Semester-I

BIOSTATISTICS			
CourseCode	MBT101	CIEMarks	50
TeachingHours/Week(L:P:SDA)	2:0:2	SEEMarks	50
TotalHoursofPedagogy	3	TotalMarks	100
Credits	3	ExamHours	3

CourseLearningobjectives:

- Equipstudentswithasolidfoundationin biostatistics,includingdataclassification,samplingmethods,and descriptive statistics, essential for analyzing biological data.
- Enablestudentstoapplyvariousstatisticaltechniquessuchascorrelation,regressionanalysis,and distribution models to real-world biological problems.
- Providestudentswiththeknowledgetodesign,conduct,andanalyzebiologicalexperiments,ensuringthe validity and reliability of experimental outcomes.
- Developstudents'skillsininferentialstatistics,includinghypothesistestinganderroranalysis,todraw meaningful conclusions from biological data.
- Introducestudentstotheapplicationofbiostatisticsingenomics,particularlyintheanalysisofmicroarray data, and equip them with the tools to process and interpret complex genetic data.

Module-1

INTRODUCTIONTOBIOSTATISTICS:

Introduction to Biostatistics, classification of variables, types of data, sorting of data, sampling methods, representation of data-tabular, diagrammatic (bar diagram, line diagram, pie chart), graphical (Histogram, frequency polygon, frequency curve), box plot and pictorial, Measure of dispersion- standard deviation, quartile deviation, mean deviation, variance and coefficient of variation, logarithmic mean and harmonic mean, kurtosis andskewness.Applicationofdescriptivestatistics,casestudies.

Module-2

BI-VARIATEANALYSIS

Statistical Correlation, types of correlation, methods of correlation, Karl Pearson correlation coefficient, Spearman Rank correlation Coefficient, regression analysis- linear and non-linear, curve fitting, linearization and its application in biological studies, Baye's theorem, binomial distribution, poisson distribution, normal distribution, Significance of statistics to biological problems, case studies.

Module-3

STUDYDESIGNANDANALYSISOFEXPERIMENTS:

Basics of study design, selectivity, specificity and sensitivity with problems, biases, limitations, multiple sources of variation, replication, randomisation and blocking, experimental studies- Randomized controlled studies, historically controlled studies, cross over, cohort studies, case-control studies, outcomes, odd ratio and relative risks, factorial design- main effect and interaction effect, cluster design, stratified design, randomization, single blindanddoubleblindexperiments,Randomizedcontrolledstudies-Randomblockdesign,Completely randomizeddesign,Ethicalconsiderations,casestudies

Module-4

INFERENTIALSTATISTICS:

Point estimation, interval estimation- single mean and two mean, sample size estimation, testing of hypothesis,Test statistics-z-test, t-test, F-test, chi-squared test, Wilcoxon Signed Rank Test, Wilcoxon-Mann-Whitney Test, ANOVA-One-way and Two-way, T-tests; application of inferential statistics in epidemiology, type 1 error and type IIerror,Casestudies.

Module-5

STATISTICSINMICROARRAY:

Microarraytoolforgeneexpressionanalysis,Typesofmicroarrays,fabricationofmicroarray,digitalimage processing of microarrays, microarray analysis and visualisation tools-box plots, gene pies, scatter plot, data pre- processing techniques, ANOVA for data analysis

AssessmentDetails(bothCIEandSEE)

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 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE.A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

ContinuousInternalEvaluation:

1. TwoUnitTestseachof**25Marks**
2. Twoassignmentseachof**25Marks**or**oneSkillDevelopmentActivityof50marks** toattaintheCOsandPOs

Thesumoftwotests,twoassignments/skillDevelopmentActivities,willbe**scaleddownto50marks**

CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyasperthe outcomedefinedforthecourse.

Semester-EndExamination:

1. TheSEEquestionpaperwillbesetfor100marksandthemarksscoredwillbeproportionatelyreducedto50.
2. Thequestionpaperwillhavetenfullquestionscarryingequalmarks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of foursub-questions)from each module.
4. Eachfullquestionwillhaveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswillhavetoanswerfivefullquestions,selectingonefullquestionfromeachmodule

SuggestedLearningResources:

Books

1. Biostatistics,AlvinE.Lewis,McGraw-HillProfessionalPublishing,2013
2. StatisticsandNumericalMethodsinBASICforBiologists,D.LeeandT.D.Lee,VanNostrandReinhold Company, 1982
3. NumericalMethods,WolfgangBoehmandHartmutPrautzsch,CRCPress,1993
4. Numerical Methods of Statistics, John F. Monahan,Cambridge UniversityPress, 2011 Numerical Methods for Engineers and Joe D. Hoffman CRC Press 2001
5. Statistical Methods in Bioinformatics: An Introduction Warren, J. Ewensregory Grant, Springer Science &Business Media, 2005.

WeblinksandVideoLectures(e-Resources):

1. https://archive.nptel.ac.in/courses/102/106/102106051/
2. https://archive.nptel.ac.in/courses/111/102/111102112/ https://archive.nptel.ac.in/courses/103/106/103106120/
3. https://www.youtube.com/watch?v=KhjM8YI3agk
4. https://nptel.ac.in/courses/102106065.

