**RASHTRASANT TUKADOJI MAHARAJ NAGPUR UNIVERSITY, NAGPUR**

'Established by Government of Central Provinces Education Department by Notification No. 513, dated the 1st of August, 1923 & presently a State University governed by Maharashtra Public Universities Act, 2016 ( Mah. Act No VI of 2017)

**(Academic Section)**

**Jamnalal Bajaj Administrative Building, Campus Square to Ambazari T-Point Road, Nagpur-33.**

No. Acad/22/457 Date: 23/08/2022

# NOTIFICATION

It is notified for general information of all concerned that the Hon'ble Vice Chancellor has approved the recommendation of the Board of Studies in Bio-Technology in its emergent meeting held on 19/08/2022, under section 12(7) of Maharashtra Public Universities Act, 2016 on behalf of Faculty of Science & Technology and Academic Council, regarding the new syllabus for 5th & 6th semester will come to effect from the session **2022-2023** and onwards (Phase wise).

**Note:- Above Examination Scheme is available on, RashtrasantTukadoji Maharaj Nagpur University website (www.nagpuruniversity.ac.in)**

**(Dr. Raju Hiwase)**
**Registrar**

**Copy forwarded for information and necessary action to:-**

1. The Principal, All Engineering Colleges affiliated to R. T. M. Nagpur University, Nagpur.
2. The Dean/Associate Dean, Faculty of Science& Technology, R. T. M. Nagpur University, Nagpur.
3. The Chairman, Board of Studies in Bio-Technology, R. T. M. Nagpur University, Nagpur.
4. The Director Board of Examination & Evaluation, R. T. M. Nagpur University, Nagpur.
5. The Deputy Registrar (Examinations/Coll. Sec./V.C Office) R. T. M. Nagpur University, Nagpur.
6. The Asstt. Registrar (Exam/Prof. Exam./Conf./Exams & Enquiry & Ordinance Section), R. T. M. Nagpur University, Nagpur.
7. The Officer-in-Charge, Publication Section, R. T. M. Nagpur University, Nagpur.
8. The P. A. to the Hon'ble Pro-Vice-Chancellor, R. T. M. Nagpur University, Nagpur.
9. The P. A. to the Registar, Nagpur, R. T. M. Nagpur University, Nagpur.
10. Dr. Prashant Maheshwary, Dean Faculty of Science& Technology and Director, Multi-Facility Computer Centre, R. T. M. Nagpur University, Nagpur.

**(Dr. Rajendra Utkhede)**
**Deputy Registrar (Acad.)**

# Syllabus for Fifth Semester UG degree in

# B.Tech.Biotechnology

## Submitted to

## RTMNU, Nagpur

**By**

**Board of B.Tech.Biotechnology**

**Science and Technology,**
**R.T.M. Nagpur University, Nagpur.**
**Syllabus for B.Tech. Biotechnology**
**(Fifth Semester)**

## Subject: Entrepreneurship and Startups (BT-HS-501T)

Total credits: 02
Teaching Scheme:
Lectures: 1 Hour/Week
Tutorial: 1 Hour/Week

Examination Scheme:
Duration of Paper: 02 Hours
University Assessment: 35Marks
College Assessment: 15 Marks

**Course Objective(s):** The objective of the course is to create awareness among learners about the various essential aspects of entrepreneurship development and the idea of startup.

## Course Contents:

**Unit 1: Concept of Entrepreneurship**
Concept of entrepreneurship, characteristics of an Entrepreneur, types of Entrepreneurship, Functions of Entrepreneurs, Women entrepreneurship in India, Problems and challenges of women entrepreneurs, Government's support system to develop women entrepreneurship.

**Unit 2: Concept of start up**
Concept of startup, Types of startups: Scalable startup, small business startup, lifestyle startup, buyable startup, social startup, big business startup, Startup ecosystem.

**Unit 3: Concept of Ideation**
Concept of ideation, ideation process, idea incubation, design thinking approach, ideation techniques (brainstorming, sketching, SCAMPER, and prototyping), success factors for ideation.

**Unit 4: Funding for Start up**
Funding for startups, angel funding, venture funding, difference between angel and venture funding, private equity fund, ownership of startups, causes of startups failures, Startup success case studies: Instagram, LinkedIn, Snapchat, WhatsApp.

## Text Books/References:


1.Entrepreneurial Development By, S. S. Khanka S. Chand & Co. Ltd. New Delhi, 1999.
2.Entrepreneurial Development. By, S.Anil Kumar. New Age International.
3.Small- Scale Industries and Entrepreneurship, By, Dr. Vasant Desai, Himalaya Publication.
4.Management of Entrepreneurship. By, N.V.R. Naidu, I.K. International Pvt Ltd.
5.Trajectory: Start up: Ideation to Product/Market Fit by Dave Parker, Matt Holt Books
6. Your First Startup: Speaking Entrepreneurship by Raman Bansal, BFC Publications
7.Funding Your Startup By Dhruv Nath, Penguin Books India PVT, Limited 2020


Confirmed
19/8/22

**Course Outcomes:** By the end of the course, students will be able to :
**CO1:** Acquire a know-how on entrepreneurship development
**CO2:** Get the knowledge of various types of startups
**CO3:** Understand the concept of ideation
**CO4:** Know the funding for startups

## Subject: Immunology & Immunotechnology (BT-PC- 502 T)

Total credits: 03
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s): Course Objective(s):** This course will introduce the students with basic principles of immunology and recent advancements in the field of adaptive immunity. It gives students the opportunity to develop a grounded knowledge base in the biology underlying infection and the immune system, its relevance to diverse disease processes and the application of immunological techniques to the broader field of Biomedical Science.

**Course Contents:**

**Unit 1:** Introduction, innate and acquired immunity, active and passive immunity. Introduction to cells (T & B lymphocytes, NK cells, mast cells, dendritic cells) and organs of immune system –Primary and secondary (bone marrow, thymus, lymph nodes, CALT and MALT).Structure of antigens and antibody. Antigens – classification, isotypes, functions and diversity. Antibody – structure, functions, types, monoclonal and polyclonal antibody, Major histocompatibility complex

**Unit 2:** B and T cell receptors- cytokines and their biological role, T-cell development, negative/positive selection, TCR rearrangement, co-stimulatory molecules brief idea about antigen processing and presentation. Humoral and cell mediated immune response. Complement system:-concept of activation, classical and alternative pathway.

**Unit 3:** Immunology Techniques-Antigen-antibody interaction, precipitin reaction, agglutination, immuno-diffusion. Immunoassay techniques-Immuno-electrophoresis, ELISA, RIA, Immunochemistry, immunofluorescence, Flow Cytometry. Blood group determination.

**Unit 4:** Vaccines-Active and passive immunization; Live, killed, attenuated, subunit vaccines; Vaccine technology-. Design of recombinant antibodies, recombinant vector vaccines, synthetic peptide vaccines and subunit vaccines, DNA vaccines. Antibody engineering- Commercial production of polyclonal and monoclonal antibodies, Chimeric antibody, humanized antibody. Methods of preparation, their clinical applications and applications in Research and development.

**Unit 5:** Hypersensitivity- Types, Immunotherapy Transplantation Immunology:- Types of graft, mechanism of graft rejection, prevention of graft rejection, Tumor immunology:- Tumor Associated antigens and Tumor Specific Antigens.

**Text Books/References:**


1. Immunology Kuby, R.A. Goldsby, T.J. Kind 1997, 4th Edition B.A. Osborne.
2. Essential of immunology Ivan Riot-Blackwell 1997, 4th Edition B.A. Osborne
3. Fundamentals of Immunology Paul W.E. (Eds.) 1998 Raven press, New York.
4. William, R. Clark The Experimental Foundations of Modern Immunology (1991)(4th Edition) John Wiley and Sons, New York.
5. Principles of Immunology by Dr.N.V.Shastri, Himalaya Publication.
6. Principles of Microbiology and Immunology by Harper and Row
7. Immunology Introduction text book by Nandini Shetty, New age international limited publishers.


**Course Outcomes:** After completing the course, the students will be able to:

**CO1:** Define, understand the structure and function of molecules, cells and organs of the immune system. Distinguish between innate and acquired Immunity. Recognizes significance of foreign,self and nonself, understand structure of antigen ,antibodies and molecular basis of immune response.

**CO2:** Describe cell mediated and antibody-mediated immunity and role of complement proteins in defense mechanism.

**CO3:** Learn different serological techniques such as agglutination, precipitation, immunoelectrophoresis RIA, ELISA routinely used in clinical analysis and diagnosis

**CO4:** Classify vaccines and learn the techniques of design of different vaccines ,monoclonal antibody productions and their applications in research.

**CO5:** Summarize and understand types of hypersensitivity reactions, Immune tolerance and mechanism of graft rejection including tumor immunology.

## Subject: Genetic Engineering and rDNA Technology (BT-PC- 503 T)

Total credits: 03

Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** The advancement of recombinant DNA technology adds a new dimension to life science and provides a powerful tool for genetic engineering. This course is to acquaint the students with versatile tools and techniques of various modification enzymes, cloning vectors, methods for gene cloning, protein engineering and genetically modified organisms and associated methods to serve in research and industry.

## Course Contents:

**Unit 1:**Modification enzymes (all enzymes necessary for genetic engineering) and their use in recombinant DNA technology, DNA markers, Marker Assisted Selection and its application.

**Unit 2:** Concept of recombinant DNA Technology, vectors – plasmids, bacteriophages, phagemids, cosmids, Yeast artificial chromosomes. T-DNA. Purification of recombinant protein.

