowledge and practical skills for using instruments in biology.
2. The ability to perform and evaluate methods used to identify microbes and their activity.
3. In-depth knowledge on microbial physiology including metabolism, regulation and replication.
4. Assess and apply knowledge of microbiology in various field.
5. Hands on practice with the basic instruments of laboratory.

HC-104	PRACTICAL BASED ON PAPERS HC 101, HC 102, HC 103	6CH	100 Marks

1. Learning the equipments of a common microbiology laboratory.
2. Learning the techniques of sterilization(Autoclave, Laminar air flow).
3. Preparation of culture media (agar/ broth).
4. Isolation of pure culture by spread plate, streak plate and pour plate.
5. Study of colony morphology and counting.
6. Gram staining
7. Estimation of proteins.
8. Paper chromatography.
9. Precipitation method – Immunodiffusion
10. ELISA method
11. SDS PAGE Electrophoresis
12. Western Blotting
13. Affinity purification

14. To perform the experiments using following instruments
    a. pH Meter (to measure the pHof the supplied sample)
    b. Microscope (to identify the morphology of the supplied sample)
    c. Spectrophotometer (to determine the absorption maxima, measure the concentration of the supplied sample)
    d. Chromatography(to separate the supplied sample on the basis of mass, charges)
    e. Centrifuge (to separate biomass of the supplied sample)

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	5	2	4	2	4	2	2	4	4
CO2	5	4	4	5	5	5	5	4	2	2
CO3	5	5	4	4	5	4	4	2	4	4
CO4	5	4	5	5	4	4	2	5	2	4
CO5	5	2	4	2	4	4	4	2	2	2

HC-201: Fermentation Technology

Course Outcome:

After reading this paper, students should have:

1. An idea regarding the design of bioreactors and its types.
2. Basic knowledge about the structure of a fermenter and its types.
3. Deeper understanding related to media required for fermentation process.
4. knowledge on down stream processing.
5. Indepth knowledge of micrbial production of industrial chemicals.

SEMESTER-II

HC201	Fermentation Technology	5CH	100 Marks

Unit 1 Introduction to Fermentation Technology, Bioreactor Design. Bioreactor types: CSTR, PFR, Air-lift fermentor, control systems, sterilization, Bioprocess principles; kinetics of biomass production, Batch and Continuous culture, Fed batch culture.

Unit 2 Design of a basic fermenter, bioreactor configuration, design features, individual parts, baffles, impellers, foam separators, sparger, culture vessel, cooling and heating devices, probes for online monitoring, computer control of fermentation process, measurement and control of process. Reactors for specialized applications.

Unit 3 Medium requirements for fermentation processes, Design and usage of commercial media for industrial fermentation, Oxygen transfer in submerged fermentation processes;

Heat transfer and Mass transfer processes in biological systems, Recovery and purification of products.

Unit 4 Downstream processing Separation of cells and other in solubles from fermented broth. Industrial Centrifuges and filtration systems, Cell disruption: Physical methods (osmotic shock, grinding with abrasives, solid shear, liquid shear), Chemical methods (alkali, detergents), Enzymatic methods; Extraction and adsorption method, Crystallization and drying.

Unit 5 Microbial production of Industrial Chemicals (Lactic acid, Acetone, Aldehyde etc) foods and beverages (Soya Sauce, Vinegar, Beer, Alcohol), Therapeutic antibiotics (Penicillin, streptomycin etc).

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	2	2	4	5	4	5	2	4	5
CO2	5	2	5	5	5	4	5	5	5	2
CO3	4	4	4	4	2	5	4	4	4	4
CO4	4	5	4	5	4	4	4	5	4	4
CO5	5	4	4	2	2	4	4	2	2	2

HC-202: Microbial Physiology and Genetics

Course Outcome:

After reading this paper, students should have:

1. Explanatory knowledge on photosynthetic microorganisms and their physiology.
2. Deeper understanding on bacterial aerobic respiration.
3. An indea on molecular basis of spontaneous and induced mutations.
4. Deeper knowledge on organization of transcriptional units and regulation of gene expression.
5. In-depth knowledge on different factors on induction and stages of sporulation in bacteria.

HC202	Microbial Physiology and Genetics	5CH	100 Marks

Unit 1 Photosynthetic microorganisms, photosynthetic pigments, and generation of reducing power by cyclic and non-cyclic photophosphorylation, electron transport chain in photosynthetic bacteria. Carbon dioxide fixation pathways.