SkillDevelopmentActivitiesSuggested

1. NGSandMicroarraydataAnalysis
2. Proteomicdatanetworkanalysis.
3. AVpresentationbystudents(onspecifictopics).
4. Discussionofcasestudiesbasedonresearchfindings

Courseoutcome(CourseSkillSet)

Attheendofthecoursethestudentwillbeableto:

Sl. No.	Description	BloomsLevel
CO1	Students will be able to identify and classify different types of variables and data, and recall the methods of data representation and measures of dispersion.	L1
CO2	Studentswillunderstandtheconceptsofcorrelation,regression,andvarious distribution models, and explain their significance in biological data analysis.	L2
CO3	Students will apply knowledge of study design principles and statistical methods to conduct and analyze biological experiments effectively.	L3
CO4	Students will analyze data using inferential statistical techniques, including hypothesis testing and error analysis, to interpret biological data accurately.	L4
CO5	Studentswillevaluatemicroarraydatathroughadvancedstatisticalmethods, assessing the significance and reliability of gene expression analyses.	L5

ProgramOutcomeofthiscourse

Sl. No.	Description	POs
1	**Engineeringknowledge:**Applytheknowledgeofmathematics,science,engineering fundamentals,andanengineeringspecializationtothesolutionofcomplexengineering problems.	PO1
2	**Problemanalysis:**Identify,formulate,reviewresearchliterature,andanalysecomplex engineeringproblemsreachingsubstantiatedconclusionsusingfirstprinciplesof mathematics,naturalsciences,andengineeringsciences.	PO2
3	**Design/developmentofsolutions**:Designsolutionsforcomplexengineeringproblems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, andenvironmental considerations	PO3
4	**Conductinvestigationsofcomplexproblems**:Useresearch-basedknowledgeand research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to providevalid conclusions.	PO4
5	**Moderntoolusage**:Create,select,andapplyappropriatetechniques,resources,andmodernengineering and ITtools includingpredictionandmodelingtocomplexengineering activitieswithanunderstandingofthelimitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engagein independent and life-long learning in the broadest context of technological change.	PO12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		2										
CO3			3	2								
CO4				3	2							
CO5					3							2

Semester-I

BIOPROCESSTECHNOLOGY			
CourseCode	**MBT102**	CIEMarks	50
TeachingHours/Week(L:P:SDA)	3:2:0	SEEMarks	50
TotalHoursofPedagogy	40hoursTheory+10-12Labslots	TotalMarks	100
Credits	4	ExamHours	3

Courseobjectives:

- Developanunderstandingofmediadesignprinciplesandoptimizationtechniques,focusingonindustrial and commercial applications using statistical tools like Plackett Burman design and Response Surface Methodology.
- Gain knowledge of sterilization methods for fermentation processes, including the kinetics of thermal death,designofthermalsterilizationprocesses,andalternativesterilizationtechniquessuchasradiation and chemical methods.
- Explorethekineticsofmicrobialgrowthandproductformationusingunstructuredmodels,understanding the relationship between cell growth, product formation, and associated kinetic models.
- Learntheprinciplesofmasstransfer,includingmoleculardiffusion,Fick'slaw,andtheapplicationofthese principles in the design and operation of stirred tank reactors.
- Understandtheprinciplesofreactordesignforhomogeneoussystems,includingbatch,continuous,and fed-batch reactors, and develop skills.

Module-1

MEDIADESIGNANDOPTIMISATIONUSINGSTATISTICALTOOLS

Designofmediaforcommercialandindustrialapplications.PlackettBurmandesign,Responsesurface methodology – Central composite design.

Module-2

STERILIZATIONFORFERMENTATIONPROCESSES

Kinetics of thermal death of cells & spores, Design of batch and Continuous thermal sterilization, Coupling of Arrhenius equation and cell death kinetics, Sterilization of air and filter design, Radiation and chemicalsterilization.

Module-3

KINETICSOFMICROBIALGROWTHANDPRODUCTFORMATION(UNSTRUCTUREDMODEL)

Kinetics of cell growth and product formation; Simple unstructured kinetic models for microbial growth; Growthassociated and non-growth associated product formation kinetics; Monod and Leudeking-Piret models.

Module-4

MASSTRANSFER

Principlesofmoleculardiffusion,Fick'slawofdiffusion,diffusionofgasesandliquids,theoriesofmasstransfer, conceptofmasstransfercoefficients.Masstransferandpowerrequirementinstirredtankreactors.

Module-5

REACTORS,SCALE–UPOF REACTORS

Design for homogeneous systems, Batch, Continuous and Fed-batch systems. Reactors in series-Non-Ideality inreactors. Scale up criteria -procedure and scale-down.

PRACTICALCOMPONENTOFIPCC

Sl.NO	Experiments
1	Classicalmethodofmediaoptimization.
2	Statisticalmethodofmediaoptimization(PlackettBurman).
3	Statisticalmethodofmediaoptimization(ResponseSurfaceMethodology).
4	Thermaldeathkineticsofmicroorganisms.
5	GrowthkineticsinBatchculture.
6	ProductkineticsinBatchculture.
7	Estimationofmasstransfercoefficientusingdynamicdegassingmethods.

8	Flowreactors–Air-lift,
9	Flowreactors–Packed–bed
10	Flowreactors–Fluidizedbedreactors
11	CitricacidproductionusingTabletopfermenter
12	Vineproductionusinggrapes

AssessmentDetails(bothCIEandSEE)

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 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE.A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together

CIEforthetheorycomponentofIPCC

1. TwoTestseachof**25Marks**
2. Twoassignmentseachof**25Marks/OneSkillDevelopmentActivityof50marks**
3. TotalMarksoftwotestsandtwoassignments/oneSkillDevelopmentActivityaddedwillbeCIEfor 60 marks, marks scored will be proportionally scaled down to **30 marks**.

CIEforthepracticalcomponentofIPCC

- On completion of every experiment/program in the laboratory, the students shall be evaluated and marks shall be awarded on the same day.The **15 marks** are for conducting the experiment and preparation of the laboratory record, the other **05 marks shall be for the test** conducted at the end of the semester.
- 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 at the end /after completion of all the experiments shall be conducted for **50 marks** and scaled down to **05 marks.**

Scaled-downmarksofwrite-upevaluationsandtestsaddedwillbeCIEmarksforthelaboratory component of IPCC for **20 marks**.

