



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Biotechnology

Subject Code: BE05004031

Subject Name: Genetic Engineering

w. e. f. Academic Year:	2024-2025
Semester:	5
Category of the Course:	Professional Core Course

Prerequisite:	Cell Biology, Molecular Biology and Genetics
Rationale:	Genetic Engineering involves the manipulation of genetic material to alter the characteristics of organisms for scientific, medical, agricultural, and industrial applications. This subject provides students with the knowledge and practical skills required to understand recombinant DNA technology, gene cloning, and genome editing tools such as CRISPR.

Course Outcomes:

Sr. No.	CO statement	Marks% weightage
CO-1	Discuss the basic and advanced techniques in Genetic Engineering	20
CO-2	Select the appropriate host and vector system for cloning and expression	20
CO-3	Employ the cloning strategies to produce recombinant molecules	20
CO-4	Understand the DNA sequencing technology and gene modification approaches	20
CO-5	Apply genetic engineering principles for biotechnological and biomedical applications	20

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/ CA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Content:

Sr. No.	Content	Total Hrs
1	Basic Techniques: Agarose gel electrophoresis, Nucleic acid blotting: Southern, western and northern blotting, PCR, Competent cell preparation, transformation of <i>E. coli</i> , Advance Techniques in gene expression and analysis: RT-PCR, Real-Time PCR, microarray.	10



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2	Cutting and joining DNA molecules: various restriction enzymes, ligases, Cloning Vectors: Plasmids and Phage Vectors, Cosmids, Phasmids and other advanced vectors for recombinant protein production and purification, animal and plant vector; Introducing DNA into bacterial cells, cloning in bacteria, animal and plant cells, recombinant clone selection, transient and inducible expression system.	10
3	Genomic libraries and sequencing: DNA and cDNA library preparation, cloning strategies for library preparation, screening of libraries, Sequencing: DNA sequencing, concept of next generation sequencing technology, whole genome sequencing, analyzing sequence data, mapping and identification coding and non-coding gene, transgenic animals and plants, molecular pharming.	10
4	Transgenics and Molecular Pharming: The creation and use of genetically modified organisms (GMOs) for research or agricultural purposes, including the introduction of foreign genes into animal or plant genomes, Molecular Pharming: The use of genetically modified organisms (such as plants, animals, or bacteria) to produce pharmaceutical proteins or vaccines.	10
5	Advanced genomics : CRISPR/Cas9 Gene Editing, Single-Cell RNA Sequencing, Gene Drives: Gene Therapy: Synthetic Genomics	5
TOTAL		45

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	20	20	20	10	10

R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

The syllabus of Advanced Power Electronics directly contributes to

SDG 3	The syllabus supports the development of recombinant therapeutics, vaccines, molecular diagnostics, gene therapy, and genome editing technologies for improved disease prevention and healthcare.
SDG 2	Genetic engineering contributes to the development of genetically modified crops with enhanced productivity, nutritional quality, and resistance to pests and environmental stress.
SDG 9	The subject promotes innovation in recombinant DNA technology, molecular pharming, genome sequencing, and synthetic genomics for industrial biotechnology applications.



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SDG 12	Genetic engineering supports sustainable biotechnological production of pharmaceuticals, enzymes, and biomolecules using engineered organisms.
SDG 13	Development of genetically modified organisms with improved environmental adaptability contributes to climate-resilient agriculture and sustainable biological systems.
SDG 15	Advanced genomics and genetic engineering help in biodiversity conservation, plant improvement, and sustainable agricultural practices.