Unit 2 Bacterial aerobic respiration, components of electron transport chain, free energy changes and electron transport, oxidative phosphorylation and theories of ATP formation, inhibition of electron transport chain.

Unit 3 Sporulating bacteria, molecular architecture of spores, induction and stages of sporulation, Influence of different factors on sporulation. Cytological and macromolecular changes during sporulation. Heat resistance and sporulation.

Unit 4 Mutations : spontaneous and induced mutations, Effects of Mutations, Mutant Detection, Mutant Isolation, DNA Repair, Recombination, Bacterial transformation, conjugation, transfection.

Unit 5 Regulation of gene expression: levels of regulation of gene expression, regulation of transcription initiation: Lac and Trp Operon, Regulation of transcriptional elongation: attenuation, riboswitches, Regulation of Translation

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	5	4	4	4	2	4	4	4
CO2	4	4	5	5	5	2	5	4	5	2
CO3	4	4	5	4	2	4	4	4	4	4
CO4	4	2	4	4	4	2	4	5	4	4
CO5	4	4	4	5	4	4	4	2	2	2

HC-203: Food Microbiology

Course Outcome:

After reading this paper, students should have:

1. Understanding on the principles involving food preservation via fermentation processes, the role and significance of microbial inactivation, adaptation and environmental factors (i.e., Aw, pH, temperature) on growth.
2. Examined the response of microorganisms in various environments, and conditions, including sanitation practices.
3. Developed knowledge regarding important pathogens and spoilage microorganisms are commonly inactivated, killed or made harmless in foods
4. Observed the impact of intrinsic and extrinsic factors affecting the growth of microbes in foods.
5. Knowledge on application of microbial enzymes in food and dairy industry

HC-203	Food Microbiology	5CH	100 MARKS

Unit 1 Introduction to food microbiology, intrinsic and extrinsic factors and their relationship to microbial growth; the principles of food fermentation and the role of beneficial microbes; Application of Starter cultures in food fermentation, Food sterilization

Unit 2 The role of microorganisms and food spoilage; pathogenic microorganisms, infection and intoxication, mycotoxin, the principles to control microbial growth; as well as qualitative and quantitative microbiological analysis, Foodborne infections and intoxications; Quality assurance: Microbiological quality standards of food.

Unit 3 Radiations–Food preservation techniques, Pasteurization and types, UV, Gamma and microwave, Temperature, Chemical and naturally occurring antimicrobials, Biosensors in food industry. Government regulatory practices and policies.

UNIT 4 Economic importance of fermented food products**,** Microbiology of fermented milk products, Role of microorganisms in beverages production, Fermented Meat – Sausages, Microbial examination of contamination detection.

Unit 5 Application of microbial enzymes in food industry, Genetically modified foods, Applications of microbial enzymes in dairy industry [Protease, Lipases]. Utilization and disposal of dairy by-product – whey

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	5	4	2	4	2	2	4	4
CO2	4	4	5	5	4	2	5	4	5	2
CO3	4	4	5	4	5	2	4	2	4	4
CO4	4	2	4	4	4	4	2	5	2	4
CO5	4	4	4	5	4	4	4	2	2	2

HC-204: PRACTICAL BASED ON PAPER -201, 202, 203 & CE-201 A/B
Course Outcome:

After reading this paper, students should have:

1. Performed experiments related to isolation of industrially important bacteria.
2. Practised the methods involved in antimicrobial assay.
3. Performed bioinformatics related practicals like BLAST search.
4. Measured TDS and TSS of samples.
5. Performed experiments related to bioinformatics.

HC-204	PRACTICAL BASED ON PAPER -201, 202, 203 & CE-201 A/B	6CH	100 MARKS

1. Isolation of bacteria from waste water treatment plants.
2. Isolation of heavy metal reducing bacteria.
3. Isolation of lactic acid producing bacteria.
4. Isolation of antibiotic resistant bacteria.
5. Separation and purification of biomass from spent medium.
6. Calculation of dry biomass of microbial samples.
7. Production and measurement of bio generated acid.
8. Study of antimicrobial assay through zone inhibition method.
9. Measuring total dissolved solids (TDS) and total suspended solids (TSS) of supplied samples.
10. Determination of indices of pollution by measuring BOD/COD of different effluents.
11. Isolation of hexavalent chromium (+ 6) resistant microbial strain
12. Searching gene bank accession number in PubMed database
13. NCBI data bases, BLAST BLASTn, BLASTp, search
14. Construction of Phylogenetic tree in NCBI database