SEEforIPCC

TheorySEEwillbeconductedbytheUniversityasperthescheduledtimetable,withcommonquestion papers for the course (duration 03 hours)

1. Thequestionpaperwillbesetfor100marksandmarksscoredwillbescaleddownproportionately to 50 marks.
2. Thequestionpaperwillhavetenquestions.Eachquestionissetfor20marks.
3. Therewillbe2questionsfromeachmodule.Eachofthetwoquestionsunderamodule(witha maximum of 3 sub-questions), **should have a mix of topics** under that module.
4. Thestudentshavetoanswer5fullquestions,selectingonefullquestionfromeachmodule.

ThetheoryportionoftheIPCCshallbeforbothCIEandSEE,whereasthepracticalportionwill haveaCIEcomponentonly.QuestionsmentionedintheSEEpapershallincludequestions from

thepracticalcomponent).

- The minimum marks to be secured in CIE to appear for SEE shall be the 15 (50% of maximum marks-30) in the theory component and 10 (50% of maximum marks -20) in the practical component. The laboratory component of the IPCC shall be for CIE only. However, in SEE, the questions from the laboratorycomponent shall be included**.** The maximum of04/05 questions to be set from the practical component of IPCC, the total marks of all questions should not be more than the 20 marks.
- SEE will be conducted for 100 marks and students shall secure 40% of the maximum marks to qualify in the SEE. Marks secured will be scaled down to 50.(Student has to secure an aggregate of50%ofmaximummarksofthecourse(CIE+SEE)

SuggestedLearningResources:

Books

1. Michael L. Shuler, Fikret Kargi, Matthew DeLisa 2017. Bioprocess Engineering, 3rd Edition, Prentice Hall International Series.
2. PeterStanbury,PrinciplesofFermentationtechnology2015,thirdedition,Butterworth-Heinemann
3. Shigeo Katoh and Fumitake Yoshida, 2010, Biochemical Engineering - A Textbook for Engineers, Chemists and Biologists, WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.

WeblinksandVideoLectures(e-Resources):

1. https://www.youtube.com/watch?v=DF4ba5AHDiY
2. https://www.youtube.com/watch?v=rJYEmRhgPxo
3. https://www.youtube.com/watch?v=f95B06bRfec
4. http://digimat.in/nptel/courses/video/102105064/L01.html
5. http://acl.digimat.in/nptel/courses/video/102105058/L20.html

ActivityBasedLearning(SuggestedActivitiesinClass)/PracticalBasedlearning Skill Development Activities Suggested

1. NGSandMicroarraydataAnalysis
2. Proteomicdatanetworkanalysis.
3. AVpresentationbystudents(onspecifictopics).
4. Discussionofcasestudiesbasedonresearchfindings

Courseoutcome(CourseSkillSet)

Attheendofthecoursethestudentwillbeableto:

Sl. No.	Description	BloomsLevel
CO1	Recall the fundamental principles of media design and optimization techniques used in industrial applications.	BTL1
CO2	Explainthekineticsofthermaldeathofcellsandspores,anddescribethedesign principles for thermal sterilization processes in fermentation.	BTL2
CO3	Applyunstructuredkineticmodelstoanalyzemicrobialgrowthandproduct formation in different fermentation processes..	BTL3
CO4	Analyze the principles of mass transfer and determine the mass transfer coefficients in stirred tank reactors.	BTL4
CO5	Evaluate the design and scale-up criteria for reactors, considering factors like non-ideality and scale-down procedure	BTL5

ProgramOutcomeofthiscourse

Sl. No.	Description	POs
1	**Engineeringknowledge:** Apply the knowledge of mathematics, science, engineeringfundamentals,andanengineeringspecializationtothesolutionof complex engineeringproblems.	PO1
2	**Problemanalysis:**Identify,formulate,reviewresearchliterature,andanalyse complexengineeringproblemsreachingsubstantiatedconclusionsusingfirst principlesofmathematics,naturalsciences,andengineeringsciences.	PO2
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs withappropriateconsiderationforthepublichealthandsafety,andthecultural, societal,andenvironmentalconsiderations	PO3
4	**Conductinvestigationsofcomplexproblems**: Useresearch-based knowledgeand researchmethodsincludingdesignofexperiments,analysisandinterpretationof data, and synthesis of the information to providevalid conclusions.	PO4
5	**Moderntoolusage**:Create,select,andapplyappropriatetechniques,resources,and modernengineeringandITtoolsincludingpredictionandmodelingtocomplex engineeringactivitieswithanunderstandingofthelimitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engageinindependentandlife-longlearninginthebroadestcontextof technological change	PO12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		2	2									
CO3				3	3							
CO4			3	3								
CO5					3							2

Semester-I

ADVANCED BIOCHEMISTRY			
CourseCode	MBT103	CIEMarks	50
TeachingHours/Week(L:P:SDA)	3:0:0	SEEMarks	50
TotalHoursofPedagogy	3	TotalMarks	100
Credits	3	ExamHours	3

CourseLearningobjectives:

- Developafoundationalunderstandingofbiochemistry,includingtheprinciplesofsolutions,pH,buffers, and the characteristics of biomolecules relevant to bioprocesses.
- Gainin-depthknowledgeofcarbohydratestructures,metabolism,andtheirregulatorymechanisms, including the role of redox reactions and energy metabolism.
- Studythestructuralorganizationofproteins,theirstructure-activityrelationships,andthemechanismsof enzyme action.
- Understandthestructure,properties,andfunctionsofmembranelipidsandproteins,aswellasthe processes of lipid metabolism and membrane transport.
- Learnaboutthetypesofcellularsignaling,receptortypes,andthemechanismsoftransportandsignal transduction within cells.

Module-1

INTRODUCTIONNTOBASICBIOCHEMISTRYCONCEPTS.