**Unit 3:** Concept of gene cloning and cDNA synthesis. cDNA and Genomic Library construction and screening. Methods for gene transfer (Indirect and Direct ).

**Unit 4:** Site directed mutagenesis, Protein Engineering, Ames mutagenicity test.

**Unit 5:** Application of genetically modified organisms (Agriculture, Pharmaceuticals, and fermentation industries) Environmental release of GMOs- risk analysis and assessment.

## Text Books/References:


1. Gene Cloning :-T.A. Brown 4th Ed Print 2001.
2. Gene VII:- Benzamin Lewin Oxford University Press.1st Ed.Print 2003
3. From genes to Clones:- Winacker 1st Ed..Panima Publishing Corp. Print 2003
4. An Introduction to Genetic Engineering, Desmond S. T. Nicholl, Cambridge university press,3 Edition
5. Gene manipulation:-Old and Primrose. Blackwell Science prints 2001.
6. Genetic Engineering by S.Rastogi and N.Pathak. Oxford University Press 2009.
7. B. R. Glick., et al. Molecular Biotechnology: Principles & Applications of Recombinant DNA (ASM Press, ed. 4, 2009)


**Course Outcomes:**At the end of the course the student will be able to:

**CO1:** Understand the uses of modification enzymes. Explain the different DNA fingerprinting techniques and its application in Marker assisted selection.

**CO2:** Summarize the r-DNA technology

**CO3:** Analyze various concepts and methods for gene cloning.

**CO4:** Identify problems associated with Protein Engineering and protein purification

**CO5:** Construct GMOs and apply it for problem solving.

## Subject: Fluid Mechanics and Solid Handling (BT-PC- 504 T)

Total credits: 03
Teaching Scheme:
Lectures: 2 Hours/Week
Tutorial: 1 Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** This subject is a combination of fluid mechanics and mechanical operations. The objectives are to introduce students to the fundamentals of fluid mechanics, measurement of fluid flow with flow measuring devices and detailed ideas about transportation of fluids. To make aware about solid handling techniques such as size reduction, filtration, mixing etc.

### Course Contents:

**Unit 1:** Nature of Fluid and Fluid Flow. Mechanism of non-compressible fluid flow, Rheological properties of fermentations broths. Continuity equation, Bernoulli equation, Reynold's number, frictional losses in pipe line.

**Unit 2:** Measurement of Fluid flow, Orifice meter and Venturi meters, Pitot tube, Rotameter, Notches and weirs.

**Unit 3:** Pumps: Classification and selection of pumps, Positive displacement pumps and centrifugal pumps

**Unit 4:** Size reduction and Separation- Properties of solids, size reduction, types of equipment, power requirements, laws of crushing and grinding, open and closed-circuit grinding.

**Unit 5:** Filtration: Theories of filtration and washing, constant rate and constant pressure filtration, optimum cycle, handling of compressible cake and use of filter aids.

Mixing in bioreactors: Fundamentals of mixing and characteristics of mixing equipment, power consumption and efficiencies.

### Text Books/References:


1. Introduction to Chemical Engineering by Badger and Banchero, McGraw Hills International Students Edition.
2. Unit Operations in Chemical Engineering by McCabe and Smith, McGraw Hill
3. Unit Operations by Brown, John Wiley and Sons Inc. New York.
4. Chemical Engineering by Coulson and Richardson, Vol. I and II, Pergamon Press, New York.
5. M. White, Fluid Mechanics, 8 th Edition, Tata-McGraw Hill, 2016.
6. R.P. Vyas, Fluid Mechanics , Second Edition, Dennett & Co. Publication, 2008
7. R.K. Bansal, Fluid Mechanics and Hydraulic Machines. Laxmi Publication.


**Course Outcomes:** At the end of the course, students will be able to:

**CO1:** Understand the knowledge of fundamental concepts of fluid and fluid flow, and distinguish the types of flows.

**CO2:** Understand and apply the flow measurement devices by their operation and applications.
**CO3:** Apply principles of fluid mechanics to the operation, and selection of fluid machinery such as pumps.
**CO4:** Review the practical importance and relevance of unit operations used for crushing, grinding and size separation.
**CO5:** Understand filtration theory, equipment for filtration, operation etc. and to analyze mixing processes.

## Subject: Professional Elective-I (BT-PE-505i T)

## Big Data Analytics

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** This subject will help the students for organized harness their data and use it to identify new opportunities. That, in turn, leads to smarter business moves, more efficient operations, higher profits and happier customers using big data analytics.

### Course Contents:

**Unit 1: Introduction to Big Data**: Types of Digital Data-Characteristics of Data – Evolution of Big Data – Definition of Big Data – Challenges with Big Data – 5 Vs of Big Data, Big data Technology Components, Big data importance and its application, Big data features- security, compliance, auditing and protection, Big data privacy and ethics, Big data analytics, analytics processes and tools, modern analytics tools

**Unit 2: Hadoop**: History of Hadoop, Apache Hadoop, the Hadoop distributed file system, Components of Hadoop, data format, analyzing data with Hadoop, scaling out, Hadoop streaming, Hadoop pipes, Hadoop Echo System, Application development in Hadoop, Getting your database in Hadoop

**Unit 3: MapReduce**: MapReduce framework and basics, how map reduce works, developing a map reduce application, unit test with MR unit, test data and local test, MapReduce types, input format, output formats, MapReduce features, Real world map reduce.

**Unit 4: HDFS ( Hadoop Distributed file system)** : Design of HDFS, HDFS Concepts, benefits and challenges, files sizes, block sizes and block abstraction in HDFS, data replication, how does HDFS store, read and write files, java interfaces to HDFS, command line interface, Hadoop file system interface, data flow, data ingest with flame and scoop, Hadoop archives.

**Unit 5: Hadoop Environment**: Setting up a Hadoop cluster, Cluster specification, cluster setup and installation, Hadoop configuration, security in Hadoop, administering Hadoop, HDFS monitoring and maintenance, Hadoop benchmarks, Hadoop in the cloud. Hadoop Ecosystem and YARN: Hadoop ecosystem components, scheduler fair and capacity, Hadoop 2.0 new features- Name Node high availability, HDFS federation, MRv2, YARN, Running MRv1 in YARN

**Text Books/References:**


1. Seema Acharya, Subhashini Chellappan, "Big Data and Analytics", Wiley Publication, 2015.
2. Michael Minelli, Michelle Chambers and Ambiga Dhiraj, " Big data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Business", Wiley


**Course Outcomes:** At the end of the course, students will be able to:

**CO1:**Understand , identify big data and its business implications.

**CO2:**Analyze scalability and performance of Hadoop system

**CO3:**Apply MapReduce programming model to access and process data on distributed file systems.

**CO4:**Understand the capability of HDFS(Hadoop Distributed file system)

**CO5:**Manage Job execution in the Hadoop environment and develop big data solutions by applying Hadoop Eco system Components.

## Subject: Professional Elective-I (BT-PE-505ii T)
## Advanced Bioprocess Control

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):**To introduce students about different control systems and explain their application of controllers to various systems which is extensively used in industry and enables mass production of continuous processesindustries. Process control enables automation, with which a small staff of operating personnel can operate a complex process from a central control room.

**Course Contents:**

**Unit 1:** Transient response of the first and second order systems. Time constant, damping coefficient. Transfer function for liquid level and mixing processes. Linearization. Response of the first order systems in series. Transfer function and transient response of interacting and non-interacting systems. Transportation lag.

**Unit 2:** Linear closed loop systems. Bio-chemical reactor control system. Block diagram, pneumatic and electronic controllers and final control elements. Choice of controllers, stabilization time, characteristics of proportional integral and derivative control modes.

**Unit 3:** Concept of stability for linear systems. Routh criteria, root locus diagram for positive and negative feedback systems.

**Unit 4:** Control systems design by frequency response method. Gain and phase margins. Ziegler-Nichols controller settings.

**Unit 5:** Instrumentation : Measurement of temperature- Expansion Thermometer, resistance temperature detectors (RTD), Thermistor, Thermocouple, Measurement of pressure and vacuum, Measurement of head and level, Composition Analysis.

**Text Books/References:**


1. Process Systems analysis and control coughanowr and Koppel.
2. Process Control: Peter Harriot, Tata Mc-Graw Hill Publication.
3. Process Dynamics and Control, D.Edgar, 2nd Edition Wiley Publication.
4. Chemical Process Control-George Stephanopoulos, PTR Prentice hall
5. Process Control and Instrumentation- R.P.Vyas, Dennet& Co.2010


**Course Outcomes:** On successful completion of the course the students will be able to

**CO1:** To understand the order of control systems as a means of conveniently representing process control systems.

**CO2**: Establish and apply to represent control systems over biological processes and develop the block diagram of the control system.

**CO3**: Apply the concept of Concept of stability for linear systems.

**CO4**: Study and design the basic knowledge of frequency analysis.

**CO5**: Develop an ability to understand the measurement of parameters by various instrumentation that is applicable to biochemical industries.

## Subject: Professional Elective-I (BT -PE – 505iii T)
## Biosimilars Technology

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To introduce the design and development of different kinds of biosimilars compounds and their application. Further, the course will introduce the regulatory framework for Biosimilars.

## Course Contents:

**Unit-1: Introduction to Biopharma**

Generics in Biopharma, definition of biologics, biosimilars, differences between chemical genetics and biosimilars, developmental and regulatory challenges in biosimilar development, Prerequisites for Biosimilar development.