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	4	4	2	2	4	4
CO2	4	4	5	5	5	2	4	4	4	2
CO3	2	4	5	4	5	2	4	4	4	4
CO4	4	2	4	4	4	4	2	5	2	2
CO5	4	4	4	5	4	4	4	2	2	2

CE-201 A: Recombinant DNA Technology & Bioinformatics

Course Outcome:

After reading this paper, students should have:

1. Understanding regarding the basics of recombinant DNA technology.
2. In-depth knowledge regarding cloning vectors and methods of clone identification and selection.
3. An idea about the techniques of gene expression analysis.
4. Understanding related to biological database and modes of database search.
5. Elucidated various techniques involved in genome sequencing.

CE-201 A	Recombinant DNA Technology & Bioinformatics	5CH	100RKS

Unit 1 Basics of recombinant DNA technology: modifying enzymes: Restriction enzymes: types, mode of action and nomenclature, DNA Polymerase, DNA ligase: Types, Properties and specificity, Nucleic acid End modifying Enzymes, Nucleases

Unit 2 Cloning vectors: Definition and properties of cloning vectors- plasmid (phage, PACs, BACs, YACs) Expression Vectors, Process of gene cloning, Introducing DNA into cell-transformation, transfection, Methods of clone identification and selection.

Unit 2 PCR – Principle and procedure, Enzymes used in PCR, Types of PCR- Real-Time PCR , Reverse-Transcriptase (RT-PCR), Multiplex PCR, Nested PCR. DNA sequencing methods, Maxim-Gilbert, Sanger dideoxy, Genetic Mapping, Physical Mapping, Whole genome Shotgun sequencing, Sequence Assembly

Unit 4 Gene expression analysis techniques- northern blotting, Use of reporter genes. DNA microarrays, Promoter analysis, Mapping transcriptional start sites.
Techniques to study Protein DNA interaction :DNA footprinting, Gel Retardation Assay, Yeast-1-hybrid. ChIP. Techniques to study Protein-Protein Interaction: PYeast-2-hybrid, Yeast-3-Hybrid, Co-Immunoprecipitation, Pull-downs, Split YFP, FRET.

Unit 5 Biological database, modes of database search, GenBANK, EMBL, DDBJ, PDB. Concept of local and global sequence alignment, multiple sequence alignment. BLAST, FASTA and GCC. Search and retrieval of biological information and database sequences. Basic concept of phylogenetic analysis, Phylogenetic tree construction methods (UPGMA, Neighbour-joining, Maximum parsimony, maximum likelihood).

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	5	4	4	4	2	2	4	4
CO2	5	4	5	5	5	2	4	4	4	2
CO3	5	4	5	4	5	2	4	4	4	4
CO4	4	2	4	4	4	4	2	4	2	4
CO5	5	4	4	2	4	4	4	2	2	2

CE-201 B: Bioremediation

Course Outcome:

After reading this paper, students should have:

1. Understanding of the environmental contaminants, and their microbial degradation techniques.
2. Understanding regarding bioremediation approaches for treatment of contaminated soils and water.
3. Knowledge about the basic principles of chemical and biological degradation of toxic chemicals and familiarize students with the application of bio remedial technologies in natural environments.
4. Understanding related to occurrence and ecological significance of toxic organic chemicals.

5. In-depth knowledge associated to chemistry of contaminants, kinetics and mechanisms of degradation (chemical and biological).

CE-201 B	Bioremediation	5CH	100 MARKS

Unit 1 Introduction of Bioremediation; History of bioremediation, Advantages and applications; Bioremediation processes, Types of bioremediation, Current bioremediation practices, benefits of bioremediation

Unit 2 The soil environment; Sources, Fate and transport of contaminants in soils and water bodies, Environments where bioremediation is used. Chemical transformations, Screening and selecting remediation alternatives

Unit 3 Bioremediation using naturally occurring microorganism, Removal of spilled oil and grease deposits, Use of oleophilic fertilizers, Use of a mixture of bacterial strains, Use of genetically engineered microbes).

