
REVA UNIVERSITY
Bengaluru, India

# SCHOOL OF APPLIED SCIENCES

## M.Sc. – MICROBIAL TECHNOLOGY

**HANDBOOK: 2024-26**

**Rukmini Educational**
Charitable Trust

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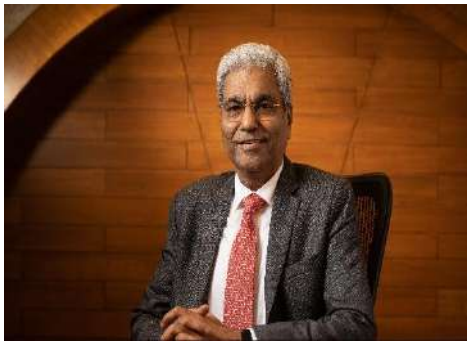
# Chancellor's Message



*"Education is the most powerful weapon which you can use to change the world."*
***- Nelson Mandela.***

There was a time when survival depended on just the realization of physiological needs. We are indeed privileged to exist in a time when 'intellectual gratification' has become indispensable. Information is easily attainable for the soul that is curious enough to go look for it. Technological boons enable information availability anywhere anytime. The difference, however, lies between those who look for information and those who look for knowledge.

It is deemed virtuous to serve seekers of knowledge and as educators it is in the ethos at REVA University to empower every learner who chooses to enter our portals. Driven by our founding philosophy of 'Knowledge is power', we believe in building a community of perpetual learners by enabling them to look beyond their abilities and achieve what they assumed impossible.

India has always been beheld as a brewing pot of unbelievable talent, acute intellect, and immense potential. All it takes to turn those qualities into power is a spark of opportunity. Being at a University is an exciting and rewarding experience with opportunities to nurture abilities, challenge cognizance and gain competence. For any University, the structure of excellence lies in the transitional abilities of its faculty and its facility. I'm always in awe of the efforts that our academic board puts in to develop the team of subject matter experts at REVA. My faculty colleagues understand our core vision of empowering our future generation to be ethically, morally, and intellectually elite. They practice the art of teaching with a student-centered and transformational approach. The excellent infrastructure at the University, both educational and extra-curricular, magnificently demonstrates the importance of ambience in facilitating focused learning for our students.

A famous British politician and author from the 19th century - Benjamin Disraeli, once said 'A University should be a place of light, of liberty and of learning'. Centuries later this dictum still inspires me, and I believe, it takes teamwork to build successful institutions. I welcome you to REVA University to join hands in laying the foundation of your future with values, wisdom, and knowledge.

**Dr. P. Shyama Raju**
The Founder and Hon'ble Chancellor, REVA University

# Vice-Chancellor's Message

The last two decades have seen a remarkable growth in higher education in India and across the globe. The move towards inter-disciplinary studies and interactive learning have opened several options as well as created multiple challenges. India is at a juncture where a huge population of young crowd is opting for higher education. With the tremendous growth of privatization of education in India, the major focus is on creating a platform for quality in knowledge enhancement and bridging the gap between academia and industry.

A strong believer and practitioner of the dictum "Knowledge is Power", REVA University has been on the path of delivering quality education by developing the young human resources on the foundation of ethical and moral values, while boosting their leadership qualities, research culture and innovative skills. Built on a sprawling 45 acres of green campus, this 'temple of learning' has excellent and state-of-the-art infrastructure facilities conducive to higher teaching-learning environment and research. The main objective of the University is to provide higher education of global standards and hence, all the programs are designed to meet international standards. Highly experienced and qualified faculty members, continuously engaged in the maintenance and enhancement of student-centric learning environment through innovative pedagogy, form the backbone of the University.

All the programs offered by REVA University follow the Choice Based Credit System (CBCS) with Outcome Based Approach. The flexibility in the curriculum has been designed with industry-specific goals in mind and the educator enjoys complete freedom to appropriate the syllabus by incorporating the latest knowledge and stimulating the creative minds of the students. Bench marked with the course of studies of various institutions of repute, our curriculum is extremely contemporary and is a culmination of efforts of great think-tanks - a large number of faculty members, experts from industries and research level organizations. The evaluation mechanism employs continuous assessment with grade point averages. We believe sincerely that it will meet the aspirations of all stakeholders – students, parents and the employers of the graduates and postgraduates of REVA University.

At REVA University, research, consultancy, and innovation are regarded as our pillars of success. Most of the faculty members of the University are involved in research by attracting funded projects from various research level organizations like DST, VGST, DBT, DRDO, AICTE and industries. The outcome of the research is passed on to students through live projects from industries. The entrepreneurial zeal of the students is encouraged and nurtured through EDPs and EACs.

REVA University has entered collaboration with many prominent industries to bridge the gap between industry and University. Regular visits to industries and mandatory internship with industries have helped our students become skilled with relevant to industry requirements. Structured training programs on soft-skills and preparatory training for competitive exams are offered here to make students more employable.

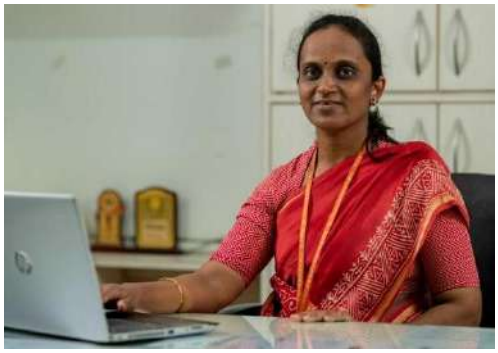
100% placement of eligible students speaks the effectiveness of these programs. The entrepreneurship development activities and establishment of "Technology Incubation Centers" in the University extend full support to the budding entrepreneurs to nurture their ideas and establish an enterprise.

With firm faith in the saying, "Intelligence plus character –that is the goal of education" (Martin Luther King, Jr.), I strongly believe REVA University is marching ahead in the right direction, providing a holistic education to the future generation, and playing a positive role in nation building. We reiterate our endeavor to provide premium quality education accessible to all and an environment for the growth of over-all personality development leading to generating "GLOBAL PROFESSIONALS".

**Welcome to the portals of REVA University!**

**Dr. N Ramesh,**
Vice-Chancellor (I/C), REVA University

# Director Message



Microbial Technology as interdisciplinary subject assimilates in itself a number of disciplines and as such has grown rapidly. M Sc in Microbial Technology offered by REVA University aims to provide the required skills and knowledge necessary to pursue a successful career in Microbiology. This program imparts need based, practical education in contemporary world to develop global competence among students. It strives to prepare students to become leaders in the field of Life Sciences in general and Microbiology in particular by encouraging them to inculcate scientific thinking coupled with creative and innovative ideas.

MSc Microbial Technology provides the specialization of three major domains of microbiology such as Industrial & Food Microbiology, Agriculture & Environmental Microbiology and Medical & Diagnostic Microbiology based on the interest of the students in collaboration with the industry partners. The program provides hands-on and industry-based training and practical skills in the specialized field of Microbiology and basics of Molecular genetics, Bioinformatics, Biochemical techniques & Enzymology, Environmental Microbiology, Molecular biology and Applied Microbiology aligning to current demand in the field of research & industry.

As far as employment is concerned Microbiology has become one of the fast-growing sectors. Employment record shows that Microbiology has a great scope in future. Microbiologists can find careers with pharmaceutical companies, chemical, agricultural and allied companies. They can be employed in the areas of planning, production and management of bio-processing industries. There is a large-scale employment in research laboratories run by the government as well as the corporate sectors. Further, there is great demand for biotechnology experts in numerous industries and sectors after the completion of MSc Biotechnology course, some of which are: Agriculture, Animal Husbandry, Environment Conservation, Genetic Engineering, Health Care, Medicine, Industrial Research and Development.

This handbook provides you outline of regulations for master's degree, scheme of instruction, and detailed syllabus. I am sure the students choosing MSc Microbiology at REVA University will enjoy the curriculum, teaching and learning environment, the vast infrastructure and the experienced faculties with excellent involvement and guidance. We will strive to provide all the necessary comfort and congenial environment for their studies. I wish all students a pleasant stay at REVA and grand success in their career.

**Prof.Shilpa BR**
Director (I/C), SoAS

# RUKMINI EDUCATIONAL CHARITABLE TRUST

It was the dream of late Smt. Rukmini Shyama Raju to impart education to millions of underprivileged children as she knew the importance of education in the contemporary society. The dream of Smt. Rukmini Shyama Raju came true with the establishment of Rukmini Educational Charitable Trust (RECT), in the year 2002. **Rukmini Educational Charitable Trust** (RECT) is a Public Charitable Trust, set up in 2002 with the objective of promoting, establishing, and conducting academic activities in the fields of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology, among others. In furtherance of these objectives, the Trust has set up the REVA Group of Educational Institutions comprising of REVA Institute of Technology & Management (RITM), REVA Institute of Science and Management (RISM), REVA Institute of Management Studies (RIMS), REVA Institute of Education (RIE), REVA First Grade College (RFGC), REVA Independent PU College at Kattigenahalli, Ganganagar and Sanjaynagar and now REVA University. Through these institutions, the Trust seeks to fulfill its vision of providing world class education and create abundant opportunities for the youth of this nation to excel in the areas of Arts, Architecture, Commerce, Education, Engineering, Environmental Science, Legal Studies, Management and Science & Technology.

Every great human enterprise is powered by the vision of one or more extraordinary individuals and is sustained by the people who derive their motivation from the founders. The Chairman of the Trust is Dr. P. Shyama Raju, a developer and builder of repute, a captain of the industry in his own right and the Chairman and Managing Director of the DivyaSree Group of companies. The idea of creating these top notched educational institutions was born of the philanthropic instincts of Dr. P. Shyama Raju to do public good, quite in keeping with his support to other socially relevant charities such as maintaining the Richmond Road Park, building, and donating a police station, gifting assets to organizations providing accident and trauma care, to name a few.

The Rukmini Educational Charitable Trust drives with the main aim to help students who are in pursuit of quality education for life. REVA is today a family of ten institutions providing education from PU to Post Graduation and Research leading to PhD degrees. REVA has well qualified experienced teaching faculty of whom majority are doctorates. The faculty is supported by committed administrative and technical staff. Over 13,000 students study various courses across REVA's three campuses equipped with exemplary state-of-the-art infrastructure and connective environment for the knowledge driven community.

# ABOUT REVA UNIVERSITY

REVA University has been established under the REVA University Act, 2012 of Government of Karnataka and notified in Karnataka State Gazette No. 80 dated 27thFebruary, 2013. The University is empowered by UGC to award degrees any branch of knowledge under Sec.22 of the UGC Act. The University is a Member of Association of Indian Universities, New Delhi. The main objective of the University is to prepare students with knowledge, wisdom, and patriotism to face the global challenges and become the top leaders of the country and the globe in different fields.

REVA University located in between Kempegowda International Airport and Bangalore city, has a sprawling green campus spread over 45 acres of land and equipped with state-of-the-art infrastructure that provide conducive environment for higher learning and research. The REVA campus has well equipped laboratories, custom-built teaching facilities, fully air-conditioned library and central computer center, the well-planned sports facility with cricket ground, running track & variety of indoor and outdoor sports activities, facilities for cultural programs. The unique feature of REVA campus is the largest residential facility for students, faculty members and supportive staff.

REVA consistently ranked as one of the top universities in various categories because of the diverse community of international students and its teaching excellence in both theoretical and technical education in the fields of Engineering, Management, Law, Science, Commerce, Arts, Performing Arts, and Research Studies. REVA offers 28 Undergraduate Programmes, 22 Full-time and 2 Part-time Postgraduate Programmes, 18 Ph. D Programmes, and other Certificate/ Diploma/Postgraduate Diploma Programmes in various disciplines. The curriculum of each Programme is designed with a keen eye for detail by giving emphasis on hands-on training, industry relevance, social significance, and practical applications. The University offers world-class facilities and education that meets global standards.

The programs being offered by the REVA University are well planned and designed after detailed study with emphasis with knowledge assimilation, applications, global job market and their social relevance. Highly qualified, experienced faculty and scholars from reputed universities/institutions, experts from industries and business sectors have contributed in preparing the scheme of instruction and detailed curricula for this program. Greater emphasis on practice in respective areas and skill development to suit to respective job environment has been given while designing the curricula. The Choice Based Credit System and Continuous Assessment Graded Pattern (CBCS – CAGP) of education has been introduced in all programs to facilitate students to opt for subjects of their choice in addition to the core subjects of the study and prepare them with needed skills. The system also allows students to move forward under the fast track for those who have the capabilities to surpass others. These programs are taught by well experienced qualified faculty supported by the experts from industries, business sectors and such other organizations. REVA University has also initiated many supportive measures such as bridge courses, special coaching, remedial classes, etc., for slow learners to give them the needed input and build in them confidence and courage to move forward and accomplish success in their career. The University has also entered MOUs with many industries, business

firms and other institutions seeking their help in imparting quality education through practice, internship and assisting students' placements.

REVA University recognizing the fact that research, development, and innovation are the important functions of any university has established an independent Research and Innovation division headed by a senior professor as Dean of Research and Innovation. This division facilitates all faculty members and research scholars to undertake innovative research projects in engineering, science &technology, and other areas of study. The interdisciplinary-multidisciplinary research is given the topmost priority. The division continuously liaisons between various funding agencies, R&D Institutions, Industries, and faculty members of REVA University to facilitate undertaking innovative projects. It encourages student research projects by forming different research groups under the guidance of senior faculty members. Some of the core areas of research wherein our young faculty members are working include Genetics, Molecular Biology, Biotechnology, Biochemistry, Chemical Sciences, Synthetic chemistry, Nano chemistry, Nanotechnology, bioinformatics, Plant and Agricultural Research, Data Mining, Cloud Computing, Image Processing, Network Security, VLSI and Embedded Systems, Wireless Censor Networks, Computer Networks, IOT, MEMS, Nano- Electronics, Wireless Communications, Bio-fuels, Nano-technology for coatings, Composites, Vibration Energies, Electric Vehicles, Multilevel Inverter Application, Battery Management System, LED Lightings, Renewable Energy Sources and Active Filter, Innovative Concrete Reinforcement, Electro Chemical Synthesis, Energy Conversion Devices, Nano-structural Materials, Photo-electrochemical Hydrogen generation, Pesticide Residue Analysis, Nano materials, Photonics, Nana Tribology, Fuel Mechanics, Operation Research, Graph theory, Strategic Leadership and Innovative Entrepreneurship, Functional Development Management, Resource Management and Sustainable Development, Cyber Security, General Studies, Feminism, Computer Assisted Language Teaching, Culture Studies etc.

The REVA University has also given utmost importance to develop the much-required skills through variety of training programs, industrial practice, case studies and such other activities that induce the said skills among all students. A full-fledged Career Development and Placement (CDC) department with world class infrastructure, headed by a dynamic experienced Professor& Dean, and supported by well experienced Trainers, Counselors and Placement Officers. The University also has University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director facilitating skill related training to REVA students and other unemployed students. The University has been recognized as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana. The Centre conducts several add-on courses in challenging areas of development. It is always active in facilitating student's variety of Skill Development Training programs.

The University has collaborations with Industries, universities abroad, research institutions, corporate training organizations, and Government agencies such as Florida International University, Oklahoma State University, Western Connecticut University, University of Alabama, Huntsville, Oracle India Ltd, Texas Instruments, Nokia University Relations, EMC2, VMware, SAP, Apollo etc., to facilitate student exchange and teacher–scholar exchange programs and conduct training programs. These collaborations with foreign

universities also facilitate students to study some of the programs partly in REVA University and partly in foreign university, viz, M.S in Computer Science one year in REVA University and the next year in the University of Alabama, Huntsville, USA.

The University has also given greater importance to quality in education, research, administration, and all activities of the university. Therefore, it has established an independent Internal Quality division headed by a senior professor as Dean of Internal Quality. The division works on planning, designing, and developing different quality tools, implementing them, and monitoring the implementation of these quality tools. It concentrates on training entire faculty to adopt the new tools and implement their use. The division further works on introducing various examination and administrative reforms.

To motivate the youth and transform them to become innovative entrepreneurs, successful leaders of tomorrow and committed citizens of the country, REVA organizes interaction between students and successful industrialists, entrepreneurs, scientists, and such others from time to time. As a part of this exercise great personalities such as Bharat Ratna Prof. C. N. R. Rao, a renowned Scientist, Dr. N R Narayana Murthy, Founder and Chairman and Mentor of Infosys, Dr. K Kasturirangan, Former Chairman ISRO, Member of Planning Commission, Government of India, Dr. Balaram, Former Director IISc., and noted Scientist, Dr. V S Ramamurthy, Former Secretary, DST, Government of India, Dr. V K Aatre, noted Scientist and former head of the DRDO and Scientific Advisor to the Ministry of Defence Dr. Sathish Reddy, Scientific Advisor, Ministry of Defence, New Delhi and many others have accepted our invitation and blessed our students and faculty members by their inspiring addresses and interaction.

As a part of our effort in motivating and inspiring youth of today, REVA University also has instituted awards and prizes to recognize the services of teachers, researchers, scientists, entrepreneurs, social workers, and such others who have contributed richly for the development of the society and progress of the country. One of such awards instituted by REVA University is **'Lifetime Achievement Award'** to be awarded to successful personalities who have made mark in their field of work. This award is presented on occasion of the "**Founders' Day Celebration"** of REVA University on 6th January of every year in presence of dignitaries, faculty members and students gathering. The first **"REVA Lifetime Achievement Award"** for the year 2015 has been awarded to Shri. Kiran Kumar, Chairman ISRO, followed by Shri. Shekhar Gupta, renowned Journalist for the year 2016, Dr. K. J. Yesudas, renowned play back singer for the year 2017. REVA also introduced **"REVA Award of Excellence"** in the year 2017 and the first Awardee of this prestigious award is Shri Ramesh Aravind, Actor, Producer, Director, Screen Writer and Speaker.

REVA organizes various cultural programs to promote culture, tradition, ethical and moral values to our students. During such cultural events, the students are given opportunities to unfold their hidden talents and motivate them to contribute innovative ideas for the progress of the society. One of such cultural events is REVAMP conducted every year. The event not only gives opportunities to students of REVA but also students at other Universities and Colleges. During three days of this mega event students participate in debates, Quizzes, Group discussion, Seminars, exhibitions, and variety of cultural events. Another important

event is Shubha Vidaaya, - Graduation Day for the final year students of all the programs, wherein, the outgoing students are felicitated and are addressed by eminent personalities to take their future career in a right spirit, to be the good citizens and dedicate themselves to serve the society and make a mark in their respective spheres of activities. During this occasion, the students who have achieved top ranks and won medals and prizes in academic, cultural and sports activities are also recognized by distributing awards and prizes. The founders have also instituted medals and prizes for sports achievers every year. The physical education department conducts regular yoga class is every day to students, faculty members, administrative staff and their family members and organizes yoga camps for villagers around.

**Vision**

REVA University aspires to become an innovative university by developing excellent human resources with leadership qualities, ethical and moral values, research culture and innovative skills through higher education of global standards.

**Mission**

- To create excellent infrastructure facilities and state-of-the-art laboratories and incubation centres
- To provide student-centric learning environment through innovative pedagogy and education reforms
- To encourage research and entrepreneurship through collaborations and extension activities
- To promote industry-institute partnerships and share knowledge for innovation and development.
- To organize society development programs for knowledge enhancement in thrust areas
- To enhance leadership qualities among the youth and enrich personality traits, promote patriotism and moral values.

**Objectives**

- Creation, preservation and dissemination of knowledge and attainment of excellence in different disciplines
- Smooth transition from teacher - centric focus to learner - centric processes and activities
- Performing all the functions of interest to its major constituents like faculty, staff, students, and the society to reach leadership position.
- Developing a sense of ethics in the University and Community, making it conscious of its obligations to the society and the nation
- Accepting the challenges of globalization to offer high quality education and other services in a competitive manner.

# ABOUT SCHOOL OF APPLIED SCIENCES

The School of Applied Sciences offers graduate and post graduate programs in Biotechnology, Biochemistry, Chemistry, Physics and Mathematics which are incredibly fascinating. It aims to attract talented youth and train them to acquire knowledge and skills useful to industrial sectors, research laboratories, and educational institutions. The school presently offers M.Sc. degree programs in Biochemistry, Biotechnology, Bioinformatics, Microbial Technology, Genetics, Chemistry, Physics, Mathematics and B Sc with various combinations viz, Biotechnology, Biochemistry, Genetics, (BBG), Microbiology, Chemistry and Genetics (MCG), and Bioinformatics, Statistics and Computer Science (BStCs). The school also facilitates research leading to PhD in Biotechnology, Microbiology, Biochemistry, Physics, Chemistry, Mathematics, and related areas of study.

The School of Applied Sciences is shouldered by well qualified, experienced, and highly committed faculty. The state-of-the-art infrastructure digital classrooms, well equipped laboratories, conference rooms and the serene academic atmosphere at REVA University will enhance the transfer as well as creation of knowledge. The school provides an interactive, collaborative peer tutoring environment that encourages students to break down complex problems and develop strategies for finding solutions across a variety of situations and disciplines. The school aims to develop a learning community of critical thinkers who serves as models of innovative problems solving in the university environment to enrich their academic and professional careers.

### Vision

To nurture intellect, creativity, character, professionalism, and research culture among students and impart contemporary knowledge in various branches of Chemical, Biological, Physical and Mathematical Sciences that are socially relevant and transform them to become global citizens with leadership qualities.

### Mission

- To achieve excellence in studies and research through pedagogy and support interface between industry and academia
- To create intellectual curiosity, academic excellence, and integrity through multidimensional exposure
- To establish state of the art laboratories to support research and innovation and promote mastery of science.
- To inculcate an ethical attitude and make students competitive to serve the society and nation.

# Board of Studies in Microbial Technology

| S. No. | Name, Designation & Affiliation | External/ Internal Member |
|---|---|---|
| 1 | **Prof. Shilpa B.R**<br>Associate Professor,<br>Director (I/C) and Head of the Department, Department of | Chairperson |

| | | |
|---|---|---|
| | Biotechnology, School of Applied Sciences, REVA University, Bengaluru, Karnataka, India. | |
| 2 | **Dr. Pasupuleti Visweswara Rao**<br>Associate Dean, School of Applied Sciences,<br>REVA University, Bengaluru, Karnataka, India. | Internal Member |
| 3 | **Dr. Mahesh M,**<br>Chief Executive Officer, Azyme Biosciences Pvt. Ltd.,<br>Bengaluru,<br>Karnataka, India | Industry Member |
| 4 | **Dr. Basavaraj Girennavar**<br>Chairman and Managing Director, Criyagen Agri & Biotech Pvt. Ltd., Bengaluru,<br>Karnataka, India | Industry Member |
| 5 | **Dr. Pannuru Padmavati,**<br>Managing Director, DR Biosciences LLP,<br>Bengaluru, Karnataka, India | Industry Member |
| 6 | **Mr. Gokul S Bajaj**<br>HOD, Biotechnology Department, Brijlal Biyani Science College, Amravati, Maharashtra, India | Alumni Member |
| 7 | **Dr. Mahesh Yandigeri,**<br>Principal Scientist, Division of Genomic Resources,<br>National Bureau of Agricultural Insect Resources (NBAIR),<br>Hebbal, Bengaluru, Karnataka, India | Academic Member |
| 8 | **Dr. G.B. Manjunatha Reddy,**<br>Scientist, ICAR - National Institute of Veterinary Epidemiology andDisease Informatics (ICAR – NIVEDI),<br>Yelahanka, Bangalore, Karnataka, India | Academic Member |
| 9 | **Dr. Ramachandra R**<br>Associate Professor Department of Biotechnology School of Applied Sciences, REVA University, Bangalore, Karnataka, India | Internal Member |
| 10 | **Dr. NM. Guruprasad**<br>Associate Professor Department of Biotechnology School of Applied Sciences, REVA University, Bangalore,<br>Karnataka, India | Internal Member |
| 11 | **Mr. Chethan J**<br>Assistant Placement Officer, career Development Cell<br>REVA University, Bangalore, Karnataka, India | Invited Member |
| 10 | **Ms. Jasmitha Walla**<br>2nd Semester M.Sc. MT, Department of Biotechnology,<br>SoAS, REVA University, Bengaluru | Current Student |
| 11 | **Ms. Ananya N Rao**<br>2nd Semester M.Sc. MT, Department of Biotechnology,<br>SoAS, REVA University, Bengaluru | Current Student |

# M.Sc. Microbial Technology Program Overview

The Masters' program in Microbial Technology is Industry Oriented Program, majorly focused on the applied aspects of microbiology in various specialized areas of science and technology such as industry, agriculture and medicine. Microbial Technology emphasizes hands-on learning through laboratories sessions, internships, and skill development programs conducted every semester.