**Unit -2: Types of Biosimilar drugs**

Proteins, Enzymes, Vaccines, Nucleic acid based therapies (DNA, RNA, etc.), Cell based therapies (including stem cells), Biosimilar market potential, Introduction to "Orange book" & "Purple book".

**Unit-3: Characterization of Biosimilars**

Aggregation-precipitation, floccule strength, precipitate aging & kinetics, adsorption of proteins & peptides on surfaces, hydration & thermal stability of proteins; analytical characterization of proteins.

**Unit-4: Bioequivalence studies**

Immunogenicity & allergenicity of biosimilars; post-translational modifications, formulations, impurities, types of bioequivalence (average, population, individual), experimental designs for bioequivalence studies.

**Unit -5: Case studies**

Products - Erythropoietin, Insulin, Somatotropin, Factor VIIa, Factor IX, Factor VIII, interferons, streptokinase, monoclonal antibodies.

## Text Books/References:


1. Niazi, Sarfaraz K. "Handbook of Biogeneric Therapeutic Proteins: Regulatory,Manufacturing, Testing, and Patent Issues". CRC Press, 2006
2. Laszlo Endrenyi, Paul Declerck and Shein-Chung Chow, Biosimilar Drug Development,Drugs and Pharmaceutical Sciences, Vol 216, CRC Press.
3. Cheng Liu and K. John Morrow Jr., Biosimilars of Monoclonal Antibodies: A Practical Guide to Manufacturing, Preclinical and Clinical Development. Wiley, Dec 2016.


**Course Outcomes:** At the end of the course, students would be able to:

**CO 1.** Demonstrate appropriate depth and breadth of knowledge in Biologics.

**CO 2.** Describe principles of the formulation of biological products and requirements for FDA approval of biologics.

**CO 3.** Understand the concept and characteristics of biologics, biosimilars, and bioequivalence.

**CO 4.** Recognize the process and approaches for evaluation of biologics safety components.

**CO 5.** Apply knowledge to identify problems and justify solutions in case study with biologics

## Subject: Open Subject-I (BT-OS–506i T)
## 3D Printing & Design

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1 Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** The course is designed to impart knowledge and skills related to 3D printing technologies, selection of material and equipment and develop a product using this technique in the Industry 4.0 environment.

### Course Contents:

**Unit 1:** 3D Printing (Additive Manufacturing) & CAD for Additive Manufacturing Introduction, Process, Classification, Advantages, Additive V/s Conventional. Manufacturing processes, Applications.CAD Data formats, Data translation, Data loss, STL format.

**Unit 2:** Additive Manufacturing Techniques Stereo- Lithography, LOM, FDM, SLS, SLM, Binder Jet technology.Process, Process parameter, Process Selection for various applications. Additive Manufacturing Application Domains: Aerospace, Electronics, Health Care, Defense, Automotive, Construction, Food Processing, Machine Tools.

**Unit 3:** Materials Polymers, Metals, Non-Metals, Ceramics Various forms of raw material-Liquid, Solid, Wire, Powder; Powder Preparation and their desired properties, Polymers and their properties.Support Materials

**Unit 4:** Additive Manufacturing Equipment Process Equipment, Design and process parameters. Governing Bonding Mechanism Common faults and troubleshooting Process Design

**Unit 5:** Post Processing: Requirement and Techniques & Product Quality Inspection and testing Defects and their causes.

### Text Books/References:


1. Sabrie Soloman, "3D Printing and Design", Khanna Publishing House, Delhi.
2. Lan Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2010.
3. Andreas Gebhardt, "Understanding Additive Manufacturing: Rapid Prototyping, Rapid Tooling, Rapid Manufacturing", Hanser Publisher, 2011.
4. CK Chua, Kah Fai Leong, "3D Printing and Rapid Prototyping- Principles and Applications", World Scientific, 2017.
5. J.D. Majumdar and I. Manna, "Laser-Assisted Fabrication of Materials", Springer Series in Material Science, 2013.

6. L. Lu, J. Fuh and Y.S. Wong, "Laser-Induced Materials and Processes for Rapid Prototyping", Kluwer Academic Press, 2001.
7. Zhiqiang Fan and Frank Liou, "Numerical Modeling of the Additive Manufacturing (AM) Processes of Titanium Alloy", InTech, 2012.

**Course Outcomes:** After completion of this course, the students will be able to:
**CO1:** Develop CAD models for 3D printing.
**CO2:** Import and Export CAD data and generate .stl file.
**CO3**: Select a specific material for the given application.
**CO4**: Select a 3D printing process for an application.
**CO5**: Produce a product using 3D Printing or Additive Manufacturing (AM).

## Subject: Open Subject-I (BT-OS–506ii T)

### Internet of Things

Total credits: 04

Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1 Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** The objective of this course is to impart necessary and practical knowledge of components of the Internet of Things and develop the skills required to build real-life IoT based projects.

**Course Contents:**

**Unit 1:** Introduction to IoT Architectural Overview, Design principles and needed capabilities, IoT Applications, Sensing, Actuation, Basics of Networking, M2M and IoT Technology FundamentalsDevices and gateways.

**Unit 2**: Data management, Business processes in IoT, Everything as a Service(XaaS), Role of Cloud in IoT, Security aspects in IoT.

**Unit 3**: Elements of IoT Hardware Components- Computing (Arduino, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces. Software Components- Programming API's (using Python/Node.js/Arduino) for Communication Protocols-MQTT, ZigBee, Bluetooth, CoAP, UDP, TCP.

**Unit 4:** IoT Application Development Solution framework for IoT applications-Implementation of Device integration, Data acquisition and integration, Device data storage-Unstructured data storage on cloud/local server, Authentication, authorization of devices.

**Unit 5:** IoT Case Studies IoT case studies and mini projects based on Industrial automation, Transportation, Agriculture, Healthcare, Home Automation.

**Text Books/References:**


1. Vijay Madisetti, Arshdeep Bahga, Ïnternet of Things, "A Hands on Approach", University Press
2. Jeeva Jose, "Internet of Things", Khanna Publishing House, New Delhi, 2018.
3. Dr. SRN Reddy, Rachit Thukral and Manasi Mishra, "Introduction to Internet of Things: A practical Approach", ETI Labs
4. Pethuru Raj and Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press
5. Adrian McEwen, "Designing the Internet of Things", Wiley
6. Raj Kamal, "Internet of Things: Architecture and Design", McGraw Hill
7. Cuno Pfister, "Getting Started with the Internet of Things", O Reilly Media


**Course Outcomes:** After the completion of this course, the students will be able to:

**CO1**: Understand the Internet of Things
**CO2**: Understand the hardware and software components.
**CO3**: Interface I/O devices, sensors & communication modules.
**CO4**: Remotely monitor data and control devices.
**CO5**: Develop real life IoT based projects.

## Subject: Open Subject-I (BT-OS-506iii T)
## Cheminformatics & Medicinal Chemistry

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1 Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To introduce the small molecule ligand-oriented *in-silico* Physicochemical aspects of rational drug design with and without known macromolecules, assessing activity and toxicity and drug ability.

**Course Contents:**

**Unit 1: Chemistry & Information technology:** Definition and History of Cheminformatics,Overview of Rational Drug Design, Ligands and Targets, *in*-silico representation of chemical information. Stereochemistry and mechanism, coordination chemistry for drug design.

**Unit 2: Chemical Databases:** Data Mining, Chemical/biochemical data collation, retrieval, analysis & interpretation. Data Pre-processing methods-Normalization, Standardization, Correlation, Cross-correlation, Feature selection, Outlier detection.

**Unit3: Organic Synthesis and In-silico drug design (Modeling) Techniques:** Organic reaction mechanism, Logic in organic synthesis, chemistry of drug action, Structure and Ligand based

drug design approaches, Virtual Screening Techniques- Drug likeness screening rules, Similarity based methods and Pharmacophore based screening.

**Unit4: Computer-aided formulation development:** Pharmaceutical Preformulation, Optimization parameters, Factorial design, Optimization technology &Screening design. Solid State Pharmaceutics.Simulation methods for molecules and materials like Molecular Docking and Molecular Dynamics.

**Unit 5: Chemical data science:** QSAR modeling techniques- Hansch analysis, Free Wilson analysis, Multiple Linear Regression, Partial Least Squares, Discriminant Analysis, Cluster Analysis, Artificial intelligence in chemistry, ADMET properties in drug screening.

## Text Books/References:


1. Muthukumarasamy Karthikeyan and Renu Vyas. Practical chemoinformatics. Springer,soft-cover ISBN 9788132234913, 2014.
2. Silverman, Richard B., and Mark W. Holladay. The organic chemistry of drug design and drug action. Academic Press, 2014.
3. Bajorath, Jurgen. Chemoinformatics for Drug Discovery. John Wiley & Sons, 2013.
4. Cramer, C.J., Essentials of Computational Chemistry, 2nd Ed., John Wiley & Sons Ltd., 2004.
5. Essentials of Foye's Principles of Medicinal Chemistry – 2016.
6. Medicinal Chemistry by Ashutosh Kar.
7. Drug Design Volumes by Arienes, Academic Press, Elsevier Publishers, Noida, Uttar Pradesh.
8. Computational and structural approaches to drug design edited by Robert M Stroud and Janet. F Moore.


**Course Outcomes:** At the end of the course, student would be able to

**CO1:** Understand the concept and characteristics of chemical components to design drug molecules.

**CO2:** Knowing how to use chemical databases for silico based drug design.

**CO3:** Describe the structure of molecules to predict physicochemical features and action of molecules.

**CO4:** Apply knowledge to design molecule which are relevant to the process of drug discovery

**CO5:** Recognize the process and approaches for chemical data based information and evaluate to predict biological activity of compounds.