Unit 3 Reducing environment Impact of agricultural practices (Weed control and herbicides, Pest control and bio pesticides,

Unit 4 Use of microbes for Heavy metal detoxification. Biodegradation Aerobic vs. anaerobic Degradation; Microbial basis of Biodegradation.

Unit 5 Biodegradation of common contaminants, In situ bioremediation strategies Strategies of microbial degradation and bioremediation, Biotransformation of chemicals Environmental effects on microbial degradation

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	5	4	2	2	4	4
CO2	4	4	5	5	5	4	5	4	4	2
CO3	2	4	5	4	5	5	4	4	4	4
CO4	4	2	4	4	4	4	2	2	2	2
CO5	2	4	4	5	4	4	4	2	2	2

OE-201 A: HUMAN HEALTH AND HYGIENE

Course Outcome:

After reading this paper, students should have:

1. In-depth knowledge about the major life style diseases affecting each organ system.
2. Brief idea about the common infectious communicable diseases and their specific symptoms.
3. An idea about the implications of climate change and management of communicable diseases.
4. The understanding of management of communicable diseases.
5. A deeper knowledge about the causes, treatment and prevention of cardiovascular disorders.

OE-201A	HUMAN HEALTH AND HYGIENE	4CH	50 MARKS

Unit-I: Human health, disease and lifestyle disorders**:** WHO definition of health, disease, disorder and classification of diseases based on source of pathogens, terminologies used in infectious disease (etiology, epidemiology, vector, incubation period, infective period, causative agent, carrier, notifiable disease, epidemic, endemic, pandemic, signs, symptoms, prevention/prophylaxis, treatment).Vaccination: Definition of vaccine, types of vaccines, vaccination programmes in India

Unit-II: Cardiovascular disorders: blood pressure and heart attack (causes, treatment and prevention). Myocardial infarction (cause, treatment and prevention)**,** Cancer: Definition, Types, causes of cancer, prevention and control, Diabetes mellitus: Types (Type I and Type II); Type II diabetes- causes, clinical symptoms, treatment, control and prevention. Obesity: Definition, cause, prevalence, effect and preventive measures.

Unit-III: Communicable Diseases: Water borne diseases: Typhoid (causative agents, transmission, signs and symptoms, treatment and prevention). Air borne disease: Influenza, H1N1 (causative agents, transmission, signs and symptoms, treatment and prevention). Vector borne disease: Malaria (causative agents, transmission, signs and symptoms, treatment and prevention, eradication). Food-borne disease: Botulism (cause, epidemiology, clinical symptoms, treatment, control and prevention). Animal-borne disease: Rabies (cause, epidemiology, clinical symptoms, treatment, control and prevention). STDs: AIDS (causative agents, transmission, signs and symptoms, treatment and prevention, eradication)**.**

Unit-IV: Implications of climate change and management of communicable diseases, Climate Change: Meaning, causes and impact on human health; Management of communicable diseases: Disinfectants, antiseptics and antibiotic; Definition, various types of antiseptics (hypochlorite, phenol, ethanol, isopropanol, aldehydes, detergents, chloroxylenol), antibiotics, types (biostatic, biocidal) and most commonly used antibiotic, antibiotic resistance

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	5	4	2	2	4	4
CO2	4	4	4	5	5	5	5	4	5	2
CO3	2	4	2	4	5	5	4	4	4	4
CO4	4	2	4	4	4	4	2	5	2	4
CO5	2	4	4	2	4	4	4	2	4	2

HC-301: Environmental Microbial Technology

Course Outcome:

After reading this paper, students should have:

1. The knowledge to demonstrate the basic knowledge of microbial ecosystems.
2. The ability to describe the methodological approaches for investigations in environmental microbiology.
3. An idea about waste water treatment.
4. In-depth knowledge regarding the effects of mining with microorganisms.
5. Developed knowledge on mechanism of antibiotic resistance in bacteria.

SEMESTER III

HC 301	**Environmental Microbial Technology**	**5CH**	**100 MARKS**

Unit 1 Microbial ecosystems: General concepts of ecosystem, trophic levels. Biogeochemistry and nutrient cycles. Environments and microenvironment. Surface and Biofilms. Microbial habitats: Terrestrial and Aquatic habitats, Extreme habitats.

