SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

Learning Outcome based Curriculum Framework

(LOCF)

For

M.Sc. I Zoology

Postgraduate Programme

From

Academic year

2023-24

Vision & Mission

Mission:

- Equip the student with knowledge and skills of their chosen vocation,
- Inculcate values.
- Provide them opportunities for all round growth and prepare them for life.

Vision:

- To equip the students with advanced knowledge and skills in their chosen vocation.
- To provide value-based education and opportunities to students.
- To help them to face challenges in life.
- To nurture a scientific attitude, temperament and culture among the students.
- To continually review, develop and renew the approach to build India of the Founder's dream.

Goals and Objectives:

- To build a strong Academia-Industry bridge.
- To provide flexibility in the courses offered and proactively adapt to the changing needs of students and the society.
- To establish a centre for multidisciplinary activities.
- To mould individuals who would nurture the cultural heritage of our country and contribute to the betterment of the society.

Board of studies in Zoology

Undergraduate and Postgraduate

	Name	Designation	Institute/Industry
Head of the Department			
1	Dr. Vikrant Deshmukh	Chairman	K J Somaiya college of science and commerce
Subject Expert nominated by Vice-Chancellor			
1	Dr. Meghana Talpade	Associate Professor	Mithibai College, vileParle
Research Scientist- Member			
1	Dr. Ashok Jaiswar	Principal Scientist	CIFE, Mumbai
2	Dr. Sabyasachi sautya	Scientist and Assistant Professor	CSIR-NIO, Mumbai
Subject experts			
1	Dr. Arshad Ali Haider	Assistant Professor	Maharashtra College, Mumbai Central
2	Dr. Vaishali Somane	Associate Professor	MD College, Parel
Representative from Industry/corporate sector/allied area			
1	Mr. Amit Sharma	Deputy Technical Manager	Ultratech Environmental Consultancy and Laboratory, Thane
Meritorious Alumnus			
1	Ms. Roshni Yadav	MSc Oceanography 2018-19	K J Somaiya college of Science and Commerce

Faculty of the specialisation			
1	Dr. Amol Patwardhan	Assistant Professor	K J Somaiya college of science and commerce
2	Ms. Shreya Patil	Assistant Professor	K J Somaiya college of science and commerce
3	Dr. Shanti Upadhye	Assistant Professor	K J Somaiya college of science and commerce
4	Ms. Chetana Kanekar	Assistant Professor	K J Somaiya college of science and commerce
5	Ms. Madhuri Padaya	Assistant Professor	K J Somaiya college of science and commerce
6	Ms. Roshni Yadav	Assistant Professor	K J Somaiya college of science and commerce
7	Ms. Meghna Verma	Assistant Professor	K J Somaiya college of science and commerce
8	Ms. Divya Sarang	Assistant Professor	K J Somaiya college of science and commerce
9	Mr. Rishiraj Duggal	Assistant Professor	K J Somaiya college of science and commerce

Foreword

Autonomy reflects efforts for excellence in academic performances, capability of self-governance and enhancement in the quality of education. In the year 2012, the UGC and University of Mumbai conferred the Autonomous Status to K J Somaiya College of Science and Commerce. Post this recognition and having several accolades to our credit, we made significant changes to our existing syllabi to reflect the changing business, industrial and social needs. A holistic education that provides opportunities to gain and share knowledge, experiment and develop beyond curriculum, is offered at our College.

An Autonomous college carries a prestigious image for the students and the teachers and we have made a collaborative attempt to maintain a high level of quality in the standard of education that we impart.

Structured feedback obtained from the students, alumni and the experts from the industry and the changes suggested by them were duly incorporated in the syllabi. The Board of Studies constituted for each department meets to carry out in depth discussions about different aspects of the curriculum taking into cognizance the recent trends in the discipline.

The IQAC team has facilitated the conduct of a number of workshops and seminars to equip the faculty with the necessary skill set to frame the syllabi and competencies to deliver the same. Training was also provided to employ innovative evaluation methods pertaining to higher cognitive levels of revised Bloom's taxonomy. This has ensured the attainment of the learning outcomes enlisted in the syllabus. Audits are conducted to critically review the practices undertaken in

teaching, learning and evaluation. Innovative learning methodologies such as project-based learning, experiential learning and flip- class learning practiced by a committed fleet of faculty and supported by several hands have been our unique outstanding propositions. All efforts have been made to nurture the academic ambitions as well as the skills in co-curricular activities of the most important stakeholder i. e. student.