## Subject: Open Subject-I (BT-OS-506iv T)
## Biomaterials

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To introduce students to various types of available biomaterials, their chemistry, and application. This will help the student in gaining the insight about the various materials and to develop their application in the medicinal field.

### Course Contents:

**Unit 1:** Introduction: Definition of biomaterials, requirements & classification of biomaterials,Comparison of properties of some common biomaterials. Effects of physiological fluid on the properties of biomaterials. Biological responses (extra and intra-vascular system). Surface properties of materials, physical properties of materials, mechanical properties.

**Unit 2:** Metallic implant materials: Stainless steel, Co-based alloys, Ti and Ti-based alloys. Importance of stress-corrosion cracking. Host tissue reaction with bio metal, corrosion behavior and the importance of passive films for tissue adhesion. Hard tissue replacement implant, Soft tissue replacement implants.

**Unit 3:** Ceramics and glasses-bio ceramics: Type of Ceramics and their classification, Calcinations, Annealing, Sintering, nearly inert ceramics, bio-reactive glasses and glass ceramics, Calcium phosphate ceramics. Composite implant materials: Mechanics of improvement of properties by incorporating different elements. Composite theory of fiber reinforcement (short and long fibers, fibers pull out)

**Unit 4:** Introductions to polymers: Definition, classification, Polymerization and structure-properties relationship. Biodegradable polymers; Natural polymers, Composites, Pyrolytic carbon, Carbon nanotubes: Bulk Properties, Surface properties and modification of surface properties. Basic principles, methods and applications common manufacturing processes of polymers, Concept of biomimetic synthesis.

**Unit 5:** Biocompatibility & Toxicological screening of biomaterials: Definition of biocompatibility, blood compatibility and tissue compatibility. Toxicity tests: acute and chronic toxicity studies (in situ implantation, tissue culture, haemolysis, thrombogenic potential test, systemic toxicity, intracutaneous irritation test).

### Text Books/References:

1. Biomaterials Science - An Introduction to Materials in Medicine, Buddy Ratner Allan Hoffman Frederick Schoen Jack Lemons, ISBN: 9780080470368, Academic Press, Published Date: 18th August 2004.

2. Biomaterials: An Introduction- J. B. Park.
3. Materials Science and Engineering- Callister.
4. Materials for Medical Engineering- Euromat 99 vol-2.
5. Biomaterials - Temenoff and Mikos (Pearson Prentice Hall; ISBN 0-13-009710-1)

**Course Outcomes:**

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

**CO1**: Analyze different types of Biomaterials and its classification and apply the concept of nanotechnology towards biomaterials use.

**CO2**: Identify significant gap required to overcome challenges and further development in metallic and ceramic materials

**CO3**: Identify significant gap required to overcome challenges and further development in polymeric materials

**CO4**: Create combinations of materials that could be used as a tissue replacement implant.

**CO5**: Evaluate the testing standards applied for biomaterials.

## Subject: Open Subject-I (BT-OS-506v T)
## Green Economy and Sustainability

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To provide students with the concepts of green economy at societal, regional and national level, along with the international sphere and transition towards greener economy. This will allow effective application of knowledge in practical activities -in order to teach, encourage society to undertake new pro-ecological activities and strategies for green business in different sectors.

**Course Contents:**

**Unit 1:** Introduction to Green & Transition Economy: Overview of green economy with global and regional environment challenges, Economic opportunities for integrating the environment into new economic concept, Introduction to Elements of sustainable development, Identify the key conditions for transition to green economy and effective policy implementation, Policy tools that enable green economy transition, Market based tools to facilitate the green economy transition.

**Unit 2:** Greening the economy: sectors and strategies: Identify the issues related to five key economic sectors, Enabling conditions required for transition to green economy in these sectors, Sector specific approach to move towards green economy.

**Unit 3:** Strategies and planning for reaching green economy policy objectives: Illustrate the role of diverse stakeholders in a green transition, Identify approaches for ensuring a participatory process, Examples of national strategies and planning, Green economy - legal regulations

**Unit 4:** International Development and support to green economy: Describe major international frameworks guiding efforts towards inclusive green economies, highlight green economy efforts from development finance institutions, Outline supporting initiatives at global and regional levels.

**Unit 5:** Progress towards Green economy: Indicators to track progress towards social, economic and environmental outcomes of green economy, Green economy indicators to links to post 2015 development agenda and new sustainable development goals, The SWITCH to green initiative and Green flagship initiative, Inclusive green economy initiatives around the world.

## Text Books/References:


1. M Mustafa erdoğdu, thankom arun and Imran habib ahmad, Handbook of research on green economic development initiatives and strategies, 13: 9781522504405
2. A guidebook to the green economy, Division for sustainable development, UNDESA
3. Joel Makower (Author), Cara Pike(Afterword), Strategies for the Green Economy: Opportunities and Challenges in the New World of Business 1st Edition, McGraw- Hill; 1 edition), (October 1, 2008), 978-0071600309
4. Edward b. Barbier and anil markandya, A new blueprint for a green economy, Dorrance publishing, 978-1-84971349-8(hbk)


**Course Outcomes:** At the end of the course, the student should be able to:

**CO1**: Understand the concept of a green economy as well as sustainable development from the perspective of economy.

**CO2**: Learn sector specific approach towards green economy.

**CO3**: Illustrates the roles of different stakeholders for sustainable development (policy makers, enterprises, consumers, etc.) and relevant planning processes in support of a green transformation.

**CO4**: Identify the range of international, national and regional green initiatives and support services to foster green development.

**CO5**: Apply the concept of green economy indicators to a real and practical world and learn new flagship programs.

## Subject: Indian Constitution (BT-AU-507 T)

Total credits: Audit
Teaching Scheme:
Lectures: 2 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: NIL
College Assessment: 50 Marks

**Course Objective**: To create an understanding of the Indian Constitution and develop respect for the same.To createawareness of India as a State Indian culture and Tradition.

### Course Content:

**Unit 1:** Concept of Culture and Civilization,Vedic Civilization and Indus Valley Civilization,Introduction to Vedas, Ashram system, Varna System&Concept of Social Engineering

**Unit 2:** Meaning and Scope of Industrial Psychology and Industrial Sociology. Recruitment, Selection and Training of Workers, Fatigue in industry.Motives for work in industry

**Unit 3:** Sustainable Development, Social change, Professional Ethics &Concept and styles of Leadership in Industry

**Unit 4:** Indian Constitution and Federal System, Fundamental Rights and Directive Principles of State Policy &Role of Bureaucracy in Modern Society

**Unit 5:** Industrial Democracy, Works Organization: Formal and Informal Organization, Concept of Power, Authority and Status system; Industrialization, Urbanization and Study of Slums in India

### Text Books/References:


1. A New Look into Social Sciences- Shabbir, Sheik and Dwadashiwar
2. An Introduction to Sociology- Vidya Bhushan and Sachdeva
3. Social Science: The Indian Scene-Yogesh Atal
4. Applied Humanities-Rajni Tandon
5. A History of World Civilizations-J.E.Swain
6. Industrial Psychology-Haire Mason
7. Introduction to Constitution of India- Durga Das Basu
8. Industrial Sociology in India-N.R.Seth
9. Human Resource Development and Management- Dr.A.M.Sheikh
10. The Economics of Sustainable Development-Surender Kumar


**Course Outcomes:** At the end of the course, the student should be able to:

**CO1:** Become aware of Indian culture and civilization and their role in the development of society.

**CO2**: Understand Industrial work-culture.

**CO3**: Sensitized towards professional ethics.

**CO4**: Understand the Indian Constitution and governance of the country.

**CO5**: Understand the structure and system of work organizations.

## PRATICALS

### Subject: Immunology &Immunotechnology Laboratory (BT-PC-508 P)

Total credits: 1.5
Teaching Scheme:
Practical: 3 Hours/Week

Examination Scheme:
Duration of Examination: 06 Hours
University Assessment: 25 Marks
College Assessment: 25 Marks

**List of Experiments:**

1. Experiments based on Ouchterlony Double Diffusion (ODD) for antigen-antibody pattern.
2. Radial Immunodiffusion (RID).
3. Immunoelectrophoresis.
4. Rocket Immunoelectrophoresis (RIEP).
5. Latex Agglutination.
6. Use a commercially available immune diagnostic strip tests
7. Demonstration of ELISA
8. Western blotting technique of proteins

### Subject: Genetics& rDNA Technology Laboratory (BT-PC-509 P)

Total credits: 1.5
Teaching Scheme:
Practical: 3 Hours/Week

Examination Scheme:
Duration of Examination: 06 Hours
University Assessment: 25 Marks
College Assessment: 25 Marks

**List of Experiments:**

1. Isolation of the plasmid from bacterial culture
2. Preparation of competent cells
3. Transformation of the selected plasmid
4. Selection of transformed E. coli and validation of cloning
5. PCR amplification
6. Ligation of DNA fragment with cloning vector
7. DNA fingerprinting

# Syllabus for Sixth Semester UG degree in

# B.Tech.Biotechnology

## Submitted to

## RTMNU, Nagpur

By
Board of B.Tech.Biotechnology

**Science and Technology,**
**R.T.M. Nagpur University, Nagpur.**
**Syllabus for B.Tech. Biotechnology**
**(Sixth Semester)**

## Subject: Bioseparation Engineering (BT-PC- 601 T)

Total credits: 03
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To impart basic undergraduate level knowledge in the area of separation technologies for the biomolecules, it also be able to assimilate recent research findings, advancement and development in the separation of bioproducts.