Basic concepts of solutionsEffect of solvent and additive Mechanism of solvation Normality, Molartity, Molality Percentage Ph and Buffers for biochemical reagents, buffering capacity, and numerical problems on buffer preparation,pHandtheHenderson-Hasselbalchequation.CharacteristicsofBiomoleculesrelevanttoBioprocesses Carbohydrate,ProteinsandLipids.

Module-2

CARBOHYDRATES

stereoisomerism, sugar derivatives, disaccharides, homo and heteropolysaccharides, glycosaminoglycan (GAGs), proteoglycans, bacterial cell wall polysaccharides, glycoproteins, lectins and medical applications of oligosaccharides.Basic Carbohydrate metabolism and regulation. Redox reactions, redox potential and Nernst equation.Thermodynamics.Highenergycompounds.RoleofATPinenergymetabolism.Substratelevel phosphorylation,Oxidativephosphorylationandphotophosphorylation

Module-3

PROTEINS

Structural organisation of Proteins. Structure activity relationship of proteins- haemoglobin, myoglobin, collagen, keratin,Insulin,Enzymecoenzymesandcofactors.Mechanismofenzymeaction,withreferencetoserineproteases.

Module-4

LIPIDSANDMEMBRANES

Membranelipids&proteins;structure&propertiesofmembranelipids;fluidmosaicmodel;function(carriers, receptors,enzymes,anchors,cell-cellrecognition);osmosis&diffusion,tonicity;TAGcatabolism,anabolism (animalmetabolism)

Module-5

SignallingandTransport

Signalingtypes,receptortypes(intravssurface);transport:bulk(endocytosis,exocytosis),selective(facilitated, active); ion channels, transporters; signal transduction cascades: GPCRs, cytokine, TK; apoptosis.

AssessmentDetails(bothCIEandSEE)

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 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE.A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

ContinuousInternalEvaluation:

1. TwoUnitTestseachof**25 Marks**
2. Twoassignmentseachof**25Marks**or**oneSkillDevelopmentActivityof50marks** toattaintheCOsandPOs

Thesumoftwotests,twoassignments/skillDevelopmentActivities,willbe **scaleddownto50marks CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyasperthe outcomedefinedforthecourse.**

Semester-EndExamination:

1. TheSEEquestionpaperwillbesetfor100marksandthemarksscoredwillbeproportionatelyreducedto50.
2. Thequestionpaperwillhavetenfullquestionscarryingequalmarks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions)from each module.
4. Eachfullquestionwillhaveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswillhavetoanswerfivefullquestions,selectingonefullquestionfromeachmodule

SuggestedLearningResources:

Books

1. DavidLNelson,MichaelMCox,AlbertLLehninger(2013)LehningerPrinciplesofBiochemistry-6th edition, New York : W.H. Freeman.
2. JeremyMBerg,JohnLTymoczko,GregoryJGatto,LubertStryer(2015)Biochemistry-8thEdition, Palgrave MacMillan.
3. DonaldVoet,JudithGVoet(2010)Biochemistry-4thEdition,WileyIndiaPvtLtd.

WeblinksandVideoLectures(e-Resources):

1. https://www.digimat.in/nptel/courses/video/102106087/L01.html
2. https://www.youtube.com/watch?v=82yp3h2IzlQ
3. https://www.digimat.in/nptel/courses/video/102105034/L21.html
4. http://acl.digimat.in/nptel/courses/video/102106087/L12.html
5. https://www.digimat.in/nptel/courses/video/104105102/L29.html

SkillDevelopmentActivitiesSuggested

1. NGSandMicroarraydataAnalysis
2. Proteomicdatanetworkanalysis.
3. AVpresentationbystudents(onspecifictopics).
4. Discussionofcasestudiesbasedonresearchfindings

Courseoutcome(CourseSkillSet)

Attheendofthecoursethestudentwillbeableto:

Sl. No.	Description	BloomsLevel
CO1	Recallthebasicconceptsofsolutions,pH,buffers,andthecharacteristicsof carbohydrates, proteins, and lipids.	L1
CO2	Explainthestereoisomerismofcarbohydrates,sugarderivatives,andthebasic mechanisms of carbohydrate metabolism and energy regulation.	L2
CO3	Apply knowledge of protein structure to analyze structure-activity relationships and enzyme mechanisms in biochemical processes.	L3
CO4	Analyzethestructureandfunctionofmembranelipidsandproteins,andevaluate their roles in osmosis, diffusion, and cell signaling.	L4
CO5	Evaluatethemechanismsofcellularsignalingandtransport,includingsignal transduction cascades and their implications in cellular function and apoptosis.	L5

ProgramOutcomeofthiscourse

Sl. No.	Description	POs
1	**Engineeringknowledge:**Applytheknowledgeofmathematics,science,engineering fundamentals,andanengineeringspecializationtothesolutionofcomplexengineering problems.	PO1
2	**Problemanalysis:**Identify,formulate,reviewresearchliterature,andanalysecomplex engineeringproblemsreachingsubstantiatedconclusionsusingfirstprinciplesof mathematics,naturalsciences,andengineeringsciences.	PO2
3	**Design/developmentofsolutions**:Designsolutionsforcomplexengineeringproblemsand design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, andenvironmental considerations	PO3
4	**Conductinvestigationsofcomplexproblems**:Useresearch-basedknowledgeand research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to providevalid conclusions.	PO4
5	**Moderntoolusage**:Create,select,andapplyappropriatetechniques,resources,andmodern engineering and ITtools includingpredictionandmodelingtocomplexengineering activitieswithanunderstandingofthelimitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engagein independent and life-long learning in the broadest context of technological change.	PO12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		2										
CO3			2	3								
CO4				3	2							
CO5					3							2

Semester-I

APPLIED MICROBIOLOGY			
CourseCode	MBT104	CIEMarks	50
TeachingHours/Week(L:P:SDA)	3:0:0	SEEMarks	50
TotalHoursofPedagogy	3	TotalMarks	100
Credits	3	ExamHours	3

CourseLearningobjectives:

- Understandtheprinciplesandmethodsofmicrobialclassificationandthestructureofvarious microorganisms.
- Analyzethefactorsinfluencingmicrobialgrowthandthemethodsusedtocontrolmicrobialpopulations.
- Comprehendthevariousmicrobialinteractionsandtheirrolesinecosystemsandhumanhealth.
- Applyknowledgeofindustrialmicrobiologytobioprocessesandenvironmentalapplications.
- Evaluatemicrobialprocesses,includingproduction,optimization,andenzymetechnology,forindustrial applications.