Unit 2 Methodological approaches to investigations in environmental microbiology. Sampling, isolation, taxonomic and functional annotation and quantification; Microbial sampling, Culture based and culture independent tools Overview of methods for determining position and composition of microbial communities. Steps in identification of microorganism responsible for an ecological process.

Unit 3 Wastewater treatment. Aerobic and anaerobic oxidation. Wastewater microbiology. Importance of wastewater treatment. Activated sludge and activated sludge associated food web. Basics of Drinking water treatment, Pathogens of concern that lead to water borne microbial diseases. Analysis of pathogens in drinking water by indicator microorganisms.

Unit 4 Solid municipal waste management. Landfills. Process of Anaerobic decomposition-hydrolysis, fermentation, acidogenesis, methanogenesis. Microbial ecology of landfills. Antimicrobial resistance. Mechanisms of antibiotic resistance in bacteria. Acquisition of resistant genes by bacteria.

Unit 5 Mining with microorganisms: Acid mine drainage. Bioremediation- of Uranium-contaminated environments. Microbial degradation of xenobiotics like organic pollutant hydrocarbons, pesticides and plastics. Biosensors. Microbially influenced corrosion of metals.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**4**	**4**	**2**	**4**	**2**	**4**	**5**	**5**	**4**	**4**
CO2	**5**	**2**	**5**	**5**	**4**	**2**	**5**	**4**	**4**	**2**
CO3	**4**	**4**	**4**	**4**	**5**	**2**	**4**	**5**	**4**	**4**
CO4	**4**	**2**	**4**	**4**	**4**	**4**	**4**	**5**	**2**	**4**
CO5	**5**	**4**	**4**	**2**	**4**	**4**	**4**	**5**	**4**	**2**

HC-302: Microbial diseases and their control

Course Outcome:

After reading this paper, students should have:

1. Explanatory knowledge regarding the pathogenicity of microorganisms.

2. In-depth knowledge related to important developments of antimicrobial chemotherapy.

3. Basic concept on epidemiology of Infectious Disease.

4. Comparative idea about emerging and re-emerging pathogens.

5. Idea about the mechanism of emergence of new microbial pathogens.

HC 302	**Microbial diseases and their control**	**5 CH**	**100 MARKS**

Unit 1 Pathogenicity of Microorganisms**:** Host-Parasite Relationships, Pathogenesis of Viral Diseases: Entry, Contact, and Primary Replication, Viral Spread and Cell Tropism, Cell Injury and Clinical Illness, Host Immune Response, Recovery from Infection.

Unit 2 Pathogenesis of Bacterial Diseases**:** Maintaining a Reservoir of the Bacterial Pathogen, Transport of the Bacterial Pathogen to the Host, Attachment and Colonization by the Bacterial Pathogen, Invasion of the Bacterial Pathogen, Growth and Multiplication of the Bacterial Pathogen, Regulation of Bacterial Virulence Factors, Pathogenicity Islands, Toxigenicity, Microbial Mechanisms for Escaping Host Defenses,

Unit 3 Antimicrobial Chemotherapy**:** General Characteristics of Antimicrobial Drugs, Determining the Level of Antimicrobial Activity, Mechanisms of Action of Antimicrobial Agents, Factors Influencing the Effectiveness of Antimicrobial Drugs, Mechanisms of Drug Resistance, Antibacterial Drugs, Antifungal Drugs, Antiviral Drugs.

Unit 4 Emerging and re-emerging pathogens**:** Illustrate emerging and re-emerging pathogens using *V. cholera*, *M. tuberculosis*, *Helicobacter pylori*, SARS virus, AIDS, Dengue. Mechanisms of emergence of new pathogens: microbial change and adaptation.

Unit 5 Epidemiology of Infectious Disease: Recognition of an Infectious Disease in a Population, Recognition of an Epidemic, The Infectious Disease Cycle, Virulence and the Mode of Transmission, Control of Epidemics.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	2	4	5	5	4	4
CO2	2	4	5	5	5	2	5	4	5	2
CO3	4	4	4	4	5	2	4	4	4	4
CO4	4	2	4	4	4	4	4	5	2	2
CO5	4	4	4	2	4	4	4	5	2	2

HC-303: Practical related to paper Practical related to paper HC-301, HC- 302 and CE-301 A/B, CE-302 A/B

Course Outcome:

After reading this paper, students should have:

1. Idea about the isolation of microorganism from waste water samples.
2. Deeper knowledge regarding molecular biology experiments like ELISA and SDS PAGE.
3. Ability to solve the problems related to mean, median, mode, SD, SE, ANOVA and Correlation.
4. An idea about the isolation of nitrogen fixing, phosphate and sulphate solubilising bacteria from soil.
5. Deeper knowledge regarding lab scale production of bacterial, algal and fungal biofertilizer.