With sincere gratitude, I acknowledge the constant support and guidance extended by Shri Samir Somaiya, President- Somaiya Vidyavihar, and all the esteemed members of the Governing board and Academic council of the College. I also would like to acknowledge the Heads of the Departments and all the faculty members for their meticulous approach, commitment and significant contribution towards this endeavour for academic excellence.

Dr. Pradnya Prabhu
Principal

Acknowledgement

Syllabus Revision is an essential part of academic sustenance. This year, with the implementation of NEP 2020, we now have the added responsibility of delivering a curriculum that focuses on both- a sound knowledge base along with higher order skills that will support all round development and vocation of the learner. At the outset, I would like to thank our Principal Dr. Pradnya Prabhu for her guidance and support during the curriculum restructuring process. I am also deeply obliged to all the esteemed members of the Board of Studies, for their constructive suggestions and contributions.

Above all, I am indebted to my young and vibrant colleagues in the Department of Zoology for their sincere and painstaking efforts during the compilation of the restructured syllabus as per NEP 2020 guidelines.

Dr. Vikrant Deshmukh
Chairperson
Board of Studies in Zoology

Table of Contents

Preamble

This Learning Outcome-based Curriculum Framework (LOCF) supports the fundamental principle of providing quality education in India. We endeavour to mould young minds to participate, contribute and add value to every milestone in their path towards academic excellence. The introduction of Choice Based Credit System (CBCS) has maximized the benefits of the newly designed curriculum manifold.

The LOCF will assist teachers to envisage the outcome expected from the learners at the end of the programme. It will help them to strategize their teaching effectively. At the same time, this document will guide the students through the new curriculum and help them acquire all the skills and knowledge sets required for their personal and academic growth. Higher education qualifications such as the Master's degree Programme are awarded on the basis of demonstrated achievement of outcomes and academic standards; and this is the very essence of this curriculum.

Education is one of the most critical yardsticks in any country's development. The new National Education Policy (NEP) 2020 is an essential and comprehensive policy framework that aims to revamp the country's educational system from its foundation and to bring it at par with global standards. The larger aim of this policy is to transform the Indian education system by making it more inclusive, flexible and relevant to the changing needs of the society. Some of the key features of this policy are the introduction of vocational training, elective courses, emphasis on cultural studies, development of global skill sets and the promotion of multilingualism.

The policy seeks to bring about significant changes in the Higher Education structure, such as introducing a four-year postgraduate degree Programme,

establishing multidisciplinary education and research universities, pooled credit banks and creating a National research Foundation to promote and support research activities in various fields. The new education policy enables every student to get quality education irrespective of their socio-economic background, gender or disability. NEP 2020 enables teachers to use a variety of learning techniques and experiments.

In the current fast paced world, simply cascading the knowledge in the classroom is not sufficient especially when the global requirements keep changing. Every learner should be encouraged to exchange ideas and thoughts in a collaborative approach. This leads to developing an environment which is cognitive in nature and not a one-way information flow. Keeping all this in mind, the curriculum under Learning Outcome-based Curriculum Framework (LOCF) is designed.

1. Introduction

The M.Sc. Zoology programme is developed by keeping in mind the interest of learners to explore and achieve in depth knowledge and skills in the field of Zoology. The flexible framework helps to maintain the ethos of Zoology degree programmes through periodic programme review within a broad framework of agreed/expected post graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The M.Sc. programme is planned in such a way that it allows flexibility and innovation in programme design, syllabi development, teaching-learning process and quality assessment of student's learning levels. Updating teaching, learning pedagogy and outcome-based education form the pillars of the programme.

This curriculum framework is developed on the principles of student centric learning pedagogy. The platform intends to empower graduates with the skills required for pursuing wildlife-related careers, higher education in Zoology and its allied subjects.