Reference Books:

1. Old RW and Primrose SB, Principles of gene manipulation, BlackWell Scientific Publications, 2013, 7th Edition
2. Michael R. Green, Joseph Sambrook, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press, 2013, 4th Edition.
3. T. A. Brown, Gene Cloning and DNA Analysis: An Introduction, Wiley BlackWell Scientific, Publications, 2013, 6th Edition

List of Experiments / Practical Demonstrations

1. Isolation of genomic DNA from bacteria / plant / animal cells
2. Isolation of plasmid DNA from *E. coli*
3. Restriction digestion of DNA and agarose gel electrophoresis
4. Ligation of DNA fragments and transformation into competent cells
5. Screening and selection of recombinant colonies
6. Polymerase Chain Reaction (PCR) amplification of target gene
7. Analysis of PCR products by gel electrophoresis
8. Expression of recombinant protein in host cells (optional)

Major Equipment

1. Laminar air flow cabinet
2. PCR thermocycler
3. Gel electrophoresis unit and power supply
4. Gel documentation system
5. Microcentrifuge

Open-Source Software / Learning Websites

1. SnapGene Viewer
2. ApE (A plasmid Editor)
3. Benchling (free academic account)
4. BLAST (NCBI)
5. Expasy Bioinformatics Tools
6. Geneious (trial / educational use)
7. MIT OpenCourseWare – Genetic Engineering



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List of suggested activities for Project Based Learning (PBL):

Sr. No.	PBL Category	Name of the Activity	No. of Hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Visit to molecular biology laboratory / genetic engineering research institute / biotech company involved in recombinant protein production or molecular diagnostics	Visit = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Based on report submitted. Report should contain observations on recombinant DNA technology, PCR workflow, cloning systems, sequencing, and industrial genetic engineering applications.
2	Video Based Learning	Technical video-based learning related to recombinant DNA technology, PCR, CRISPR, sequencing, cloning, and molecular pharming (MOOC/NPTEL)	Video duration = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Report/presentation based on learning outcomes and understanding of genetic engineering concepts.
3	Assignment / Technical Writing / Research Writing	Numerical and theory-based assignments related to cloning vectors, restriction digestion, PCR analysis, sequencing, and gene expression	5 assignments × 2 hrs = 10 hrs	Based on assignment quality, technical understanding, interpretation, and presentation.
4	Complex Problem-Solving Targeting Relevant SDGs / Mini Project	Design of a recombinant cloning strategy for therapeutic protein production or CRISPR-based disease correction model	15 hrs	Based on problem-solving ability, cloning strategy, innovation, and scientific feasibility.
5	Research Paper Review / Analysis	Review of SCOPUS-indexed research papers on CRISPR-Cas9, recombinant DNA technology, sequencing, gene therapy, or synthetic genomics	5 research papers = 20 hrs	Based on summary, critical analysis, technical depth, and understanding of scientific parameters.



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6	Poster / Chart / PowerPoint Presentation	Preparation of poster/PPT on topics such as Gene Cloning, PCR, DNA Sequencing, Gene Therapy, CRISPR, GMOs	6 hrs	Based on technical content, presentation quality, creativity, and communication skills.
7	Micro Project / Mini Project	Working/non-working model of PCR amplification workflow, cloning vector system, restriction digestion mapping, or CRISPR mechanism	5 hrs / 10 hrs	Based on innovation, technical relevance, understanding of mechanism, and evaluation.
8	Group Discussion / Quiz / Simulation	Group discussion on emerging areas such as Synthetic Genomics, Gene Drives, Personalized Medicine, Genome Editing Ethics	1 hr each	Based on participation, technical knowledge, and communication skills.
9	Case Study Analysis / Seminar	Case study on genetic disorders, CRISPR-based therapies, GMO applications, or recombinant vaccine development	Data collection/study = 5 hrs, Report preparation = 5 hrs Total = 10 hrs	Based on technical depth, fact-finding, scientific understanding, and conclusions.
10	Other	Patent Search and Innovation Gap Identification in gene editing, recombinant therapeutics, sequencing technologies, or molecular diagnostics	10 hrs (Search + Report)	Based on patents reviewed and identification of innovation opportunities.

Note:

1. Mini Project – 10 Marks , Micro Project – 5 Marks
2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