HC 303	**Practical related to paper Practical related to paper HC-301, HC- 302 and CE-301 A/B, CE-302 A/B**	**6CH**	**100 MARKS**

1. Isolation of microorganism from waste water samples.
2. Isolation of multi metal resistant bacteria from heavy metal polluted soil samples.
3. Isolation of bacteria from contaminated food samples.
4. Isolation of Nitrogen Fixing Bacteria from soil (Rhizobium, Azospirillum, Azotobacter)
5. Isolation and culture of Phosphate and sulphate Solubilizing bacteria
6. Isolation and culture of Cyanobacteria (Anabaena from Azolla; Nostoc from soil)
7. Laboratory scale production of Bacterial, algal, and fungal Biofertilizer.
8. Problems relate to mean, median, mode, SD, SE, ANOVA and Correlation.
9. Testing the difference between two samples by t-test.
10. Testing the difference between expected value and observed value by Chi-square test.
11. Testing the interaction of factors by F-test.
12. Determination of antibody concentration in the given sample using ELISA.
13. Determination of microbial proteins molecular weight in given sample using SDS PAGE.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	2	4	5	5	4	4
CO2	5	4	4	5	4	2	5	4	5	2
CO3	4	4	5	4	5	2	4	4	4	4
CO4	4	2	4	4	4	4	4	5	2	2
CO5	5	4	4	2	4	4	4	5	2	2

CE-301 A: Microbes, Bio fertilizer and Bioinsecticide

Course Outcome:

After reading this paper, students should have:

1. The ability to distinguish the types of biofertilizers and methods of application in field.
2. Idea regarding integrated management for best results using nitrogenous and phosphate biofertilizers.
3. The ability to demonstrate the low-cost media preparation.
4. The idea to impart training on eco-friendly agricultural inputs in biofertilizer production.
5. Understanding about microbes as bioinsecticides and their advantages over synthetic pesticides.

CE- 301 A	Microbes, Bio fertilizer and Bioinsecticide	5CH	100RKS

Unit-1: Introduction, Chemical fertilizers and its demerits, History and concept of Bio fertilizers, status scope and importance of Bio fertilizers, Classification of Bio fertilizers, Advantages of Biofertilizers and its environmental impacts.

Unit -2: Structure and characteristic features of bacterial Bio fertilizers: Nitrogen fixation, Nitrogen Biofertilizers (Azospirillum, Azotobacter, Bacillus, Pseudomonas, Rhizobium and Frankia; Cynobacterialbiofertilizers- Anabaena, Nostoc, Azolla), Phosphate solubilizing Microorganisms, fungal biofertilizers- Mycorrhizae.

Unit -3: Production technology: Strain selection, Strain Improvement, mass production of carrier based and liquid bio fertilizers (Bacterial and Fungal). FCO specifications and quality control of bio fertilizers,

Unit4: Biofertilizers -Storage, shelf life, quality control and marketing. Factors influencing the efficacy of bio fertilizers. Application technology for seeds, seedlings, tubers etc

Unit-5: General account of microbes used as bioinsecticides and their advantages over synthetic pesticides, Bacillus thuringiensis, production, Field applications.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	2	4	5	5	4	4
CO2	4	4	5	5	4	2	5	4	5	2
CO3	4	4	5	4	5	2	4	5	4	4
CO4	4	2	4	4	4	4	5	5	2	4
CO5	4	4	4	2	4	4	4	5	4	2

CE-301 B: Virology

Course Outcome:

After reading this paper, students should have:

1. Brief idea on general principles of virology.
2. The ability to distinguish and classify the types of Viruses.
3. Hands on practice on virus cultivation methods.
4. Deeper knowledge regarding the life cycle of Viruses.
5. Understanding on oncogenic viruses and their types.