Module-1

MICROBIALCLASSIFICATIONANDSTRUCTURE

Classical and modern methods and concepts; Domain and Kingdom concepts in classification of microorganisms; Criteria for classification; Molecular methods – Denaturing Gradient Gel Electrophoresis (DGGE), Temperature Gradient Gel Electrophoresis (TGGE), Amplified rDNA Restriction Analysis and Terminal Restriction Fragment Length Polymorphism (TRFLP) in assessing microbial diversity; 16S rDNA sequencing. Ultrastructure of Archaea (Methanococcus);Eubacteria(E.coli);UnicellularEukaryotes(Yeast)andviruses(Bacterial,Plant,Animaland Tumorviruses).

Module-2

MICROBIALGROWTHANDCONTROL

Culture media. Isolation and identification of microbes, culture techniques. Preservation of cultures Microbial growth: Growth kinetics, Thermal death kinetics, Batch, fed-batch, continuous culture, synchronous growth, yield constants methods of growth estimation, stringent response, death of a bacterial cell.; Physical and chemical methods for the control of microbes. Sterilization.

Module-3

MICROBIALINTERACTION

Microbial interaction -Symbiosis (Nitrogen fixation and ruminant symbiosis); Antagonism (Pathogenesis) Microbes and Nutrient cycles; Microbial communication system- Quorum sensing, Biofilms; Microbial fuel cells; Prebioticsand Probiotics; Vaccines, Multidrug resistance-Mechanism and Example. Extremophiles (with classical example from each group).

Module-4

INDUSTRIALAPPLICATIONS

Basic principles in bioprocess technology; Media Formulation; Sterilization- Batch and continuous sterilization systems; Primary and secondary metabolites; Biotechnologically important products; Extracellular enzymes exopolymers;Bioprocesscontrolandmonitoringvariablessuchastemperature,agitation,pressure,pH. Environmentalapplicationofmicrobes;Oreleaching;Toxicwasteremoval;soilremediation.

Module-5

MICROBIALPROCESSES

Microbial processes-production, optimization, screening, strain improvement; factors affecting downstream processing and recovery; Representative examples of ethanol, organic acids, Antibiotics; Enzyme Technology production, recovery, stability and formulation of bacterial and fungal enzymes-amylase, protease,penicillinacylase,glucoseisomerase;ImmobilisedEnzymeandCell-application,biotransformations-steroids, antibiotics,alkaloids

AssessmentDetails(bothCIEandSEE)

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ContinuousInternalEvaluation:

1. TwoUnitTestseachof**25 Marks**
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toattaintheCOsandPOs

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CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyasperthe outcome defined for the course.

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1. TheSEEQuestionpaperwillbesetfor100marksandthemarksscoredwillbeproportionatelyreducedto50.
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4. Eachfullquestionwillhaveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswillhavetoanswerfivefullquestions,selectingonefullquestionfromeachmodule

SuggestedLearningResources:

Books

1. Prescott'sMicrobiology,8thEdition,JoanneM.Willey,LindaSherwood,ChristopherJ.Woolverton.McGraw HillHigherEducation,2008
2. PelczarM.J.Jr.,ChanE.C.S.andKreigNR.,Microbiology,6thEdition,TataMcGrawHill,1993.
3. Maloy S.R., CronanJE Jr. and Freifelder D, Microbial Genetics, Jones Bartlett Publishers 2nd Edition, Jones & Bartlell Publisher, 1994.
4. CruegerandA.Crueger,ATextbookofIndustrialMicrobiology,SinauerAssociatesInc,2ndEdition,2001

WeblinksandVideoLectures(e-Resources):

1. https://www.youtube.com/watch?v=Bhe6Tj2Ebys
2. https://www.youtube.com/watch?v=cdeScYRotrU
3. https://www.youtube.com/watch?v=shWayTlt4hk
4. https://www.youtube.com/watch?v=9USGWb8Af2Y

SkillDevelopmentActivitiesSuggested

1. NGSandMicroarraydataAnalysis
2. Proteomicdatanetworkanalysis.
3. AVpresentationbystudents(onspecifictopics).
4. Discussionofcasestudiesbasedonresearchfindings

Courseoutcome(CourseSkillSet)

Attheendofthecoursethestudentwillbeableto:

Sl. No.	Description	BloomsLevel
CO1	Recallthecla ssicalandmodernmethodsofmicrobialclassification,includingthe criteria and molecular techniques used for assessing microbial diversity.	L1
CO2	Explaintheprinciplesofmicrobialgrowthkinetics,culturetechniques,andthe various methods for controlling microbial growth.	L2
CO3	Apply knowledge of microbial interactions to analyze their roles innutrient cycles, symbiosis, and biotechnological processes.	L3
CO4	Analyze the principles of bioprocess technology and evaluate the role of microbes in industrialapplicationssuchasoreleaching,toxicwasteremoval,andsoil remediation.	L4
CO5	Evaluatemicrobialprocessesinvolvedintheproductionandoptimizationof industrialproducts,andassessfactorsaffectingdownstreamprocessingand recovery in biotechnological applications.	L5