The curriculum of the program is reviewed and approved by esteemed members from reputed industries and research organizations to make is industry oriented in true sense. Students will have an opportunity to take up projects either at department or at reputed industries as well as state and central governments research organizations in the final semester. Well qualified faculty members with rich industry and research experience guide the students to excel in academics and research. Three different specializations have been offered for the program like Industrial and Food Microbiology, Plant and Agricultural Microbiology and Medical and Pharmaceutical Microbiology in collaboration with reputed industries like Azyme Biosciences Pvt. Ltd., Criyagen Agri & Biotech Pvt. Ltd., to ensure right skill sets for students as per chosen specialization.

Curriculum is well designed with hardcore (HC) and softcore (SC) courses. MOOC/Swayam/ Coursera Online Courses, short term certification courses and workshops are offered to equip the students with skill sets required for employability and research. There are a wide range of career options for MSc Microbial Technology program in various domains of life sciences. The career opportunities include teaching, Scientist, Industries, Research Organizations, State and Central Universities, Agriculture Universities, Hospitals, Diagnostic laboratories, Nutritionist, Project Assistant, Research Assistant, Research Analyst, Clinical Research Associates, Teaching Assistant, Lecturer and Business start-ups. In this context, University Programmes at undergraduate and postgraduate level in Life Sciences across the country have become relevant.

M. Sc. Microbial Technology at REVA UNIVERSITY has been designed to meet the human resources needs of existing and futuristic Life Science industries, research organizations and academic institutions. The program is designed to produce graduates with higher order critical, analytical, problem solving and research skills, ability to think rigorously and independently to meet higher level expectations of biotech industries, research organization and academic institutions. The program also provides sufficient skills and training on entrepreneurship development in Life Sciences

# Program Educational Objectives (PEOs)

After few years of graduation, the graduates will:

| | |
|---|---|
| PEO-1 | Become a professional Microbiologist with academic excellence, ethics and communication skills and perform in a team. |
| PEO-2 | Equip with necessary analytical and research skills to establish themselves as a competent scientist/microbiologist. |
| PEO-3 | Become successful entrepreneurs with an ability to develop new products/processeswith an attitude of lifelong learning. |

# Program Outcomes (POs)

**PO1: Master of Science Knowledge:** Apply the knowledge of microbiology and applied microbiology to the solution of complex biological problems.

**PO2: Problem analysis**: Identify, formulate, review research literature and analyze complex biological problems reaching substantiated conclusions using various principles of life science domain and microbiology.

**PO3: Design/development of Solutions:** Design solutions for complex biological problems and design protocols or processes that meet the specified needs with appropriate consideration for the public health and safety, conservation of biodiversity, better understanding of the microorganisms and necessary tools for finding solutions of various crippling human/plant diseases with ethical, societal, and environmental considerations.

**PO4: Conduct investigations of complex Problems:** Use the various protocols developed through extensive research-based knowledge and methods including design of experiments, analysis and interpretation of data, and provide valid and reproducible conclusions.

**PO5: Environment and Sustainability:** Apply the classic and modern biological theoretical and practical knowledge gained to address societal, health, microbial and plant biodiversity studies, safety, ethical and cultural issues and the consequent responsibilities relevant to the professional upgradation of the student and society as a need for sustainable development.

**PO6: Ethics:** Apply ethical principles established by different government agencies and commit to research ethics, responsibilities and norms to undertake their current and future research and development.

**PO7: Individual and team Work:** Be an independent thinker and researcher effectively as an individual, and as a member or leader of different teams, and in multidisciplinary research Institutions and Universities.

**PO8: Communication**: Communicate effectively on complex research activities with the scientific community and with society at large, as a scientist or a teacher, be well versed with scientific writing and write effective reports and design research projects, make effective presentations, and be able to defend it efficiently.

**PO9: Project management and finance:** Write good research and development projects relevant to the needs of society and environment and attract extra mural funds for himself and his team in the Institute or University from various funding agencies and manage R&D projects effectively.

**PO10: Life-long learning:** Apply the discipline, ethics and knowledge obtained to engage in independent and life-long learning in their respective fields of interest wherever they go for further higher studies or jobs**.**

# Program Specific Outcomes (PSOs)

After successful completion of the programme, the graduates shall be able to

**PSO1:** Understand about environmental microbiology, food & diary Microbiology, Industrial Microbiology, and many other technologies involved in microbiology industries and academic institutions.

**PSO2:** Provide a strong foundation for a career working skills with project management, business development or venture capital within the microbiology, agriculture, food, environment, medical technology or related industries.

**PSO3:** Utilize the skills to design, perform and analyze a research problem which has a social relevance and outcome with acquired skills of presentation and scientific writing.

**REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Postgraduate Degree programs- 2024-25**

(Framed as per the provisions under Section 35 (ii), Section 7 (x) and Section 8 (xvi) & (xxi) of the REVA University Act, 2012)

## 1. Tie and Commencement:

**1.1.** These Regulations shall be called the **"REVA University Regulations for Choice Based Credit System (CBCS) and Continuous Assessment Grading Pattern (CAGP) for Post Graduate Degree Programs- 2024-25".**

**1.2.** These Regulations shall come into force from the date of assent of the Chancellor.

## 2. The Programs:

The following programs and all Graduate Degree programs to be instituted and introduced in REVA University in coming years shall follow these regulations.

**M.Sc. in:**

Biotechnology
Bioinformatics
Microbial Technology
Biochemistry
Chemistry
Physics
Mathematics

## 3. Definitions:

**Course:** Every course offered will have three components associated with the teaching-learning process of the course, namely:

(i) L= Lecture (ii) T= Tutorial (iii) P=Practice; where:

**L** stands for **Lecture** session consisting of classroom instruction.

**T** stands for **Tutorial** session consisting participatory discussion / self-study/ desk work/ brief seminar presentations by students and such other novel methods that make a student to absorb and assimilate more effectively the contents delivered in the Lecture classes.

**P** stands for **Practice** session, and it consists of Hands-on Experience / Laboratory Experiments / Field Studies / Case Studies that equip students to acquire the much-required skill component.

## 4. Courses of study and Credits

**4.1** The study of various subjects in M. Sc., degree program is grouped under various courses. Each of these course carries credits which are based on the number of hours of teaching and learning.

**4.1.1.** In terms of credits, every **one-hour session of L amounts to 1 credit per Semester.**

In terms of credits, every **one-hour session of L amounts to 1 credit per Semester** and a minimum of **two-hour session of T or P amounts to 1 credit per Semester** over a period of one Semester of 16 weeks for teaching-learning process.

**4.1.2. The total duration of a semester is 20 weeks inclusive of semester-end examination.**

**4.1.3. A course shall have either or all the four components.** That means a course may have only lecture component, or only practical component or combination of any two or all the three components.

**4.1.4.** ***The concerned BoS will assign Credit Pattern for every course based on the requirement. However, generally, courses can be assigned with 1-4 Credits depending on the size of the course.***

**4.1.5.** Different **Courses of Study** are labelled and defined as follows:

**Core Course:**

A course which should compulsorily be studied by a candidate as a core-requirement is termed as a Core course. The CORE courses of Study are of THREE types, viz – (i) Hard Core Course, and (ii) Soft Core Course, (iii) Open Elective and Skill Enhancement Courses

**a. Hard Core Course (HC):**

The **Hard-Core Course** is a Core Course in the main branch of study and related branch(es) of study, if any that the candidates must complete compulsorily.

**b. Soft Core Course (SC):**

A Core course may be a **Soft Core** if there is a choice or an option for the candidate to choose a course from a pool of courses from the main branch of study or from a sister/related branch of study which supports the main branch of study.

**c. Open Elective Course (OE):**

An elective course chosen generally from other discipline / related subject, with an intention to seek exposure to the related subjects other than the main discipline the student is studying is called an O**pen Elective Course.**

**d. Skill Enhancement Course (SEC):**

It is a Hard course to equip students with skill development certificate-based programs required as per the industry expectation. Candidate will seek exposure through workshops and other certificate-based courses.

**e. Mandatory Course:**

It is a mandatory course to equip students with skill sets required as per the industry expectation. Candidate will seek exposure through workshops and other certificate-based courses.

**f. Project Work / Dissertation:**

Project work / Dissertation work is a special course involving application of knowledge in solving / analysing /exploring a real-life situation / difficult problem. A project work carrying **FOUR or SIX** credits is called **Minor Project** work / **Dissertation.** A project work of **EIGHT, TEN, TWELVE or SIXTEEN** credits is called **Major Project** work / **Dissertation**. **A Project work may be a hard core, or a Soft Core as decided by the BoS / concerned.**

**5. Eligibility for Admission:**

**5.1.** The eligibility criteria for admission to Two Years master's degree Program (4 Semesters) is given below:

Bachelor's degree of three years with Biotechnology or any Life Science subject as one of the cognate / majors / optional subjects with 60% (40% in case of candidates belonging to SC/ST) of marks in aggregate from any recognized University / Institution or any other qualification recognized as equivalent there to.

**5.2** Provided further that the eligibility criteria are subject to revision by the Government Statutory Bodies, such as UGC from time to time.

**6. Scheme, Duration and Medium of Instructions:**

**6.1.** M.Sc., degree program is of 4 semesters - 2 years' duration. A candidate can avail a maximum of 6 semesters (3 years) including blank semesters, if any to successfully complete M.Sc. degree. Whenever a candidate opts for blank semester, he/she must study the prevailing courses offered by the school when he/she resumes his/her studies.

**6.2**. The medium of instruction shall be English.

**7. Credits and Credit Distribution**

**7.1.** A candidate must earn 90 credits for successful completion of Two-Year Postgraduate degree with a distribution of credits for different courses as given in Table - 1 given below:

**Table-1**

**Credits and Credit Distribution for Two Year Post Graduate degree program in sciences**

| **Course Type** | **Credits for Two Year (4 Semesters) Post Graduate Degree Programs** |
|---|---|
| Hard Core Course | A minimum of 60 but not exceeding 70 |
| Soft Core Course | A minimum of 10 but not exceeding 30 |
| Open Elective | A minimum of 4 |
| SEC | A minimum of 2 |
| Project/Dissertation | A minimum of 10 |
| MOOC / Swayam/ Coursera/Soft Skill Training | A minimum of 0 - 4 |
| **Total** | **90** |

**7.2**. The concerned BOS based on the credits distribution pattern given above shall prescribe the credits to various types of courses and shall assign title to every course including project work, practical work, field work, self-study elective, as **Hard Core (HC) or Soft Core (SC) Open Elective (OE)**, **Mandatory Course (MC)** and **Skill Enhancement course (SEC)**.

**7.3.** Every course including project work, practical work, field work, self-study elective should be entitled as **Hard Core (HC) or Soft Core (SC) or Open Elective (OE), Mandatory Course (MC)** and **SEC (Skill Enhancement Course),** by the BoS concerned.

**7.4**. The concerned BOS shall specify the desired Program Objectives, Program Educational Objectives, Program Specific Outcomes and Course Outcomes while preparing the curriculum of a particular program.

**7.5**. A candidate can enrol for a maximum of 30 credits and a minimum of 10 credits per Semester. However, he / she may not successfully earn a maximum of 30 credits per semester. This maximum of 30 credits does not include the credits of courses carried forward by a candidate.

**7.6.** Only such full-time candidates who register for a minimum prescribed number of credits in each semester from I semester to IV semester and complete successfully 90 credits in 4 successive semesters shall

be considered for declaration of Ranks, Medals, Prizes and are eligible to apply for Student Fellowship, Scholarship, Free ships, and such other rewards / advantages which could be applicable for all full-time students and for hostel facilities.

**8. Add-on Proficiency Certification / Diploma:**

**8.1 Add- on Proficiency Certification:**

To acquire Add on Proficiency Certification a candidate can opt to complete a minimum of 4 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

**8.2 Add on Proficiency Diploma:**

To acquire Add on Proficiency Diploma, a candidate can opt to complete a minimum of 18 extra credits either in the same discipline /subject or in different discipline / subject in excess to 90 credits for the Two Year Post Graduate degree programs.

The Add on Proficiency Certification / Diploma so issued to the candidate contains the courses studied and grades earned.

**9. Assessment and Evaluation**

**a)** Each course is assessed for a total weight of 100%. Out of the total 100% weight; 50% weight is for Continuous Internal Assessment (CIA or IA) and the remaining 50% for the Semester End Examination (SEE). This applicable for theory, laboratory, workshop, skill development and any such courses

**b)** Out of 50% weight earmarked for Internal Assessment (IA)- 15% for test-1, 15% for test-2 and 20% for Assignments and this is applicable for theory-based courses.

**c)**. The tests and assignments are conducted as per the semester academic calendar provided by the University.

**The details as given in the table.**

| Component | Description | Conduction | Weight Percentage |
|---|---|---|---|
| **C1** | Test-1: IA1 | 8th week from the starting date of semester | 15 |
| | Test-2: IA2 | 16th week from the starting date of semester | 15 |
| **C2** | 1 Assignment | 7th week | 10 |
| | 2 Assignment | 14th week | 10 |
| **C3** | SEE including practical | between 17th Week-20th Week | 50 |
| **Results to be Announced** | | | **By the end of 21st Week** |

Note: IA or CIA includes C1 and C2

**d).** The assessment and evaluation procedure for integrated course with theory 4 credits and practical 2 credits that has been designed.

Theory: L: T: P: C - 4-0-0 (Total Contact Hours 4hrs)

Practical's: L: T: P: C - 0-0-2 (Total Contact Hours 3hrs)

Total semester end theory examination and practical examination marks will be scaled down to 50 The marks distribution is - IA1 +IA2 + SEE (Theory and practical) = 25+25+50=100.

**e).** Students are required to complete courses like technical skills, placement related courses, Open electives and any such value addition or specialized courses through online platforms like SWAYAM/NPTEL/Any other reputed online education aggregator. Students are required to choose the courses on the advice of their course coordinator/Director and required to submit the course completion certificate along with percentage of marks/grade scored in the assessment conducted by the online education aggregator. If the online education aggregator has issued a certificate along with the grade or marks scored to students, such courses will be considered for SGPA calculations, in case the aggregator has issued only a certificate and not marks scored, then such courses will be graded through an examination by concerned School, in case, if grading is not possible, students will be given a pass grade and award the credit and the credits will not be considered for SGPA calculations.

Such of those students who would like to discontinue with the open elective course that they have already registered for earning required credits can do so, however, they need to complete the required credits by choosing an alternative open elective course as mentioned above.

**Setting question paper and evaluation of answer scripts.**

i. For SEE, three sets of question papers shall be set for each theory course out of which two sets will be by the internal examiners and one set will be by an external examiner. In subsequent years by carrying forward the unused question papers, an overall three sets of question papers should be managed and depending on the consumption of question papers either internal or external examiner be called for setting the question paper to maintain an overall tally of 3 papers with the conditioned mentioned earlier. The internal examiner who sets the question paper should have been course tutor.

ii. The Chairman of BoE shall get the question papers set by internal and external examiners.

iii. The Board of Examiners shall scrutinize and approve the question papers and scheme of valuation. It is the responsibility of the BoE to see that all questions contained in the question paper are within the prescribed syllabus of the concerned course.

iv. There shall be single valuation for all theory papers by internal examiners. However, there shall be moderation by the external examiner who has the subject background. In case no external examiner with subject background is available, a senior faculty member within the discipline shall be appointed as moderator.

v. The SEE examination for Practical work / Field work / Project work/Internship will be conducted jointly by internal and external examiners as detailed below: However, the BoE on its discretion can also permit two internal examiners.

vi. If a course is fully of (L=0): T:(P=0) type or a course is partly P type i.e., (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

**10. Evaluation of Practical's and Minor Project / Major Project / Dissertation**

**10.3.1.** A practical examination shall be assessed based on:

**a)** Knowledge of relevant processes.

**b)** Skills and operations involved.

**c)** Results / products including calculation and reporting.

**10.3.2.** In case a course is fully of P type (L=0: T=0: P=4), the performance of a candidate shall be assessed for a maximum of 100 marks as explained below:

a). Continuous Internal assessment (CIA) = 50 marks

b). Semester end practical examination (SEE) = 50 marks

The 50 marks for continuous assessment shall further be allocated as under (IA or CIA):

| | | |
|---|---|---|
| i | Conduction of regular practical throughout the semester | 20 marks |
| ii | Maintenance of lab records /industry reports/SDP reports | 15 marks |
| iii | Laboratory test and viva | 15 marks |
| | Total | 50 marks |

The 50 marks meant for Semester End Examination, shall be allocated as under:

| | | |
|---|---|---|
| i | Conduction of semester end practical examination | 30 marks |
| ii | Write up about the experiment / practical conducted | 10 marks |
| iii | Viva Voce | 10 marks |
| | Total | 50 marks |

**10.3.3.** The SEE for Practical work will be conducted jointly by internal and external examiners. However, if external examiner does not turn up, then both the examiners will be internal examiners.

**10.3.4.** In case a course is partly P type i.e., (L=3): (T=0) (P=1), then the examination for SEE component will be as decided by the BoS concerned.

**10.3.5.** The duration for semester-end practical examination shall be decided by the concerned School Board.

**10.4.** Evaluation of Minor Project / Major Project / Dissertation:

Right from the initial stage of defining the problem, the candidate must submit the progress reports periodically and present his/her progress in the form of seminars in addition to the regular discussion with the supervisor. At the end of the semester, the candidate must submit final report of the project / dissertation for final evaluation. The components of evaluation are as follows:

| | | | |
|---|---|---|---|
| 1 | First Dissertation presentation describing the problem definition | Should be done a semester before the project semester | Weightage: 0% |
| 2 | Dissertation Progress presentation 1 | 7$^{th}$ week from the start date of project semester | Weightage: 25% |
| 3 | Dissertation progress presentation 2 | 14$^{th}$ Week from the start date of project semester | Weightage -25% |
| 4 | Final project Viva and Dissertation | 17$^{th}$ -20$^{th}$ Week of project | Weightage: 30% for |

| | | | |
|---|---|---|---|
| | Submission | Semester | Dissertation Weightage: 20% for Final Viva Voce |

**11. Provision for Appeal**

If a candidate is not satisfied with the evaluation of C1, C2 components, he/she can approach the grievance cell with the written submission together with all facts, the assignments, test papers etc, which were evaluated. He/she can do so before the commencement of semester-end examination. The grievance cell is empowered to revise the marks if the case is genuine and is also empowered to levy penalty as prescribed by the university on the candidate if his/her submission is found to be baseless and unduly motivated. This cell may recommend taking disciplinary/corrective action on an evaluator if he/she is found guilty. The decision taken by the grievance cell is final.

For every program there will be one grievance cell. The composition of the grievance cell is as follows: -

- The Controller of Examination - Ex-Officio Chairman / Convener
- One Senior Faculty Member (other than those concerned with the evaluation of the course concerned) drawn from the school / department/discipline and/or from the sister schools / departments/sister disciplines – Member.
- One Senior Faculty Members / Subject Experts drawn from outside the University school / department – Member.

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**12. Eligibility to Appear Semester End Examination (SEE)**

**12.1.** Only those students who fulfil a minimum of 75% attendance in aggregate of all the courses including practical courses / field visits etc., as part of the course(s), as provided in the succeeding sections, shall be eligible to appear for SEE examination.

**12.2. Requirements to Pass a Course**

Students are required to score a total minimum of 40% (Continuous Internal assessment and SEE) in each course offered by the University/ Department for a pass (other than online courses) with a minimum of 20 (40% of 50) marks in final examination

**13. Requirements to Pass the Semester**

To pass the semester, a candidate must secure minimum of 40% marks in each subject / course of the study prescribed in that semester.

**13.1 Provision to Carry Forward the Failed Subjects / Courses:**

A student who has failed in a given number of courses in odd and even semesters of first year shall move to third semester of second and final year of the study. However, he / she shall have to clear all courses of all semesters within the double duration, i. e., within four years of admission of the first semester failing which the student has to re-register to the entire program.

**13.2 Provision for Supplementary Examination**

In case candidate fails to secure a minimum of 25% (13 marks) in Semester End Examination (SEE) and a minimum of 40% marks together with IA and SEE to declare pass in the course, such candidate shall seek supplementary examination of only such course(s) wherein his / her performance is declared unsuccessful. The supplementary examinations are conducted after the announcement of even semester examination results. The candidate who is unsuccessful in each course(s) shall appear for supplementary examination of odd and even semester course(s) to seek for improvement of the performance.

**13.3. Provision to Withdraw Course:**

A candidate can withdraw any course within ten days from the date of notification of results. Whenever a candidate withdraws a course, he/she must register for the same course in case it is hard core course, the same course, or an alternate course if it is Soft Core Course or Open Elective Course. A DROPPED course is automatically considered as a course withdrawn.

**13.4**. **Re-Registration and Re-Admission:**

**a)**. In case a candidate's class attendance in aggregate of all courses in a semester is less than 75% or as stipulated by the University, such a candidate is considered as dropped the semester and is not allowed to appear for end semester examination (C3) and he / she shall have to seek re-admission to that semester during subsequent semester / year within a stipulated period.

**b)**. In such case where in a candidate drops all the courses in a semester due to personal reasons, it is considered that the candidate has dropped the semester and he / she shall seek re-admission to such dropped semester.

**14. Attendance Requirement:**

**14.1** All students must attend every lecture, tutorial and practical classes.

**14.2** In case a student is on approved leave of absence (e g:- representing the university in sports, games or athletics, placement activities, NCC, NSS activities and such others) and / or any other such contingencies like medical emergencies, the attendance requirement shall be minimum of 75% of the classes taught.

**a)** Any student with less than 75% of attendance in aggregate of all the courses including practical courses / field visits etc, during a semester shall not be permitted to appear to the end semester (C3) examination and such student shall seek re-admission as provided in 7.8.4.

**b)** Teachers offering the courses will place the above details in the School Board meeting during the last week of the semester, before the commencement of C3, and subsequently a notification pertaining to the above will be brought out by the Director of the School before the commencement of C3 examination. A copy of this notification shall also be sent to the office of the Registrar &Controller of Examination.

**15. Absence during Mid Semester Examination:**

In case a student has been absent from a mid-semester (C1, C2) examination due to the illness or other contingencies he / she may give a request along with necessary supporting documents and certification from the concerned class teacher / authorized personnel to the concerned Head of the School, for make-up

examination. The Head of the School may consider such request depending on the merit of the case and after consultation with course instructor and class teacher and arrange to conduct a special test for such candidate(s) well in advance before the C3 examination of that respective semester. Under no circumstances C1, C2 test shall be held after C3 examination.

## 16. Grade Card and Grade Point

**16.1. Provisional Grade Card**: The tentative / provisional grade card will be issued by the Controller of Examination at the end of every semester indicating the courses completed successfully. The provisional grade card provides **Semester Grade Point Average** (SGPA).

**16.2. Final Grade Card:** Upon successful completion of M.Sc., Degree a Final Grade card consisting of grades of all courses successfully completed by the candidate will be issued by the Controller of Examination.

**16.3. The Grade and the Grade Point:** The Grade and the Grade Point earned by the candidate in the subject will be as given below.

| **Marks P** | **Grade G** | **Grade Point (GP=V x G)** | **Letter Grade** |
|---|---|---|---|
| 90 -100 | 10 | v*10 | O |
| 80 - 89 | 9 | v*9 | A+ |
| 70 - 79 | 8 | v*8 | A |
| 60 - 69 | 7 | v*7 | B+ |
| 55 -59 | 6 | v*6 | B |
| 50 - 54 | 5.5 | V*5.5 | C + |
| 40 -49 | 5 | v*5 | P |
| 0 - 39 | 0 | v*0 | F |
| ABSENT | | | AB |

*O - Outstanding; A+-Excellent; A-Very Good; B+-Good; B-Above Average; C+-Average; C-Satisfactory; F – Unsatisfactory.*

Here, P is the percentage of marks (P=[C1+C2+C3]) secured by a candidate in a course which is **rounded to nearest integer**. V is the credit value of course. G is the grade and GP is the grade point.

### 16.3.1. Computation of SGPA and CGPA

The Following procedure to compute the Semester Grade Point Average (SGPA)

The SGPA is the ratio of sum of the product of the number of credits with the grade points scored by a student in all the courses taken by a student and the sum of the number of credits of all the courses undergone by a student in each semester, i.e.:

**SGPA (Si) = ∑ (Ci x Gi) / ∑Ci** where Ci is the number of credits of the ith course and Gi is the grade point scored by the student in the ith course.

