Rajiv Gandhi Proudyogiki Vishwavidyalaya, Bhopal

Branch- Common to All Discipline

ES301	**Energy & Environmental Engineering**	**3L-1T-0P**	**4 Credits**

The objective of this Course is to provide *an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternative energy sources and their technology and application.*

Module 1: Introduction to Energy Science:

- Introduction to energy systems and resources; Introduction to Energy, sustainability & the environment; Overview of energy systems, sources, transformations, efficiency, and storage; Fossil fuels (coal, oil, oil-bearing shale and sands, coal gasification) - past, present & future, Remedies & alternatives for fossil fuels - biomass, wind, solar, nuclear, wave, tidal and hydrogen; Sustainability and environmental trade-offs of different energy systems; possibilities for energy storage or regeneration (Ex. Pumped storage hydro power projects, superconductor-based energy storages, high efficiency batteries)

***Module2*: Ecosystems**

- Concept of an ecosystem; Structure and function of an ecosystem; Producers, consumers and decomposers; Energy flow in the ecosystem; Ecological succession; Food chains, food webs and ecological pyramids; Introduction, types, characteristic features, structure and function of the following ecosystem (a.)Forest ecosystem (b) Grassland ecosystem (c) Desert ecosystem (d) Aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries)

***Module 3*: Biodiversity and its conservation**

- Introduction – Definition: genetic, species and ecosystem diversity; Bio-geographical classification of India; Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values; Biodiversity at global, National and local levels; India as a mega-diversity nation; Hot-sports of biodiversity; Threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts; Endangered and endemic species of India; Conservation of biodiversity: In-situ and Ex-situ conservation of biodiversity.

***Module 4:* Environmental Pollution**

- Definition, Cause, effects and control measures of Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards; Solid waste Management: Causes, effects and control measures of urban and industrial wastes; Role of an individual in prevention of pollution; Pollution case studies; Disaster management: floods, earthquake, cyclone and landslides.

Module 5: **Social Issues and the Environment**

- From Unsustainable to Sustainable development; Urban problems related to energy; Water conservation, rain water harvesting, watershed management; Resettlement and rehabilitation of people; its problems and concerns. Case Studies
  Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Case Studies Wasteland reclamation; Consumerism and waste products; Environment Protection Act; Air (Prevention and Control of Pollution) Act; Water (Prevention and control of Pollution) Act; Wildlife Protection Act; Forest Conservation Act; Issues involved in enforcement of environmental legislation; Public awareness.

Module 6: Field work

- Visit to a local area to document environmental assets-river/forest/grassland/hill/mountain
- Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds.
- Study of simple ecosystems-pond, river, hill slopes, etc.

REFERENCE

1. Brunner R.C., 1989, Hazardous Waste Incineration, McGraw Hill Inc.
2. Clark R.S., Marine Pollution, Clanderson Press Oxford (TB).
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. 2001, Environmental Encyclopedia, Jaico Publ. House, Mumabai,
4. De A.K., Environmental Chemistry, Wiley Eastern Ltd.
5. Trivedi R.K., Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards', Vol I and II, Enviro Media (R)
6. Boyle, Godfrey, Bob Everett, and Janet Ramage (Eds.) (2004), Energy Systems and Sustainability: Power for a Sustainable Future. Oxford University Press.
7. Schaeffer, John (2007), Real Goods Solar Living Sourcebook: The Complete Guide to Renewable Energy Technologies and Sustainable Living, Gaiam

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New Scheme Based On AICTE Flexible Curricula

Biotechnology, III-Semester

BT302: Biochemistry

Module I: Foundations of Biochemistry

- **Structure and properties of water**: hydrogen bonding, ionization of water, pH, buffers, and their relevance in biological systems.
- **Biomolecules Overview**:
  - **Carbohydrates**: Monosaccharides, disaccharides, polysaccharides (starch, glycogen, cellulose), glycoproteins.
  - **Lipids**: Fatty acids, triacylglycerols, phospholipids, sphingolipids, sterols, lipoproteins.
  - **Amino acids and proteins**: Structure, classification, acid-base properties.
  - **Nucleic acids**: Structure of DNA and RNA, purine and pyrimidine bases, nucleotides.