Various graduate attributes are emphasised in this framework such as critical thinking, basic psychology, scientific reasoning, moral ethical reasoning, etc. While designing this framework, an important aspect considered was the measurable teaching-learning outcome to ensure employability of the graduates. Implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, NPTEL, SWAYAM and other e-learning platforms are suggested through this framework. The framework also focuses on issues relevant to India and also of the rest of the world;

Every course is designed in such a way that students get decent exposure to each topic by keeping an equilibrium between these topics and thus creating interest to pursue further education in the field of Zoology. It covers the fundamental concepts of Zoology to establish a strong foundation of the subject and helps students to explore the subject more. Topics varying from Taxonomy, Phylogeny, Genetics, Cellular pathways, Diseases, Ecology, Animal Behaviour, Environment, Conservation, Biotechnology & its applications, Biostatistics etc are taught. Our chosen area of Specialisation is Oceanography. Hence the curriculum includes various aspects of physical , chemical and biological oceanography. Subjects having enormous vocational and research scope such as marine ecology, planktonology, marine pollution are also covered.

The practical sessions are designed to help the students gain necessary skills in biochemical analysis, media preparations, fish identification, chromatography, as well as water analysis. Students are also encouraged to improve their scientific writing skills through various assignments. The research-based project work and

On-the Job training in the curriculum instills team building attitude within students and ensures the building of a strong industry interface. The project evaluation method is designed in such a way that it helps in creating a strong background for the research, skills to generate systematic reports and create effective presentation. The Research project or Dissertation helps the students greatly to improve their understanding of the subject and apply their knowledge to the field.

2. Learning Outcome based Curriculum Framework

LOCF focuses on curriculum framework, curriculum aims, learning targets and objectives. The curriculum framework also provides examples of effective learning, teaching and assessment practices. As the curriculum development is a collaborative and an on-going enhancement process, the LOCF instructs periodic reviews and revisions of the curriculum in accordance with the ever changing needs of students, teachers and society.

The framework describes how students are given exposure towards core knowledge of the subject, specialisation, choice based learning and other skill enhancement courses ensuring development of an integrated personality and employability. The template defines expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness along with specific learning course outcomes at the starting of each course. The Learning Outcomes based Curriculum Framework (LOCF) for M.Sc. Zoology will certainly be a valuable document in the arena of outcome-based curriculum design.

2.1 Nature and extent of M.Sc. Zoology

The M.Sc. Zoology programme is of two years duration. Each year is divided into two semesters. The post graduate program in Zoology is designed to include both classical core topics from basic branches like Taxonomy, phylogeny, anatomy, evolution etc. along with applied branches such as genetics, biotechnology and biostatistics as well as specialisation topics like Chemical oceanography, Microbial oceanography, Marine Biotechnology etc. The Zoology programme thus strikes a perfect balance between fundamental and advanced concepts. The scope of each topic varies with the nature of the specific branch. In our endeavour to improve the employability of the post graduates of the Oceanography program, the curriculum offers courses on entrepreneurial skills in Zoology and its allied fields as well.

The curriculum will be taught through formal lectures with the aid of power-point presentations, audio and video tools and other teaching aids can be used as and when required. Wherever possible RBPT approach will be adopted to make the process of learning more learner-centric. ICT-based teaching-learning tools will be incorporated through which even the mundane aspects could be made more interesting and relevant.

2.2 Programme Education Objectives (PEOs)

The overall aims of Master's degree program in Zoology are to:

1. Elucidate core knowledge and skills in Zoology.

2. Create a sound academia-industry interface.

3. Develop technical skills in Oceanography and gain knowledge of research methodologies and skills of problem solving methods.

4. Provide skills to carry out internship programme and research projects to develop scientific skills

5. Apply the obtained scientific knowledge to address relevant research problems of global importance.

6. Pursue higher studies such as a doctoral degree, or appear for national eligibility test (NET)/(SET) state eligibility test or select any other professional career related to Zoology.

7. Display traits of global citizenship, empathy for all life forms and sustainability.

3. Graduate Attributes in Zoology

Attributes expected from the graduates of M.Sc. Zoology Programme are:

GA-1. Disciplinary knowledge: A deep understanding of the diversity of animals from the evolutionary, functional, and ecological perspective

GA-2. Scientific reasoning: Developing Skills specific to the study of animals such as making observations, generating and presenting data, experimental design, statistical analysis, writing reports, identifying species, mounting specimens, using microscopes and interpreting classification keys.