## Course Contents:

**Unit-1: Introduction to Bioseparation**

Introduction to separation of biomolecules and its importance in Biotechnology, Range and characteristics of bioproducts, Economic importance of Bioseparation, Characteristics of Fermentation Broths, Stages of Downstream Processing.

**Unit -2: Cell Disruption and Withdrawal of insoluble**

Different methods of cell disruption for the release of cellular products: Physical, chemical, enzymes and mechanical methods. Removal of insoluble solutes: Pre-treatments of fermentation broths. Microfiltration and Centrifugation.

**Unit-3: Concentration of Bioproducts**

Extraction of low molecular weight and high molecular weight bioproducts. Extraction of biomolecules by liquid–liquid, aqueous two-phase, reverse micellar, and supercritical fluid extraction. Precipitation techniques using salt and solvent.

**Unit-4: Purification process**

Membrane separation: Basic principles and advantages, Modes of operation, Pressure-driven processes (MF, UF, NF & RO), Concentration-driven by Pervaporation. Chromatographic separation: Ion exchange, affinity, size exclusion chromatography.

**Unit -5: Finishing process**

Lyophilization and product formulation: Freeze drying, spray drying. Excipients: thickeners, surface agents, preservatives, colorings and flavorings. Dosage forms.

**Text Books/References:**


1. 1. Raja Ghosh (2006) Principles of Bioseparation engineering, World Scientific Publishing Co Pte Ltd
2. 2. Ladisch, M.R., "Bioseparations Engineering: Principles, Practice, and Economics", Wiley-Interscience., 1st Edition, 2001.
3. 3. Bioseparations - Principles and techniques, B. Sivasankar, Prentice Hall of India, N Delhi, 2005, pp 280.
4. 4. Product recovery in Bioprocess technology (1992) Butterworth- Heinemann, Biotol series.
5. 5. Mukesh D, Gaikar V and Anil Kumar Biotransformations Bioprocesses, Marcel Dekker, New york,(2004).
6. 6. Belter P.A., Cussler E.L., Houhu W., "Bioseparations: Downstream Processing for Biotechnology", Wiley India Pvt. Ltd., 1st Edition, 2011
7. 7. Harrison R.G, Todd P.W, Rudge S.R, Petrides D.P., "Bioseparations Science and Engineering". Oxford University Press., 2nd Edition, 2015.


**Course Outcomes:** At the end of the course, students would be able to:

**CO 1.** Understand the significance of downstream processing in a bioproduct separation.

**CO 2.** Apply the knowledge of unit operations for the separation of insoluble from bioreactor.

**CO 3.** Evaluate the concentration of bioproduct from the fermentation broth.

**CO 4.** Recognize the process to separate and purify biological macromolecules of interest.

**CO 5.** Demonstrate the skills and techniques to design a process for a product.

## Subject: Mass Transfer in Biotechnology (BT-PC-602 T)

Total credits: 03
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objectives:** To introduce students to the fundamentals of Mass transfer theories, interphase mass Transfer, coefficient and their correlations with different mass transfer operations such as diffusion, distillation, gas absorption, extraction, crystallization, drying etc.

**Course Contents:**

**Unit 1:** Molecular diffusion in fluids, Diffusion in solids. Interphase Mass Transfer, coefficient and their correlations. Concept of effective diffusivity. Diffusion through membranes and applications. Measurement of $k_{La}$. Oxygen transfer methodology in fermenters.

**Unit 2:** Distillation: Vapor liquid equilibrium, T-x,y and P-x,y diagrams, estimation of VLE using vapor pressure data and relative volatility. Differential distillation, Equilibrium distillation, Rectification.

**Unit 3:** Gas Absorption: Equilibrium relationship, Mass transfer theories. Plate column for absorption, analytical and graphical calculation of number of plates. Mass transfer in packed and fluidized beds.

**Unit 4:** Liquid- Liquid Extraction: Equilibrium for immiscible and partially miscible systems. Supercritical fluid extraction. Concept of number of stages for cocurrent and countercurrent contacting

**Unit 5**: Drying: Characteristics of the biological materials. Theory and mechanism of drying. Evaluation of drying rates. Equipment for dehydration of biological materials. Crystallization, Theory of crystallization.

## Text Books/References:


1. Chemical Engineering by Coulson and Richardson, Vol I & II. Pergamon Press, New York.
2. Mass Transfer operations by R.E.Treybal, MGH International.
3. Unit Operation by G.G.Brown, CBS publications.
4. Transport Processes and Separation Process Principles by Christie John Geankoplis, Phi Learning.
5. Unit Operations of Chemical Engineering by W.L. Mccabe, J.C. Smith, Peter Harriott, McGraw-Hill Publications.
6. Introduction to Biochemical Engineering by D. G. Rao, McGraw-Hill Publications.


**Course Outcomes:** On completion of this course, the students shall be able to:

**CO1**: Analyze diffusion of fluids and describe practical applications of diffusive mass transfer processes in biochemical engineering.

**CO2**: Evaluate the vapor liquid equilibrium and various techniques of distillation.

**CO3**: Analyze the gas Absorption operation.

**CO4**: Understand the equilibrium and design of Liquid- Liquid Extraction processes.

**CO5**: Apply the knowledge of drying of biological materials and crystallization.

## Subject: Bioprocess Engineering (BT-PC-603 T)

Total credits: 03
Teaching Scheme:
Lectures: 2 Hours/Week
Tutorial:1 Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To Introduce students to the basic concepts microbial and enzyme kinetics, various physical and chemical enzyme immobilization techniques, enzyme inhibition reactions and design of bioreactor.

### Course Contents:

**Unit 1: Introduction to Microbial Kinetics**
Phases of cell growth, Cell growth measurement, Microbial growth kinetics, Evaluation of Monod kinetic parameters, substrate utilization, and product formation kinetics

**Unit 2: Enzyme Kinetics**
Enzyme catalyzed Reaction- Briggs Haldane approach, Michaelis-Menten Kinetics, Factors affecting enzyme reactions, evaluation of enzyme kinetic parameters.

**Unit 3: Enzyme Immobilization**
Various Immobilization techniques of enzyme-Physical methods, chemical methods, effect of mass transfer resistance.

**Unit 4: Enzyme Inhibition**
Types of enzyme Inhibition reactions- competitive, non-competitive and uncompetitive inhibition kinetics, Protein Ligand Interaction- Hill equation and Hill plot, Model for Hemoglobin Oxygen Interaction

**Unit 5: Design of Bioreactors/Fermenter**
Design of Single Ideal Reactors, Design of bioreactors- batch, fed-batch and/or continuous bioreactors, Multiple fermenter system.

### Text Books/References:


1. Biochemical Engineering -James M. Lee, Prentice-Hall Inc. in 1992
2. Introduction to Biochemical Engineering by D. G. Rao, McGraw-Hill Publications
3. Bioprocess Engineering: Basic Concepts 3rd edition by F.Kargi and M.L.Shuler
4. Chemical reaction Engineering-I by K.A.Gavhane, Nirali Publications
5. Chemical Reaction Engineering,3rd Edition – O.Levenspiel, Wiley Eastern 1999
6. Chemical Kinetics and Reactor Calculations- Scott Fogler, Prentice Hall
7. Principles of Biochemistry by A.Lehninger
8. Bioreaction Engineering, Bioprocess Monitoring (Bioreaction Engineering) by Karl Schügerl


**Course Outcomes:** After completion of the course, students will be able to
**CO1**: Acquire fundamental knowledge and analyze microbial growth.
**CO2**: Analyze and evaluate the kinetics of Enzyme reaction.

**CO3**: Illustrate various methods of enzyme immobilization.
**CO4**: Analyze enzyme inhibition reaction kinetics.
**CO5**: Apply the knowledge of cell and enzyme kinetics for bioreactor design.

## Subject: Plant Tissue culture Technology (BT-PC-604 T)

Total credits: 03
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** The course intends to acquaint students with the principles, technical requirement, scientific and commercial applications of plant tissue and cell culture. To expose students to supporting methodologies of plant tissue and cell culture, micropropagation techniques and applications of tissue and cell culture to plant improvement using non transgenic and transgenic approach.

### Course Contents:

**Unit 1**: Introduction: history and types of plant tissue culture techniques. Concept of totipotency, types of culture media for plants tissue culture. Role of auxin, cytokinin and other growth regulators. Solid and liquid media.
**Unit 2:** Techniques of Plant Tissue Culture: Somaclonal variation, Callus culture, Suspension Culture, Micropropagation, Endosperm culture, Embryo culture, embryo rescue technique. In vitro mutagenesis.
**Unit 3:** Applications of Plant tissue culture: Protoplast Isolation, culture and regeneration, somatic hybridization. In vitro production of secondary metabolites, pharmaceuticals and aromatic chemicals.
**Unit 4:** Gene transfer methods in plant tissue culture: Agrobacterium mediated Gene transfer Method, Marker free transformation; Crop engineering using CRISPR. Molecular techniques for analysis of transgenics (copy number, transgene stability, silencing; segregation)
**Unit 5:** Evaluation and selection of transgenic events for target traits. Application of genetic transformation: for quality, yield, biotic, and abiotic stresses. Edible vaccines. Plant Biotechnology for biofuels, floriculture.