Module II: Protein Structure and Enzyme Kinetics

- **Protein architecture**: Primary, secondary (α-helix, β-sheet), tertiary and quaternary structures; Ramachandran plot; protein folding, denaturation, and renaturation.
- **Enzymology**:
  - Enzyme classification and nomenclature.
  - Mechanism of enzyme action, coenzymes, prosthetic groups, and enzyme specificity.
  - Enzyme kinetics: Michaelis-Menten equation, Km and Vmax, Lineweaver-Burk plot.
  - Inhibition: competitive, non-competitive, uncompetitive; allosteric regulation.

Module III: Bioenergetics and Metabolism I – Carbohydrates

- **Principles of bioenergetics**: Thermodynamics in biological systems, high-energy compounds (ATP, NADH, FADH□).
- **Metabolic pathways**:
  - Glycolysis, gluconeogenesis, glycogen metabolism.
  - Pentose phosphate pathway.
  - TCA cycle and its amphibolic role.

Module IV: Metabolism II – Lipids, Amino Acids, and Nucleotides

- **Lipid metabolism**: β-oxidation of fatty acids, biosynthesis of fatty acids, triacylglycerols, phospholipids.

- **Amino acid metabolism**: Transamination, oxidative deamination, urea cycle, biosynthesis of non-essential amino acids.
- **Nucleotide metabolism**: Purine and pyrimidine synthesis and degradation; clinical disorders (e.g., gout, Lesch-Nyhan syndrome).

Module V: Molecular Techniques in Biochemistry

- **Biochemical techniques**:
    - Spectrophotometry, UV-visible absorption.
    - Chromatography: paper, TLC, ion-exchange, gel filtration, HPLC.
    - Electrophoresis: PAGE, SDS-PAGE, isoelectric focusing.
    - Centrifugation: differential and density gradient.
    - Enzyme-linked immunosorbent assay (ELISA).
- **Radioisotopic techniques**: Use of radioactive isotopes in metabolism and tracing.

Laboratory Experiments (Representative)

1. Estimation of proteins by Lowry or Bradford method.
2. Enzyme activity assay (e.g., amylase or invertase kinetics).
3. pH and buffer preparation.
4. Separation of amino acids by paper chromatography.
5. Estimation of reducing sugars by DNS method.
6. Isolation of lipids from plant/animal tissues.
7. Qualitative analysis of carbohydrates, proteins, and lipids.
8. Lipid extraction and TLC profiling from biological samples.
9. Urease activity assay and enzyme kinetics study.
10. Isolation of DNA and A260/A280 purity check.

Textbooks

1. **Lehninger, A. L. et al.** Principles of Biochemistry, W.H. Freeman.
2. **Voet, D., & Voet, J.G.** Biochemistry, Wiley.
3. **Nelson, D. L., & Cox, M. M.**Lehninger Principles of Biochemistry, Macmillan.

References

1. **Mathews, C. K., van Holde, K. E., & Ahern, K. G.** Biochemistry, Pearson.
2. **Murray, R. K. et al.** Harper's Illustrated Biochemistry, Lange.
3. **Zubay, G.** Biochemistry, W.C. Brown Publishers.
4. **Garrett, R. H., & Grisham, C. M.** Biochemistry, Cengage.

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New Scheme Based On AICTE Flexible Curricula

Biotechnology, III-Semester

BT303: Genomics and Genetic Engineering

Module I: Molecular Genetics and Genome Architecture

- **Structure of DNA and RNA**: Watson-Crick model, forms of DNA (A, B, Z), DNA supercoiling, RNA types and structure.
- **Genome organization**: Prokaryotic vs. eukaryotic genome, plasmids, transposons, repetitive sequences, mitochondrial and chloroplast genomes.
- **Gene structure**: Promoters, enhancers, operons, introns, exons, UTRs, epigenetic regulation.
- **Chromatin and nucleosome dynamics**: Histone modification and chromatin remodeling.

Module II: DNA Replication, Transcription, and Translation

- **DNA replication**: Semi-conservative mechanism, replication fork, enzymes (helicase, primase, DNA polymerases), telomeres and telomerase.
- **Transcription**: RNA polymerase, initiation, elongation, termination, RNA processing (splicing, capping, polyadenylation), alternative splicing.
- **Translation**: Genetic code, tRNA charging, ribosome structure, translation initiation, elongation, and termination; regulation of gene expression in prokaryotes (lac operon) and eukaryotes.