GA-3. Analytical reasoning: An appreciation of the uniqueness of Indian biodiversity and wildlife and to develop the ability to analyse, think, plan, execute and review this knowledge.

GA-4. Research-related skills: An awareness of the importance of research to the development of the discipline of Zoology and the curiosity to practice the same.

GA-5. Self-directed learning: An understanding of the gaps or deficits in the current knowledge and an attempt to fill those gaps. Entrepreneurial skills as an offshoot of interaction with several Industry experts and monetize the acquired knowledge.

GA-6. Communication Skills: Expertise in all forms of written, spoken, scientific and presentation skills. Personal skills in written and oral communication, analysis, problem solving and decision making.

GA-7. Leadership readiness/qualities: Curiosity, creativity and the ability to learn and to work both independently and effectively as part of a team. Gain life skills such as team work, leadership, patience as a result of group project participation.

4. Qualification descriptors

Upon successful completion of the programme, students receive a Master's degree in Zoology. M.Sc. Zoology graduates of this department acquire knowledge pertaining to various core and applied branches under Zoology along with the development of Practical skills in their specialisation. The postgraduates are expected to demonstrate the extensive knowledge of various concepts in Zoology and their applications. The postgraduates are thus able to contribute to research and development, Academia, Government and public sectors. This programme will establish a solid foundation for the student to pursue further studies in Zoology such as Doctoral work or field based research in the subject.

The list below provides a synoptic overview of possible career paths provided by an postgraduate training in Zoology:

1. Academics
2. Research
3. Eco tourism
4. Pharmaceutical Industry
5. Life science-based Industries
6. Food quality monitoring and packaging technology
7. Environmental monitoring and Analysis
8. Wildlife Photography
9. Wildlife Journalism
10. Animal Behaviour Psychology
11. Medical Laboratory Technology
12. Clinical Research Institutes
13. Entrepreneurship (Apiculture, Aquaculture, etc.)

14. Government service [IFS}

Job Roles for M.Sc. Zoology postgraduate:

After graduation one can seek a professional career as:

1. Academicians
2. Researchers
3. Forest Officer /Ranger
4. Eco tourism facilitators
5. Medical Representatives
6. Technicians in Industries/Laboratories
7. Officers/ Managers in Environmental monitoring, Quality Control and Packaging Technology
8. Wildlife Photographers
9. Wildlife Journalists
10. Animal Behaviour Psychologists
11. Entrepreneurs
12. Clinical Researchers
13. Data Analysts

Higher Education options for M.Sc. Zoology postgraduate:

1. PhD in their respective specializations
2. Clinical Research
3. Medical coding

The learners who complete two years of full-time study of the postgraduate programme of study will be awarded a Master's degree in zoology.

5. Programme Specific Outcomes (PSOs)

After the successful completion of modules in different courses of M.Sc. Zoology, the learner will be able to:

PSO I. Elucidate on basic concepts of taxonomy, physiology, ecology, applied Zoology, developmental biology, genetics, Evolutionary biology, Biotechnology and instrumentation.

PSO II. Demonstrate various practical performance skills.

PSO III. Describe modern concepts of Oceanography, microbial Oceanography, Oceanographic instruments,mineral resources found in the sea.

PSO IV. Explain concepts of General, Physical, Chemical and Biological Oceanography, marine biodeterioration, Planktonology, Fisheries Science, Fish Immunology

PSO V. Develop technical skills in oceanography, marine biotechnology, biostatistics, Advanced in vitro techniques in marine cultures

PSO VI. Analyse anthropogenic effect on marine environment

PSO VII. Demonstrate research aptitude and ability to draft a research proposal for Dissertation

PSO VIII. Develop skills for scientific writing, effective presentation and communication .