CE- 301 B	Virology	5CH	100 MARKS

Unit 1 General Principles of virology, Introduction to Virology, Virus Structure and Classification, Virus Entry and Viral Pathogenesis

Unit 2 Classification of viruses, Physical and chemical Structures of different Viruses on the basis of capsid symmetry - enveloped (Herpes virus), helical (TMV) and icosahedral (Polyoma viruses), Capsids, complex (Bacteriophage, and Virion size, enveloped (Herpes), helical (TMV) and icosahedral (Polyoma), Capsids.

Unit 3: Virus cultivation methods, methods for purification of viruses, virus transmission; effects of viruses on host cells; virus genome structures, lytic and lysogenic pages (lambda phage) concept of early and late proteins, regulation of transcription in lambda phage

Unit 4: Life cycle: Herpesviruses, SARS, Papillomaviruses, Influenza (Flu) Viruses, Human Immunodeficiency Virus, Tobacco Mosaic Virus, Latent and persistence viral infection

Unit 5: Oncogenic viruses and its types, Antiviral compounds and their mode of action, Interferon and their mode of action. General principles of viral vaccination. Use of viral vectors in cloning and expression, Gene therapy and Phage display

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	2	4	2	4	5	4	4	4
CO2	4	4	2	2	5	2	5	4	5	2
CO3	4	4	2	4	5	2	4	4	4	4
CO4	2	2	4	4	4	4	5	5	2	2
CO5	4	4	4	2	4	4	4	4	2	2

CE-302 A: RESEARCH METHODOLOGY

Course Outcome:

After reading this paper, students should have:

1. The ability to choose methods appropriate to research aims and objectives.
2. Understanding about the limitations of the particular research methods.
3. Developed skills in qualitative and quantitative data analysis.

4. Developed advanced critical thinking skills.
5. Developed skill relate to the principal concepts of bio-statistics.

CE 302A	RESEARCH METHODOLOGY	5 CH	100 MARKS

Unit-I: Research fundamental, Research Meaning, Objectives, motivation of research. Types of research: Descriptive, Analytical, Applied, Fundamental, Quantitative, Qualitative, Conceptual, and Empirical research. Significance of research. Research methods versus Research methodology. Research and scientific method.

Unit-II: Research process: Steps of research process, criteria of good research. Research design: Meaning, need, features of good research design. Data collection: Primary and secondary data collection: Method of data collection, schedules and questionnaire.

Unit-III: Population, Sample, Steps in sampling design, Census versus sampling methods. Probability and non-probability sampling, Different types of sampling methods: Simple random sampling, stratified random sampling, Cluster sampling, Purposive sampling.
Measurement of scales, sources of error in measurement, test of sound measurement.

Unit-IV: Bio-statistics Introduction, application, uses and limitations. Diagrammatic presentation of data: Bar diagrams, Pie diagram**,** Frequency distribution, Measures of central tendency: mean, mode, median. Dispersion: Range, Standard deviation, Coefficient of variation.

Unit V-: Correlation: correlation coefficient, Properties of correlation coefficient. Regression: Regression coefficients, regression linesTest of hypothesis: test of significance, null hypothesis, alternative hypothesis, Type I and Type II errors, *t*-tests (For single mean and for two means), chi-square test (test of goodness of fit and test of independence).

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	2	4	2	4	5	4	4	4
CO2	4	4	4	5	4	2	5	4	4	2
CO3	4	4	5	4	2	2	4	4	4	4
CO4	5	2	4	4	4	4	4	5	2	2
CO5	2	4	4	2	4	4	4	5	2	2

CE-302 B: WASTE MANAGEMENT

Course Outcome:

After reading this paper, students should have:

1. Basic concept on the types of waste management, beginning from source generation to waste disposal in a system of municipality organizational structure.

2. Developed understanding on various technological applications for processing of waste and their disposals in various ways.

3. Acquired knowledge on waste to energy productions in the perspectives of sustainable development.

4. Basic concepts in hazardous waste management and integrated waste management for urban areas.

5. Acquired knowledge on waste characterization and its management practiced in various cities of India.

CE 302B	WASTE MANAGEMENT	5 CH	100 MARKS

Unit-I: Waste: Introduction, types of waste, solid, liquid, gaseous, degradable, non-degradable, biodegradable, hazardous and non-hazardous waste. Sources of waste, impact of waste on environment and human health

Unit-II: Solid waste: Definition, Classification, Origin/source and characterization, Disposal methods of solid waste, Landfill, Incineration, Composting and Vermiculture, Municipal Solid Waste Management

Unit-III: Liquid Waste: Introduction, source, composition, characteristics, collection and transport and safe disposal methods. Food waste: Meaning, composition, source, adverse impact on mankind, its' safe disposal and management.