Module III: Techniques in Genomics

- **Genomics**:
    - DNA sequencing (Sanger and Next-Generation Sequencing), genome assembly, annotation.
    - Transcriptomics (RNA-Seq), proteogenomics, and metabolomics basics.
    - Comparative genomics, functional genomics, and epigenomics.
    - SNPs, copy number variation, microarray, and gene expression profiling.
- **Bioinformatics tools**: Basic genome browsers (NCBI, UCSC), BLAST, alignment algorithms, genome databases.

Module IV: Genetic Engineering Tools and Strategies

- **Gene cloning fundamentals**: Restriction enzymes, ligases, linkers, adaptors.
- **Vectors**: Plasmids, phagemids, cosmids, BACs, YACs, expression vectors, shuttle vectors.

- **Gene transfer techniques**: Transformation (heat shock, electroporation), transduction, conjugation, Agrobacterium-mediated transfer, liposome-mediated delivery.
- **Screening and selection**: Blue-white screening, colony PCR, reporter genes (GUS, GFP, LacZ).
- **Library construction**: Genomic and cDNA libraries.

Module V: Applications of Genetic Engineering and Ethical Considerations

- **Recombinant proteins**: Insulin, growth hormones, vaccines (e.g., Hepatitis B), monoclonal antibodies.
- **Gene therapy**: Somatic vs. germline, viral and non-viral vectors, approved therapies (e.g., Luxturna, Zolgensma).
- **CRISPR-Cas systems**: Mechanism, types, applications in gene editing.
- **Ethical, legal, and social implications (ELSI)**: GMOs, biosafety regulations (Cartagena Protocol), IPR issues in genetic manipulation.

Laboratory Components (Representative List)

1. Isolation and quantification of genomic DNA (from bacteria or plant).
2. Agarose gel electrophoresis for DNA visualization.
3. Restriction enzyme digestion and analysis.
4. PCR amplification of target genes.
5. Competent cell preparation and transformation.
6. Cloning and blue-white screening using plasmid vectors.
7. Introduction to genome databases and sequence alignment tools (BLAST).
8. Miniprep and plasmid DNA isolation from E. coli.
9. CRISPR-Cas9 design exercise using online tools.
10. Southern blotting (demonstration or dry lab using simulated gel).

Textbooks (Latest Editions Recommended)

1. **Brown, T.A.** Genomes (Oxford University Press).
2. **Lodish, H. et al.** Molecular Cell Biology, W.H. Freeman.
3. **Watson, J.D. et al.** Molecular Biology of the Gene, Pearson.
4. **Sambrook, J., & Russell, D.W.** Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press.

References

1. **Primrose, S.B., & Twyman, R.M.** Principles of Gene Manipulation and Genomics, Wiley.
2. **Strachan, T. & Read, A.** Human Molecular Genetics, Garland Science.
3. **Albert, B. et al.** Molecular Biology of the Cell, Garland Science.
4. Recent journal articles from Nature Genetics, Genome Research, Trends in Genetics.

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Biotechnology, III-Semester

BT304: Microbiology

Module I: Fundamentals of Microbiology

- **History and scope** of microbiology.
- **Classification systems**: Bergey's Manual, Whittaker's five-kingdom and three-domain system.
- **Structure and function** of microbial cells: Prokaryotes (bacteria, archaea) vs. eukaryotes (fungi, protozoa, algae).
- **Viruses**: Structure, replication cycles (lytic, lysogenic), classification; prions and viroids.
- **Microscopy**: Light, phase contrast, fluorescence, and electron microscopy (SEM & TEM).

Module II: Microbial Nutrition and Growth

- **Nutritional classification**: Autotrophs, heterotrophs, phototrophs, chemotrophs.
- **Culture media**: Types (defined, complex, selective, differential), preparation, and sterilization.
- **Growth curve**: Lag, log, stationary, death phases; synchronous and diauxic growth.
- **Measurement of growth**: Viable count, turbidity, dry weight, cell counting chambers.
- **Factors affecting growth**: pH, temperature, oxygen, osmolarity.

Module III: Microbial Genetics and Molecular Biology

- **Genetic material**: Plasmids, episomes, and bacteriophage genomes.
- **Gene transfer mechanisms**:
    - Transformation
    - Transduction (generalized and specialized)
    - Conjugation (F+, Hfr, F' plasmid).
- **Mutation types and mutagens**.
- **Transposable elements**: IS elements, transposons.
- **Antibiotic resistance mechanisms** and its genetic basis.