5.1 Course Mapping

Semester	PSO / Course		I	II	III	IV	V	VI	VII	VIII
I	MJ I		√	√						
	MJ II		√	√						
	MJ III		√	√						
	MJ IV		√	√						
	Any One	DSEI DSEII DSE III		√	√	√	√			
	RM			-					√	√
II	MJ I		√	√						
	MJ II		√	√						
	MJ III		√	√						
	MJ IV		√	√						
	Any One	DSE I DSE II DSE III		√	√	√	√			
	OJT			√					√	√
III	MJ I		√	√	√	√	√			
	MJ II		√	√	√	√	√			
	MJ III		√	√	√	√	√			
	MJ IV		√	√	√	√	√			
	Any Two	DSE I	√	√			√		√	
		DSE II	√	√			√		√	
		DSE III								

IV	MJ I	√	√	√	√	√			
	MJ II	√	√	√	√	√			
	MJ III	√	√	√	√	√			
	MJ IV	√	√	√	√	√			
	RIA		√	√	√	√		√	√

6. Structure of M.Sc. Zoology programme

The programme consists of two years (two semesters per year). The syllabus is drafted such that all significant theoretical subjects are covered in the initial three semesters with an emphasis on on-the-job training and research project/ internship/ apprenticeship work in industry or certified laboratories.

Sem	Major	DSE	RM/OJT/ RIA	Total
1	14	4	RM 4	22
2	14	4	OJT 4	22
3	16	6	-	22
4	8	-	RIA 14	22

RM : Research Methodology Course

RIA: Research Project/ Internship/Apprenticeship

OJT: On Job Training.

• In semester I, the learner will have four major core courses on General zoology, one discipline specific elective and one common minor course on Research Methodology .

• In Semester II, the learner will have four major core courses on Advanced zoology, one discipline specific elective and will have to engage in an on-the-job training for 21 days.

• In Semester III the subject specialisation begins, the learner has four courses in Oceanography and two discipline specific elective courses

• In Semester IV the learner has four courses in Oceanography, and will have to complete one long Research Project and submit a dissertation at the end of the semester.

• Dissertation should be appreciable, original and of good quality. Assessment of dissertation will be based on an open viva for defense.

1. **Major Core Courses (MJ):**

a) A course which is required to be opted by a candidate as a major core course. The course designed under this category aims to cover the basics that a student is expected to imbibe in that particular subject or discipline.

b) There are sixteen Major Core courses (MJ), four each, in semesters I II, III and IV

c) Each Major Core Courses is compulsory.

d) Each Major Core Course consists of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1.5 credit per practical of two hours per week per course in every semester.

e) The purpose of fixing major core papers is to ensure that the institution follows a minimum common curriculum so as to adhere to common minimum standards with other universities/institutions.

2. **Discipline Specific Elective (DSE) :**

a) A course is chosen by the candidate from the same stream as an elective out of the three courses offered. Elective course helps the student to gain a broader understanding of the specialization in the major discipline.

b) There is one DSE course each in semester I, II and two in semester III. The credits assigned are 2 credits for theory ie. 30 hours; 2 lectures of 1 hr each per week and 2 credits for practical of four hours per week in semester 1 and 2. In semester 3, there are 2 credits for theory per course and 1 credit each for the practical.

3. **Research Methodology (RM)**

a) This is a mandatory Minor that all post graduate students of Science have to take.

b) Students are required to achieve understanding of the various nuances of research, how to formulate a research problem, plan the work and execute it effectively. Scientific writing and other skills relevant to research are taught here.

c) This course carries 4 credits (60 - hours in class teaching)

4. **On Job Training (OJT)**

a) On Job training or Internships are introduced as per the guidelines of the National Education Policy (NEP) 2020, which emphasizes the importance of research and internships in postgraduate education. The internships will be mandatory for students in three-year and four-year degree programs, with a duration of 60 to 120 hours.

b) This seeks to equip students with the ability to gain relevant soft skills such as teamwork, problem-solving, work ethics, adaptability, communication, and time management.
c) This training carries 4 credits. 1 credit corresponds to 30 hours of engagement in a semester.

5. Internship (INT):

a) One of the fundamental principles guiding the development of our education system as per NEP 2020 is the fostering of 'outstanding research as a corequisite for outstanding education and development'. with this perspective Research project / Dissertation is a mandatory component of the masters program
b) Here the learner is assigned a research problem related to their field of specialization either within the department or at a premier institute of the country. The learner has to complete their research and present their dissertation at the end of the period.
c) Internship is introduced in semester IV of M.Sc course, having 14 credits. 1 credit of internship corresponds to 30 hours of engagement in a semester.