**Illustration for Computation of SGPA and CGPA**
**Illustration No. 1**

| Course | Credit | Grade Letter | Grade Point | Credit Point (Credit x Grade) |
|---|---|---|---|---|
| Course 1 | 4 | A+ | 9 | 4X9=36 |
| Course 2 | 4 | A | 8 | 4X8=32 |
| Course 3 | 3 | B+ | 7 | 3X7=21 |
| Course 4 | 3 | O | 10 | 3X10=30 |
| Course 5 | 3 | P | 5 | 3X5=15 |
| Course 6 | 3 | B | 6 | 3X6=18 |
| Course 7 | 2 | O | 10 | 2X10=20 |
| Course 8 | 2 | A | 8 | 2X8=16 |
| | 24 | | | 188 |

Thus, **SGPA = 188 ÷ 24 = 7.83**

**Illustration No. 2**

| Course | Credit | Grade letter | Grade Point | Credit Point (Credit x Grade point) |
|---|---|---|---|---|
| Course 1 | 4 | A | 8 | 4X8=32 |
| Course 2 | 4 | B+ | 7 | 4X7=28 |
| Course 3 | 3 | A+ | 9 | 3X9=27 |
| Course 4 | 3 | B+ | 7 | 3X7=21 |
| Course 5 | 3 | B | 6 | 3X6=18 |
| Course 6 | 3 | P | 5 | 3X5=15 |
| Course 7 | 2 | B+ | 7 | 2X7=21 |
| Course 8 | 2 | O | 10 | 2X10=20 |
| | 24 | | | 175 |

Thus, **SGPA = 175 ÷ 24 = 7.29**

**Illustration No.3**

| Course | Credit | Grade Letter | Grade Point | Credit Point (Credit x Grade point) |
|---|---|---|---|---|
| Course 1 | 4 | O | 10 | 4 x 10 = 40 |
| Course 2 | 4 | A+ | 9 | 4 x 9 = 36 |
| Course 3 | 3 | B+ | 7 | 3 x 7 = 21 |
| Course 4 | 3 | B | 6 | 3 x 6 = 18 |
| Course 5 | 3 | A+ | 9 | 3 x 9 = 27 |
| Course 6 | 3 | B+ | 7 | 3 x 7 = 21 |
| Course 7 | 2 | A+ | 9 | 2 x 9 = 18 |
| Course 8 | 2 | A+ | 9 | 2 x 9 = 18 |
| | 24 | | | 199 |

Thus**, SGPA = 199 ÷ 24 = 8.29**

**Cumulative Grade Point Average (CGPA):**

Overall Cumulative Grade Point Average (CGPA) of a candidate after successful completion of the required number of credits (96) for Two year Post Graduate degree program is calculated considering all the courses undergone by a student over all the semesters of a program i. e.,

$CGPA = \sum (Ci \times Si) / \sum Ci$

Where Si is the SGPA of the ith semester and Ci is the total number of credits in that semester.

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

**Illustration: No.1**

CGPA after Final Semester

| Semester | No. of Credits | SGPA | Credits x SGPA |
|---|---|---|---|

| (ith) | (Ci) | (Si) | (Ci X Si) |
|---|---|---|---|
| 1 | 24 | 6.83 | 24 x 6.83 = 163.92 |
| 2 | 26 | 7.71 | 26 x 7.71 = 200.46 |
| 3 | 26 | 8.68 | 26 x 8.68 = 225.68 |
| 4 | 14 | 9.20 | 14 x 9.20 = 128.8 |
| Cumulative | 90 | | 718.86 |

Thus, CGPA = $\frac{24x6.83+26x7.71+26x8.68+14x9.20}{90} = \frac{718.86}{90} =$ 7.99

**16.3.2. CONVERSION OF GRADES INTO PERCENTAGE:**

*Conversion formula for the conversion of CGPA into Percentage is:*

*Percentage of marks scored = CGPA Earned x 10*

*Illustration: CGPA Earned 8.10 x 10=81.0*

**16.3.3. Classification of Results**

The final grade point (FGP) to be awarded to the student is based on CGPA secured by the candidate and is given as follows.

| **CGPA** | **Grade (Numerical Index)** | **Letter Grade** | **Performance** | **FGP** |
|---|---|---|---|---|
| | **G** | | | **Qualitative Index** |
| 9 >= CGPA 10 | 10 | O | Outstanding | Distinction |
| 8 >= CGPA < 9 | 9 | A+ | Excellent | |
| 7 >= CGPA < 8 | 8 | A | Very Good | First Class |
| 6 >= CGPA < 7 | 7 | B+ | Good | |
| 5.5> = CGPA < 6 | 6 | B | Above average | Second Class |
| > 5 CGPA < 5.5 | 5.5 | C | Average | |
| > 4 CGPA <5 | 5 | P | Pass | Satisfactory |

**Overall percentage=10*CGPA**

**17. Challenge Valuation**

For all PG courses since it is a double valuation (Internal and External Examiners), candidate shall not have an option to apply for challenge valuation.

**Mapping of PEOS with Respect to POs and PSOs**

| | PO1 | P2 | PO 3 | PO4 | PO5 | PO6 | P7 | PO8 | PO 9 | PO10 | PSO 1 | PSO2 | PSO 3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **PEO1** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **PEO2** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |
| **PEO3** | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ | √ |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M24SO0101 | CO1 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 2 |
| | CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO5 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 2 |
| | CO6 | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 3 | 0 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M24SO0102 | CO1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 |
| | CO2 | 3 | 3 | 1 | 3 | 3 | 0 | 0 | 3 | 3 | 3 | 3 | 2 | 2 |
| | CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 3 |
| | CO6 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0103 | CO1 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO5 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 1 |
| | CO6 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS111 | CO1 | 3 | 2 | 2 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 |
| | CO2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 |
| | CO3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 |
| | CO4 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| | CO5 | 3 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 |
| | CO6 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS112 | CO1 | 3 | 3 | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 2 |
| | CO3 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO6 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOS121 | CO1 | 3 | 1 | 2 | 2 | 3 | 2 | 0 | 0 | 2 | 1 | 3 | 3 | 2 |
| | CO2 | 3 | 0 | 1 | 4 | 2 | 2 | 0 | 1 | 2 | 0 | 2 | 2 | 0 |
| | CO3 | 3 | 1 | 2 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| | CO4 | 3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| | CO5 | 2 | 1 | 2 | 2 | 3 | 2 | 0 | 0 | 1 | 3 | 2 | 2 | 2 |
| | CO6 | 3 | 2 | 3 | 2 | 3 | 1 | 2 | 0 | 0 | 0 | 2 | 2 | 0 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS122 | CO1 | 3 | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| | CO2 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| | CO3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| | CO4 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| | CO5 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 |
| | CO6 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | 3 | 2 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **PO / CO** | PO1 | PO2 | PO 3 | PO4 | PO 5 | PO 6 | PO7 | PO 8 | PO 9 | PO10 | PS0 1 | PS02 | PS0 3 |
| M24SO0104 | CO1 | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 2 |
| | CO2 | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO3 | 2 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO4 | 2 | 3 | 3 | 3 | 1 | 0 | 1 | 2 | 3 | 2 | 3 | 3 | 2 |
| | CO5 | 2 | 3 | 3 | 3 | 1 | 0 | 1 | 2 | 3 | 2 | 3 | 3 | 2 |
| | CO6 | 3 | 3 | 2 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0105 | CO1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 3 |
| | CO2 | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 3 | 1 |
| | CO3 | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 3 | 2 | 2 | 3 | 2 | 1 |
| | CO4 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 |
| | CO5 | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 3 |
| | CO6 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0106 | CO1 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO5 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 1 |
| | CO6 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0201 | CO1 | 3 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 1 | 1 | 3 | 2 | 2 |
| | CO2 | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CO3 | 3 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| | CO4 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO6 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0202 | CO1 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO2 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO3 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO4 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO6 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0203 | CO1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| | CO2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CO3 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| | CO4 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO6 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS211 | CO1 | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| | CO2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CO3 | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 2 |
| | CO4 | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 3 | 2 | 2 |
| | CO5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 |
| | CO6 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS212 | CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| | CO2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| | CO3 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 1 |
| | CO4 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 3 | 1 | 1 |
| | CO6 | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS221 | CO1 | 2 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 1 |
| | CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 |
| | CO5 | 0 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO6 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS222 | CO1 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO2 | 1 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 3 | 2 |
| | CO3 | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 2 |
| | CO4 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 3 |
| | CO5 | 1 | 2 | 3 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | 2 | 3 |
| | CO6 | 1 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SO0204 | CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| | CO2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| | CO3 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | CO4 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| | CO5 | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| | CO6 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0205 | CO1 | 3 | 3 | 3 | 3 | 2 | 6 | 2 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO6 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 3 | 3 | 3 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SO0206 | CO1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 |
| | CO2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CO3 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| | CO4 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 2 |
| | CO5 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO6 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOZ301 | CO1 | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 3 |
| | CO2 | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 2 |
| | CO3 | 3 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 2 | 1 |
| | CO4 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO6 | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |
| M24SOZ302 | CO1 | 3 | 2 | 1 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| | CO2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| | CO3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| | CO4 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| | CO5 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 |
| | CO6 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOZ303 | CO1 | 3 | 2 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | 2 | 1 |
| | CO2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 1 |
| | CO3 | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 1 |
| | CO4 | 3 | 2 | 0 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 3 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 3 | 1 | 1 |
| | CO6 | 3 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS311 | CO1 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 2 | 0 | 2 | 3 | 3 | 3 | 3 | 2 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 2 |
| | CO6 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 2 | 3 | 2 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |
| M24SOS312 | CO1 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 3 | 0 | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| | CO6 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 2 | 3 | 2 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PS01 | PS02 | PS03 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M24SOZ304 | CO1 | 1 | 2 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 2 | 2 | 1 |
| | CO2 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| | CO3 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| | CO4 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 2 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 1 | 1 |
| | CO6 | 2 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ305 | CO1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 3 | 2 |
| | CO4 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| | CO5 | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | | 2 | 2 | 2 |
| | CO6 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ306 | CO1 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| | CO2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| | CO3 | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| | CO4 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| | CO5 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 2 |
| | CO6 | 3 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SLO301 | CO1 | 3 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| | CO2 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 |
| | CO3 | 3 | 0 | 1 | 3 | 3 | 3 | 2 | 1 | 2 | 0 | 1 | 0 | 0 |
| | CO4 | 2 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| | CO5 | 3 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 |
| | CO6 | 2 | 0 | 0 | 3 | 3 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 1 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SO0301 | CO1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 3 | 1 | 1 | 3 | 1 | 0 |
| | CO2 | 1 | 1 | 1 | 0 | 1 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 0 |
| | CO3 | 1 | 1 | 0 | 0 | 1 | 2 | 3 | 0 | 3 | 1 | 2 | 3 | 1 |
| | CO4 | 1 | 0 | 1 | 0 | 1 | 1 | 2 | 3 | 3 | 1 | 2 | 3 | 1 |
| | CO5 | 1 | 1 | 0 | 0 | 1 | 2 | 3 | 3 | 3 | 1 | 2 | 1 | 1 |
| | CO6 | 1 | 0 | 0 | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 3 | 1 | 1 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ307 | CO1 | 2 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 1 |
| | CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 1 | 1 | 0 |
| | CO4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| | CO5 | 0 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO6 | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M24SOZ308 | CO1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO2 | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 1 |
| | CO3 | 3 | 3 | 1 | 2 | 3 | 2 | 1 | 2 | 2 | 3 | 1 | 1 | 0 |
| | CO4 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 2 |
| | CO5 | 0 | 0 | 3 | 1 | 3 | 2 | 1 | 3 | 3 | 3 | 1 | 3 | 2 |
| | CO6 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ309 | CO1 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| | CO2 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO5 | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 |
| | CO6 | 3 | 3 | 2 | 2 | 0 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ310 | CO1 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO4 | 2 | 2 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO6 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ311 | CO1 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO4 | 2 | 2 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO6 | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ312 | CO1 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO2 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO4 | 2 | 3 | 2 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 1 | 3 |
| | CO5 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO6 | 3 | 3 | 2 | 3 | 2 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ313 | CO1 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 2 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| | CO5 | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 2 | 3 | 3 | 3 |
| | CO6 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |

| **Course Code** | **PO/ CO** | PO1 | PO2 | PO3 | PO 4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO 1 | PSO 2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| M24SOZ314 | CO1 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| | CO2 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 1 | 1 | 2 | 2 | 3 | 1 |
| | CO3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |
| | CO4 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 |
| | CO5 | 2 | 1 | 3 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | 3 | 3 |
| | CO6 | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ315 | CO1 | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| | CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |
| | CO3 | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 2 | 3 |
| | CO4 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |
| | CO5 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 1 | 3 | 1 |
| | CO6 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ316 | CO1 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO6 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ317 | CO1 | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| | CO2 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 1 | 3 | 3 | 3 |
| | CO3 | 2 | 3 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| | CO5 | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| | CO6 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SOZ318 | CO1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| | CO3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| | CO5 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| | CO6 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |
| **Course Code** | **PO / CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO 9 | PO10 | PS0 1 | PS02 | PS03 |
| M24SO0401 | CO1 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 1 | 3 | 2 | 2 |
| | CO2 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 2 |
| | CO3 | 1 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 1 | 3 | 2 | 1 |
| | CO4 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 1 |
| | CO5 | 3 | 3 | 2 | 1 | 1 | 2 | 1 | 3 | 1 | 1 | 3 | 1 | 0 |
| | CO6 | 3 | 1 | 2 | 0 | 0 | 3 | 1 | 3 | 2 | 1 | 2 | 1 | 0 |

# M.Sc. (Microbial Technology) Program

## Scheme of Instruction (effective from Academic Year 2024-26)

| S. No | Course code | Course title | HC/ SC | L | T | P | C | Hours/ Week |
|---|---|---|---|---|---|---|---|---|
| **FIRST SEMESTER** | | | | | | | | |
| 1 | M24SO0101 | Microbiological methods | HC | 4 | 0 | 0 | 4 | 4 |
| 2 | M24SO0102 | Molecular Microbial Genetics | HC | 4 | 0 | 0 | 4 | 4 |
| 3 | M24SO0103 | Bioanalytical Techniques | HC | 4 | 0 | 0 | 4 | 4 |
| 4 | M24SOS111 | Research Methodology | SC | 4 | 0 | 0 | 4 | 4 |
| 5 | M24SOS112 | Entrepreneurship in Life Sciences | | | | | | |
| 6 | M24SOS121 | Cell Culture Technology | SC | 4 | 0 | 0 | 4 | 4 |
| 7 | M24SOS122 | Microbial Metabolites | | | | | | |
| | **Practical courses** | | | | | | | |
| 8 | M24SO0104 | Microbiological Methods Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 9 | M24SO0105 | Molecular Microbial Genetics Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 10 | M24SO0106 | Bioanalytical techniques Lab | HC | 0 | 0 | 2 | 2 | 4 |
| **Total Credits** | | | | **20** | **0** | **6** | **26** | **32** |
| **Note: Industrial visits will be organized to Public/Private Sector.** | | | | | | | | |
| **S. No** | **Course code** | **Course title** | **HC/ SC/ SEC** | **L** | **T** | **P** | **C** | **Hours/ Week** |
| **SECOND SEMESTER** | | | | | | | | |
| 1 | M24SO0201 | Microbial Metabolism and Physiology | HC | 4 | 0 | 0 | 4 | 4 |
| 2 | M24SO0202 | Microbial Diversity | HC | 4 | 0 | 0 | 4 | 4 |
| 3 | M24SO0203 | Bioinformatics and Biostatistics | HC | 4 | 0 | 0 | 4 | 4 |
| 4 | M24SOS211 | Microbiology for Sustainable Environment | SC | 4 | 0 | 0 | 4 | 4 |
| 5 | M24SOS212 | Microbial Food Processing | | | | | | |
| 6 | M24SOS221 | Molecular Immunology | SC | 4 | 0 | 0 | 4 | 4 |
| 7 | M24SOS222 | Molecular Enzymology | | | | | | |
| | **Practical courses** | | | | | | | |
| 8 | M24SO0204 | Microbial metabolism and Physiology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 9 | M24SO0205 | Microbial Diversity LAB | HC | 0 | 0 | 2 | 2 | 4 |
| 10 | M24SO0206 | Bioinformatics and Biostatistics Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 11 | M24PTM201 | Soft Skill Training | MC | 0 | 0 | 0 | 0 | 2 |
| **Total credits** | | | | **20** | **0** | **6** | **26** | **34** |
| **Industrial visits will be organized to Public/Private Sectors .** | | | | | | | | |
| **THIRD SEMESTER** | | | | | | | | |
| **S. No** | **Course code** | **Course title** | **HC/ SC/ OE** | **L** | **T** | **P** | **C** | **Hours/ Week** |
| **Specialization in Industrial & Food Microbiology** | | | | | | | | |
| 1 | M24SOZ301 | Food Microbiology | HC | 4 | 0 | 0 | 4 | 4 |
| 2 | M24SOZ302 | Bioprocess Technology | HC | 4 | 0 | 0 | 4 | 4 |
| 3 | M24SOZ303 | Food Chemistry and Processing | HC | 4 | 0 | 0 | 4 | 4 |
| 4 | M24SOS311 | Nanobiotechnology and Space | SC | 4 | 0 | 0 | 4 | 4 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Microbiology | | | | | | |
| 5 | M24SOS312 | Marine Microbiology | | | | | | |
| 6 | M24SLO301 | Organic Farming | OE | 4 | 0 | 0 | 4 | 4 |
| **Practical courses** | | | | | | | | |
| 7 | M24SOZ304 | Food Microbiology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 8 | M24SOZ305 | Bioprocess Technology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 9 | M24SOZ306 | Food Chemistry and Processing lab | HC | 0 | 0 | 2 | 2 | 4 |
| 10 | M24SO0301 | Skill Enhancement Course | SEC | 2 | 0 | 0 | 2 | 2 |
| | **Total Credits** | | | **22** | **0** | **6** | **28** | **34** |
| **Specialization in Agriculture & Environmental Microbiology** | | | | | | | | |
| 1 | M24SOZ307 | Soil Microbiology | HC | 4 | 0 | 0 | 4 | 4 |
| 2 | M24SOZ308 | Plant Pathology | HC | 4 | 0 | 0 | 4 | 4 |
| 3 | M24SOZ309 | Biomass and energy systems | HC | 4 | 0 | 0 | 4 | 4 |
| 4 | M24SOS311 | Nanobiotechnology and Space Microbiology | SC | 4 | 0 | 0 | 4 | 4 |
| 5 | M24SOS312 | Marine Microbiology | | | | | | |
| 6 | M24SLO301 | Organic Farming | OE | 4 | 0 | 0 | 4 | 4 |
| **Practical courses** | | | | | | | | |
| 7 | M24SOZ310 | Soil Microbiology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 8 | M24SOZ311 | Plant Pathology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 9 | M24SOZ312 | Biomass and energy systems Lab | HC | 0 | 0 | 2 | 2 | 4 |
| 10 | M24SO0301 | Skill Enhancement Course | SEC | 2 | 0 | 0 | 2 | 2 |
| | **Total Credits** | | | **22** | **0** | **6** | **28** | **34** |
| **Specialization in Medical and Pharmaceutical Microbiology** | | | | | | | | |
| **1** | M24SOZ313 | Clinical Microbiology | HC | 4 | 0 | 0 | 4 | 4 |
| 2 | M24SOZ314 | Medical Biochemistry | HC | 4 | 0 | 0 | 4 | 4 |
| 3 | M24SOZ315 | Pharmaceutical Microbiology | HC | 4 | 0 | 0 | 4 | 4 |
| **4** | M24SOS311 | Nanobiotechnology and Space Microbiology | SC | 4 | 0 | 0 | 4 | 4 |
| **5** | M24SOS312 | Marine Microbiology | | | | | | |
| **6** | M24SLO301 | Organic Farming | OE | 4 | 0 | 0 | 4 | 4 |
| **Practical courses** | | | | | | | | |
| **7** | M24SOZ316 | Clinical Microbiology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| **8** | M24SOZ317 | Medical Biochemistry Lab | HC | 0 | 0 | 2 | 2 | 4 |
| **9** | M24SOZ318 | Pharmaceutical Microbiology Lab | HC | 0 | 0 | 2 | 2 | 4 |
| **10** | M24SO0301 | Skill Enhancement Course | HC | 2 | 0 | 0 | 2 | 2 |
| **Total Credits** | | | | **22** | **0** | **6** | **28** | **34** |
| **Industrial visits will be organized to Public/Private Sectors .** | | | | | | | | |
| **S. No** | **Course code** | **Course title** | **HC/ SC/ OE** | **L** | **T** | **P** | **C** | **Hours/ Week** |
| **FOURTH SEMESTER** | | | | | | | | |
| **1** | M24SO0401 | Major Project | HC | 0 | 0 | 10 | 10 | 10 |
| **Total Credits** | | | | **0** | **0** | **10** | **10** | **10** |
| | | | | | | | | |

**Semester-wise Summary of Credit Distribution**

| Semester | L | T | P | Credits |
|---|---|---|---|---|
| First | 20 | 0 | 6 | 26 |
| Second | 20 | 0 | 6 | 26 |
| Third | 22 | 0 | 6 | 28 |
| Fourth | 0 | 0 | 10 | 10 |
| **Total** | **62** | **0** | **28** | **90** |

HC=Hard Core; SC=Soft Core; OE=Open Elective; MC=Mandatory Course

**Distribution of Credits Based on Type of Courses**

| Semester | Hard Core (HC) | Soft Core (SC) | Open Elective (OE) | SEC | Total Credits |
|---|---|---|---|---|---|
| First | 18 | 8 | 0 | 0 | 26 |
| Second | 18 | 8 | 0 | 0 | 26 |
| Third | 18 | 4 | 4 | 2 | 28 |
| Fourth | 10 | 0 | 0 | 0 | 10 |
| **Total** | 64 | 20 | 4 | 2 | 90 |

# M.Sc. (Microbial Technology) Program
# Detailed Syllabus

**(Effective from Academic Year 2024-26)**

## FIRST SEMESTER

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0101 | **Microbiological Methods** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basic knowledge of culturing of various microorganisms.

**Course objectives**

**The overall objectives of the course are:**

1. Enhance students knowledge on understating chemical formulations.
2. Enable students to understand the basic biomolecules and their role in life.
3. Acquire the knowledge of basic and biological functions of immune system.
4. Enhance the analytical skills related to microbiology.
5. To equip students with methodologies to detect and identify the microbes.

**Course outcomes**

**After completing the course, the student should be able to:**

1. Characterize the basis and importance's of biochemical reactions involved in cells.
2. Understand the diversity of microorganisms including bacteria and fungi.
3. Learn microscopy techniques to observe and characterize microorganisms.
4. Apply the basic knowledge and importance's of immune system in organisms.
5. Apply and analyze the techniques to characterize and identify of microbes.
6. Employ the methodologies to culture and analyses the various microbes.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 3 | 2 | 3 | 2 | 2 |
| **CO6** | 2 | 3 | 2 | 2 | 3 | 1 | 1 | 3 | 3 | 1 | 3 | 3 | 0 |

**Course content**

**Unit-I Basic concepts of Chemistry and Biochemistry 13 h**

Chemical formulas and the mole concept. Avogadro's constant. Chemical reaction and equations. Mass relationship in reactions & calculations, Titrations and indicators. Scope and importance of biochemistry, Structure of water, Acid base concept and buffers, pH, Hydrogen bonding, Hydrophobic, Electrostatic and Vander Waals forces. Classification, structure and function of carbohydrates, proteins and lipids. Structure and function of amino acids and vitamins.

**Unit-II Microscopy and microbiological staining 13 h**

Light microscopy- Simple microscope, Compound microscope (Brightfield, Darkfield, Phase contrast, Fluorescence and confocal). Electron Microscopy-Principles, construction and mode of operation of Scanning, transmission electron microscope, AFM and STEM, limitations and preparation of specimens. Types of stains and principles of staining in microbiology, wet mounting and hanging drop method.

**Unit-III Microbial life process 13 h**

Bacterial growth and fungal growth-types of reproductions, Measurement of microbial growth, Growth curve and factors influencing the microbial growth. Growth stoichiometry; Kinetics of microbial growth and product formation in batch, Fed batch and continuous cultures.

**Unit-IV Culture methods and Aseptic Techniques 13 h**

Microbiological media-types, cultivation of aerobic and anaerobic bacteria, pure cultures and cultural characteristics. Serial dilution, Pure cultures and isolation techniques, Maintenance and preservation of pure cultures. Principles and methods of sterilization-Physical and Chemical Sterilization.

**Reference books**

1.Microbiology: A Laboratory Manual, 12th edition, James G. Cappuccino and Chad T. Welsh.12th edition (2021)

2.Methods in Microbiology. Book series. Elsevier. Volume 54: pp. 2 - 286. (2024)

3.Microbiology; Lansing Prescott, John P. Harley, Donald A Klein, 6thedition, McGrawHillHighereducation (2005).