Module IV: Control of Microorganisms

- **Sterilization methods**: Moist and dry heat, filtration, radiation, and chemical agents (alcohols, phenols, halogens, aldehydes).
- **Disinfection** and **antisepsis**.
- **Evaluation of antimicrobial agents**: MIC, MBC, phenol coefficient.

- **Antibiotics and chemotherapeutic agents**: Mode of action of penicillin, streptomycin, tetracycline, quinolones.
- **Biosafety levels** (BSL I–IV) and Good Microbiological Practices (GMPs).

Module V: Applied Microbiology

- **Environmental microbiology**: Bioremediation, biodegradation, microbial ecology (nitrogen, sulfur, carbon cycles).
- **Industrial microbiology**: Fermentation processes; production of alcohol, antibiotics, vitamins, enzymes.
- **Agricultural microbiology**: Biofertilizers (Rhizobium, Azotobacter), biopesticides (Bt), mycorrhizae.
- **Medical microbiology**: Pathogenic bacteria (e.g., E. coli, Salmonella, Mycobacterium), host–pathogen interaction, emerging infectious diseases, probiotics.
- **Food microbiology**: Microbes in food spoilage and preservation, foodborne pathogens, fermentation (curd, bread, cheese).

Laboratory Experiments (Illustrative List)

1. **Sterilization techniques**: Autoclaving, filter sterilization.
2. **Media preparation** and pure culture techniques (streak plate, pour plate).
3. **Microscopic examination**: Gram staining, acid-fast staining, fungal mounts.
4. **Growth curve determination**: Using spectrophotometer.
5. **Antibiotic susceptibility testing**: Kirby-Bauer method.
6. **Bacterial motility tests**: Hanging drop, semi-solid media.
7. **IMViC tests** for coliforms.
8. **Isolation of soil microorganisms** (actinomycetes, fungi, bacteria).
9. Analysis of microbial diversity in soil via serial dilution and CFU count.
10. Effect of pH and temperature on bacterial growth.

Textbooks

1. **Prescott, L.M., Harley, J.P., & Klein, D.A.** Microbiology, McGraw-Hill.
2. **Pelczar, M.J., Chan, E.C.S., & Krieg, N.R.** Microbiology: Concepts and Applications, McGraw-Hill.
3. **Madigan, M.T., Martinko, J.M., Bender, K.**, Brock Biology of Microorganisms, Pearson.

References

1. **Cappuccino, J.G. & Sherman, N.** Microbiology: A Laboratory Manual, Pearson.
2. **Tortora, G.J., Funke, B.R., & Case, C.L.** Microbiology: An Introduction, Pearson.
3. **Stanbury, P.F., Whitaker, A., & Hall, S.J.** Principles of Fermentation Technology, Elsevier.
4. **Relevant peer-reviewed journal articles**: Applied and Environmental Microbiology, Journal of Bacteriology, Frontiers in Microbiology.

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Biotechnology, III-Semester

BT305: Engineering Thermodynamics

Module I: Basic Thermodynamic Principles

- **Fundamental concepts**: Thermodynamic system and surroundings, properties, state, process, cycle.
- **Zeroth Law of Thermodynamics**: Concept of temperature and temperature scales.
- **First Law of Thermodynamics**: Internal energy, enthalpy, specific heats; energy conversion in closed and open systems; applications to non-flow and steady-flow processes (e.g., nozzles, turbines, compressors).

Module II: Second Law and Entropy

- **Limitations of First Law**: Introduction to heat engines, refrigerators, and heat pumps.
- **Second Law of Thermodynamics**: Kelvin–Planck and Clausius statements and their equivalence.
- **Reversibility and irreversibility**; Carnot cycle and Carnot efficiency.
- **Entropy**: Concept and principle of increase in entropy, entropy change in reversible and irreversible processes.

Module III: Thermodynamic Properties of Fluids

- **Pure substances**: P-v, T-v, T-s, h-s diagrams; phase transformation, quality of steam.
- **Equation of state**: Ideal gas law and van der Waals equation.
- **Thermodynamic property relations**: Maxwell's equations, Clapeyron equation.
- **State postulates**: Use of property tables and charts.

Module IV: Thermodynamic Cycles and Applications

- **Air-standard cycles**: Otto, Diesel, Dual cycles; efficiency analysis and comparison.
- **Vapor power cycles**: Rankine cycle, reheat and regenerative cycles, steam power plants.
- **Refrigeration cycles**: Vapor compression and absorption systems; coefficient of performance.
- **Thermodynamic aspects of biotechnology systems**: Energy balance in bioreactors, fermenters, heat exchangers, etc.