Unit-IV: Definition of bio-medical waste Biomedical Waste and its Management: characterization, source, types, quantity, segregation, treatment and disposal. E-waste: composition, sources, E-waste generation at global and national level; Management of E-waste Recycling and disposal strategies. Radioactive waste disposal and management

Unit-V: Plastic waste generation, sources, adverse impact on environment, animals; man Management of plastic waste. Waste management: Principle of 3Rs of waste management Refuse, Recycle and Reuse

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	5	2	2	4	2	4	5	5	4	4
CO2	4	4	5	5	2	2	5	4	5	2
CO3	4	4	2	4	5	2	4	4	4	4
CO4	5	2	4	4	4	4	5	5	2	2

CO5	**2**	**4**	**4**	**2**	**4**	**4**	**4**	**5**	**2**	**2**

HC401	**SUBJECT OVERVIEW**	**5 CH**	**100 MARKS**

Course Outcome:

After reading this paper, students should have:

1. Developed the concept of review writing.
2. Understanding regarding development of proposal and research writing.
3. Achieved a new area of interest for research.
4. Innovative idea in research topic to contribute for mankind.
5. Followed the research ethics while carrying out research work.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**4**	**4**	**4**	**4**	**4**	**4**	**2**	**2**	**4**	**4**
CO2	**4**	**2**	**4**	**5**	**4**	**2**	**5**	**4**	**5**	**5**
CO3	**4**	**4**	**5**	**4**	**2**	**2**	**4**	**4**	**4**	**4**
CO4	**4**	**2**	**4**	**4**	**4**	**4**	**2**	**5**	**5**	**5**
CO5	**1**	**2**	**2**	**1**	**2**	**2**	**2**	**1**	**3**	**3**

HC402	**SEMINAR**	**5CH**	**100 MARKS**

Course Outcome:

After reading this paper, students should have:

1. Developed the concept of presentation in public
2. Prepared a good comparative data on the research field.
3. Prepared well explainable power point presentation.
4. Prepared concise and comprehensible presentation.
5. Presented their research findings.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	**4**	**2**	**2**	**4**	**2**	**4**	**2**	**2**	**4**	**4**
CO2	**5**	**4**	**5**	**5**	**5**	**2**	**5**	**4**	**5**	**5**
CO3	**4**	**4**	**5**	**4**	**5**	**2**	**4**	**4**	**4**	**4**
CO4	**4**	**2**	**4**	**4**	**4**	**4**	**2**	**4**	**4**	**5**
CO5	**2**	**4**	**4**	**2**	**4**	**4**	**4**	**2**	**5**	**5**

HC403	DISSERTATION	5 CH	100 MARKS

Course Outcome:

After reading this paper, students should have:

1. Developed experimental and practical knowledge in lab and field research work.
2. Carried out a coordinated research work.
3. Developed the concept of writing a proposal for research.
4. An idea about exposure to industrial domain.
5. Carried out efficient research using various instruments.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	2	2	2	4	2	4	2	2	4	4
CO2	4	4	4	5	4	2	5	4	5	5
CO3	5	4	2	4	5	2	4	4	4	4
CO4	4	2	4	4	4	4	2	5	5	5
CO5	2	4	4	2	4	4	4	2	4	4

CE401	Dissertation evaluation	5 CH	100 MARKS

Course Outcome:

After reading this paper, students should have:

1. Developed the concept of public speaking and presentation.
2. Presented their research findings.
3. Developed skill for Sequential compilation of obtained research data.
4. Analysed data using different biostatistical tools.
5. Developed mental flexibility at par with the ongoing research studies.

MAPPING OF COURSE OUTCOMES WITH THE PROGRAM OUTCOMES

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	4	2	2	4	2	4	2	2	4	4
CO2	2	4	5	5	5	2	5	4	5	5
CO3	4	4	2	4	2	2	4	4	4	5
CO4	2	2	4	4	4	4	2	4	4	5
CO5	5	4	4	2	4	4	4	2	4	5

- 3 Note related: 1
- From What Related: 2
- Nutral: 3
- Moderately Related: 4
- Highly Related: 5