ProgramOutcomeofthiscourse

Sl. No.	Description	POs
1	**Engineeringknowledge:**Applytheknowledgeofmathematics,science,engineering fundamentals,andanengineeringspecializationtothesolutionofcomplexengineering problems.	PO1
2	**Problemanalysis:**Identify,formulate,reviewresearchliterature,andanalysecomplex engineeringproblemsreachingsubstantiatedconclusionsusingfirstprinciplesof mathematics,naturalsciences,andengineeringsciences.	PO2
3	**Design/developmentofsolutions**:Designsolutionsforcomplexengineeringproblems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, andenvironmental considerations	PO3
4	**Conductinvestigationsofcomplexproblems**:Useresearch-basedknowledgeand research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to providevalid conclusions.	PO4
5	**Moderntoolusage:**Create,select,andapplyappropriatetechniques,resources,andmodern engineering and ITtools includingpredictionandmodelingtocomplexengineering activitieswithanunderstandingofthelimitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engagein independent and life-long learning in the broadest context of technological change.	PO12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		2										
CO3			2	2								
CO4				3	2							
CO5					3							2

Semester-I

BIOANALYTICAL TECHNIQUES			
CourseCode	MBT105	CIEMarks	50
TeachingHours/Week(L:P:SDA)	3:0:0	SEEMarks	50
TotalHoursofPedagogy	3	TotalMarks	100
Credits	3	ExamHours	3

CourseLearningobjectives:

- Graspthebasicprinciplesunderlyingvariousspectroscopicandchromatographictechniques,includingtheirinter action with electromagnetic radiation.
- Acquireknowledgeoftheinstrumentationandtechnicaldetailsinvolvedintechniquessuchas NMR,ESR,massspectro metry, X-ray spectroscopy, and chromatography.
- Developtheabilitytointerpretandanalyzespectra,diffractionpatterns,andchromatogramstoderivemeaningfulconclu sions about molecular structure and composition.
- Understandhowtheseanalyticaltechniquescanbeappliedtosolvecomplexproblemsinbiology,pharmacy,andrelated fields.

Module-1

ELECTROMAGNETICSPECTRUMANDABSORPTIONOFRADIATIONS:

Electro-magnetic Spectrum, Theory of spectroscopy, Scattering, Emission and absorption by molecules, choice of solvent and solvent effects, modern instrumentation – design and working principle. Principles of vibrational spectroscopy, instrumentation, interpretation of sample spectra, applications in biology. FTIR - theory, instrumentation and applications in biology, interpretation of sample spectra Attenuated Total Reflectance (ATR) – theory and applications in biology, interpretation of sample spectra. Laser Raman Spectroscopy - theory, instrumentation, and applications to biology, interpretation of sample spectra. UV-Visible spectroscopy - Theory, Beer-Lambert's law, instrumentation and Applications in biology, interpretation of sample spectra. Fluorescence Spectroscopy.

Module-2

NMR,ESR/EPRandCD/ORDSPECTROSCOPY:

NMR: Theory and Instrumentation, solvents, chemical shift, and factors affecting chemical shift, spin-spin coupling, coupling constant, and factors influencing the value of coupling constant, spin-spin decoupling, proton exchange reactions, FT-NMR, 2D –NMR, Difference between Proton NMR and C13 NMR. Applications in biology andPharmacy, interpretation of sample spectra. Magnetic resonance Imaging (MRI).

ESR:

Theory and Instrumentation, interpretation of sample spectra, Hyperfine interactions and spectral splitting, Spin labelling techniques and their applications. Interpretation of sample spectra.

Circular Dichroism: basics of polarization, the origin of optical activity, Circular birefringence and optical rotation, Theory and Instrumentation, Circular dichroism and the study of biological molecules. Interpretation of sample spectra. ORD Principle, Plain curves, curves with cotton effect, octant rule and its applications, circular dichroism and its relation to ORD.

Module-3

MASSSPECTROSCOPY:

Fragmentation processes and fragmentation pattern, Chemical ionization mass spectroscopy (CIMS), Field Ionization Mass Spectrometry (FIMS), Fast Atom Bombardment MS (FAB MS), Matrix Assisted laser desorption / ionization MS (MALDI-MS), Tandem MS techniques: GC-MS. LC-MS. MS-MS. Discussions with Case studies.

Module-4

X-RAYSPECTROSCOPY:

Generation of X-rays, X-ray diffraction, Bragg's law, X-ray powder diffraction, interpretation of diffraction patterns and applications. Single crystal diffractions of biomolecules. Fibre diffraction. Neutron diffraction. The basicphysical process in XAS, characteristic excitation energies of various elements, X-ray absorption in condensed matter,XASandvalencestate,XASandlocalatomicstructure,applicationsofX-rayPhotoelectronSpectroscopy (XPS), photoelectric effect, binding energies, instrumentation, qualitative analysis. X-ray fluorescence spectroscopy and applications. Energy Dispersive X-ray Spectroscopy (EDS/EDX) and applications.

Module-5

CHROMATOGRAPHICTECHNIQUES:

Classification of chromatographic methods based on mechanism of separation: paper chromatography, thin layer chromatography, column chromatography - ion exchange chromatography, affinity chromatography. Gel filtration chromatography – technical questions and applications. Single step purification by Ni-NTA column. Gas Chromatography:Theoryandprinciple,columnoperation,instrumentation,derivatisationmethodsand applications.HPLC,HPTLC,GC-MS,LC-MS.DiscussionswithCasestudies.

AssessmentDetails(bothCIEandSEE)

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 50% of the maximum marks. Minimum passing marks in SEE is 40% of the maximum marks of SEE.A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each subject/ course if the student secures not less than 50% (50 marks out of 100) in the sum total of the CIE (Continuous Internal Evaluation) and SEE (Semester End Examination) taken together.