4.General Microbiology; RYIngraham, JLWheels, M.L.Painter, 5thEdition, ThessMacmillanPressLtd.(2003).0

5.Applications of Molecular Microbiological Methods.Casey R. J. Hubert, Sean M. Caffrey, Torben Lund Skovhus.Caister Academic Press. (2014)

6.Microbiology; M.J.Pelczar, E.C.SChanandN.R. Kreig, TataMacGrawHill(2004).

7.Bergey's Manual of Systematic Bacteriology, Breed and Buchanan, 2ndEdition, (Volumes1-6)(2001–2003).

8.General Microbiology; R.Y.Stanier, E.A.Adelberg, J.L.Ingraham, 4thedition, MacMillanPress, London (2000).

9.Microbiology-An Introduction. Gerard J. Tortora, Berdell R. Funke, Christine L. Case. Publishe-Pearson. (2013)

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0102 | **Molecular Microbial Genetics** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students to know basics and importance of DNA and RNA.

**Course Objectives**

1.Understand the basics of genetic material and hereditary.

2.Study the mechanism of transcription and translation of genetic information.

3.Understand the mechanism of recombinant and genetic transfer in bacteria

4.Discuss the genome structure and functions bacteriophages and eukaryotic microorganisms.

**Course Outcome**

By the end of the course the student will be able to:

1.Outline the genetic inheritance in prokaryotic and eukaryotic microorganisms.

2.Explore the mechanism of transcription and translation in microorganisms.

3.Acquire the knowledge of genetic transfer mechanisms in microorganisms.

4.Exploit the knowledge of microbial genetics in allied research.

5.Upgrade the knowledge on molecular mechanisms of genetics

6.Understand the genetic makeup and replication of phages

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 1 | 3 | 3 | 0 | 0 | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 2 | 3 | 3 |
| **CO6** | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**Course content**

**Unit-I Molecular Basis and life process 13 h**

Nucleic acids as hereditary material and concept of central dogma. Structure and functions of DNA and RNA, Forms of DNA and Types of RNA- rRNA, tRNA and mRNA. RNA Biology-iRNA & miRNA. DNA replication in prokaryotes and eukaryotes. Models of DNA replication, Cell cycle and regulation of DNA replications, mutations and DNA repair.

**Unit-II Gene Expression and regulation 13 h**

Genetic code, Transcription, RNA polymerases, Types of promoters, Reverse transcriptase and RNA replicase, Post-transcriptional modification, maturation and splicing of RNA transcripts and catalytic RNA. Translation in prokaryotic and eukaryotic microbes. Post-translational modification and protein targeting. Gene regulation.

**Unit-III Genetic Recombination in microorganisms 13 h**

Methods of gene transfer in bacteria-Conjugation and types - nature of donor strains and compatibility, interrupted mating and temporal mapping and molecular pathway of recombination. Transformation-natural transformation systems, gene mapping, Transduction- generalized and specialized or restricted transduction.

**Unit-IV Genetics of phage and fungi 13 h**

T4 virulent phage-structure, life cycle, genetic map and DNA replication. Lambda phage: Structure, genetic map, lytic and lysogenic cycle. Applications of phages in microbial genetics. Transposons- Insertion sequences and composite transposons, phages as transposons, replicative, non-replicative and conservative

transposition. Aspects of fungal Genetics: Meiotic and mitotic mapping, gene conversion, mitotic segregation and recombination,

.**Reference Books**


1. Gene IX; Benjamin Lewin Oxford University Press, New York (2005).
2. Principles of Genetics; Snustad and Simmons, 4th Edition, John Wiley and Sons, Inc (2006).
3. Molecular Cell Biology; Lodish et.al., W. H. Freeman and Company (2006).
4. Genomes; T.A. Brown, John Wiley and sons (Asia) PTE LTD, New York (2001).
5. Principles of Gene Manipulation and Genomics; S.B. Primrose and R. M. Twyman, 7th Edition, Blackwell Publishing, U.K (2002).
6. Modern Microbial Genetics; Streips and Yasbin, 2nd Edition Wiley Ltd (2002).
7. Molecular Biology of the Gene; J.D. Watson, T.A. Baker, S.P. Bell, A. Gann, M. Levine, R. Losick, 7th Edition, Pearson (2014).


| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0103 | **Bioanalytical Techniques** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Student should have a knowledge of biomolecules and separation techniques.

**Course Objectives**

1.To develop the skills and competency in biochemical techniques

2.To equip with separation of biomolecules through various chromatographic techniques

3.To provide new skills for the separation and characterization of biomolecules

4.Empower the knowledge of physico-chemistry to analyse the biomolecules

**Course Outcome**

By the end of the course the student will be able to:

1.Equip with biochemical techniques for handling the biomolecules.

2. Apply the knowledge of practical skills in separation of biomolecules

3. Explore various methods to characterize the biomolecules.

4. Quantify the biomolecules with optimized methods.

5. Understand the concepts acids, bases ,buffers and preparation of reagents.

6. Analyze and interpret the results to draw the final conclusion.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 1 |
| **CO6** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 |

**Course content**

**Unit -1 Centrifugation** **13 h**

Principles of separation techniques, Centrifugation-classification, types and applications, High speed and Ultracentrifugation, Differential and Density-gradient centrifugation, Analytical centrifugation and applications, Factors affecting Sedimentation, Preparative and analytical centrifugation, Safety measures of centrifugation. Filtration techniques**.**

**Unit -II Chromatography 13 h**

Chromatography techniques classification, factors affecting the separation, Thin layer chromatography, Column chromatography, gel permeation chromatography, ion-exchange chromatography, Affinity chromatography, HPLC, GC, applications.

**Unit-III Electrophoresis 13 h**

Electrophoresis, principle of electrophoresis, Paper and gel electrophoresis, factors affecting electrophoresis, gelatin gel, starch gel, Agarose gel electrophoresis, factors affecting separation, troubleshooting, Poly Acrylamide gel electrophoresis, SDS-PAGE, capillary electrophoresis; Isoelectric focusing and isotachophoresis, PFGE, Hybridization and blotting techniques.

**Unit-IV Spectroscopy and Radioactivity 13 h**

Principles of spectroscopy – UV, visible, CD, NMR, Electromagnetic spectrum and interaction of radiation with matter, UV and Visible spectroscopy; Beer-Lambert's law and its limitation; IR spectroscopy, NMR and ESR, CD/ORD, X-ray crystallography. Mass spectrometry-MALDI TOF, TANDEM Mass spectrometry, GC-MS and LC-MS. Radioactivity-Introduction to Isotopes, detection and measurement of radioactivity, Autoradiography.

**Reference Textbooks**

1. Microbiology; M.J. Pelczar, E.C.S Chan and N.R. Kreig, Tata MacGraw Hill (2004).

2. Biochemical techniques; Manikam and Sadasivam, New Age International, (2008).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS111 | **Research Methodology** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should be knowing about the research ideas and recent ongoing research works.

**Course Objectives**

1.Acquire basic knowledge on qualitative and quantitative methods.

2.Identify and formulate the research problems and design the research.

3.Familiarize the student in using statistical tools in research methods.

4.Student will acquire the knowledge biological information and relevant ethical concerns.

**Course outcomes**

By the end of the course the student will be able to:

1.Students will demonstrate a comprehensive understanding of the fundamental concepts of research, including definitions, significance, and types of research methodologies applicable to various fields.

2.The course will enable students to identify, formulate, and articulate research problems clearly, ensuring that they can define the scope and objectives of their research projects effectively.

3.Students will learn to select and design appropriate research methodologies, including experimental and observational designs, tailored to their specific research questions and objectives.

4.The course will provide students with knowledge of various sampling techniques and data collection methods, allowing them to choose the most suitable approaches for gathering reliable and valid data.

5.Students will develop skills in analyzing qualitative and quantitative data, utilizing appropriate statistical tools, and effectively reporting their findings in a structured format.

6.The course will address the ethical and regulatory considerations in research, including issues related to research integrity, plagiarism, and the importance of adhering to ethical standards in conducting research.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 3 | 3 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 2 |
| **CO4** | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 |
| **CO6** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 2 |

**Course content**

**Unit I Fundamental concepts in Research** **13 h**

Concept of theory, empiricism, deductive and inductive theory, types of research-qualitative and quantitative research. Utility for research, characteristics of scientific methods-understanding the language of research and language in scientific research.

**Unit II Research Problem and Research design** **13 h**

Scientific Research-problem, definition, objectives, types, purposes and components of research problem. concept and importance in research-features of a good research design, exploratory research design and descriptive research designs

**Unit III Sampling, data analysis and reporting in research** **13 h**

Sampling methods and sampling errors, determining size of the sample. Experimental design- concept of independent & dependent variables. Fundamentals of statistical analysis, correlation and regression. Research reports-structure, components, types and layout of research report and articles, writing and interpreting research results, figures and graphs.

**Unit IV Tools in research and Regulatory considerations** **13 h**

Research Guides, Handbook, Academic Databases for Biological Science Discipline. Methods to search required information effectively. Data mining tools, searching and bioinformatics databases. Guidelines-animal ethical committee, animal models, various routes of drug administrations, LD50, ED50 and EPA for environment. Biosafety and Biosecurity, IPR.

**Reference Textbooks**

1.Introduction to research methods: a practical guide for anyone undertaking a research project; C. Dawson, 4th Revised Edition, Oxford: How To Books (2010).

2.Random Data: Analysis and Measurement Procedures; J.S. Bendat, A.G. Piersol, 4th Edition, Wiley (2011)
3.Research in Medical and Biological Sciences: From Planning and Preparation to Grant Application and Publication; P. Laake, H. Benestad, B. Olsen, 1st Edition, Elsevier (2015).
4.Research Design: Qualitative, Quantitative, and Mixed Methods Approaches; J. Creswell, 4th Edition, SAGE Publications (2013).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS112 | **Entrepreneurship in Life Sciences** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should be knowing about business in life sciences and important facts.

**Course Objectives**

1.Acquire the knowledge of entrepreneur skills related to life science.

2.Opportunities of business opportunities in various fields of life science.

3.Inculcate the ideas of business development and commercialization of products/services.

4.Familiarize about the regulations and protection of intellectual property right related to business.

**Course outcomes**

By the end of the course the student will be able to:

1.Differentiate the various entrepreneurial skills related to life science.

2.Classify the parameter to access opportunities and constrains, ideas in startups.

3.Explore the systematic process of select and screen of novel business ideas

4.Understand the regulatory bodies in protecting the business.

5.Develop skills in creating business plans, including market analysis, product development, and financial projections.

6.Strategies for bringing life sciences innovations to market, including product development, market entry strategies, and scaling operations.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 2 |
| **CO3** | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 2 | 1 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO6** | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |

**Course content**

**Unit I Fundamentals of Bio-business** **13 h**

Concept of Bio-business, contemporary vs antique, bio-business, wealth creation in bio-business, healthcare, biomedical sciences, industrial life sciences and biotechnology, quick survey of regional and global strengths and capabilities, Startups related opportunities, company registration and funding opportunities.

**Unit II Life Science based bio-business** **13 h**

Agriculture based business, food industry, business related to environment management, bioremediation, bioleaching and waste management. Case studies of business failure and success stories, biotech clusters, process of business commencement, ethics in business, reason for business failures, causes and preventive measures.

**Unit III Entrepreneurship development** **13 h**

Myths of Entrepreneurship, factors affecting entrepreneurship growth, future of entrepreneurship, entrepreneurship development programs (EDP) technology business incubator, open discussion recent updates, group project presentation: case studies of different industries and their strategic planning**.**

**Unit IV Protection of IP in bio-business** **13 h**

Opportunities for business, Policy and Regulatory Concerns, Human Resource, Financing incentives and subsidies & bounties for business units by government and NGOs. Intellectual Property, Technology Licensing and Branding, Patenting-country of origin and international origin, Copyright, Geographical Indicator, Trade Secret and case studies.

**Reference Books**

1.101 Real Life Business Lessons for Emerging Entrepreneurs Hardcover; B. Green, Koehler Books (2017).

2.Tools of Titans: The Tactics, Routines, and Habits of Billionaires, Icons, and World-Class Performers; T. Ferriss, Random Houses (2016).

3.My Misadventure in the Start-Up Bubble; D. Lyons, Hachette Books (2016).

4.An Entrepreneur's Vision of the Future; S. Case, Simon & Schuster (2016).

5.Pivot: The Only Move That Matters Is Your Next One; Jenny Blake, Portfolio (2016).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| **M24SOS121** | **Cell Culture Technology** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should be knowing about the culturing of cells and its importance in research.

**Course objectives**

1.Explain the different types of cell lines in animal cell culture techniques

2.Deep understanding of the composition and preparation methodology of the different types of cell culture media.

3.Illustrate the importance and methodology for transferring genes into the different types of animal and plant cells.

4.Apply the knowledge for a better understanding of the different explant-based plant tissue culture callus formation and as suspension culture methods.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Elaborate the fundamentals of animal cell culture and types of media used in animal cell culture.

2.Classify the different types of stem cells as well as compare and contrast the various types of stem cells and outline the different cord blood-based stem cell techniques.

3.Extend and apply the fundamental knowledge for the production of animal and plant tissue culture- based products.

4.Outline the methods involved in gene transfer techniques in animal and plant cells.

5.Utilize assays and techniques to assess cell viability, proliferation, and metabolic activity.

6.Explore the ethical, regulatory, and commercial aspects related to cell culture.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 1 | 2 | 2 | 3 | 2 | 0 | 0 | 2 | 1 | 3 | 3 | 2 |
| **CO2** | 3 | 0 | 1 | 4 | 2 | 2 | 0 | 1 | 2 | 0 | 2 | 2 | 0 |
| **CO3** | 3 | 1 | 2 | 2 | 3 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0 |
| **CO4** | 3 | 2 | 3 | 3 | 3 | 2 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| **CO5** | 2 | 1 | 2 | 2 | 3 | 2 | 0 | 0 | 1 | 3 | 2 | 2 | 2 |
| **CO6** | 3 | 2 | 3 | 2 | 3 | 1 | 2 | 0 | 0 | 0 | 2 | 2 | 0 |

**Course content**

**Unit I Cell culture techniques 13 h**

Essentials of animal cell culture-Animal cell culture, primary cells, cell lines. CPE (Cytopathic effects), Adherent and non-adherent cells. Resources of cell lines and viability testing. Media and methods to culture animal cells. Subculturing and maintenance of animal cells. Medium preparation and methods to avoid contamination. Continuous and batch mode of large-scale cell culture. 2D and 3D culture methods. Methods for encapsulation of animal cells and its advantages. Methods for Immortalization of primary cells and industrial applications of cell culture.

**Unit II Stem cell technology 13 h**

Embryonic stem cells, cord blood stem cells, and Induced pluripotent stem cells. Difference between Totipotent, Multipotent and pluripotent stem cells. Methods for obtaining stem cells and their advantages with drawbacks. Methods for tissue development using in-vitro cultured cells.

**Unit III Plant tissue and cell culture 13 h**

Different explants used for plant tissue culture with advantages and disadvantages. Callus and suspension culture. Methods to induce callus from explants, somatic embryos. MS medium, shoot medium and root medium. Methods in plant cell culture for crop improvement. Production of metabolites using plant cell suspension culture, Bioelicitation studies, Industrial application of Plant cell culture.

**Unit IV Gene transfer techniques in to host cells 13 h**

In Animal cells- Transfection, Transduction, electroporation. Transient and stable expression of transgene in animal cells and Plant Cells- Protoplast fusion technique and its advantages. Methods for gene transfer in plant cells and generation of transgenic plants. Selection and identification techniques of transformants in plants and animal cells.

**Reference Books**

1. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications; R.I.Freshney, 6th Edition, Elsevier, (2011).

2. Plant Cell Culture:EssentialMethods; M.R.Davey, P.Anthony, Springer(2010).
3. PlantCellCultureProtocols; L.Vargas, M.Víctor, Ochoa-Alejo, Springer(2012).
4. Embryonic Stem Cells; J.R Masters, B.O. Palsson, J.A. Thomson, 6th Volume, Springer(2010).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS122 | **Microbial Metabolites** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basic knowledge of commercial products from microbes.

**Course Objectives**

1. Acquire the knowledge of various metabolites from microbes and their applications
2. Describeanddesignamicrobialproductionofprimarymetabolitesfrommicrobes.
3. Inculcate the various microbial metabolites and their importance
4. Familiarize about the value-added products from the microbes.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will gain knowledge about the differences between primary and secondary metabolites produced by microorganisms, including their roles in microbial growth and their applications in industries such as pharmaceuticals and food.

2.The course will cover the processes and conditions necessary for the production of primary metabolites, such as amino acids, nucleotides, and organic acids, emphasizing industrial fermentation techniques.

3.Students will learn about the types of microbial enzymes, their mechanisms of action, and their applications in various industries, including food processing, biofuels, and biotechnology.

4.The course will provide skills in isolating and characterizing microbial products, enabling students to analyze their properties and potential applications.

5.Students will explore the diverse applications of microbial metabolites in medicine, agriculture, and environmental management, understanding their significance in sustainable practices.

6.The course will address the regulatory frameworks governing the use of microbial products, including safety assessments and quality control measures necessary for their application in food and pharmaceuticals.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| **CO2** | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 |
| **CO6** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 3 | 3 | 2 |

**Course content**

**Unit I Microbial products as primary and secondary metabolites 13 h**

Metabolites-trophophase-Ideophase relationships in production of secondary metabolite; Role of secondary metabolites in physiology of organisms producing them; Pathways for the synthesis of primary and secondary metabolites of commercial importance; Metabolic control mechanisms: substrate induction; catabolic regulation; feedback regulation; amino acid regulation of RNA synthesis; Energy charge regulation

and permeability control; Bypassing/ disorganization of regulatory mechanisms for over production of primary and secondary metabolites

**Unit II Microbial Primary metabolites production 13 h**

Fermentation process and phases of metabolite production, metabolic pathways and their fermentation products. Organic feedstock: ethanol; Acetone; Ethanol Organic acids: Production of Citric acid; Acetic acid; Lactic acid; Gluconic acid; Amino acids: Use of amino acids in industry; methods of production on; Production of individual amino acids (L-Glutamic acid; L Lysine; L-Tryptophan).

**Unit III Microbial enzymes 13 h**

Enzymes-classification, nomenclature, and commercial applications of enzymes – food industry, textile, therapeutic, paper, and pulp, in various fields, production of Amylases; Glucose Isomerase; L Asparaginase Proteases Renin; Penicillin acylases; Lactases; Pectinases; Lipases,

**Unit IV Microbial Products 13h**

Vitamins-VitaminB12; Riboflavin; Beta-carotene; production of antibiotics: beta-Lactam antibiotics; Tetracycline and anthracyclines; Nucleoside antibiotics; Aromatic antibiotics; bioplastics(PHB; PHA); biotransformation of steroids.

**Reference Books**

1.A Text book of Industrial Microbiology; W.CruegerandA.Crueger, Sinauer Associates(2010).

2.Industrial microbiology; G.Reed, CBS(2010).

3.Biology of Industrial microorganisms; A.L.Demain(2012).

4.Principles of fermentation technology; P. Stanbury, A. Whitaker and S.J. Hall, 3rd Edition(2016).

5.Fermentation and Biochemical Engineering Handbook: Principles, Process Design, and Equipment; H.C. Vogell, C.L. Todaro, C.C. Todaro, Noyes Data Corporation/ Noyes Publications (2015).

6.NewProductsandNewAreasofBioprocessEngineering(AdvancesinBiochemicalEngineering/Biotechnology, 68); T. Scheper. Springer Verlag(2012)

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0104 | **Microbiological Methods Lab** | HC | 0 | 0 | 2 | 2 | 2 |

**Prerequisites/Pre reading for the course:**

Students should be aware of various culture media and culturing aspects of microorganisms.

**Course Objectives**

1.Practical exposure in isolation of microorganisms from different samples

2.Analyse various staining and quantification procedures used in microbiology

3.Determine the biochemical analysis of carbohydrates, proteins, and fats

4.Estimation and preparations of the reagents and solutions for biochemical assay**Course outcomes**

**By the end of the course the student will be able to:**

1.Hands on exposures to isolate and quantify the microorganisms

2.Demonstrate proficiency in sterile handling of microbial cultures to prevent contamination.

3.Exploit the staining protocols used in the microbiology

4.Perform biochemical assays to identify microbial species based on metabolic capabilities.

5.Quantify the carbohydrates and protein in the various samples

6.Exploit the preparation and analysis of reagents and buffers for biochemical analysis

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 3 | 2 |
| **CO2** | 2 | 3 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO3** | 2 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO4** | 2 | 3 | 3 | 3 | 1 | 0 | 1 | 2 | 3 | 2 | 3 | 3 | 2 |
| **CO5** | 2 | 3 | 3 | 3 | 1 | 0 | 1 | 2 | 3 | 2 | 3 | 3 | 2 |
| **CO6** | 3 | 3 | 2 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |

**Course content**

**1**.Preparation of standard and buffer solutions.

2.Isolation of microflora from air, soil and water.

3.Simple and Differential staining techniques in microbiology

4.Sugar fermentation tests, urease test, triple sugar iron test, oxidase, lipid, DNAse, catalase and casein hydrolysis test.

5.Enumerating the yeast cells by the hemocytometer

6.Estimation of microbial total sugars by the anthrone method.

7.Estimation of microbial reducing sugars by DNS method.

8.Estimation of Microbial proteins by Lowrys' method

9.Estimation of saponification and iodine value of oils and fats from microbes

10.The specific activity of Amylase

**Reference Books**

1.Basic Techniques in Biochemistry, Microbiology and Molecular Biology-Principles and Techniques.Aakanchha Jain, Richa Jain, Sourabh Jain. Springer. (2021).

2.Analytical Techniques in Biochemistry. Mahin Basha. Publisher: Humana Press (2019).

3.Analytical techniques in Biochemistry and molecular Biology; R.Katoch, Springer(2011)

4.Basic Methods for the Biochemical Lab; M.Holtzhaue, Springer (2007).

5.Principles and Techniques of Biochemistry and Molecular Biology; K.WilsonandJ.Walker, 7thEdition, Cambridge University Press(2010).

6.Experiments in Applied Microbiology; S.Singer Academic Press(2001).

7.Microbiological methods; C.H.Collins, M.L.Tatrica andJ.M.Grange, 8thEdition, HodderArnoldpublishers(2004).

| **Course code** | **Course Title** | **HC/ SC/ OE** | **L** | **T** | **P** | **C** | **Hrs./ Wk.** |
|---|---|---|---|---|---|---|---|
| M24SO0105 | **Molecular Microbial Genetics** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basic knowledge of isolation of DNA from cells.

**Course objectives**

1.Practical knowledge on the DNA and RNA analysis

2. Determine the DNA and RNA in the various samples

3.Understand the bacterial genetic process occurring in nature

4.Inculcate the molecular mechanism for the research uses.

**Course outcomes**

**By the end of the course the student will be able to:**

1. Practical approaches in the DNA and RNA analysis

2. Estimate the DNA and RNA in the various samples

3.Demonstrate the bacterial process happening in nature

4.Experiment the molecular analysis of research purpose.

5. Perform bacterial transformation, α-Complementation Agarose gel electrophoresis.

6. Induction of Mutation through various sources.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 3 |
| **CO2** | 3 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 3 | 2 | 2 | 3 | 1 | 1 | 3 | 2 | 2 | 3 | 2 | 1 |
| **CO4** | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 3 |
| **CO5** | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 2 | 3 | 3 | 2 | 3 |
| **CO6** | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 3 |

**Course Content**

1.Isolation of bacterial genomic DNA and analysis by AGE

2.Isolation of plasmid DNA and analysis PAGE.

3.Estimation of DNA by DPA method.

4.Estimation of RNA by orcinol method.

5.Bacterial transformation byα-complementation.

6.Demonstration of Bacterial conjugation

7.Demonstration of Bacterial transduction

8.Determination of streptomycin resistance in E.coli by gradient plate method.

9.Restriction Digestion

10.Induction of mutation in bacteria by UV radiation.

**Reference Books**

1.Molecular Biology of the Cell; B.Alberts, A.Johnson, J.Lewis, D.Morgan, M.Raff, K.Roberts, P. Walter, 6thEdition, Garland Sciencepublisher (2014).

2.Molecular Cell Biology; H.Lodish, A.Berk, C.A.Kaiser, M.Krieger, A.Bretscher, H.Ploegh, A. Amon, M.P.Scott, 7th Edition, Macmillan Publishers(2012).