Module V: Biothermodynamics and Energy Integration in Biotech Systems

- **Bioenergetics**: ATP generation and coupling, Gibbs free energy in biological reactions, standard biochemical reactions.

- **Thermodynamics of metabolic pathways**: Glycolysis, TCA cycle, oxidative phosphorylation.
- **Energy requirements and heat generation** in cell culture, fermentation, and downstream processing.
- **Energy integration**: Heat recovery, process optimization, sustainability in biotechnology plants.

Laboratory Experiments / Case Studies

1. **Verification of First Law** using calorimetry.
2. **Determination of enthalpy and specific heat** of substances.
3. **Study of steam tables and Mollier charts**.
4. **Simulation of bioreactor energy balances** using MATLAB/Excel.
5. **Entropy calculation** in ideal gases and real processes.
6. **Efficiency evaluation** of an actual Rankine cycle (via simulation or lab models).
7. Calorific value determination of biofuels (using bomb calorimeter/simulation).
8. Application of entropy concepts in biochemical systems (case study format).
9. Energy balance simulation for a fermentation process.
10. Verification of the second law via heat engine simulation kit.

Textbooks

1. **Nag, P.K.** Engineering Thermodynamics, McGraw-Hill.
2. **Cengel, Y.A., & Boles, M.A.** Thermodynamics: An Engineering Approach, McGraw-Hill.
3. **Moran, M.J., & Shapiro, H.N.** Fundamentals of Engineering Thermodynamics, Wiley.

References

1. **Smith, J.M., Van Ness, H.C., & Abbott, M.M.** Introduction to Chemical Engineering Thermodynamics, McGraw-Hill.
2. **Atkins, P., & de Paula, J.** Physical Chemistry, Oxford University Press.
3. **Alberty, R.A.** Biochemical Thermodynamics: Applications of Mathematica, Wiley-Interscience.
4. **Van Holde, K.E., Johnson, W.C., & Ho, P.S.** Principles of Physical Biochemistry, Pearson.
5. **Recent publications in journals** such as Biotechnology Progress, Biochemical Engineering Journal, Thermochimica Acta.

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Biotechnology, III-Semester

Semester 3Biotechnology Laboratory - I

BT302: Biochemistry

- Estimation of proteins by Lowry or Bradford method.
- Enzyme activity assay (e.g., amylase or invertase kinetics).
- pH and buffer preparation.
- Separation of amino acids by paper chromatography.
- Estimation of reducing sugars by DNS method.
- Isolation of lipids from plant/animal tissues.
- Qualitative analysis of carbohydrates, proteins, and lipids.
- Lipid extraction and TLC profiling from biological samples.
- Urease activity assay and enzyme kinetics study.
- Isolation of DNA and A260/A280 purity check.

BT303: Genomics and Genetic Engineering

- Isolation and quantification of genomic DNA (from bacteria or plant).
- Agarose gel electrophoresis for DNA visualization.
- Restriction enzyme digestion and analysis.
- PCR amplification of target genes.
- Competent cell preparation and transformation.
- Cloning and blue-white screening using plasmid vectors.
- Introduction to genome databases and sequence alignment tools (BLAST).
- Miniprep and plasmid DNA isolation from E. coli.
- CRISPR-Cas9 design exercise using online tools.
- Southern blotting (demonstration or dry lab using simulated gel).

BT304: Microbiology

- Sterilization techniques: Autoclaving, filter sterilization.
- Media preparation and pure culture techniques (streak plate, pour plate).
- Microscopic examination: Gram staining, acid-fast staining, fungal mounts.
- Growth curve determination: Using spectrophotometer.
- Antibiotic susceptibility testing: Kirby-Bauer method.
- Bacterial motility tests: Hanging drop, semi-solid media.
- IMViC tests for coliforms.
- Isolation of soil microorganisms (actinomycetes, fungi, bacteria).
- Analysis of microbial diversity in soil via serial dilution and CFU count.

- Effect of pH and temperature on bacterial growth.

BT305: Engineering Thermodynamics

- Verification of First Law using calorimetry.
- Determination of enthalpy and specific heat of substances.
- Study of steam tables and Mollier charts.
- Simulation of bioreactor energy balances using MATLAB/Excel.
- Entropy calculation in ideal gases and real processes.
- Efficiency evaluation of an actual Rankine cycle (via simulation or lab models).
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