ContinuousInternalEvaluation:

1. TwoUnitTestseachof**25 Marks**
2. Twoassignmentseachof**25Marks**or**oneSkillDevelopmentActivityof50marks** toattaintheCOsandPOs

Thesumoftwotests,twoassignments/skillDevelopmentActivities,willbe **scaleddownto50marks**

CIEmethods/questionpaperisdesignedtoattainthedifferentlevelsofBloom'staxonomyasperthe outcomedefinedforthecourse.

Semester-End Examination:

1. TheSEEquestionpaperwillbesetfor100marksandthemarksscoredwillbeproportionatelyreducedto50.
2. Thequestionpaperwillhavetenfullquestionscarryingequalmarks.
3. Each full question is for 20 marks. There will be two full questions (with a maximum of four sub-questions)from each module.
4. Eachfullquestionwillhaveasub-questioncoveringallthetopicsunderamodule.
5. Thestudentswillhavetoanswerfivefullquestions,selectingonefullquestionfromeachmodule

SuggestedLearningResources:

Books

1. FundamentalsofBioanalyticalTechniquesandInstrumentation,SabariGoshal&AKSrivastava,PHI,2009
2. PrinciplesofInstrumentalAnalysis,4thEdition,DonglasA.Skoog,James,J.Leary,SaundersCollege Publishing, Philadelphia,1992
3. PracticalPharmaceuticalChemistry,4thEdition,H.Beckett&J.Stenlake,AcademicPress,1988
4. InstrumentalMethodsofChemicalAnalysis,B.K.Sharma,GoelPublishingHouseMeerut,2000
5. BiochemicalMethodsofAnalysis,SarojDua&NeeraGarg,AlphaScience,2010

WeblinksandVideoLectures(e-Resources):

1. https://archive.nptel.ac.in/courses/104/106/104106122/
2. https://archive.nptel.ac.in/courses/104/108/104108097/
3. https://archive.nptel.ac.in/courses/115/105/115105122/
4. https://onlinecourses.nptel.ac.in/noc21_bt50/preview
5. https://archive.nptel.ac.in/courses/102/107/102107028/

SkillDevelopmentActivitiesSuggested

1. NGSandMicroarraydataAnalysis
2. Proteomicdatanetworkanalysis.
3. AVpresentationbystudents(onspecifictopics).
4. Discussionofcasestudiesbasedonresearchfindings

Courseoutcome(CourseSkillSet)

Attheendofthecoursethestudentwillbeableto:

Sl. No.	Description	BloomsLevel
CO1	Recallfundamentalprinciplesofspectroscopy,includingelectromagneticspectrum, scattering,emission,absorption,andthetheoreticalaspectsofvariousspectroscopic techniques	L1
CO2	Explaintheprinciplesofdifferentspectroscopicandchromatographictechniques, suchasUV-Visiblespectroscopy,FTIR,NMR,andtheirapplicationsinbiological contexts.	L2
CO3	Applyknowledgeofspectroscopicandchromatographictechniquestointerpret samplespectra,performexperimentalanalysis,andsolvepracticalproblemsin biologyandchemistry..	L3
CO4	Analyzecomplexspectraandchromatographicdatatoidentifycompounds, determinetheirconcentrations,andunderstandtheirstructuralandchemical properties.	L4
CO5	Evaluatetheeffectivenessandlimitationsofdifferentanalyticaltechniquesin solvingspecificresearchproblems,andproposeimprovementsoralternative methods based on the results obtained.	L4

Program Outcomeofthiscourse

Sl. No.	Description	POs
1	**Engineeringknowledge:**Applytheknowledgeofmathematics,science,engineering fundamentals,andanengineeringspecializationtothesolutionofcomplexengineering problems.	PO1
2	**Problemanalysis:**Identify,formulate,reviewresearchliterature,andanalysecomplex engineeringproblemsreachingsubstantiatedconclusionsusingfirstprinciplesofmathematics, natural sciences, and engineering sciences.	PO2
3	**Design/developmentofsolutions**:Designsolutionsforcomplexengineeringproblems and designsystemcomponentsorprocessesthatmeetthespecifiedneedswithappropriate consideration for the public health and safety, and the cultural, societal, andenvironmental considerations	PO3
4	**Conductinvestigationsofcomplexproblems**:Useresearch-basedknowledgeand research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to providevalid conclusions.	PO4
5	**Modern tool usage**:Create, select, and apply appropriate techniques, resources, andmodern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.	PO5
6	**Life-long learning:** Recognize the need for, and have the preparation and ability to engagein independent and life-long learning in the broadest context of technological change.	PO12

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		2										
CO3			3	2								
CO4				3	2							
CO5					3							2

ADVANCEDBIOCHEMISTRY LAB			
CourseCode	**MBTL106**	CIEMarks	50
TeachingHours/Week(L:T:P:S)	0:2:2	SEEMarks	50
Credits	2	ExamHours	3

Courseobjectives:

- Gainproficiencyinavarietyofanalyticalmethodsfordeterminingthechemical compositionoffoodand biological samples, including moisture content, ash, protein, fat, and carbohydrates.
- Acquirehands-onexperiencewithlaboratoryequipmentandtechniques,includingthehotairoven, muffle furnace, Kjeldahl apparatus, Soxhlet extractor, and colorimetric methods.
- Learntoperformaccuratequantitativeanalysisoffoodandbiologicalsamples,usingtitrimetricand colorimetric methods for assessing acidity, sugar content, and other constituents.
- Developtheabilitytopreparesamplesandutilizebasicinstrumentationpracticesforchemicalanalysis, ensuring precise and reliable results.
- Enhanceskillsinevaluatingandinterpretinganalyticaldata,includingtheassessmentofsensory propertiesusingtechniqueslikethe9-PointHedonicScale.