3.The Cell: A molecular approach; G.M.CooperandR.E.Hausman, 7th Edition, Sinauer Associates, USA (2016).

| **Course code** | **Course Title** | **HC/ SC/ OE** | **L** | **T** | **P** | **C** | **Hrs./ Wk.** |
|---|---|---|---|---|---|---|---|
| M24SO0106 | **Bioanalytical techniques Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge of separation and analysis of biomolecules.

**Course objectives**

1.Handson experience in the preparation of reagents and buffers

2.Acquireanalyticalskillsindeterminationofmolecularweightofmicrobial proteins

3.Exploitthevariousadvancedskillsforseparationandcharacterisationofbiomolecules.

4.Optimization of protein purification through various methods.

**Course outcomes**

**By the end of the course the student will be able to:**

1. Equip with biochemical techniques for handling the biomolecules.
2. Apply the knowledge of practical skills in separation of biomolecules
3. Explore various methods to characterize the biomolecules.
4. Quantify the biomolecules with optimized methods.
5. Understand the concepts acids, bases ,buffers and preparation of reagents.
6. Analyze and interpret the results to draw the final conclusion.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 1 | 2 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 1 | 2 | 3 | 2 | 1 |
| **CO6** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |

**Course content**

1. pH metric titrations for determining Ka of a weak acid for optimizing buffer capacity
2. Separation of bacterial amino acids by paper chromatography
3. Separation of secondary metabolites by TLC
4. Separation of secondary metabolites by column chromatography
5. Separation of proteins by gel filtration chromatography.
6. Molecular weight detection of separated proteins by silver staining of -SDS-PAGE
7. Molecular weight detection of native proteins by PAGE (CBB stain)
8. Polymerase Chain Reaction (PCR)
9. Western Blotting To Load sequence from a remote server.

**Reference Books**


1. Principles of Biochemistry; Lehninger and D.L.Nelson, 6thEdition, Macmillan Publications(2012)
2. Genes XI, L.Benjamin, J.E.Krebs, E.S.Goldstein, S.T.Kilpatrick, JonesandBartlettLearning(2014).
3. Biochemistry; J.M.Berg, J.L.ToymoczkoandLubertStrye, 8thEdition, Macmillan Publications (2015).


# SECOND SEMESTER

| **Course code** | **Course Title** | **HC/ SC/ OE** | **L** | **T** | **P** | **C** | **Hrs./ Wk.** |
|---|---|---|---|---|---|---|---|
| M24SO0201 | **Microbial Metabolism and Physiology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should be aware of basic concepts of microbial process in the nature.

**Course objectives**

1.Gain the knowledge of microbial photosynthesis and their extreme adaptations.

2.Understand the microbial metabolic pathway occurring in nature.

3.Explore a better understanding of lipid and nucleic acid metabolism.

4.Exploit the biological nitrogen fixation for other applications.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will be able to analyze the energy yield from various biological reactions, understanding how microorganisms generate and utilize energy through different metabolic pathways, including photosynthesis and chemosynthesis.

2.Students can describe the central pathways of carbohydrate metabolism in microbes, such as glycolysis, the pentose phosphate pathway, and the tricarboxylic acid cycle, and evaluate their importance for microbial physiology.

3.Students will understand the biosynthesis pathways for lipids, fatty acids, amino acids, and nucleic acids in microorganisms, demonstrating an understanding of anabolic processes.

4.Students will explain how microbes assimilate nitrogen from various sources and describe the key steps in nitrogen fixation, nitrification, denitrification, and ammonia assimilation.

5.Students will determine metabolic rates in both closed and continuous cultures, as well as assess carbon and reducing power balances in various metabolic processes.

6.The course will enable students to describe the diverse mechanisms by which microorganisms adapt to their environments, including extremophiles, and link microbial physiology to the genomics of cells.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 1 | 1 | 3 | 2 | 2 |
| **CO2** | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| **CO4** | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO6** | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 2 |

**Course content**

**Unit-I Microbial photosynthesis** **13 h**

Brief account of microbial photosynthesis – Light and dark reaction, oxygenic and anoxygenic photosynthesis; Oxidative photophosphorylation, fixation of CO2-Calvincycle-C3-C4pathway.Chemolithotrophy–sulphur, iron, hydrogen, nitrogen oxidation, methanogenesis and luminescence.

**Unit-II Microbial metabolism of carbohydrates** **13 h**

Respiratory metabolism-glycolysis, pentose phosphate pathway, EntnerDoudroff pathway, glyoxalate pathway, Krebs cycle-oxidative and substrate level phosphorylation, reverse TCA cycle. Fermentation-homo and hetero lactic fermentation. Enzymes-mechanism of action; Factors affecting enzyme action and Immobilization of enzymes.

**Unit-III Metabolism of lipids and nucleic acids** **13 h**

Lipid metabolism: β-oxidation, Biosynthesis of fatty acids, degradation of fatty acids. Synthesis of purines and pyrimidines-denovo and salvage pathways. Biosynthesis of glycoproteins and peptidoglycan.

**Unit-IV Nitrogen Metabolism** **13 h**

Nitrogen metabolism, Biological nitrogen fixation process by symbiotic bacteria and by free-living bacteria and cyanobacteria, Nif genes, Nodulation, urea cycle, degradation and biosynthesis of essential and non-essential amino acids.

**Reference Books**

1.Microbiology; M.J.Pelczar, E.C.SChanandN.R. Kreig, TataMacGrawHill(2004).

2.Principles of Biochemistry; Nelson and Cox, 5th Edition, W.H. Freeman & Co., New York, (2010).

3.Biochemistry; D.VoetandJ.G. Voet, JohnWileyand Sons, Inc(2000).

4.Microbial Physiology; A.G.Moat, 4th Edition, Wiley(2000).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0202 | **Microbial Diversity** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have the basics of different classes of microorganisms and their importance.

**Course objectives**

1.Acquire knowledge and explore the diverse form microorganisms.

2.Illustrate the various importance's and applications of microorganism.

3.Explore the eukaryotic microorganisms and their applications in various fields.

4.Explore the microbial ecology and its importance in environmental sustainability

**Course outcomes**

**By the end of the course the student will be able to:**

1.Acquire the basic knowledge of diverse microbial life and their classifications.

2.Explore the recent methodologies in field of microbiology.

3.Exploit the biology and significance of bacteria and viruses in other areas.

4.Utilize the biological and significance of eukaryotic microbes for commercial purpose.

5.Classify microorganisms into their respective domains and kingdoms using different taxonomic methods.

6.Explore the ecological diversity roles of microorganisms in various environments

**Mapping of Course Outcomes with Programme Outcomes**

| PO/CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO6** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |

**Course content**

**Unit-I Microbial World and Microbial Taxonomy 13 h**

Origin and historical development of Microbiology, contribution of microbiologist, biogenesis & abiogenesis theory. Microbiology as interdisciplinary science, importance and scope. Five kingdoms and domain classification, classification criteria in microbiology, Bergeys' classification, binomial nomenclature and classification systems in different microbial classes.

**Unit-II Importance and Conservation of Microbial Diversity 13 h**

Importance of microbial diversity in agriculture, forestry, environment, industrial & food biotechnology, animal & human health. Metagenomics approaches in the microbial community's determination. Importance of conservation. In-situ conservation and Ex-situ conservation. Role of culture collection centers in conservation.

**Unit-III Bacterial and Viral Diversity 13 h**

Brief history of bacteriology, general characteristics of bacterium, classification of bacteria based on the morphology, flagella and nutritional aspects, ultrastructure of bacterial cells and functions of bacterial structure. Brief history of virology, general characteristics, classification of viruses, life cycle of bacteriophage (lambda, T4, M13), Animal virus(LSDV), human virus (COVID-19, hepatitis) and plant virus (Begomovirus, CaMV)importance.

**Unit-IV Fungal and Algal Diversity 13 h**

Fungal characteristics, growth, reproduction, life cycle, classification & importance. Study of thallus structure, reproduction and life cycle of Pythium, Rhizopus, Aspergillus, Penicillium, Fusarium and Agaricus. Major applications of fungi in various fields. Algae characteristics, structures, growth, reproduction, life cycle, classification & importance. Study of thallus structure, reproduction and life cycle of Cyanobacteria, Chlorella, Scenedesmus, Spirogyra, Diatoms and Gracilaria. Various applications of algae.

**Reference Books**


1. Introductory Mycology; C.J. Alexopoulos and C.W. Mims, 3rd Edition, Wiley Eastern, New Delhi (2007).
2. Introduction to Modern Virology; N.J.Dimmock, A.J.EastonandK.N.Leppard, 5thEdition, Blackwell Publishing, USA (2001).
3. Natural Resource Conservation and Environment Management; A.Ghosh, Aph Publishing Corp. Calcutta (2008).
4. Brock Biology of microorganisms; M.T. Madigan, M.J. Martinko and J. Parker, Pearson Education(2003)
5. Microbiology; M.J. Pelczar, E.C.S Chan and N.R. Kreig, Tata Mac Graw Hill(2004).

6. Microbial Diversity–Current Perspectives and Potential Applications; T. Satyanarayana and B.N. Johri, IK Int. Pvt. Ltd. New Delhi (2005).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0203 | **Bioinformatics for Microbiology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basics of computers and mathematical calculations.

**Course objectives**

1.To introduce the basic knowledge of bioinformatics

2.To emphasis the applications of bioinformatics in biological research

3.To develop knowledge on various kinds of research design

4.To acquire basic knowledge on quantitative and qualitative analysis.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will be able to integrate concepts from microbiology, to address biological problems, fostering a comprehensive understanding of bioinformatics applications in microbiology.

2.Students will develop proficiency in analyzing genomic data, to interpret biological information computationally and contribute to research in microbiology.

3.Students will gain hands-on experience with bioinformatics tools and databases, enabling them to perform tasks such as sequence alignment for microbial genomics.

4.Students will learn to apply statistical models and techniques for analyzing biological data, which are essential for understanding microbial diversity and function.

5.Students will acquire practical skills in laboratory techniques related to bioinformatics, including the use of software for data analysis and the interpretation of high-throughput sequencing data.

6.Students will be prepared to engage in research projects that require the application of bioinformatics in microbiology, including the development of new methodologies for disease diagnostics and therapeutic strategies based on microbial genomics.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| **CO4** | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO6** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |

**Course content**

**Unit-I: Fundamentals of Bioinformatics** **13hours**

Introduction to Bioinformatics, Goal, Scope, Applications, Limitations, Biological Databases: Types of Databases, Literature databases: Open access and open sources, PubMed, PubMed Central, Information

Retrieval from Biological Databases; NCBI, UniProt, EMBL-EBI, DDBJ, Data Formats (GenBank, ENA, DDBJ, SRA, RefSeq, SwissProt, PDB), Genome Databases: Viral genome database (ICTVdb, VirGen), Bacterial Genomes database (Genomes Online Database –GOLD, Microbial Genome Database-MBGD), Organism specific Genome database (OMIM / OMIA, SGD, Worm Base, PlasmoDB, Fly Base, TAIR), and Genome Browsers (ENSEMBL, VEGA genome browser, NCBI-NCBI map viewer, UCSC Genome Browser), Metabolic databases: KEGG, Interactome databases, Ligand databases.

**Unit-II: Sequence Analysis** **13hours**

Download a sequence from NCBI &UniProt, Basic concepts of sequence similarity, identity and homology; Scoring matrices: basic concept of a scoring matrix, Matrices for nucleic acid and proteins sequences, PAM and BLOSUM series, matrix derivation methods and principles. Pairwise sequence alignment: Global and Local Alignments, Alignment Tools, gap penalties. Sequence similarity search Using BLAST, Types of BLAST, Multiple Sequence Alignment: Clustal-Omega, MUSCLE. Phylogenetic Analysis. Gene Structure and Protein Structure prediction: Single Motif, multiple motifs, Full Domain, mixing different methods of motifs, Protein 3D structure.

**Unit-III: DNA Sequencing Applications** **13hours**

Primer Designing: Oligonucleotide design parameters, Applications of primers; Introduction to Metagenomics, Applications of Metagenomics, Introduction to DNA Sequencing, Types of sequencing, Sanger sequencing, Short read sequencing, DNA-Sequencing in metagenomic and single-cell sequencing, file types, data structures and applications; Sequencing data analysis – Quality analysis, Genome annotation and alignment, Assembly with DTU server, Assembly with MG-RAST server. Classification based on 16s rRNA Gene Sequence Comparison, Taxonomic Hierarchy, Genera, Families, Orders, Classes, and Phyla, Multilocus Sequence Analysis (MLSA), 16S rRNA and 18s rRNA Amplicon. Ribotyping

**Unit-IV: Applications of Biostatistics** **13hours**

Introduction to Biostatistics, Applications of Biostatistics, Methods of data collection, classification, and tabulation of data. Diagrammatic and graphical representation of data, Sampling errors, Measure of central tendency, Measure of dispersion: Range, Mean deviation, Standard Deviation, Coefficient of variation, Probability, Coefficient of variation, Regression, Chi-Square test, T-Test, F-test, Z-Test, ANOVA: One-Way and Two-Way.

**Reference Books**

1. Henrik Christensen, "Introduction to Bioinformatics in Microbiology", Springer Nature, 2018.

2. Wayne W. Daniel, "Biostatistics: A Foundation for analysis in the Health Sciences"9th Edition, Wiley Publications. 2009.

3. Olive Jean Dunn, Virginia A. Clark, "Basic Statistics: A Primer for the Biomedical Sciences" Forth Edition. Wiley Publications. 2009.

4. Introduction to bioinformatics; A.M. Lesk, Oxford UniversityPress, (2002).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS211 | **Microbiology for Sustainable Environment** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should know about the role of microbes in the environment and their importance.

**Course objectives**

1.Facilitate the students to understand the role of microbes in environment suitability.

2.Impart the knowledge of pollution control and waste management in society.

3.Utilization of beneficial microbes for sustainable agriculture.

4.Inculcate the knowledge to produce bioenergy from using waste.

**Course outcomes**

By the end of the course the student will be able to:

1.Students will gain a comprehensive understanding of the role of microbes in various ecosystems and their interactions with environmental factors.

2.Students will learn effective microbial strategies for waste management, including the use of microorganisms in the treatment and recycling of waste materials to minimize environmental impact.

3.Students will explore the application of microbes in sustainable agriculture, including their role in soil health, crop enhancement, and pest management.

4.Students will acquire knowledge of bioremediation processes, understanding how microbes can be utilized to remediate contaminated environments, such as soil and water.

5.Students will learn about the potential of microbes in bioenergy production, including the processes involved in converting biomass into biofuels and other renewable energy sources.

6.The course will encourage students to engage in research and innovative practices that leverage microbial technology for sustainable environmental solutions, preparing them for careers in environmental biotechnology and related fields.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 3 | 3 | 2 | 3 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 2 |
| **CO4** | 3 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 3 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 2 | 2 |
| **CO6** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 3 | 3 | 2 |

**Course content**

**Unit-I Microbes in environment** **13 h**

Role and diversity of microbes in nature, culture-based and non-culture-based techniques to study microbes in the environment. Biogeochemical cycles- N, C, S, P with the role of microorganisms. Pathogens of animals, humans and plants in nature and saprophytes in the environment.

**Unit-II Microbial Waste management** **13 h**

Solid and Liquid waste Treatment of sewage and industrial effluents, Secondary waste treatment –aerobic, anaerobic and Composting, Bioleaching of metals, Microbes as food, Genetically modified microbes in waste management and its applications and hazards.

**Unit-III Microbes in sustainable agriculture & Bioremidiation** **13 h**

Role of Microbes in Agriculture– bioinoculants-types –nitrogen fixers, mineral solubilizers, Potassium solublisers, Mycorhiza and production of bioinoculants, biodegradation of xenobiotic compounds-pesticides and petroleum products, techniques of bioremediation using microbes. Biocontrol agents- Fungi Bacteria and Viruses.

**Unit-IV Microbes in Bioenergy** **13 h**

Microbial Enhanced Oil Recovery, Bio-ethanol and bio-diesel production, commercial production from lignocellulosic waste, Algal biomass for fuel; Biogas production: Methane and hydrogen production using microbial culture. Bioplastics from microorganisms.

**Reference Books**

1.Wood and Cellulosic Chemistry; D.N.S. Hon, S. Nobuo, CRCPress (2000).

2.Renewable Energy; B. Sorensen, Academic Press(2010).

3.Sustainable Bioenergy and Bioproducts; G. Kasthurirangan, J.H. van Leeuwen, C. Robert; Springer (2012).

4.Advances in Clean Energy Technology, A.K.Azad, Elsevier (2020).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS212 | **Microbial Food Processing** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of microorganisms in food industries.

**Course objectives**

1.To provide the basic knowledge of microbes associated with food.

2.To provide the impact of microbes in food spoilage and preservation.

3.To study the microbial process of beneficial microbes in the food industry.

4.To acquire knowledge of microbial food safety measures.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will gain knowledge about the various constituents of food, including carbohydrates, proteins, fats, vitamins, and minerals, and how these components interact with microorganisms during processing and preservation.

2.The course will cover the different types of microorganisms associated with food, including beneficial microbes like probiotics and harmful pathogens. Students will learn how these associations affect food quality and safety.

3.Students will develop an understanding of the mechanisms of food spoilage caused by microorganisms and the various preservation methods (such as refrigeration, drying, and chemical preservatives) used to extend shelf life and maintain food safety.

4.The course will emphasize the significance of prebiotics and probiotics in food processing, including their health benefits and applications in functional foods.

5.Students will learn about different techniques for detecting microorganisms in food products, including culture-based methods, molecular techniques, and rapid detection systems, which are crucial for ensuring food safety.

6.The course will provide insights into the legal frameworks governing food safety, including food laws and regulations that ensure the safe production and sale of food products, as well as the ethical considerations in food processing.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| **CO2** | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| **CO3** | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 1 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 3 | 1 | 1 |
| **CO6** | 3 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |

**Course content**

**Unit I Microbial association of the food 13 h**

Structure, properties and metabolic functions of food constituents-composition and nutritive value of common food items- organoleptic properties of food–undesirable constituents in food. Microorganisms associated with Harmful and beneficial effects on food, Various factors viz. Intrinsic factors, extrinsic factors, implicit factors, processing factors affect microbial growth.

**Unit II Microbial food spoilage and food preservations 13 h**

Microorganisms and food spoilage– Spoilage of fruits, vegetables, fresh and processed meat, poultry and seafood and cereals and pulses, Foodborne microbes causing health hazards-Food poisoning and intoxication-causes– symptoms– strategies employed for prevention and treatment. chemical and biological-methods of preservation. Food additives, definition, types and functions.

**Unit III Prebiotic, Probiotics and lactic acid bacteria 13 h**

Prebiotics, probiotics, LAB, Types of lactic acid bacteria– homo-fermentation and hetero-fermentation– Role of LAB in fermented food products–Genetic transfer systems in lactic acid bacteria- Uncontrolled and controlled genetic alterations in lactic acid bacteria- Use of genetically modified LAB in food production-Probiotics and its importance. Importance of prebiotics.

**Unit IV Microbial detection in Foods and food laws 13 h**

Conventional methods - Membrane filters- Microscope colony counts - agar syringe methods-surface methods–rapid detection methods- nucleic acid-based methods- biosensors-immunological methods. Inspection – Microbial Indicators of product quality – Indicators of food safety–Microbiological safety of foods- control strategies–Hazard Analysis Critical Point System (HACCP concept)- FSSAI and guidelines, Prevention of adulteration.

**Reference Books**

1. Food Microbiology; J.M. Jay, M.J. Loessner, D.A. Modern, 7th Edition, CBS Publishers, New Delhi, India (2011).

2.Food Oxidants and Antioxidants-Chemical, Biological, and Functional Properties; G. Bartosz, 1st Edition, CRCPress, New York, USA (2014).

3.Food Safety Management- A Practical Guide for the Food Industry; Y. Motarjemi, H. Lelieveld, 1st Edition, Academic Press, London, UK (2014).

4.Food Microbiology; Adams, R. Martin, M.O. Moss, 3rd Edition, Royal Society of Chemistry, Washington DC, USA(2017).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS221 | **Molecular Immunology** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of basics of Immunology.

**Course objectives**

1.To provide the basic knowledge of immunology.
2.To provide the impact of immune system on health.
3.To study the antigen-antibody reactions .
4.To acquire knowledge of immune regulation.

**Course outcomes**

**By the end of the course the student will be able to:**

1. Understand the various concepts in immunology.
2. Apply the scientific knowledge required for immune response.
3. Analyse various immune assay techniques.
4. Evaluate the expression and regulation of immune system.
5. Explore the various mechanisms involved in transplantation.
6. Advances in understanding the Immune system.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 3 | 3 | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 2 | 3 | 3 | 3 |
| **CO5** | 0 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO6** | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 |

**Course content**

**Unit – 1 Immune System 13hours**

Types of immune system, Organs and cells involved in immune system and immune response. Lymphocytes, their subpopulation, their properties and functions, membrane bound receptors of lymph cells, B cells. T cells lymphocyte trafficking. antigen processing and presentation

**Unit – II Immunoglobulins and Antigens 13hours**

Immunoglobulins: Structure and properties of immunoglobulin classes, structural basis of antibody diversity. Theories of antibody formation, hybridoma technology for monoclonal antibodies and designer monoclonal antibodies. Freund's adjuvants and its significance. Concept of haptens, determinants, conditions of antigenicity, antigens and immunogenecity, superantigen.

**Unit – III Antigen – Antibody reactions 13hours**

Antigen-Antibody reaction by precipitation, agglutination and complement fixation.Non-specific immune mechanism: - Surface defenses, tissue defenses, opsonization, inflammatory reaction, and hormone balance. Tissue metabolites with bactericidal properties (lysozyme, nuclein, histone, protamine, basic peptides of tissues – leukins, phagocytins, lecterins, haemocompounds. Transplantation immunology: MHC, types of grafts, grafts rejection, GVH reactions, mechanism of graft rejection, and prevention of graft rejection.

**Unit – IV Expressions and Regulation of Immune Response 13hours**

Regulation of immune response:Generation of humoral and cell mediated immune response, activation of B and T lymphocytes, cytokines and their role in immune regulation, T cell regulation, immunological tolerance. Cell mediated cytotoxicity: Mechanism of T cells and NK mediated lysis, antibody dependent cell mediated cytotoxicity, and macrophage mediated cytotoxicity.Complement system: Classical, alternate, lectin pathway of complement activation. Regulation of complement activation.

**Reference Textbooks**

1. Essentials of Immunology by Riott I .M. 1998. ELBS, Blackwell Scientific Publishers, London.
2. Immunology 2 nd Edition by Kuby J. 1994. W.H. Freeman and Co. New York.
3. Immunology - Understanding of Immune System by Claus D. Elgert. 1996. Wiley - Liss, New York.
4. Cellular and Molecular Immunology. 3rd Edition by Abbas.
5. Immunobiology: The Immune System in Health and Disease. 3rd Edition by Travers.
6. Immunology- A short Course. 2nd Edition by Benjamin.
7. Manual of Clinical Laboratory and Immunology 6th Edition. 2002 by Noel R. Rose, Chief Editor: Robert G. Hamilton and Barbara Detrick (Eds.) , ASM Publications.
8. Pocket Guide to Clinical Microbiology. 2 nd Edition. 1998 by Patrick R. Murray, ASM Publications.

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS222 | **Molecular Enzymology** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of basics of Immunology.

**Course Objectives**

1.To provide the basic knowledge of immunology.

2.To provide the impact of immune system on health.

3.To study the antigen-antibody reactions .

4.To acquire knowledge of immune regulation.**Course outcomes**

**By the end of the course the student will be able to:**

1. Comprehend the structural conformations of enzyme proteins and their role
2. Apply the principles of enzyme kinetics to understand factors affecting enzyme-mediated reactions.
3. Analyze enzyme engineering techniques with respect to modification and functions.
4. Explore the applications of microbial enzymes across various industries.
5. Advances in understanding the action of various enzymes
6. Knowledge on the various sources of enzymes.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO2** | 1 | 2 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 2 | 3 | 3 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 2 | 3 |
| **CO5** | 1 | 2 | 3 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | 2 | 3 |
| **CO6** | 1 | 3 | 2 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |

**Course content**

**Unit –I Properties of Enzymes 13hours**

Different structural conformations of enzyme proteins. Enzymes as biocatalysts, catalytic power, activation energy, substrate specificity, active site, theories of mechanisms of enzyme action. Mechanism of action of lysozyme, chymotrypsin and ribonuclease. Monomeric, Oligomeric and multienzyme complex, isozymes and allosteric enzymes. Extremozymes - thermostable, solventogenic and non- aqueous enzymes. Ribozymes and abzymes.