### Text Books/References-


1. Hudson T Hartmann: Plant Propagation-Principle and Practices, Pearson Education India; 8 edition
2. Principles of Plant Biotechnology- An Introduction of Genetic Engineering in Plants by S.H. Mantell, J.W. Mathews and R.A. Mckee, Blackwell Scientific Publications.
3. Chopra V L, Sharma R P &Swaminathan M S: Agricultural Biotechnology by Science Pub Inc
4. Hamish A, Collin & Sue Edwards: Plant Cell Culture, BIOS Scientific Publishers
5. Razdan M K: An Introduction to Plant Tissue Culture, Science Publishers

6. Plant Tissue Culture: Theory and Practice by S.S. Bhojwani M.K. Razdan, Elsevier Science
7. H.S. Chawla. Plant Biotechnology, Oxford & IBH Publishing

**Course Outcomes:** After successful completion of the course the students will be able to:

**CO1:** Understand the principle and basic requirements for plant tissue culture.
**CO2**: Explain the difference between tissue and organ culture and their applicability.
**CO3**: Understand haploid culture and in vitro selection of mutants.
**CO4**: Analyze somaclonal variation for improved crop varieties in vitro cultures.
**CO5**: Develop transgenic plants through genetic manipulations.

## Subject: Professional Elective-II (BT-PE-605i T)
## Machine Learning

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):**To facilitate the learner to introduce students to the basic concepts and techniques of Machine Learning, to Utilize data pre-processing techniques and dimensionality reduction techniques for given data.

### Course Contents:

**Unit 1: Introduction to Machine learning**
Types of Learning: Rote Learning, Learning by General Problem Solving, Concept Learning, Learning by Analogy, learning problems and designing the learning systems, Machine Learning: Types of Problems in Machine Learning, Aspects of Inputs to Training, Supervised, unsupervised, semi supervised, reinforcement learning, overfitting, underfitting.

**Unit 2: Data Pre-processing and Dimensionality Reduction**
Data cleaning, data integration, data reduction, data transformation and data discretization, Bias/Variance trade-off.

**Unit 3: Supervised Learning**
Regression: Correlation and regression, line fitting by least square, outliers, linear and multiple regression
Classification: Logistic regression, Nearest Neighbor Classification: K-nn, Introduction to Decision tree and Bayesian Classification
Performance Measures: Types of Errors: RMSE, MSE.

**Unit 4: Unsupervised Learning**
Introduction to Clustering methods, k-means clustering, Hierarchical clustering: agglomerative clustering method, decisive clustering method, Apriori Algorithm

**Unit 5:** Introduction to Artificial Neural networks, application of machine learning in day to day life.

## Text Books/Reference Books:


1. Peter Flach, "Machine Learning: The Art and Science of Algorithms that make sense of data", Cambridge University Press, 1st Edition, 2015, ISBN No.:978-1-316-50611-0
2. Ethem Alpaydin, "Introduction to Machine Learning", PHI, 2nd edition, 2013,
3. ISBN 978-0- 262-01243-0
4. Jiawei Han, Micheline Kamber, Jian Pei, "Data Mining: Concepts and
5. Techniques", 3rd Edition, 2012, Morgan Kaufmann publishing, ISBN:978-0-12-381479-1
6. V. Susheela Devi, M. Narasimha Murty, "Pattern Recognition: An introduction", University Press, 2011, ISBN 978-81-7371-725-3
7. Rodolfo Bonnin, "Machine learning for developers" , Packt publication, 2017,
8. ISBN 978-1-78646-987-8
9. Vinod Chandra S. S., Anand Hareendran S., 'Artificial Intelligence and machine learning', PHI, (2014), ISBN 978-81-
10. Tom M. Michell, 'Machine Learning', McGraw Hill Education, Indian edition
11. 2013, ISBN 978-1-25-909695-2.
12. John Paul Mueller, Luca Massarom, "Machine learning (in python and R)
13. dummies", Wiley publication, 2016, ISBN 978-81-265-63050
14. Manohar Swamynathan, "Mastering Machine learning with python in six steps", Apress publication, 2018, ISBN 978-1-484-24044-1


**Course Outcomes:** After completion of the course, students will be able to:

**CO1**: Acquire fundamental knowledge of machine learning theory.

**CO2**: Evaluate data pre-processing and dimensionality reduction technique for given data.

**CO3**: Apply supervised machine learning techniques such as classification and regression for problem solving and evaluate the designed technique using performance measures.

**CO4**: Solve the problems using various unsupervised machine learning techniques such as clustering

**CO5**: Apply the artificial neural network technique to solve the problem.

## Subject: Professional Elective-II (BT -PE – 605ii T)
## Waste Management

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To introduce fundamental aspects of types of waste and its management with various waste management technologies and to enable students to think innovative ways to develop concepts in waste management.

### Course Contents:

**UNIT 1: Waste management:** The definition of waste, and its classification in the context of EU legislation, policy and other drivers for change, including the planning and permitting regime for the delivery of waste management solutions. Liquid waste collection, treatment and disposal systems, Air Pollution management and treatment

**UNIT 2: Waste treatment technologies:** waste incineration and energy from waste, pyrolysis and gasification, anaerobic digestion, composting and mechanical, biological treatment of wastes, managing biomedical waste.

**UNIT 3:** Health considerations in the context of operation of facilities, handling of materials and impact of outputs on the environment; Advances in waste recycling and recovery technologies to deliver added value products; Landfill engineering and the management of landfill leachate and the mining of old landfills.

**UNIT 4:** Interface of waste and resource management in the context of sustainable waste management in global cities and developing countries; and Use of decision support tools including multi-criteria analysis, carbon foot-printing and life-cycle analysis, as appropriate.

**UNIT 5:** Waste Upcycling, waste reuse, Waste down cycling, waste upcycling a social enterprise, Case study in each area. Innovative technologies for sustainable waste management.

### Text Books/References:


1. O.P. Gupta, "Elements of Solid & Hazardous Waste Management", Khanna Publishing House, New Delhi, 2019.
2. George Tchobanoglous et.al., "Integrated Solid Waste Management", McGraw-Hill Publishers, 1993.
3. B.Bilitewski, G.HardHe, K.Marek, A.Weissbach, and H.Boeddicker, "Waste Management", Springer, 1994


**Course Outcomes:** After completion of the course, students will be able to

**CO1**: Understand knowledge on waste and its sustainable management.

**CO2**: Apply the knowledge of various waste treatment technologies. should get enough knowledge on safety guidelines of waste management.

**CO3**: Evaluate impact of outputs on the environment in the context of operation of facilities

**CO4**: Analyze decision support tools including multi-criteria analysis, carbon foot-printing and life-cycle analysis
**CO5**: Apply innovative technologies for sustainable waste management.

## Subject: Professional Elective-II (BT-PE- 605iii T)
## Stem-Cell Technology

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1 Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To impart knowledge of wide-ranging topics related to stem cells which will provide students with the building blocks necessary for understanding, examining, and dissecting the dynamic field of stem cell research. The course is designed to give a broad view of stem cells, different types and how they are cultured and preserved. The topics will cover the basic biology, technique used and applications of stem cells to potential treatments of human diseases.

### Course Contents:

**Unit 1:** Principles and properties of stem cells, types of stem cells, comparison of embryonic and adult stem cells. Differentiation of stem cells and their role in self-renewal, Scope of Stem Cells.
**Unit 2:** Stem cells derived from amniotic fluid, extra embryonic membrane, germ cells, hematopoietic organs, neurons and kidney, cord blood transplantation, donor selection, HLA matching, patient selection, peripheral blood and bone marrow transplantation, bone marrow and cord blood collection procedures and cryopreservation and their applications.
**Unit 3:** Isolation and differentiation of human adult stem cells, embryonic stem cells and mouse stem cells, stem cell techniques: fluorescence activated cell sorting (FACS), time lapse video, green fluorescent protein tagging.
**Unit 4:** Parkinson's disease, Cancer stem cell, Neural stem cell for central nervous system repair, Spinal cord injury, use of ESC to treat heart disease, Burns and skin ulcers, Orthopedic applications of stem cell, Insulin-producing cells derived from Stem Cells: A Potential Treatment for Diabetes.
**Unit 5:** Stem cell policy and ethics, stem cell research: Hype, hope and controversy.

**Text Books/References:**


1. Stem cells by C.S Potten., Elsevier, 2006.Essentials of Stem Cell Biology by Robert Lanza., fourth edition. Elsevier 2014.
2. Potten.C S, "Stem Cells," Elsevier, 1996.
3. Ariff Bongso, Eng Hin Lee, "Stem Cells: From Bench to Bedside," World Scientific, 2011.
4. Daniel R. Marshak, "Stem cell biology," Cold Spring Harbor Laboratory Press, 2001.
5. Peter Quesenberry, "Stem cell biology and Gene Therapy," Wiley-Liss, 1998.
6. Kursad Turksen., Embryonic Stem cells – Protocols, Second Edition Humana Press, 2002.
7. Ali Gholamrezanezhad., Stem cells in clinic and Research, Intech, 2013.
8. Stem Cell Biology and Gene Therapy. Quesenberry PJ, Stein GS, eds. (£65.00.) Wiley, 1998.
9. Stem Cells Handbook: Stewart Sell, Humana Press; Totowa NJ, USA; Oct. 2003,
10. 11.Human Embryonic Stem Cells: The Practical Handbook by Stephen Sullivan and Chad A Cowan.
11. Stem Cell Biology, Daniel Marshak, Richard L. Gardener and David Gottlieb, Cold Spring Harbour Laboratory Press


**Course Outcomes:** At the end of the course, student would be able:

**CO1**: To understand the basic properties of stem cells.

**CO2**: To categorize the different stem cells as per their sources and understand their preservation.

**CO3**: To demonstrate human stem cells and their technique for identification.

**CO4**: To illustrate the various medical applications of stem cells.

**CO5**: To report the various ethical issues of stem cells.

## Subject: Open Subject-II (BT-OS-606i T)
## Artificial Intelligence

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** This course will allow gaining expertise in one of the most fascinating and fastest-growing areas of Computer Science through a classroom program that covers fascinating and compelling topics related to human intelligence and its applications in industry, defense, healthcare, agriculture, and many other areas.