Sl.NO	Experiments
1	DeterminationofMoistureContentbyHotAirOvenMethod
2	DeterminationofCrudeAshcontentUsingMuffleFurnace
3	DeterminationofCrudeProteinbyKjeldahl/Biuret/Lowry's/BradfordMethod
4	DeterminationofCrudeFatbySoxhletMethod
5	DeterminationofTotalCarbohydratebyFurfuralColorimetric/AnthroneReagent/PhenolSulphuricAcid methods
6	EstimationofTitrableAciditybyTitrimetricmethod/pH Meter.
7	EstimationofReducingSugarbyTitration/Nelson-Somogyi's/DinitroSalicylicMethod
8	EstimationofTotalSugarandNon-ReducingSugar
	DemonstrationExperiments(ForCIE)if any
9	ComparingSensoryevaluationofthesubjectiveparameterson 9PointHedonicScaletoobjective parameters of food items.
10	BasicInstrumentationPractices
11	SamplePreparationforChemicalAnalysis
12	DeterminationofConstituentsbyPhysicalMethods

Courseoutcomes(CourseSkillSet):

Attheendofthecoursethestudentwillbeableto:

1. Recalltheproceduresfordeterminingmoisturecontent,crudeash,andcrudeproteinusingstandard laboratory methods.
2. Explaintheprinciplesbehindthemethodsusedforcrudefatdetermination,carbohydrateanalysis,and acidity estimation.

3. ApplytheSoxhletmethodtodeterminecrudefatcontentandtheNelson-Somogyi'smethodtoestimate reducingsugarsinvarioussamples.
4. Analyzetheresultsoftitrimetricandcolorimetricassaystodifferentiatebetweentotalsugarandnon-reducing sugar content in samples.
5. Evaluatetheaccuracyandreliabilityofexperimentaldatabycomparingdifferentanalyticaltechniques and interpreting the results from basic instrumentation practices.

AssessmentDetails(bothCIEandSEE)

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 50% of the maximum marks. A student shall be deemed to have satisfied the academic requirements and earned the credits allotted to each course. The student has to secure not less than 40% of maximum marks in the semester-end examination(SEE). In total of CIE and SEE student has to secure 50% maximum marks of the course.

ContinuousInternalEvaluation(CIE):

CIEmarksforthepracticalcourseis**50Marks**.

Thesplit-upofCIEmarksforrecord/journalandtestareintheratio **60:40**.

- Eachexperimenttobeevaluatedforconductionwith anobservationsheetandrecordwrite-up.Rubricsfor the evaluation of the journal/write-up for hardware/software experiments designed by the faculty who is handling the laboratory session and is made known to students at the beginning of the practical session.
- Recordshouldcontainallthespecifiedexperimentsinthesyllabusandeachexperimentwrite-upwillbe evaluated for 10 marks.
- **Totalmarksscoredbythestudentsarescaleddownto30marks**(60%ofmaximummarks).
- Weightagetobegivenforneatnessandsubmissionofrecord/write-upontime.
- Departmentshallconduct01testsfor100marks,testshallbeconductedafterthe14thweekofthesemester.
- Intest,testwrite-up,conductionofexperiment,acceptableresult,andproceduralknowledgewillcarrya weightage of 60% and the rest 40% for viva-voce.
- Thesuitablerubricscanbedesignedtoevaluateeachstudent'sperformanceandlearningability.
- **Thetestmarksisscaleddownto20marks**(40%ofthemaximummarks).

TheSumof**scaled-down**marksscoredinthereportwrite-up/journalandmarksoftestisthetotalCIEmarks scored by the student.

SemesterEndEvaluation(SEE):

SEEmarksforthepracticalcourseis50Marks.

SEEshallbeconductedjointlybythetwoexaminersofthesameinstitute,examinersareappointedbythe University.

Alllaboratoryexperimentsaretobeincludedforpracticalexamination.

(Rubrics) Breakup of marks and the instructions printed on the cover page of the answer script to be strictly adhered to by the examiners.**OR** based on the course requirement evaluation rubrics shall be decided jointly by examiners.

Students can pick one question (experiment) from the questions lot prepared by the internal /external examiners jointly.

Evaluation of test write-up/ conduction procedure and result/viva will be conducted jointly by examiners.

GeneralrubricssuggestedforSEEarementionedhere,writeup-20%,Conductionprocedureandresultin -60%, Viva-voce 20% of maximum marks. SEE for practical shall be evaluated for 100 marks and scored marks shallbe scaled down to 50 marks (however, based on course type, rubrics shall be decided by the examiners)

Changeofexperimentisallowedonlyonceand 10%Marksallottedtotheprocedureparttobemadezero. The duration of SEE is 03 hours

SuggestedLearningResources:

1. S.SuzanneNielsen,FoodAnalysis,Springer,2017(4thEdition)
2. P.A.E.ChichesterandM.L.V.Martin,MethodsofFoodAnalysis:Physical,Chemical,andInstrumental, Academic Press, 1991
3. AmericanPublicHealthAssociation(APHA),StandardMethodsfortheExaminationofDairyProducts, American Public Health Association, Year of Publication: 2011 (17th Edition)
4. LeoM.L.NolletandFidelToldrá,HandbookofFoodAnalyticalChemistry:Chemical,Sensory,andInstrumental Methods, Wiley, 2004
5. DouglasA.Skoog,F.JamesHoller,andStanleyR.Crouch,PrinciplesofInstrumentalAnalysis,Cengage Learning,2017 (7th Edition)

Slno	Description	PO
1	**Engineering knowledge:**Applytheknowledgeofmathematics,science,engineering fundamentals,andanengineeringspecializationtothesolutionofcomplexengineeringproblems.	PO1
2	**Problem analysis:** Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.	PO2
3	**Conductinvestigationsofcomplexproblems**:Useresearch-basedknowledgeandresearch methodsincludingdesignofexperiments,analysisandinterpretationofdata,and synthesisofthe informationtoprovidevalidconclusions.	PO4

MappingofCOSandPOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	P11	P12
CO1	3											
CO2		3										
CO3				3								
CO4				3								
CO5												