**Unit –II Enzyme kinetics 13hours**

Importance of enzyme kinetics, factors affecting rates of enzyme mediated reactions (pH, temperature, substrate concentration, enzyme concentration and reaction time). Derivation of Michaelis - Menton equation and its significance in enzyme kinetic studies. Lineweaver-Burke plot, Haldane-Briggs relationship, sigmoidal kinetics steady state kinetics and transient phases of enzyme reaction.

**Unit – III Enzyme Engineering 13hours**

Chemical modification and site-directed mutagenesis to study the structure-function relationship of industrially important enzymes. Therapeutic enzymes: design and delivery. Synthetic Biology Approaches in Enzyme Engineering, Taq Polymerase vent & pfu. Challenges and opportunities in enzyme engineering.

**Unit – IV Applications of microbial enzymes 13hours**

Microbial enzymes in biomedical, therapeutics, agriculture, dairy, food, textile, leather, wood industries and detergents. Enzymes in clinical diagnostics. Enzyme sensors for clinical processes and environmental analyses.

**Reference Books**

1. Enzyme Kinetics by Paul Engel. 1977. John Wiley and Sons. Inc., New York.
2. Enzymes by Dixon and Webb, 3 rd Edition 1979. Academic Press, New York
3. Biochemistry by Stryer 5th Edition WH Freeman 2001
4. Principles of Enzyme Kinetics. 1976. By Athel Cornish - Bowden.
Butterworth and Co.
5. Fundamentals of Enzymology. 3rd Edition by Price

**PRACTICAL COURSE**

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0204 | **Microbial Metabolism and Physiology Lab** | HC | | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should know the basics of biochemical testing and culturing of microbes.

**Course objectives**

1.Explore the practical aspects of isolation and culturing of microorganisms

2.Exploit the practical knowledge of microbial enumerations.

3.Analytical techniques to evaluate the microorganisms associated with various samples

4.To identify and characterize the microbial products by various metabolic processes.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will analyze different types of microbial growth and evaluate the factors affecting growth, enabling them to relate theoretical concepts to practical observations.

2.Learners will accurately measure and interpret the cell sizes of various microbial species, enhancing their understanding of microbial diversity and its implications for physiology.

3.Students will explain the concepts of enzyme induction and repression, demonstrating their ability to analyze how microbial metabolism is regulated in response to environmental changes.

4.Learners will describe the processes of sporulation and spore germination in bacteria, linking these phenomena to microbial survival strategies under adverse conditions.

5.Students will conduct experiments to produce amino acids and vitamins through microbial processes, illustrating the practical applications of microbial metabolism.

6.Students will evaluate bacterial growth under various conditions and perform morphological, physiological, and biochemical tests on selected bacterial cultures, reinforcing their practical laboratory skills and understanding of microbial physiology.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO6** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |

**Course content**

1.Measurement of cell size of microbes.

2.Study of microbial growth–types of growth (synchronous, diauxic, batch),

3.Study factors affecting growth

4.Sporulation and spore germination in bacteria

5.Induction and repression of enzymes

6.Study of bacterial growth under aerobic, microaerophilic and anaerobic conditions

7.Morphological, Physiological and Biochemical tests of selected bacterial cultures.

8.Production of amino acids (Leucine and Glutamic acid) by microorganisms.

9.Production of vitamins (Vitamin-A) by microorganisms.

10.Production of extracellular enzymes- Alkaline phosphatase

**References Books**

1.Applications– (A Laboratory Manualin General Microbiology); H.J.Benson, WmC Brown Publishers (2010).

2.A Laboratory Manual in Biochemistry; J.G. Cappuccino and N. Sherman, Addison-Wesley (2010).

3.Laboratory Techniques in Biochemistry and Molecular Biology; T.S. Work and R.H.E. Work, Elsevier Science (2010).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0205 | **Microbial Diversity Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge of diverse classes of microbes and their culturing aspects.

**Course objectives**

1.Enumeration of microflora from food and water samples.

2.Explore beneficial microflora from soil samples.

3.Identify the phytopathogens from soil microflora.

4. Quantitative estimation of microflora in various samples.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Inculcate the knowledge the of analyzing the microflora in various samples.

2.Exploit the use of beneficial microflora for commercial purposes.

3.Identification and characterization of phytopathogens.

4.Quantitative analysis of microflora in different samples

5.Explore the microbes from different environment.

6.Understand the microbial interaction with biotic and abiotic factors.

**Mapping of Course Outcomes with Programme Outcomes**

| PO/CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 6 | 2 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO6** | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 3 | 3 | 3 |

**Course content**

1.Isolation and identification and study of actinomycetes from the soil, biological sample(cow dung).

2.Isolation and identification and study of cyanobacteria from soil/paddy field.

3.Isolation and study of bacteriophages from sewage.

4.Isolation and identification of endophytic fungi.

5.Isolation and identification of fungi from soil/ cereals/ water by serial dilution technique.

6.Staining of vesicular arbuscular mycorrhizae from the soil.

7.Isolation and identification and study of algae from the water.

8.Microscopic examination of lichens.

9.Isolation and identification and study of phytopathogens.

10.Isolation of Lactobacillus from milk and yogurt.

**Reference books**

1.Microbiology; Lansing M Prescott, John P. Harley, Donald A Klein, 6th edition, Mc Graw Hill Higher education (2005).

2.Microbial Diversity–Current Perspectives and Potential Applications; T. Satyanarayana and B.N. Johri, IKInt. Pvt. Ltd. New Delhi (2005).

3.Biodiversity of Microbial Life: Foundation of Earth's Biosphere; J.T. Stanley, A.L. Reysenbach, Wiley Publication, New York (2001).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0206 | **Bioinformatics for Microbiology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have a theoretical background in computers and software's for statistical studies.

**Course objectives**

1.To acquire fundamental knowledge of bioinformatics techniques.

2.Emphasis on the application of bioinformatics in biological database stores solve research problems.

3.Practical exposure to use wide applications of computational biology and apply the same to resolve biological research.

4.To evaluate the biological data using the biostatistics tools.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will learn to use various bioinformatics tools and software to analyze biological data, particularly in the context of microbiological research.

2.Students will develop skills in analyzing genomic and proteomic data, enabling them to interpret biological information through computational methods.

3.Students will gain knowledge in analysis and interpretation

4.Students will acquire practical skills in sequencing and data interpretation.

5.Students will understand the interdisciplinary nature of bioinformatics and microbiology, learning how computational methods can enhance microbiological research and applications.

6.Students will be encouraged to engage in research projects, fostering skills in experimental design, data collection, and scientific communication within the scope of bioinformatics applications in microbiology.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 |
| **CO2** | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 |
| **CO3** | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 1 | 2 | 2 | 1 |
| **CO4** | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 2 |
| **CO5** | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO6** | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |

**Course content**

1. Understanding Biological Databases: Genome Databases, Protein Databases, Organism Specific Databases.
2. Sequence Alignment: Global, Local and Multiple sequence alignment
3. Phylogenetic Analysis using MEGA
4. Genome Seq Data Analysis using MG-RAST
5. Primer designing
6. Multilocus Sequence Analysis
7. Gene Structure prediction
8. Protein structure prediction
9. 16s and 18s rRNA annotation and alignment
10. Genome Enrichment Analysis

**Reference Books**

1.Introduction to Bioinformatics; T. Attwood, P.S. David, Pearson Education Ltd., New York (2006).

2.Bioinformatics A Practical Guide to Analysis of Genes and Proteins; A.D. Baxevanis, B.F.F. Ouellette, 3rd Edition. John Wiley and Sons, NewYork (2006).

3.Bioinformatics and molecular evolution; T.K. Attwood, P.G. Higgs, Blackwell Publishers, London (2005).

4.Introduction to Bioinformatics; A.M. Lesk, Oxford University Press (2002).

# THIRD SEMESTER

## Specialization in Industrial & Food Microbiology

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ301 | **Food Microbiology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basis of microbial food processing and preservation aspects.

**Course objectives**

1.Understand the principles of microorganisms during various food-processing and preservation steps.

2.Isolation, identification, and enumeration of the most common microorganisms found in specific food products.

3.Recognize specific types of microbial spoilage during various food shelf-life stages.

4.Analyze different foods for presence of hazardous microorganisms using traditional and modern food microbiology technology.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Explain the interactions between microorganisms and the food environment, and factors influencing their growth and survival

2.Explain the significance and activities of microorganisms in food

3.Describe the characteristics of foodborne, waterborne and spoilage microorganisms, and methods for their isolation, detection and identification

4.Understand the microbiology of food preservation and food commodities

5.Explain the principles and methods for the microbiological examination of foods

6.Describe microbiological quality control, and quality schemes

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 3 | 2 | 3 |
| **CO2** | 3 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 3 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 2 | 1 |
| **CO4** | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO6** | 3 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |

**Course content**

**Unit-I History and Development of Food Microbiology 13 h**

History of Microorganisms in Food Important microorganisms associated with food: bacteria, molds, virus. Sources of microbes in food. Food as a substrate for growth. Factors affecting the growth of microbes on food: Intrinsic and extrinsic. Combined Intrinsic and Extrinsic Parameters-lactic antagonism and hurdle concept.

**Unit-II Microorganisms in Foods and Methods for Detection 13 h**

Foodborne diseases: Intoxications (Botulism and Staphylococcal); Mycotoxins. Food Infections (E.coli, Salmonella), viruses and parasites in food. Food Spoilage microbes: an overview. Spoilage of Meat and poultry, fruits and vegetable, canned foods, cereals and milk. Food fermentation: Bread, vinegar, oriental fermented foods. Sampling Methods for detecting microbes in food.

**Unit-III Food Preservation & Principles of Quality Control 13 h**

Physical preservation: Radiation, Low and high temperature, Drying, High-Pressure Processing Pulsed Electric Fields. Chemicals Preservation: definition and types. Aseptic Packaging, Mano-thermo-sonication, Microbiological quality standards of food, Government regulatory practices and policies, FDA, HACCP and ISI, FASSI and NABL guidelines.

**Unit-IV Applications of Food Microbiology 13 h**

Application and scope of Food Microbiology: Beneficial uses of microorganisms in Food, Beneficial Gut microbes: Concept of Prebiotics, Probiotics and Synbiotics, Genetically modified foods. Biosensors in foods: Components, factors associated and applications**.**

**Reference Books**

1.Microbiology; Adams, R.Martin, M.O.Moss, 3rdEdition, Royal Society of Chemistry, Washington DC, USA (2017).

2.Basic Food Microbiology; Banwart GeorgeJ.; Elsevier (2010).

3.Food Microbiology: Fundamentals and Frontiers; Dolle, Springer(2010).

4.Fundamentals of Dairy Microbiology; Prajapati, New Age Publishers(2011).

5.Essentials of Food Microbiology; J. Garbult. Arnold International Students Edition(2011).

6.Microbiology of Fermented Foods (VolumeII); J.W.Brian, Elsevier Applied Science Publication (2011).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ302 | **Bioprocess Technology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge about fermentation and its products for microbes.

**Course objectives**

1.Gain a knowledge of the basis for upstream process in fermentation technology.

2.Better understand of working principle and design of the bioreactor.

3.Optimize the techniques and formulate the downstream processing of the products.

4.Design the plan for the production of industrially important products through fermentation.**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will understand the fundamental principles of bioprocessing, including the types and significance of various bioprocesses in biotechnology.

2.Students will apprehend on design and operations of bioreactors, understanding the critical parameters that influence microbial growth and product yield.

3.Students will gain knowledge in microbial fermentation processes, including the metabolic pathways involved in the production of key industrial products.

4.Students will learn techniques for downstream processing, including separation, purification, and formulation of bioproducts.

5.Students can explore various applications of microbial products in different sectors, such as pharmaceuticals, food, and environmental biotechnology.

6.The course will encourage students to engage in research and innovation, preparing them for advanced studies or careers in bioprocess technology and related fields.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 3 | 3 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 |
| **CO6** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 3 | 3 | 2 |

**Course content**

**UNIT I Introduction to Bioprocess 13 h**

Engineering: Basic concepts of bioprocess engineering- A brief survey of organisms, processes, products. Fermentation-Bacterial, Fungal and Yeast, Biochemistry of fermentation. Industrial strain improvement for better productivity; Fermentation media and Fermentation Process: Natural and synthetic media; Strategies for media formulation, sources of carbon, nitrogen, vitamins and minerals with anti-nutritional factors. Sterilization- Dry and moist heat; Types of fermentation process-submerged, surface and solid state.

**UNIT II Bioreactors & fermentation process 13 h**

Architecture of advanced bioreactors and their working mechanisms; Design features; Heat and Mass transfer; Specialized bioreactors-design and their functions; Bioreactors-Airlift, Tubular, Membrane, Tower, Fluidized-bed and Packed-bed; photobioreactors and disposable reactors. Modes of cultivation-batch, fed-batch and continuous fermentation; Kinetics of fermentation, bioprocess control, monitoring of variables-Dissolved oxygen(DO), temperature, agitation, pH and pressure

**UNIT III Downstream processing 13 h**

Overview of unit operations and their principles, Physical and rheological characteristics of fermentation broths; Pre-treatment-Cell disruption, heating and chemical treatment; solid-liquid separation-filtration and centrifugation; Product isolation-Adsorption, precipitation and extraction; Purification- Chromatography-Size exclusion, affinity and ion-exchange and HPLC; Finishing operations– Freeze-drying, drying and crystallization.

**UNIT IV Microbial fermentation & products** **13 h**

Microbiology of cheese and beverage fermentation. Microbiology of fermented milk products (acidophilus milk, yoghurt). Role of microorganisms in beverages–tea and coffee fermentations. Vinegar Fermentation Biosensors in food, Applications of microbial enzymes in dairy industry [Protease, Lipases]. Utilization and disposal of dairy by-product-whey. Production of value-added products: Biopreservatives, Biopolymers, Industrial Enzymes, Biofuels, Cheese, Beer and Single Cell Protein. Fermented meat products. Production of recombinant protein shaving therapeutic and diagnostic applications, and vaccines.

**Reference Books & Articles**

1.Biotechnology; U.Satyanarayana, BooksandAllied (P)Ltd(2005).

2.A Textbook on Biotechnology; H.D. Kumar, 2nd Edition, EastWest PressPvt.Ltd(2000).

3.Concepts in Biotechnology; D. Balasubramanian et al., UniversitiesPress Pvt.Ltd(2004).

4.Basic Biotechnology; Ratledge, Colin and Bjorn Kristiansen, 2nd Edition, Cambridge University Press (2001).

5.A Textbook of Biotechnology; R.C. Dubey, S. Chand and Co. Ltd (2006).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ303 | **Food Chemistry and Processing** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge macro and micronutrients present in the foods.

**Course objectives**

1.Scientific basis of water and carbohydrates in nature and their interactions.

2.Better understanding of chemistry and importance of the oils and fats.

3.Gain knowledge about the food processing and preservation technology

4.Understand the various food packaging technology and its mechanisms.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will be able to describe food processing in terms of unit operations, both conceptually and in practical applications within a pilot plant setting.

2.Students will demonstrate proficiency in using mass and energy balances to analyze food processing systems, allowing for optimization of processes.

3.Students will gain practical experience with common food processing equipment, enhancing their technical skills in food technology.

4.Students will learn to analyze experimental data effectively.

5.Students will develop teamwork skills by working effectively in groups to conduct experiments, analyze results, and communicate findings.

6.Students will apply critical thinking skills to address new challenges in food processing, enabling them to propose innovative solutions based on their laboratory experiences

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 1 | 2 | 1 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO2** | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 1 | 1 | 2 | 1 |
| **CO3** | 3 | 3 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 1 |
| **CO4** | 3 | 2 | 0 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 3 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 3 | 1 | 1 |
| **CO6** | 3 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 3 | 3 | 2 |

**Course content**

**Unit I Water and Carbohydrates for food** **13 h**

Role of water and chemistry of carbohydrates and proteins, Physicochemical properties of water, water weak interactions in Aqueous Systems. Role of water in food, Moisture in foods and determination of moisture. Sources of Carbohydrates and proteins, composition and factors affecting composition of foods, Chemistry of cellulose, starches, other polysaccharides -starch enzymes, Gel formation and starch degradation- Pectic substances, their occurrence, structure, properties and applications in foods., Classification of proteins, physical and chemical properties of proteins, Conformation, functional properties of proteins in foods, hydrolysis of proteins-Changes in proteins during processing-Determination of Proteins.

**Unit II Chemistry of Oils and Fats** **13 h**

Nomenclature and classification, Physical and chemical properties of fats, rancidity and flavour reversion, processing of oil-bearing materials, refining of oils and fats, fat hydrolysis and trans-esterification, hydrogenation, Changes in Acyllipids of foods, Classification and Properties of Unsaponifiable constituents. Shortenings and spreads-Emulsions, Definition, surface activity, surface film theory of emulsions, properties and types of emulsions, emulsifying agents, their chemistry during processing - Essential oils, Chemistry of occurrence, Extraction-Terpene oils and their use in foods.

**Unit III Food processing and preservations** **13 h**

Food processing, preservation Processing and preservation by drying, methods of food concentration: freeze concentration, Ultra-filtration, reverse osmosis, evaporation-Drying, low-temperature, dehydration of fruits, vegetables, milk and animal products. Various methods employed in production of dehydrated commercial products, selection of methods based on characteristics of foods to be produced, advantages and disadvantages. Food irradiation, history and mechanism, the electromagnetic spectrum, forms of radiant energy. Principles of using electromagnetic radiation in food processing with advantages and disadvantages. Processing and preservation by non-thermal methods. Food additives; Definition, types and functions and safety aspects. Chemical and metal preservatives-type I and type II and permissible limits.

**Unit IV Food packaging** **13 h**

Objectives and functions of packaging and packaging materials; Types and selection of packaging materials: Paper: pulping, fibrillation and beating, types of papers; Glass: composition, properties, types of closures; Metals as packaging materials: Tinplate containers, tin free steel (TFS), aluminium containers, lacquers; Plastics: types of plastic films, laminated plastic materials, co-extrusion, edible films, biodegradable plastics. Aseptic conditions during packaging, Use of inert gases in food packaging.

**Reference Books**

1.Experimental food science; M.P. Penfield, A.M. Campbell, 3rd Edition, San Diego, CA: Academic press, 2012.

2.Food chemistry; Meyer L.H, CBS Publishers (2006).

3.Food Processing Technology: Principles and Practice, P.J. Fellows, 3rd Edition, Woodhead Publishing (2009).

4.Understanding food: Principles and Preparation; A.C. Brown, Cengage Learning (2018).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS311 | **Nanobiotechnology and Space Microbiology** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of nanotechnology in life sciences and its importance.

**Course objectives**

1.Better understanding of the synthesizes and characterization of nanomaterials

2.Describe various types of nanomaterials and their applications

3.Apply the knowledge to understand the application of nanomaterials in allied sciences

4.Have Insight and deep knowledge of space microbiology and its importance

**Course outcomes**

**By the end of the course the student will be able to:**

1.Describe the basic science behind the properties of materials at the nanometer scale

2.Understand the principles behind advanced experimental and computational techniques for studying nanomaterials.

3.Systematically solves scientific problems related specifically to nanotechnological materials using conventional scientific and mathematical notation.

4.Develop skills in applying nanobiology concepts to design nanomedicines, targeted drug delivery systems, and diagnostic tools.

5.Explain primary aspects of space microbiology that have been studied to date.

6.Explore innovative methods and technologies for studying microorganisms in space.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 0 | 2 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 2 | 2 |
| **CO6** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 2 | 3 | 2 | 3 | 2 | 3 |

**Course content**

**Unit I Concepts, synthesis and characterization of nanomaterials 13 h**

History, Definition of nanotechnology, Basic and functional Principles of nanotechnology, Methods and approaches of nanomaterial synthesis (Bottom-Up and Top-Down); Biological synthesis (use of microbes,

enzymes, plant materials). Macromolecular assemblies and its significance. Parameters affecting nanoparticle growth, shape, size and structure. Characterization of nanoparticles- UV – Vis Spectroscopy, Surface Plasmon resonance (SPR), Dynamic light scattering (DLS), XRD, Electron Microscopic; SEM & TEM, Atomic force microscopy

**UnitII Various nanostructures and their applications 13 h**

Bacterial structure relevant to Nano-biotechnology, Cubosomes, Dendrimers, DNA Nanoparticle Conjugates, DNA Octahedron, Fullerenes, Nanoshells, Carbon Nanotubes, Nanopores, Nanostructured Sillicon, Viruses as nano-particles, nano chemicals and application. Nanomaterials used in various fields and their importance.

**UnitIII Allied applications of Nanobiotechnology 13 h**

Theranostic applications of nanomaterials, nanoparticle-based immobilization assays, quantum dots technology and its application, immuno-nanotechnology. Nano biosensors principles used in construction of microelectronic devices, sensors and micromechanical structures and their functioning. DNA-based Nanostructures- DNA- protein nanostructures- Methods-Self assembled DNA nanotubes- Nucleic acid Nanoparticles.

**UnitIV Space Microbiology 13 h**

Space Microbiology: An Overview, Monitoring of astronaut's microbial flora: Alterations in the load of medically important microorganisms, ESA STONE experiment. Evaluating the Biological Potential in Samples Returned from Planetary Satellites and Small Solar System Bodies. Introduction to BSL (Biosafety levels)

**Reference Books**

1.Nanobiotechnology-concepts, applications and perspectives, C.M. Niemeyer and C.A. Mirkin, Wiley publishers (2000).

2.Nanobiotechnology of biomimetic membranes, D. Martin, Springer Verlag publishers, (2000).

3.Nanotechnology in Drug Delivery; M.D. Melgardt, A. Porang, Springer-American Association of Pharmaceutical Scientists Press (2009).

4.Bio-Nanotechnology; S.P. Elisabeth, A. Parthasarathy, New Age publishers (2010).

5.Biomedical Nanostructures, K.E. Gonsalves, C.R. Halberstadt, C.T. Laurecin, L.S. Nair, Springer (2011).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOS312 | **Marine Microbiology** | SC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of aquatic microbiology and their importance.

**Course objectives**

1.Explain the scope and challenges in the field of marine biotechnology

2.Develop better knowledge about marine ecosystems, biodiversity & taxonomy, tools and techniques used and role of marine organisms in biogeochemical cycles

3.Realize the biotechnological importance and to explore the potential of marine organisms for human betterment

4.Demonstrate the various techniques and tools necessary for studying marine microbial diversity and its applications.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Develop knowledge about marine biotechnology, compare the various marine ecosystems and explain the tools and techniques used for sample collection, isolation of micro and macro-organisms and to study their taxonomy.

2.Analyze the importance of marine organisms in various marine pathogenic microbes and their transmission to land

3.Build knowledge on the process of drug discovery from marine organisms and various assays and techniques related to it

4.Utilize marine organisms for food, fuel, agriculture, environment, cosmetics, industrial feedstock etc.,

5.Integrate knowledge from related fields such as marine biology, oceanography, and environmental science.

6.Explore the microorganisms in marine environments and their roles in oceanic processes and ecosystems.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 0 | 1 | 3 | 3 | 3 | 3 | 2 | 3 |
| **CO6** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 2 | 3 | 2 | 3 | 2 | 3 |

**Course content**

**Unit I Marine Ecology and Diversity 13 h**

Benthic and Pelagic Zone; Photic, dysphotic and aphotic zones- importance and their significance. Biological divisions of the sea- estuaries and backwaters, lagoons, mangroves, coastal waters, inshore, offshore, deep sea/oceanic zone. Sampling, cultivation and taxonomy of microorganisms and metagenomic approaches. Bacteria, fungi, algae and archaea, Extremophilic microorganisms.

**Unit II Marine microbial pathogen 13 h**

Microbial pathogens in marine environment - diversity, sources and detection of pathogens in recreational water, impact of harmful algal blooms, microbial pathogens of seafood. Effect of microbial pathogens on marine ecosystems.

**Unit III Marine Pharmacology 13 h**

Marine-derived drugs in preclinical and clinical trials- FDA and EMEA-approved marine-derived drugs, their use and mode of action. Screening of drugs High-throughput Screening Assays (HTS), Enzyme inhibitory assays, cytotoxicity assay; antimicrobial assay; DNA laddering assay; Apoptosis assay and screening for biologically active molecules from marine microorganisms.

**Unit IV Marine microbes for bioprospecting 13 h**

Marine organisms for Biofuels and bioenergy, Bioremediation, Biofouling, Biosurfactants. Marine natural products as cosmetics- cosmeceuticals, algotherapy; Thalassotherapy; Enzymes; food, supplement, nutrition and energy drinks. Marine algae as fish feed, manure and fertilizers. Recent developments in marine microbiology.

**Reference Books**

1.Aquaculture Microbiology and Biotechnology; D. Montet, Ramesh C. Ray, Volume Two 1st Edition, Science Publishers (2011).

2.Introduction to Marine Biology; G. Karleskint, R.Turner, J.Small, 4th Edition, Brooks Cole Publishers (2013).