**Course Contents:**

**Unit 1**: Introduction 130 Concept of AI, history, current status, scope, agents, environments, Problem Formulations, Review of tree and graph structures, State space representation, Search graph and Search tree.

**Unit 2:** Search Algorithms Random search, Search with closed and open list, Depth and Breadth first search, Heuristic search, Best first search, A* algorithm, Game Search.

**Unit 3:** Probabilistic Reasoning Probability, conditional probability, Bayes Rule, Bayesian Networks- representation, construction and inference, temporal model, hidden Markov model.

**Unit 4:** Markov Decision process MDP formulation, utility theory, utility functions, value iteration, policy iteration and partially observable MDPs.

**Unit 5:** Reinforcement Learning Passive reinforcement learning, direct utility estimation, adaptive dynamic programming, temporal difference learning, active reinforcement learning- Q learning.

**Text Books/References:**


1. Stuart Russell and Peter Norvig, "Artificial Intelligence: A Modern Approach", 3rd Edition, Prentice Hall
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", Tata McGraw Hill
3. Trivedi, M.C., "A Classical Approach to Artificial Intelligence", Khanna Publishing House, Delhi.
4. Saroj Kaushik, "Artificial Intelligence", Cengage Learning India, 2011
5. David Poole and Alan Mackworth, "Artificial Intelligence: Foundations for Computational Agents", Cambridge University Press 2010


**Course Outcomes:** After undergoing this course, the students will be able to:

**CO1**: Build intelligent agents for search and games.
**CO2**: Solve AI problems through programming with Python.
**CO3**: Learning optimization and inference algorithms for model learning.
**CO4**: Design and develop programs for an agent to learn and act in a structured environment.
**CO5**: Perform Reinforcement Learning

## Subject: Open Subject-II (BT-OS-606ii T)
## Synthetic & Systems Biology

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** This course introduces students to the rapidly evolving field of Systems & synthetic biology. Successful examples illustrating tremendous application potentials of synthetic biology in the fields of biofuels, biomedicine, and other areas will also be discussed.

Emphasis has also been laid on the use of online bio-design software and computer labs to design new circuits and assemblies to evaluate their functionality

**Course Content:**

**Unit 1:** Introduction to Synthetic biology & Systems biology Introduction to synthetic biology. Background of Gene Regulatory Mechanisms (Gene Parts- Gene Structure, Promoters, Terminators, Enhancers, Inducers, Repressors, Transcription Factors, Co-factors, transcriptional and post-transcriptional regulation, post-translational modifications). Genetic Engineering and Genome Editing Various Omics & role in systems biology - genomics, proteomics, transcriptomics, metabolomics

**Unit 2:** Elements of synthetic biology - Tools, circuits, BioBricks Gene shuffling for large scale pathway assembly and engineering; Choices for microbial hosts for industrial applications– bacteria, yeast, insect. Gene editing methods – CRISPR/ Cas; Gene sequencing – Pyrosequencing, Nanopore sequencing. Bacterial circuits: feedback, feed-forward, toggle switch, signal propagators and band filter, synchronized oscillators. Introduction to Bio Bricks & its applications. Microarrays & systems biology - a basic introduction

**Unit 3:** Mathematical modeling & simulation Noise in Gene Expression. Mathematical Modeling and Simulation. Biosensors. Application of software tools for modeling gene expression. Various markup languages used in systems biology. Introduction to various metabolic pathway databases.

**Unit 4:** Commercial Applications Biomedicine, Biomaterials, Biofuels and Bioremediation; Production of artemisinin as case study. Building the new bio-economy. Introduction to Bio foundries & circuits. Role of automation and robotics in biofactories; Green chemistry - use of plants for engineering biologics & small molecules. Biosurfactants as an example of microbial cell factory-based production. Global events & competitions- iGEM, synbiobeta.

**Unit 5:** Regulations & ethics Safety & bioethics, legal & IP elements involved in synthetic biology applications for human, animals and plants.

**Text Books/References:**


1. Uri Alon, An Introduction to Systems Biology: Design Principles of Biological Circuits, Chapman & Hall/CRC (2006).
2. Eric Davidson, The Regulatory Genome: Gene Regulatory Networks In Development And Evolution, Academic Press (2006).
3. Hamid Bolouri, Computational Modeling of Gene Regulatory Networks - A Primer, Imperial College Press (1st edition) (2008).
4. Freemont, P.S and Kitney, R.I. (2012). Synthetic Biology – a Primer. World Scientific Publishing Co pte Ltd
5. Singh, V and P.K. Dhar. (2015). Systems and Synthetic Biology. Springer publishing, Netherlands
6. Fu, P and Panke, S (2009). Systems Biology and Synthetic Biology. Wiley Publishing.
7. Covert, M.W. (2014). Fundamentals of Systems Biology: from Synthetic Circuits to Whole Cell Models. CRC Press
8. Konopka, A. K. (2006). Systems Biology: Principles, Methods, and Concepts. CRC Press.
9. Church, G and Regis, E. (2012). Regenesis: How Synthetic Biology will Reinvent Nature and Ourselves. Basic Books.

9. Standards for Plant Synthetic Biology - http://onlinelibrary.wiley.com/doi/10.1111/nph.13532/full
10. Synthetic and Systems Biology for Microbial production of Commodity Chemicals http://www.nature.com/articles/npjsba20169.
11. Biotechnology and Synthetic Biology Approaches for Metabolic Engineering of Bioenergy Crops - https://www.ncbi.nlm.nih.gov/pubmed/27030440.
12. Microarray Data Analysis: Gene Expression Data Analysis. A Beginner's Guide by: Helen Causton (Imperial College), J Quackenbush and AlvisBrazma (The European Bioinformatics Institute).
13. A Practical Approach to Microarray Data Analysis (Hardcover) by Daniel P. Berrar (Editor), Werner Dubitzky (Editor), Martin Granzow (Editor).

**Course Outcomes:** At the end of the course:
**CO1**: The students will learn the concept of synthetic biology and its widespread applications in research and industry.
**CO2**: They will be able to assemble DNA and genes into biological circuits to make a biosensor or even engineer organisms.
**CO3**: The students will also appreciate that biological systems are highly dynamic and not static and can be manipulated by various design strategies.
**CO4**: The students will facilitate the commercial approach and application of bioindustries.
**CO5**: The student will analyze bioethics and application of synthetic biology.

## Subject: Open Subject-II (BT-OS-606iii T)
## Good Manufacturing and Laboratory Practice

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hours/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To understand the regulatory requirements of cGMP and GLP.

**Course Contents:**
**Unit 1:** Introduction to Good Manufacturing and Laboratory Practice, Requirement of GLP and GMP compliance for regulatory approval, Ethics in manufacturing and control.
**Unit 2:** Principles of quality by design (QBD), Introduction to the concept of Design of Experiment (DOE), Application of QBD principles in Biotech product development.
**Unit 3:** Case studies: Example of QBD and DOE in Process Development, Example of DOE in analytical development,

**Unit 4:** Introduction to ICH guidelines and their usage, National and international regulatory authorities and their function, Pharmaceutical Jurisprudence and Laws related to Product design,
**Unit 5:** Drug Development & Approval Process, Regulation of Clinical and Preclinical Studies, Formulation Production Management, Authorization and marketing of drugs.

**Text Books/References:**


1. cGMP starter guide: Principles in Good Manufacturing Practices for Beginners, Emmet P. Tobin, Createspace Independent Publishing Platform, April 2016.
2. Good Manufacturing Practices for Pharmaceuticals: GMP in Practice, B Cooper,Createspace Independent Publishing Platform, July 2017.
3. N Politis S, Colombo P, Colombo G, M Rekkas D.Design of experiments (DoE) inpharmaceutical development, Drug Dev Ind Pharm. 2017 Jun;43(6):889-901.
4. Andrew Teasdale, David Elder, Raymond W. Nims, ICH quality guidelines- Animplementation guide, Dec 2017.
5. Gajendra Singh, Gaurav Agarwal an Vipul Gupta, Drug regulatory affairs, CBS publication, 2005.
6. Marc P. Mathieu, New Drug Development: A regulatory overview, Nov 2000.


**Course Outcomes:** At the end of the course, student would be able to:

**CO 1.** Apply knowledge and ethics for Good manufacturing and laboratory practices.
**CO 2.** Understand the quality of biotech product design and formulation.
**CO 3.** Describe an essential tool to ensure products and processes satisfy quality by design requirements, imposed by regulatory agencies.
**CO 4.** Recognize the process of drug regulatory agencies to get the approval of products.
**CO 5.** Evaluate the regulations for drug development.

## Subject: Open Subject-II (BT-OS- 606iv T)
## Heat Transfer in Biotechnology

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1 Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** To provide the knowledge of various modes of heat transfer incurred during various operations in Industry. This course covers the Basic Introduction of three main modes of heat transfer common in all industries, various parameters affecting the rate of heat transfer and its application in designing the instruments like heat exchangers, Evaporators also for sterilizing the media in Biotechnology.