6.1 Course Content

Sr. No	Semester	Course number	Course Code	Course title
1	I	MJ I	23PSIZOMJIPIV	Phylogeny of Invertebrates and Vertebrates
2		MJ II	23PSIZOMJ2BMM	Biomolecules and Metabolism
3		MJ III	23PSIZOMJ3EDB	Evolution and Developmental Biology
4		MJ IV	23PSIZOMJ4INT	Instrumentation
5		MJ P	23PSIZOMJPI 23PSIZOMJP2	Practicals based on each Major Course- [MJI+MJ2=PI, MJ3+MJ4=P2]
6		DSE1	23PSIZODSE1PCO	Physical and Chemical Oceanography
7		DSE2	23PSIZODSE2ENT	Insect Classification and Diversity
8		DSE3	23PSIZODSE3ATS	Animal type Study
9		DSEP	23PSIZODSEPCOP 23PSIZODSEENTP 23PSIZODSEATSP	Practical based on the DSE course
10		RM	24PSIZORM	Research Methodology

11	II	MJ I	23PS2ZOMJIIBT	Industrial Biotechnology
12		MJ II	23PS2ZOMJ2ABE	Animal behaviour and Behavioral Ecology
13		MJ III	23PS2ZOMJ3HUD	Human diseases
14		MJ IV	23PS2ZOMJ4BHT	Biostatistics- basic concepts and hypothesis testing
15		MJ P	23PS2ZOMJP1 23PS2ZOMJP2	Practicals based on each major course
16		DSE I	23PS2ZODSE1BOM	Biological Oceanography and Marine microbiology
17		DSE 2	23PS2ZODSE2TIC	Entomology- type animal and Insect Control
18		DSE 3	23PS2ZODSE3MOB	Model organisms in Biological research
19		DSE P	23PS2ZODSEBOMP 23PS2ZODSETICP 23PS2ZODSEMOBP	Practicals based on each DSE course
20		OJT	23PS2ZOOJT	On Job Training
21	III	MJ I	24PS3ZOMJITE1	Ocean Topography, Ocean Expeditions, and Instruments

22		MJ II	24PS3ZOMJIIORB	Ocean Resources and Marine Biogeochemical Processes
23		MJ III	24PS3ZOMJIIIFPF	Fish Physiology and Fishery Science
24		MJ IV	24PS3ZOMJIVABT	Aquaculture and Biotechnology
25		MJ P	24PS3ZOMJP1 24PS3ZOMJP2 24PS3ZOMJP3 24PS3ZOMJP4	Practicals based on each major course
26		DSE 1	24PS3ZODSE1AMB	Animal and Medical Biotechnology
27		DSE 2	24PS3ZODSE3GMG	Genome Management and Advanced Genetics
28		DSE 3	24PS3ZODSE2IMA	Immunology of Malignancy and Transplant Biology and Animal Tissue culture
29		DSE P	24PS3ZODSEAMBP 24PS3ZODSEGMGP 24PS3ZODSEIMAP	Practicals based on any two DSE courses
30	IV	MJ I	24PS4ZOMJIDSP	Deep sea and polar ecology
31		MJ II	24PS4ZOMJIILPM	Life processes of Marine microorganisms and Seafood Microbiology
32		MJ III	24PS4ZOMJIIIMRB	Marine Biodiversity

33		MJ IV	24PS4ZOMJIVMMP	Marine Meteorology and Marine Pollution
36		RP/INT/A	24PS4ZORIA	ResearchProject/Internship/ Apprenticeship

6.2 Credit distribution for M.Sc. Zoology

Semester	Course number	Course title	Credits		
			Theory	Practical	Total
I	MJ I	Phylogeny of Invertebrates and Vertebrates	2	1.5	3.5
	MJ II	Biomolecules and Metabolism	2	1.5	3.5
	MJ III	Evolution and Developmental Biology	2	1.5	3.5
	MJ IV	Instrumentation	2	1.5	3.5
	DSE	Student will choose any one DSE	2	2	4
	RM	Research Methodology	4	-	4
	Total				**22**
II	MJ I	Industrial Biotechnology	2	1.5	3.5