3.Bioactive Marine Natural Products; D.S.Bhakuni, D.S. Rawat, Springer publishers (2010).

4.Marine Microbiology: Ecology and Applications; Munn and Munn, BIOS Scientific Publisher(2011).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SLO301 | **Organic Farming** | OE | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should know the organic farming basics and its importance.

**Course objectives**

1.Understand the importance of organic farming in developing a sustainable agriculture system for ensuring adequate food production.

2.Acquire the holistic concept of organic farming as a self-sustainable unit in the ecosystem.

3.Get familiarized with the practices involved in the organic farming system.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Analyse the advantages of organic farming compared to conventional chemical agriculture.

2.Understand the significance of plant nutrient management following organic practices.

3.Apply the knowledge gathered in implementing the practices in organic crop production andplant protection.

4.Explain the basic principles involved in organic farming production, certification andmarketing.

5.Explain various types of organic manures and biofertilisers as per the requirement at different stages of crop growth for various crops.

6.Understand the various package of practices followed in organic farming for important crops.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 0 | 0 | 1 | 3 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| **CO2** | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 2 | 1 | 0 | 0 |
| **CO3** | 3 | 0 | 1 | 3 | 3 | 3 | 2 | 1 | 2 | 0 | 1 | 0 | 0 |
| **CO4** | 2 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| **CO5** | 3 | 0 | 0 | 0 | 2 | 2 | 0 | 2 | 2 | 1 | 0 | 0 | 0 |
| **CO6** | 2 | 0 | 0 | 3 | 3 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 1 |

**Unit I Introduction to Organic Farming 13 h**

Organic farming, concept and development of organic farming. Principles of organic farming & need for organic farming, Agencies and institutions related to organic agriculture. Farm components for an organic farm. Benefit so organic farming. Conventional farming/organic farming. Scope and present state of organic farming; its relevance to India and global agriculture and future prospects.

**UnitII Organic Plant Nutrient Management 13 h**

Organic farming systems: Soil tillage, Choice of Varieties, crop rotation, multiple cropping systems, intercropping. Propagation: planting materials and seed treatments. Water management, Organic manures: Green manuring, Composting: Composting methods, Vermicomposting, Organic amendments and sludges, biogas. Bio-fertilizers-: methods of application and advantages.

**UnitIII Organic Plant Protection 13 h**

Plant protection: cultural, mechanical methods. Biological methods: botanical pesticides, biopesticides, biocontrol agents. Weed management. National and International Standards for organic inputs- plant protection; Integrated pest management. Organic crop production methods: areca nut, okra. Live-stock component and management in organic farming.

**UnitIV Organic Certification 13 h**

Farm economy; Basic concept of economics-Demand, supply, Economic Viability of a farm. Basic production principles, Reducing expenses, ways to increase returns. Cost of the production system. Marketing, Imports and exports. Policies and incentives of organic production, Farm inspection and certification: income generation activities: Apiculture, Mushroom production, terrace farming.

**Reference Books**

1.Organic Farming– Theory and Practice; S.P. Palaniappan, K. Anandurai, Scientific Publishers Journals Dept. (2010).

2.Soil organisms and litter decomposition (in Modern trends in applied terrestrial ecology);

G. González, Springer, Boston (2002).

3.Hand Book of Organic Farming, A. Sharma, Agrobios(2002).

4.Soil Microbiology; N.S.Subba Rao, Oxford & IBH (2002).

**PRACTICALS**

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ304 | **Food Microbiology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge of fermented food products and preservation techniques.

**Course objectives**

1.Better understanding of the laboratory design in food safety laboratory.

2.Hands-on experience in isolation and identification of microorganisms from various food items.

3.Detection and quantification of microorganisms in food samples.

4.Modern molecular detection technology is used in screening the microbes in food samples.

**Course Outcomes**

**By the end of the course the student will be able to:**

1.Use aseptic technique to properly handle microorganisms and inoculate and isolate bacteria

2.Properly use a microscope and stain microorganisms using the different staing techniques

3.Analyze food for the presence of microorganisms and evaluate the microbiological quality of raw and processed food products

4.Prepare and sterilize media, and identify types of microorganisms present in food products

5.Determine the effects of various factors such as pH, temperature, oxygen, antibiotics, and preservatives on microbial growth

6.Prepare fermented foods using microorganisms and develop probiotic cultures

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 2 | 1 | 1 | 2 | 1 | 0 | 1 | 1 | 1 | 2 | 2 | 1 |
| **CO2** | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 |
| **CO3** | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 |
| **CO4** | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 2 | 2 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 1 | 1 |
| **CO6** | 2 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 2 | 3 | 2 |

**Course content**

1.Introduction to HACCP and food safety conditions in industry.

2.Sterility tests- Direct inoculation, direct immerse inoculation & membrane filtration.

3.Isolation and identification of microbes from different food sources- Canned foods, Meat, Vegetables, Fruits &Milk

4.Microbial limit test & Anaerobic plate count

5.Determination of enteric microorganisms (Petrifilm/VRBA)-Yeast and molds petrifilm

6.Determination of MRSA from food

7.Bacteriological examination of water by multiple tube fermentation test (MPN)

8.Microbial characterization techniques- Determination of high osmotic conditions bacteria, Determination of lactic acid producing microbes, sulphate reducing bacteria, nitrifying bacteria, Oxidase listeria rapid test, AOACD is infectant test, Koch's postulates for bacterial and fungal pathogen.

9.Determination of toxic substances from food, Preservative efficiency test, MIC and MLC. Bio-burden tests, Organoleptic tests

10.Determination of microbes by PCR

**Reference Books**

1.A Textbook on Biotechnology; H.D. Kumar, 2nd Edition, East West PressPvt.Ltd(2000).

2.Concepts in Biotechnology; D. Balasubramanian et al., Universities Press Pvt.Ltd(2004).

3.Basic Biotechnology; Ratledge, Colin and Bjorn Kristiansen, 2nd Edition, Cambridge University Press(2001).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ305 | **Bioprocess Technology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge of fermentation and their products.

**Course objectives**

1.Develop skills and competencies in the fermentation process.

2.Practical skills on the downstream processing in the products.

3.Develop various skills to purify fermented products.

4.Qualitative and quantitative analysis of the various fermented products.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will be able to describe and apply essential upstream and downstream bioprocessing techniques, including fermentation and purification methods.

2.Students will gain practical skills spectrophotometers, and other laboratory instruments essential for bioprocessing.

3.Students will demonstrate knowledge of microbial growth kinetics and the ability to analyze growth data, including substrate and product inhibition effects.

4.Students will learn to analyzing experimental data and interpreting results in bioprocess technology.

5.Students will be able to set up and conduct various fermentation processes, including batch, fed-batch, and continuous fermentation, and evaluate their outcomes.

6.Students will understand the principles of quality control in bioprocessing, including techniques for monitoring sterility, toxicity, and the overall quality of bioproducts.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO3** | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 3 | 2 |
| **CO4** | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 2 | 2 | 2 |
| **CO5** | 3 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | | 2 | 2 | 2 |
| **CO6** | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 3 | 2 |

**Course content**

1.Extraction of enzyme from plant or microbial sources

2.Downstream processes- Crude extraction of enzyme

3.Purification of crude enzyme-Precipitation of enzymes (salt/solvent) and Dialysis

4.Purification by chromatography Ion-exchange and Gel filtration chromatography

5.Enzyme assay-Total protein estimation by Biuret method and 280 methods

6.Determination of specific activity

7.SDS PAGE

8.Native PAGE and Zymography

9.Immobilization of Enzymes and formulation

10.Production of lactic acid and critic acid and their estimation

**Reference Books**

1.Concepts in Biotechnology; D. Balasubramanian et al., Universities Press Pvt. Ltd(2004).

2.Basic Biotechnology; Ratledge, Colin and Bjorn Kristiansen, 2nd Edition, Cambridge University Press (2001).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ306 | **Food Chemistry and Processing Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basic details of food quality and testing requirements

**Course objectives**

1.Gain a knowledge of the various equipment and labware used in the food testing laboratory.

2.Analyze the macro and micronutrients and their roles in food preparations.

3.Determine the physicochemical properties of the food and their preparations.

4.Qualitative and quantitative analysis of the metabolites in food.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Students will be able to describe food processing in terms of unit operations, both conceptually and in practical applications within a pilot plant setting.

2.Students will demonstrate proficiency in using mass and energy balances to analyze food processing systems, allowing for optimization of processes.

3.Students will gain practical experience with common food processing equipment, enhancing their technical skills in food technology.

4.Students will learn to analyze experimental data effectively.

5.Students will develop teamwork skills by working effectively in groups to conduct experiments, analyze results, and communicate findings.

6.Students will apply critical thinking skills to address new challenges in food processing, enabling them to propose innovative solutions based on their laboratory experiences

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 |
| **CO2** | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 |
| **CO3** | 3 | 3 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| **CO4** | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 |
| **CO5** | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 3 | 1 | 2 |
| **CO6** | 3 | 2 | 1 | 2 | 1 | 0 | 1 | 1 | 2 | 2 | 2 | 2 | 2 |

**Course content**

1.Introduction to equipment and labware used in food analysis laboratory.

2.Analysis of Macronutrients in food-Determination of fat content, water content, vitamins C and cholesterol

3.Analysis of Micronutrients from food -Sulphate, calcium, phosphates, magnesium, tannins

4.Determination of moisture content, alkalinity and salt

5.Analysis of water-Physical test and chemical test

6.Analysis of milk-Organoleptic test, litmus test, Methylene blue dye reduction test, alcohol test, Adulterants and preservatives, ALP activity

7.Analysis of fruits and vegetables-Determination of salt content, acidity, added sugar and Peroxide activity in fruit content.

8.Analysis of oils and fats-Determination of specific gravity & Polybromide test for mustered oil

9.Determination of food additives-Colour (saffron, curcumin), Flavours, Hemictant (sorbitol), Emulsifiers (lecithin, monoglycerides) and Preservatives (Benzoic acid)

10.Extraction and analysis of secondary metabolites from plants.

**Reference Books**

1.Concepts in Biotechnology; D. Balasubramanian et al., UniversitiesPress Pvt.Ltd(2004).

2.Basic Biotechnology; Ratledge, Colin and Bjorn Kristiansen, 2nd Edition, Cambridge University Press(2001).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0301 | **SKILL ENHANCEMENT COURSE** | HC | 0 | 0 | 2 | 2 | 2 |

**Course outcomes**

After completing the course, the student shall be able to:

1. Acquire hands on training in various modules required from research and industry perspective.
2. Enhance the knowledge horizon from practical point of view supplementing the knowledge in theory.
3. Provide first-hand experience in various techniques learned at lab level to a higher level.
4. Equip the students with skill sets to carry out the research projects effectively.
5. Develop skills to collect, analyze and interpret experimental data.
6. Gain necessary skills to produce reliable and valid results in addressing research questions.

**Mapping of Course Outcomes with Programme Outcomes**

| PO/CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 1 | 2 | 2 | 1 | 1 |
| **CO2** | 3 | 2 | 2 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **CO3** | 1 | 1 | 1 | 3 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 1 |
| **CO4** | 2 | 2 | 1 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 2 | 1 | 1 |
| **CO5** | 1 | 2 | 2 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 |
| **CO6** | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 0 | 1 | 2 | 1 | 2 | 2 |

**Specialization in Agriculture and Environmental Microbiology**

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ307 | **Soil Microbiology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have important roles of microorganisms in the environment and agriculture.

**Course objectives**

1.To inculcate student fundamentals of soil microbiology

2.To understand the role of microbes in soil nutrition management

3.To explore the interaction of soil microbiota

4.To exploit the beneficial microflora to increase the fertility of the soil and bioremediation

**Course outcomes**

**By the end of the course the student will be able to:**

1.Acquire the basic knowledge soil microflora.

2.Understand the implications of microflora in biogeochemical cycles.

3.Interpret interaction of microflora in soil ecosystem.

4.Exploit the knowledge of microbes to increase soil fertility and bioremediation.

5.Investigate the processes of biodegradation, biodeterioration, bioleaching, and bioremediation

6.Explore the interactions between soil microbes and ecosystems

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 0 | 0 | 0 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 3 | 3 | 1 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 3 | 3 | 3 | 1 | 1 | 0 |
| **CO4** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 0 | 1 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO6** | 0 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 |

**Course content**

**UNIT I Soil microbes** **13 h**

Soil Microbiology; distribution of microorganisms in soil, Autochthonous, Allochthonous and Zymogenous microbes, quantitative estimation of microorganisms in soil, role of microorganisms in soil fertility; influence of soil and environmental factors on microflora, moisture, pH, temperature, organic matter, agronomic practices and Soil health card.

**UNIT II Biogeochemical cycles** **13 h**

Biogeochemical cycles, Carbon cycle, organic matter decomposition, humus formation, Nitrogen cycle-nitrogen fixation, ammonification, nitrification, denitrification, reactions–organisms involved. Nitrogen fixation – symbiotic - root nodulation, non-symbiotic, associative organisms, nitrogenase, hydrogenase, nif gene, nod gene. Microbial transformation of phosphorus, solubilization by phosphobacteria and P-mobilization by mycorrhizal fungi, Microbial transformation of sulphur-sulphur toxicity and sulphur bacteria.

**UNIT III Interaction of microbes with soil ecosystem** **13 h**

Interaction between soil microbes–Neutralism, Commensalism, Symbiosis, Synergism, Amensalism, Parasitism, Predation and Competition. Interrelationships between soil microbes and plants, Rhizosphere concept, R: S ratio, rhizoplane; spermosphere; phyllosphere, Mycorrhizae-types, Rumen flora, Insects microbial interactions.

**UNIT IV Biofertilizer and bioremediation** **13 h**

Biofertilizers–Rhizobium, Azotobacter, Cyanobacteria, Azolla, and VAM. Biopesticides–Bacillus thuringiensis, Psuedomonas fluroscence, Trichoderma viridae, Bavaria bassiana, Nuclear Polyheadrosis Virus. Biodegradation–Cellulose, Lignin. Biodetoriation–Wool, Leather. Bioleaching-Copper, Uranium. Biomagnification, Bioremidiation–Degradation of DDT, Atrazine (Xenobiotic Compounds) and Cleanup oil spills–P. putida.

**Reference Books**

1.Soil Microbiology; N.S.SubbaRao, 4th Edition, Oxford&IBH(2004).

2.Soil Microbiology; R.R.Mishra, 1stEdition, CBSPublishersanddistributors, NewDelhi(2004).

3.Disease of Crop Plants in India; G.RangaswamiandA.Mahadevan, 4thEdition, PHILearning(P)Ltd., NewDelhi(2002).

4.Agricultural Microbiology; G.Rangaswami and Bagyaraj, 2nd Edition, PHILearning(P)Ltd., New Delhi(2002).

5.Soil Microbiology; L.T.Robert, 2nddition, JohnWileyand Sons, Inc.NewYork(2000).

6.Microbial Ecology; R, M, Atlusand Richard Bartha, 4th Edition, An imprint of AddisonWesleyLongmanInc, New York(2000).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ308 | **Plant Pathology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of plant disease caused by microorganisms.

**Course objectives**

1.Understand the fundamentals of plant pathology.

2.Exploit the role of pathogens in disease development.

3.Familiarize with the pathogen interactions with its host.

4.Better understanding of the host defense mechanism against plant pathogens.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Identification of phytopathogens prevailing conditions.

2.Explore the basic knowledge of plant pathogens biology.

3.Comprehend and explain the host-parasite interaction.

4.Design the defence mechanism against plant pathogens to control diseases.

5.Explore the disease physiology and host pathogen interaction.

6.Understand the molecular defense mechanism of plants.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO2** | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 2 | 1 |
| **CO3** | 3 | 3 | 1 | 2 | 3 | 2 | 1 | 2 | 2 | 3 | 1 | 1 | 0 |
| **CO4** | 2 | 2 | 1 | 3 | 3 | 2 | 2 | 2 | 2 | 1 | 3 | 2 | 2 |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO5** | 0 | 0 | 3 | 1 | 3 | 2 | 1 | 3 | 3 | 3 | 1 | 3 | 2 |
| **CO6** | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 2 | 2 | 3 | 2 | 2 | 3 |

**Course content**

**UNIT I Introduction to plant pathology** **13 h**

Importance and history, definitions and concepts of plant disease. Classification of Plant Diseases: protozoan. bacterial, fungal and viral - viroids, nematodes, Losses caused by plant diseases. Principles and methods of plant disease management, integrated plant disease management. Plant nematodes and its management.

**UNIT II Plant diseases and pathobiology** **13 h**

Bacterial disease–Citrus canker, Blight of paddy, Fungal Disease-Red rot of sugarcane, Black stem rust of wheat, Tikka leaf spot, Wilt of cotton, Viral Disease–TMV, Vein clearing disease. Study of plant pathogens and phanerogamic plant parasites. General characteristics, reproduction, survival and dispersal of important plant pathogens, and symptomatology

**UNIT III Plant-pathogen interactions** **13 h**

Parasitism and pathogenicity, Host range of pathogens. Plant disease cycle - inoculation, penetration phenomena, infection, dissemination. Mechanism of pathogenesis: chemical weapons, microbial toxins, growth regulators. Suppressors of plant defense responses. Relationship between disease cycle and epidemics.

**UNIT IV Plant Defense mechanism** **13 h**

Structural and chemical defenses - oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Induced structural and biochemical defenses. Types of plant resistance to pathogens. Genetics of resistance in plant disease.

**Reference Books**

1.Plant Pathology; G.N. Agrios, 5th Edition, Academic Press, NewYork(2005).

2.Plant Pathology; R.S. Mehrotra and A.Aggarwal, 2nd Edition, Oxford&IBH, NewDelhi(2003).

3.Introduction to Principles of Plant Pathology; R.S. Singh, Oxford & IBH, NewDelhi(2002).

4.Disease and Insect Resistance in Plants; D.P.Singh, A.Singh, Oxford & IBH, NewDelhi (2007).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ309 | **Biomass and energy systems** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should know about the role of microorganisms as important bioresources.

**Course objectives**

1.Understanding of various renewable feedstocks, their availability and attributes for biofuels production.

2.Thorough understanding of the broad concept of generations of biofuel production from biomass.

3.Explore the other low-cost Agri-residues, biowastes, anaerobic digestion and biodiesel production.

4.Analyze and design processes for biofuel production using microbes.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Identify and apply potential biomass feedstocks including energy crops.

2.Understand the existing and emerging biomass to energy technologies.

3.Develop acritical thinking about sustainability & resilience.

4.Determine potential solutions for energy needs and problems by incorporating the bioenergy technologies being explored.

5.Design and optimize biomass-to-energy systems, including considerations for scaling up from laboratory to industrial scale.

6.Evaluate the environmental impacts of biomass energy systems, including greenhouse gas emissions, resource use, and waste generation.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 2 |
| **CO2** | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 2 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 1 | 3 | 2 | 3 | 1 | 2 | 3 | 2 | 3 | 3 | 3 |
| **CO6** | 3 | 3 | 2 | 2 | 0 | 1 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |

**Course content**

**Unit-I Biomass** **13 h**

Fundamentals of bioenergy/biofuel; terms and concepts, origin, characteristics, advantages, and disadvantages, use and cost of different types of biomass resources (renewable feedstocks): agricultural energy crops, agro-horticultural Lignocellulosic residual material and other biogenous waste-production, availability and attributes for bioenergy production.

**Unit II Bioenergy production for sustainable environment** **13 h**

General principles of the carbon cycle, greenhouse effect and global climate change. Bioeconomy and sustainable bioenergy system, Current and projected future technologies for producing biofuels such as ethanol, microbial fuel cells, biohydrogen.

**Unit-III Biofuel production** **13 h**

Biofuel generations, Pre-treatment technologies, structure and function of lignocellulosic biopolymers, various types of pre-treatment technologies (Physical, mechanical, chemical, biochemical, ionic liquids etcetera) bioconversion of biomass to biofuel; concept of pseudo-lignin and inhibitors, biodiesel production; environmental impacts of biofuel production; concept of biorefinery, value-added product generation in an integrated approach, processing of biofuel residues-case studies on combined heat and power (CHP)generation. The role of transgenic plants and algae.

**Unit-IV Bioenergy Technology** **13 h**

Anaerobic digestion process for biogas production, Inoculum-its stability and methane potential, Process microbiology, role of microbes, types and characterization, Effect of pH, temperature, nutrients, organic load ingrate (OLR) and hydraulic retention time (HRT) on biogas production from biogenic waste, Storage and stability of digestate-health and safety issues, Up-gradation of biogas to methane. Life cycle assessment of biofuels and biofuel technologies, India's energy demand and supply management, energy cropping, energy needs for the future: regional prospects.

**Reference Books**

1.Wood and Cellulosic Chemistry; D.N.S.Hon, S.Nobuo, CRCPress(2000).
2.Renewable Energy; B.Sorensen, AcademicPress(2010).
3.Sustainable Bioenergy and Bioproducts; G.Kasthurirangan, J.H.vanLeeuwen, C.Robert; Springer (2012).
4.Advances in Clean Energy Technology, A.K.Azad, Elsevier(2020).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ310 | **Soil Microbiology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have knowledge of microbes and their important role in agriculture.

**Course objectives**

1.To explore the aspects of microbial culture techniques

2.Formulation and production of biofertilizers

3.To develop mass production of biofertilizers

4.To understand the effect of biofertilizer in the growth of plants

**Course outcomes**

**By the end of the course the student will be able to:**

1.Knowledge of sampling protocols, sample preservation, and preparation methods

2.Application of ecological principles to interpret microbial functions and interactions in soil ecosystems.

3.Apply the knowledge of microbial enumeration and culture techniques.

4.Formulate liquid and solid biofertilizers

5.Mass production of biofertilizers through industrial fermentations.

6.Evaluate the quality and growth parameters of biofertilizers.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO4** | 2 | 2 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO6** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |

**Course content**

1.Mother culture preparation and preservation techniques

2.Isolation and purification of phosphate solubilizing microorganisms in soil.

3.Mass production of carrier-based formulation of Azospirillum brasilense, Pseudomonas fluorescens and Frateuria aurantia

4.Industrial mass production of liquid formulation of Azospirillum spp.

5.Developing liquid formulations of biofertilizers to increase shelflife

6.Hands-on training of the operation of industrial fermenters

7.Concentration of bacterial suspension through centrifugation and spray drying

8.Quality analysis of bio-fertilizers with respect to FCO standards

9.Evaluating effect of bio-fertilizers on crop growth in pot study experiment

10.Bio-fertilizer consortium preparation.

**Reference Books**

1.Agricultural Microbiology; G.RangaswamiandBagyaraj, 2ndEdition, PHILearning(P)Ltd., New Delhi(2002).
2.Soil Microbiology; L.T.Robert, 2nddition, JohnWileyandSons, Inc.NewYork(2000).
3.Microbial Ecology; R, M, AtlusandRichardBartha, 4thEdition, An imprint of AddisonWesleyLongmanInc, New York(2000).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ311 | **Plant Pathology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge about various plant pathogens and their diseases.

**Course objectives**

1.To enumerate the microbial plant pathogens

2.Characterize the plant pathogens for Kochs' postulates

3.Preservation and screening of antagonistic properties of biocontrol agents

4.Mass production of biocontrol agents.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Documentation of disease symptoms, understanding pathogen lifecycle and disease progression.

2.Understand the rules of Kochs' postulates.

3.Identification and characterization of disease-causing plant pathogens

4.Maintenance and production of biocontrol agents

5.Preparations and Formulations of fungicides and their usage in disease management.

6.Application of management practices, understanding of control methods, and evaluation of their effectiveness.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO4** | 2 | 2 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO6** | 3 | 3 | 3 | 2 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |

**Course content**

1.Demonstration of Koch postulates for fungal plant pathogens

2.Screening for antagonism by dual culture method.

3.Collection and preservation of disease specimens.

4.Extraction of Nematodes from soil and plant material.

5.Evaluation of different fungicides against the fungal pathogens.

6.Preparation of Bordeaux mixture. Burgundy mixture and Chaubattia paste and their practical usage in managing diseases.

7.Growth observations of different fungal bioagents on different growth media and at different pH regimes.

8.Mass production of Trichoderma viridae, Paecilomyces lilacinus.

9.Mass production of Entomopathogenic bio- agents viz, Metarhizium anisopliae, Verticillium lecanni and Beauveria bassiana.

**Reference Books**

1.Plant Pathology; G.N. Agrios, 5th Edition, AcademicPress, NewYork(2005).

2.Plant Pathology; R.S.Mehrotraand A.Aggarwal, 2ndEdition, Oxford&IBH, NewDelhi(2003).