## Course Contents:

**Unit 1: CONDUCTION**

General Differential equation of Heat Conduction, One Dimensional Steady State Heat Conduction: plane and Composite Systems. Unsteady Heat Conduction – Lumped parameter Analysis

**Unit 2: CONVECTION**

Free and Forced Convection: Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes. Thermal insulation and their selection. Individual and Overall Heat Transfer Coefficient

**Unit 3: RADIATION**

Electromagnetic waves, energy of radiation, Planck's Equation-Black body, Radiation exchange. Kirchhoff's law, Stefen Boltemann equation of radiant energy, Wien's law, Radiation exchange between surfaces – black, gray bodies. Application of heat in sterilization of media, batch and continuous sterilization

**Unit 4: PHASE CHANGE HEAT TRANSFER**

Condensation: Film wise condensation and drop wise condensation, Boiling: pool boiling, heat transfer to boiling liquids forced convection boiling.

**Unit 5: HEAT EXCHANGERS.**

Heat Exchanger: classification, applications, mode of operations, Fouling Factors. Heat Exchanger Analysis: LMTD method, NTU method.

## Text Books/References:


1. Principles of Heat Transfer and Mass Transfer by SD Dawande, Central Techno Publications, Nagpur.
2. Process Heat transfer by Dr. Kern Tata McGraw-Hill Education, 1950.
3. Fluid Mechanics and Heat Transfer by Kay JM, Cambridge University Press.
4. Heat Transmission by McAdams WH, McGraw Hill book Co, New York.
5. Heat Transfer by P.S.Ghoshdastidar, Oxford University Press
6. Heat Transfer by Y.Cengel, McGraw-Hill, 2003
7. Fundamentals of Heat and Mass Transfer,Frank P. Incropera, David P. DeWitt John Wiley & Sons, 2011


**Course Outcomes:** After completing the course, the students will be able to

**CO1**: Understand the basics and modes of heat transfer in steady state and unsteady state for thermal analysis of engineering system

**CO2**: Evaluate heat transfer coefficient for free and forced convection, condensation and boiling phenomenon.

**CO3**: Evaluate heat transfer coefficient for radiation.

**CO4**: Understand the heat transfer during phase change.

**CO5**: Design and analysis heat exchangers performance in various types of heat exchanger equipment.

## Subject: Open Subject-II (BT-OS-606v T)
## Environment and Sustainability

Total credits: 04
Teaching Scheme:
Lectures: 3 Hours/Week
Tutorial: 1Hour/Week

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 70 Marks
College Assessment: 30 Marks

**Course Objective(s):** The objective of the course is to provide the students with unique blend of disciplines that will prepare them with the skills necessary to work in the field of environmental sustainability and built foundation in environmental ecology and conservation as well as an understanding of sustainability in relation to water, agriculture, development and energy.

**Course Contents:**

**Unit 1: Basic concepts of sustainability:** Ecosystems and Climate Change, Factors affecting environment and society, Our Common Future, Introduction to Elements of sustainable development (Economic aspects, environmental aspects and social aspects).

**Unit 2:Energy and resources:** Growing energy needs, Non-Renewable and Renewable Energy Resources, Electricity and Power Plants, Societal Development and Energy Resources, Use of alternative energy sources

**Unit 3: Environmental impacts:** Climate change, Air pollution, Water pollution, Waste Human health, Diversity of life, Solid waste effects and control measures of urban waste

**Unit 4: Transport:** Automobile impact on global warming, The potential for changing travel behavior to promote environmental quality, Major problems in Eco friendly transportation and how to face major challenges.

**Unit 5: Sustainable communities:** Development of sustainable community, Policies for sustainable community, Government Policies for Sustainable development

**Text Books/References:**


1. Bharucha Erach, The Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmedabad
2. Miller T.O. Jr, Environmental Science, Wadsworth Publishing Co. (TB)
3. Trivedi R.K., Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards, Vol I and II, Enviro Media ( R )
4. Haslam, Paul A.; Schafer, Jessica; Beaudet, Pierre, Introduction to international development : approaches, actors, issues, and practice, Third edition, 2017
5. Al Gore, Our Choice: A Plan to Solve the Climate Crisis, 2009


**Course Outcomes:** At the end of the course, student would be able to:

**CO1.** Learn how to solve large-scale problems using a multitude of tools and approaches.
**CO2.** Demonstrate an understanding of comprehensive systematic analysis across both physical and behavioral dimensions involving society, the environment, and the economy.
**CO3.** Identify how globalized processes impact socio ecological systems.

**CO4.** Analyze the role of environmental sustainability in the promotion of comprehensive justice and equity.
**CO5.** Apply critical thinking skills to provide sustainable solutions and build resilient communities, Learn about the economic, social, and environmental aspects of sustainability and progress toward a sustainable society.

## Subject: Sports and Yoga (BT-AU-607 T)

Total credits: Audit
Teaching Scheme:
Lectures: 2 Hours/Week
Tutorial: NIL

Examination Scheme:
Duration of Paper: 03 Hours
University Assessment: 00 Marks
College Assessment: 50 Marks

**Course Objective(s):** To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

**Course Contents:**
**Unit 1:** Introduction to Physical Education, Olympic Movement of Ancient & Modern Olympics (Summer & Winter).
**Unit 2:** Physical Fitness, Wellness & Lifestyle Fundamentals of Anatomy & Physiology in Physical Education, Sports and Yoga.
**Unit 4:** Yoga, Yoga & Lifestyle.
**Unit 3:** Kinesiology, Biomechanics & Sports, Training and Planning in Sports, Psychology & Sports, Sports Medicine.
**Unit 5:** Sports/Games Following subtopics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Basketball, Chess, Cricket, Kabaddi, Lawn Tennis, Swimming, Table Tennis, Volleyball, Yoga etc.

**Text Books/References:**
1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light On Yoga by B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes)

**Course Outcomes:** On successful completion of the course the students will be able to:
**CO1.** Practice Physical activities and Hatha Yoga focusing on yoga for strength, flexibility, and relaxation.
**CO2.** Assess current personal fitness levels.
**CO3.** Identify opportunities for participation in yoga and sports activities.
**CO4.** Improve personal fitness through participation in sports and yogic activities.
**CO5.** Identify and apply injury prevention principles related to yoga and physical fitness activities.

## PRATICALS

### Subject: Mass Transfer in Biotechnology Laboratory (BT-PC-608 P)

Total credits: 1.5
Teaching Scheme:
Practical: 3 Hours/Week

Examination Scheme:
Duration of Examination: 06 Hours
University Assessment: 25 Marks
College Assessment: 25 Marks

**List of Experiments:** Required to perform minimum 09 practicals from the list given below:

1. Determination of diffusion coefficient of an organic vapor (acetone) in air.
2. Study of the drying characteristics of a given material under constant drying conditions and to report equilibrium and critical moisture content.
3. Determination of the mass transfer coefficient for the absorption of water vapor on silica gel.
4. Study the variation of mass transfer coefficient as a function of flow rate of air for the vaporization of naphthalene in a packed bed.
5. Estimation of the rate constant for the physical dissolution of benzoic acid in a liquid.
6. Determination of the diffusion coefficient for the given liquid-liquid system as a function of concentration.
7. Estimation of $K_{La}$ for air/oxygen absorption in nature.
8. Studies of crystallization phenomena in Batch Crystallization
9. To find the mass transfer coefficient in a wetted wall Column
10. To verify Rayleigh's Equation for Simple Distillation
11. To construct the boiling point diagram for binary – miscible system
12. Single/multiple stage extraction studies
13. To prepare the ternary phase diagram.
14. Soxhlet Extraction
15. Absorption studies in packed column
16. Absorption studies in bubble column
17. Membrane separation

## Subject: Bioprocess Engineering Laboratory (BT-PC-609 P)

Total credits: 1.5
Teaching Scheme:
Practical: 3 Hours/Week

Examination Scheme:
Duration of Examination: 06 Hours
University Assessment: 25 Marks
College Assessment: 25 Marks

**List of Experiments:** (Any 7 experiments from below mentioned 11 experiments)

1. Microbial growth kinetics and estimation of cell mass
2. Growth inhibition kinetics
3. Operation of pH control and dissolved oxygen measurement
4. Enzyme immobilization techniques
5. Bioconversion using immobilized enzyme preparation
6. Aerobic and anaerobic bioconversion process
7. Product formation kinetics in a fermentation process
8. analyses of process parameters
9. Effect of mixing and agitation in bioreactors
10. Mass transfer in immobilized cell
11. Estimation of volumetric oxygen transfer coefficient

## Subject: Plant Tissue culture Technology Laboratory (BT-PC-610 P)

Total credits: 1.5
Teaching Scheme:
Practical: 3 Hours/Week

Examination Scheme:
Duration of Examination: 06 Hours
University Assessment: 25 Marks
College Assessment: 25 Marks

**List of Experiments:**

1. Preparation and sterilization of standard tissue culture media.
2. Sterilization of explants and Establishment of callus/cell suspension cultures
3. Induction of Embryo/Ovary culture;
4. Induction of Anther/ pollen culture
5. Micropropagation – Explant establishment, shoot multiplication, root induction
6. Protoplast isolation and culture.
7. Invitro grown plantlets hardening and transfer to soil
8. Extraction and quantification of secondary metabolites from callus of medicinal plants
9. *Agrobacterium* mediated genetic transformation using histochemical GUS assays.