3.Introduction to Principles of Plant Pathology; R.S.Singh, Oxford&IBH, NewDelhi(2002).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ312 | **Biomass and Energy Systems Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

**Students should have theoretical knowledge of microorganisms for the energy production.**

**Course objectives**

1.To understand the soil-water plant relations

2.Analyze the quality of various sources of water samples

3.Determine organic carbon in soil samples

4.Formulations of micro and macro nutrients for plants.**Course outcomes**

**By the end of the course the student will be able to:**

1.Classification of biomass types, measurement of physical and chemical properties

2Explore the soil water plant samples and their physio-chemical parameters

3.Apply the knowledge to evaluate the physiochemical parameters of various sources of water samples.

4.Quantitative and qualitative analysis of macro and micro-nutrients

5.Biostatistical data analysis for report preparations.

6.Operation of conversion reactors, monitoring of process parameters, and collection of data on product yields and quality

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO2** | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 2 | 3 | 2 | 3 | 2 | 0 | 1 | 3 | 3 | 2 | 2 | 1 | 3 |
| **CO5** | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO6** | 3 | 3 | 2 | 3 | 2 | 0 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |

**Course content**

1.Collection and processing of soil, water and plant samples from field

2.Analyses of sewage water samples

3.Analyses of irrigation water samples for pH, EC, SO42-

4.Analyses of irrigation water samples for SAR & RSC

5.Analyses of soil samples for pH, EC, OC and macronutrients

6.Analyses of soil samples for micronutrients

7.Analyses of plant samples for macronutrients

8.Analyses of plant samples for micronutrients

9.Analyses of organic manures

10.Soil, Water and Plant analyses reports preparation.

**Reference Books**

1.Agricultural Microbiology; G.Rangaswami and Bagyaraj, 2nd Edition, PHILearning(P)Ltd., New Delhi(2002).
2.Soil Microbiology; L.T.Robert, 2nd edition, JohnWileyand Sons, Inc.New York(2000

## Specialization in Medical and Pharmaceutical Microbiology

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ313 | **Clinical Microbiology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basics of diseases caused by various classes of microorganisms.

**Course objectives**

1.Gain a knowledge on bacterial diseases and their importance

2.Acquire the knowledge in virology and diseases caused by viruses

3.Understand the life cycle and reproduction of few important protozoans and fungi.

4.Exploit cutting-edge technology in handling and analyzing pathogens.

**Course outcomes**

**By the end of the course the student will be able to:**

1.Learn about reproduction in bacteria, aspects of bacterial growth and the pathogenic nature of bacterial infections.

2.Understand the properties, pathogenicity and lab diagnosis of pathogenic viruses.

3.Collect information of the source, life cycle and diagnosis of pathogenic protozoans and fungi.

4.Explore the various techniques in the diagnosis and detection of diseases.

5.Apply immunotechnology principles, to understand the immune system.

6. Insight into the advanced technologies in understanding the clinical microbes.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 1 | 2 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 2 | 3 | 2 | 3 |
| **CO5** | 2 | 3 | 3 | 3 | 2 | 1 | 1 | 3 | 2 | 2 | 3 | 3 | 3 |
| **CO6** | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 3 | 3 |

**Course content**

**Unit–I Bacteriology** **13 h**

Bacterial toxins, Pathogenic bacteria- Staphylococcus, Streptococcus, Neisseria, Corynebacterium, Clostridium, Vibrios, Campylobacter, Mycobacterium, Pseudomonas, Spirochaetes, Chlamydiae, Rickettsiae, Mycoplasma. NABL guidelines

**Unit–II Virology** **13 h**

Poxviruses, herpesviruses, arboviruses, orthomyxovirus, paramyxoviruses, enteroviruses-polio & other enteric viruses, hepatitis viruses, rabies viruses, Coronaviruses and HIV. Culturing of viruses in embryonated eggs, experimental animals and cell culture. Identification of viruses physical and chemical methods of assays (protein-nucleic acid, radioactivity traces, electrons microscopy and plaque method).

**Unit–III Parasitology and Mycology** **13 h**

Protozoan parasites of medical importance- Entamoeba, Leishmania, Trypanosoma, Plasmodium, Toxoplasma and Pneumocystis. Medically important helminths belonging to Cestodes, Trematodes and Nematodes. Cestodes-Diphyllobothrium, Taenia, Echinnococcu and Hymenolepis, Nematodes-Trichuris, Trichinella, Ancylostoma, Ascaris, and Filarial worms. opportunistic fungi, superficial mycotic infections, subcutaneous mycoses and systemic infections. Laboratory diagnosis of fungal infections and immunity in fungal diseases.

**Unit–IV Immunotechnology** **13 h**

Brief about the immune system, innate and adaptive immunity, Antigen and antibodies. Complementation system, Antigens and Antibody reactions invitro Serological testing-agglutination, complement fixation, ELISA, western blotting, immunodiffusion, immune electrophoresis, immunofluorescence, immunoprecipitation, radioimmunoassay (RIA), Flow cytometry and serotyping. Molecular diagnostics–molecular basics of diagnostics, Hybridoma technique and PCR based techniques.

**Reference Books**

1.Medical Microbiology; G.F.Brooks, J.S.Butel, and L.N.Ornston, EditorsJawetz, Melnick & Adelberg, 24th Edition, McGraw-Hill(2007).
2.Diagnostic microbiology; A.B.Forbes, D.F.Sahm, A.S.Weissfeld, 10th Edition, Mosbypublishers, New York(2001).
3.Principles and practice of infectious diseases; G.L.Mandell, J.E.Bennett, R.Dolin, 7th Edition, Churchill Livingstone, New York(2010).
4.Clinical Microbiology; W.B.Saunders, J.Stokes, G.L.Ridway, M.W.D.Wren, 7th Edition, Edward Arnold – adivision of hodder and Stoughton (2013).
5.Immunology; I.R.Tizard, 9th Edition, Elsevier publisher(2013).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ314 | **Medical Biochemistry** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basic knowledge of human physiology and biochemical relations.

**Course objectives**

1.Acquire the knowledge of source, functions and classification of carbohydrates and lipids.

2.Better understanding of the source, properties and functions associated with the proteins and its clinical relevance.

3.Inculcate the important understanding of disorders associated with the diet and lifestyle.

4.Explore the knowledge of enzymes and their applications in diagnostic purpose.**Course outcomes**

**By the end of the course the student will be able to:**

1.Explore the important functions and disorders associated with carbohydrates and lipids.

2.Acquaint the sources, functions and malnutrition associated with proteins.

3.Understanding the importance of healthy diet and role of various sectors in health aspects.

4.Apply and analyze the enzymes in the medical applications and diagnostic purpose.

5. Assess human dietary requirements and their role in growth.

6. Upgrade the knowledge of multidimensional role of Medical Biochemistry

**Mapping of Course Outcomes with Programme Outcomes**

| PO/CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 2 |
| **CO2** | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 1 | 1 | 2 | 2 | 3 | 1 |
| **CO3** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 |
| **CO4** | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 1 | 2 |
| **CO5** | 2 | 1 | 3 | 2 | 3 | 3 | 1 | 2 | 2 | 3 | 2 | 3 | 3 |
| **CO6** | 1 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 3 |

**Course content**

**Unit–I Carbohydrates and Lipids 13 h**

Chemistry of carbohydrates and lipids-classifications, properties, classifications. fatty acids types and uses, glycerides, phospholipids, glycolipids, eicosanoids, steroids, cholesterol and lipoproteins. digestion and absorption of carbohydrates, proteins, fats and nucleic acids. Physiology and biochemistry of respiration. Detoxification mechanisms generally taking place in human body and body fluids.

**Unit–II Proteins and clinical relevance 13 h**

Amino acids-classification based on structure, requirement, metabolic rate, solubility, physical properties and chemical properties of amino acids. Proteins-definition, structure, classification and functions. Gout and genetic defects in urate-metabolism. Methods employed usually in protein quality evaluation. Nutritional experiments commonly done on laboratory animals. Recent advance techniques used in human nutrition studies

**Unit–III Nutrition and Public Health 13 h**

Human dietary requirements and deficiency diseases, BMR and BMI, daily nutritional requirements- macro and micronutrients. Malnutrition of proteins and energy, symptoms and diagnosis of nutritional deficiencies-Anaemia, blindness, beriberi, pellagra. Diet, calculation of balanced diet, disorders of protein energy malnutrition. Health determinants and standards, relevance to social aspects, future challenges in public health. Role of public, private and NGO in Health sector.

**Unit–IV Principles of diagnostic enzymology 13 h**

Introduction to enzymes and nomenclature. Enzyme kinetics and inhibitors, chromogens in brief. Medically important enzymes and factors affecting enzyme levels in blood. Principle, assay and clinical significance of transaminases, creatine kinase, lactate dehydrogenase, phosphatases, isocitrate dehydrogenase, amylase, lipase, trypsin, chymotrypsin, cholinesterase, glutamate dehydrogenase, glucose-6-phosphate dehydrogenase and ceruloplasmin.

**Reference Books**

1.Principles of Biochemistry; Lehninger and D.L.Nelson, 6thEdition, Macmillan Publications(2012).
2.Biochemistry; J.M.Berg, J.L.ToymoczkoandL.Stryer, 8th Edition, Macmillan Publications (2015).
3.Physical Biology of the Cell; R.Phillips, J.Kondev, J.Theriot, H.Garcia, 2nd Edition, Garl and Publishers (2012).
4.Biochemistry; D. Voetand J.G.Voet, 3rd edition, John Wiley and sons(2009).
5.Biochemistry; Garrett and M.G.Charles, 6th Edition, Mary Finch publisher(2013).
6.Biochemistry and Molecular Biology; Elliot, 4th Edition, Oxford University Press(2009).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ315 | **Pharmaceutical Microbiology** | HC | 4 | 0 | 0 | 4 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have basic knowledge of microbes and their importance in pharma industries.

**Course objectives**

1.Acquire the knowledge about antibiotics and their various usage in industries

2.Better understanding of the molecular mechanism of action of various antibiotics

3.Exploit the technology for the microbial production of antibiotics and their spoilage

4.Establish quality assurance and data management in the pharma industries.

**Course outcomes**

**By the end of the course the student will be able to:**

1.In-depth understanding about various types of antibiotics and their applications

2.Identify the molecular mechanistic insight of antibiotics actions

3.Utilize the technological advancement for production of antibiotics

4.Explore the quality assurance and quality control aspects involved in industries.

5.Understand the ethical issues related to the pharma industry.

6.Explore the regulatory mechanism in the industry.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 |
| **CO2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 2 | 3 | 3 |
| **CO3** | 3 | 3 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 3 | 2 | 3 |
| **CO4** | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 2 | 3 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 1 | 3 | 1 |
| **CO6** | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 2 | 3 |

**Course content**

**Unit–I Antibiotics and synthetic antimicrobial agents 13 h**

Antibiotics and synthetic antimicrobial agents-Aminoglycosides, βlactams, tetracyclines, ansamycins, macrolide antibiotics. Antifungal antibiotics, antitumor substances. Peptide antibiotics, chloramphenicol, sulphonamides and quinolinone antimicrobial agents. Chemical disinfectantsantiseptics and preservatives.

**Unit–II Mechanism of action of antibiotics 13 h**

Mechanism of action of antibiotics. Molecular principles of drug targeting. Drug delivery system in gene therapy Bacterial resistance to antibiotics. Mode of action of bacterial killing by quinolinones. Bacterial resistance to quionolinones. Mode of action of non–antibiotic antimicrobial agents.

**Unit–III Microbial production and spoilage of pharmaceutical products 13 h**

Microbial contamination and spoilage of pharmaceutical products (sterile injectables, noninjectable, ophthalmic preparations and implants) and their sterilization. Manufacturing procedures and process control of pharmaceuticals. Other pharmaceuticals produced by microbial fermentations (streptokinase, streptodornase). New vaccine technology, DNA and RNA vaccines, synthetic peptide vaccines and multivalent subunit vaccines.

**Unit–IV Quality Assurance and Validation 13 h**

Good Manufacturing Practices (GMP) and Good Laboratory Practices (GLP) in pharmaceutical industry. Regulatory aspects of quality control. Quality assurance and quality management in pharmaceuticals ISO, WHO and US certification. Sterilization control and sterility testing-chemical and biological indicators. Design and layout of sterile product manufacturing unit. Designing of Microbiology laboratory and safety in microbiology laboratory. Risk management and Risk Mitigations. NABL accreditation.

**Reference books**

1.Pharmacology and Pharmaco therapeutics; R.S.Satoskar, N.R.Rege, R.K.Tripathi, S.D.Bhandarkar, 2nd Edition, PopularPrakashan Publishers(2010).
2.Microbiology: Principles & Explorations; J.G.Black, 6thEdition, John Wiley &Sons(2010).
3.Free, Hydrometallurgy: Fundamentals and Applications; L.Michael, 1stEdition, Wiley Publications (2013).
4.Biomining: Theory, Microbes and Industrial Processes (BiotechnologyIntelligenceUnit);

D.E.Rawlings, 1stEdition, Springer publications(2012).
5.The Science and practice of Pharmacy; 20th Edition, B.T.David, B.Paul, Lippincot Williams and Wilkins(2010).

## PRACTICALS

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ316 | **Clinical Microbiology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge about physiological functions of host during disease conditions**.**

**Course objectives**

1.In-depth understanding the establishment setup of the clinical microbiology laboratory and good lab practices.

2.Hands-on experience in handling and reservations of the laboratory specimens.

3.Exposure to the various techniques in molecular diagnostic protocols.

4.Explore the basics of the molecular diagnostic laboratory.

**Course outcomes**

**By the end of the course the student will be able to:**

1. Understanding of the clinical microbiology laboratory setup.

2.Skills to handle the clinical specimens for diagnostics.

3.Explore the techniques involved in the pre-processing of molecular diagnostics.

4.Exploit the various advanced molecular techniques for diagnostics and research.

5.Perform analysis and interpretation of clinical microbiology samples.

6. Conduct and execute various assays for isolation and Identification of clinical samples

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO2** | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO6** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |

**Course content**

1. Laboratory safety: Fire, chemical, radiation, handling of biological specimens, waste, disposal regulations and workplace hazardous, PPE

2.Specimen collection, identification, transport, delivery and preservation.

3.ELISA technique-direct.

4.Indirect ELISA and analyses.

5.Separation of serum from blood and preparation for further testing.

6.Isolation of DNA followed by analysis through agarose gel electrophoresis.

7.Isolation of RNA followed by analysis through formaldehyde agarose gel electrophoresis.

8.Quality and quantitative analysis of DNA and RNA by spectrophotometer.

9.PCR for virus detection.

10.RT-PCR quantitation of viruses.

**Reference Books**

1.Molecular Diagnostics: Fundamentals, Methods and Clinical Applications; L. Buchingham and M.L.Flawsm, 1st Edition, FA Davis Company, Philadelphia, USA(2007).
2.Immunology; J.Kuby, J.Owen, J.Punt, S.Stranford; 7thEdition, W.H.FreemanandCompany(2013).
3.Essential Immunology, P.J.Delves, S.J.Martin, D.R.Burton, I.M.Roitt, 12thEdition, ELBS, BlackwellScientificPublishers, London(2011).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ317 | **Medical Biochemistry Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge of biochemical aspects in human abnormal conditions.

**Course objectives**

1.Understand the various protein extraction and analysis techniques

2.Establishment protocols and setup of Medical Biochemistry lab.

3.Hands-on experience in analysis of the cells and sub-cellular parts

4 Explore various molecular mechanisms of micro-RNA studies

**Course outcomes**

**By the end of the course the student will be able to:**

1.Understanding the biochemical methods in protein extraction and analysis.

2.Peroform analyse and interpretation of advanced methods like flow cytometry and micro-RNA.

3.Standardize the protocols for the medical biochemistry lab.

4.Exploit the molecular and biochemical analysis methods in industries and research

5.Implementation of molecular techniques to characterize

6.Skills to prepare samples for various analyzing techniques

**Mapping of Course Outcomes with Programme Outcomes**

| PO/CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | 2 | 1 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| **CO2** | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 1 | 3 | 3 | 3 |
| **CO3** | 2 | 3 | 2 | 3 | 3 | 2 | 1 | 2 | 2 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| **CO5** | 2 | 3 | 3 | 3 | 3 | 3 | 1 | 3 | 3 | 2 | 3 | 3 | 3 |
| **CO6** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 |

**Course content**

1.Tissue homogenization and cell disruption-Cell fractionation methods by ultra and gradient centrifugation

2.Protein extraction and column purification from the samples and its spectrophotometer analysis.

3.Flow cytometric analysis of blood cells.

4.Gelatin zymographic analysis.

5.SDS PAGE for isozymes detection.

6.Western blotting analysis for the gene products-biomarker analysis.

7.Preparation of immune histochemistry samples and confocal/fluorescent microscopy.

8.Preparation of samples for electron microscopy and demonstration of imaging.

9.Estimation of LDH and phosphatase levels in blood with clinical significance.

10.Isolation and identification of miRNA.

**Reference books**

1.Analytical techniques in Biochemistry and molecular Biology; R.Katoch, Springer(2011)
2.Basic Methods for the Biochemical Lab; M.Holtzhaue, Springer (2007).
3.Principles and Techniques of Biochemistry and Molecular Biology; K.WilsonandJ.Walker, 7th Edition, CambridgeUniversityPress(2010).
4.Experiments in Applied Microbiology; S.Singer Academic Press(2001).

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SOZ318 | **Pharmaceutical Microbiology Lab** | HC | 0 | 0 | 2 | 2 | 4 |

**Prerequisites/Pre reading for the course:**

Students should have theoretical knowledge of microbial quality control in pharmaceutical industries.

**Course objectives**

1.Understand the microbiological methods for determination of antibiotics.

2.Practical explore in the antimicrobial sensitivity assay for antibiotics.

3.Aid in conducting toxicity studies in the cell culture.

4.Determine the microbial spoilage and load in the pharmaceutical products.

**Course outcomes**

**By the end of the course the student will be able to:**

1. Determine the microbial methods in the antibiotic studies.

2. Exploit the antimicrobial sensitivity assay for quality analysis and research.

3. Assist and analyze the toxicity studies in cell cultures.

4. Analyze the various microbial spoilage in the pharmaceutical products

5. Perform and Interpret the bioassay of antibiotics

6. Quantify the Microbial load in preparation of syrups, creams suspensions and opthalmic.

**Mapping of Course Outcomes with Programme Outcomes**

| **PO/CO** | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO2** | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 | 3 | 3 |
| **CO3** | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO4** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **CO5** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **CO6** | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 | 3 |

**Course content**

1.Microbiological methods for the determination of griseofulvin/ streptomycin.

2.Bioassay of chloramphenicol by plate assay method.

3.Antimicrobial susceptibility testing by broth dilution method.

4.To determine MIC, LD50 of Beta-lactam/ aminoglycoside/tetracycline.

5.Sterility testing by Bacillus stearothermophilus

6.Sampling of pharmaceuticals for microbial contamination and load (syrups, suspensions, creams and ointments, ophthalmic preparations).

7.Separation of mononuclear cells by Ficoll-Hypaque and cell viability by MTT assay.

8.Identification of various types of blood cells by blood smear and microscopy

9.Isolation of peripheral blood cells PBMC and viability testing by live-dead staining method.

10.Counting and viability assessment of animal cells by direct microscopic methods.

**Reference Books**

1.Microbiological methods; C.H.Collins, M.L.Tatrica andJ.M.Grange, 8thEdition, HodderArnoldpublishers(2004).
2.Biopharmaceuticals: Biochemistry and Biotechnology; G.Walsh, 2ndEdition, JohnWiley & Sons, Wiley Publications(2013).
3.Biotechnology & Biopharmaceuticals Transforming Proteins and Genes into Drugs; R.J.Y.Ho, 2nd Edition, Wiley-Blackwell(2013).

## FOURTH SEMESTER

| Course code | Course Title | HC/ SC/ OE | L | T | P | C | Hrs./ Wk. |
|---|---|---|---|---|---|---|---|
| M24SO0401 | **MAJOR PROJECT AND DISSERTATION** | HC | 0 | 0 | 10 | 10 | 20 |

**Course outcomes**

After completing the course, the student shall be able to:

1 Apply fundamental concepts and methods in ways appropriate to their principal areas of study.

2. Demonstrate the skill sets acquired and employ the knowledge of current information in the domain.

3. Apply technological tools and techniques specific to the professional field of study.

4. Acquire real time exposure to the systematic execution of research components and methodology.

5. Attain the requisite technical writing skills and presentation skills required for project.

6. Get an understanding of ethical principles to be followed in project execution, decision-making, reporting, and communication.

**Mapping of Course Outcomes with Programme Outcomes**

| PO/CO | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PSO1 | PSO2 | PSO3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO1** | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 1 | 3 | 2 | 2 |
| **CO2** | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 3 | 2 | 1 | 3 | 3 | 2 |
| **CO3** | 1 | 3 | 3 | 3 | 2 | 2 | 3 | 2 | 3 | 1 | 3 | 2 | 1 |
| **CO4** | 3 | 2 | 3 | 3 | 3 | 3 | 2 | 3 | 2 | 1 | 3 | 3 | 1 |
| **CO5** | 3 | 3 | 2 | 1 | 1 | 2 | 1 | 3 | 1 | 1 | 3 | 1 | 0 |
| **CO6** | 3 | 1 | 2 | 0 | 0 | 3 | 1 | 3 | 2 | 1 | 2 | 1 | 0 |

**Internship:** Minimum of four weeks duration internship should be carried out by the student either in industry or in an R&D organization, including educational institutes with excellent research culture. In case, if a student is unable to secure internship either in industry or in an R&D organization, a project may be

carried out within the university. The student is expected to submit a formal report at the end of the internship Programme. The student shall be awarded the marks for internship based on the (a) presentation and (b) comprehensive viva by the panel of examiners constituted by the school.

## CAREER DEVELOPMENT AND PLACEMENTS

Having a degree will open doors to the world of opportunities for you. But Employers are looking for much more than just a degree. They want graduates who stand out from the crowd and exhibit real life skills that can be applied to their organizations. Examples of such popular skills employers look for include:

1. Willingness to learn
2. Self-motivation
3. Teamwork
4. Communication skills and application of these skills to real scenarios
5. Requirement of gathering, design and analysis, development, and testing skills
6. Analytical and Technical skills
7. Computer skills
8. Internet searching skills
9. Information consolidation and presentation skills
10. Role play
11. Group discussion, and so on

REVA University, therefore, has given utmost importance to develop these skills through variety of training programs and such other activities that induce the said skills among all students. A full-fledged Career Counselling and Placement division, namely Career Development Centre (CDC) headed by well experienced senior Professor and Dean and supported by dynamic trainers, counsellors and placement officers and other efficient supportive team does handle all aspects of Internships and placements for the students at REVA University. The prime objective of the CDC is to liaison between REVA graduating students and industries by providing a common platform where the prospective employer companies can identify suitable candidates for placement in their respective organization. The CDC organizes pre-placement training by professionals and also arranges expert talks to our students. It facilitates students to career guidance and improve their employability. In addition, CDC forms teams to perform mock interviews. It makes you to enjoy working with such teams and learn many things apart from working together in a team. It also makes you to participate in various student clubs which helps in developing team culture, variety of job skills and overall personality. The need of the hour in the field of Biotechnology is not only knowledge in the subject, but also the skills to do the job proficiently, team spirit and a flavor of innovation. This kept in focus, the CDC has designed the training process, which will commence from second semester along with the curriculum. Special coaching in personality development, career building, English proficiency, reasoning, puzzles, and communication skills to every student at REVA University is given with utmost care. The process involves continuous training and monitoring the students to develop their soft skills including interpersonal skills that will fetch

them a job of repute around his / her interest and march forward to make better career. The School of Chemical and Biological sciences also have emphasized subject based skill training through lab practice, internship, project work, industry interaction and many such skilling techniques. The students during their day-to-day studies are made to practice these skill techniques as these are inbuilt in the course curriculum. Concerned teachers also continuously guide and monitor the progress of students.

The University has also established University-Industry Interaction and Skill Development Centre headed by a Senior Professor & Director to facilitate skill related training to REVA students and other unemployed students around REVA campus. The center conducts variety of skill development programs to students to suite to their career opportunities. Through this skill development center, the students shall compulsorily complete at least two skill / certification-based programs before the completion of their degree. The University has collaborations with Industries, Corporate training organizations, research institutions and Government agencies like NSDC (National Skill Development Corporation) to conduct certification programs. REVA University has been recognized as a Centre of Skill Development and Training by NSDC (National Skill Development Corporation) under Pradhan Mantri Kaushal Vikas Yojana.

The University has also signed MOUs with Multi-National Companies, research institutions, and universities abroad to facilitate greater opportunities of employability, students' exchange programs for higher learning and for conducting certification programs.

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