	MJ II	Animal behaviour and Behavioral Ecology	2	1.5	3.5
	MJ III	Human diseases	2	1.5	3.5
	MJ IV	Biostatistics- basic concepts and hypothesis testing	2	1.5	3.5
	DSE	Student will choose one DSE	2	2	4
	OJT	On Job Training	4	-	4
	Total				**22**
III	MJ I	Ocean Topography, Ocean Expeditions, and Instruments	2	2	4
	MJ II	Ocean Resources and Marine Biogeochemical Processes	2	2	4
	MJ III	Fish Physiology and Fishery Science	2	2	4
	MJ IV	Aquaculture and Biotechnology	2	2	4
	DSEI	Student will choose one DSE	2	1	3
	DSEII	Student will choose one DSE	2	1	3
	Total				**22**

IV	MJ I	Deep sea and polar ecology	2	-	2
	MJ II	Life processes of Marine microorganisms and Seafood Microbiology	2	-	2
	MJ III	Marine Biodiversity	2	-	2
	MJ IV	Marine Meteorology and Marine Pollution	2	-	2
	RIA	Research Project/ Internship/ Apprenticeship	14	-	14
	Total				**22**

6.3 Semester Schedule

Semester	Major Core Courses (MJ)	DSE [Any one per semester]	RM/OJT	CC
I	Phylogeny of Invertebrates and Vertebrates	Physical and Chemical Oceanography	RM	-
		Insect Classification and Diversity		
	Biomolecules and Metabolism	Animal type Study		
	Evolution and Developmental Biology			
	Instrumentation			
II	Industrial Biotechnology	Biological Oceanography and Marine microbiology	OJT	-
	Animal behaviour and Behavioral Ecology	Entomology- type animal and Insect Control		

	Human diseases	Model organisms in Biological research		
	Biostatistics- basic concepts and hypothesis testing			
III	Ocean Topography, Ocean Expeditions, and Instruments	Animal and Medical Biotechnology	-	
	Ocean Resources and Marine Biogeochemical Processes	Genome Management and Advanced Genetics		
	Fish Physiology and Fishery Science	Immunology of Malignancy and Transplant Biology and Animal Tissue culture		
	Aquaculture and Biotechnology			
IV	Deep sea and polar ecology	-	-	RIA
	Life processes of Marine microorganisms and Seafood Microbiology			
	Marine Biodiversity			
	Marine Meteorology and Marine Pollution			

6.4 Course Learning Objectives

The two year postgraduate Zoology programme is designed to familiarize students with in-depth knowledge of Zoology. The objective of structured syllabus in Zoology is to make the concepts and basics of Zoology clear and interesting to students and also to ensure the development of vertical growth in the subject. The idea behind this is to enable students to develop analytical skills and critical thinking.

It is our attempt that students achieve this objective through systematic reading and class lectures and through feedback on their written work-assignments, project/research papers, presentations, discussions, debates, etc. our intention is to enable students to formulate cogent arguments, presenting the necessary evidence to establish these, based on a training in Zoology.

7. Detailed M.Sc. Zoology Syllabus

M.Sc. Syllabus with effect from the Academic year 2023–2024

Syllabus - M.Sc I Zoology

Course No.	Course Title	Course Code	Credits	Periods (1 Hr)	Module	Lectures per module (1 hr)	Examination		
							Internal Marks	External Marks	Total Marks
SEMESTER I									
Core courses THEORY									
I	Phylogeny of Invertebrates and Vertebrates	23PSIZOMJ1PIV	2	30	2	15	20	30	50
II	Biomolecules and Metabolism	23PSIZOMJ2BMM	2	30	2	15	20	30	50
III	Evolution and Developmental Biology	23PSIZOMJ3EDB	2	30	2	15	20	30	50
IV	Instrumentation	23PSIZOMJ4INT	2	30	2	15	20	30	50
Core courses PRACTICAL									
		23PSIZOMJP1 23PSIZOMJP2	6	60			CIE		50

Discipline Specific Elective DSE [Any one]									
DSE1	Physical and Chemical Oceanography	23PSIZODSE1PCO	2	30	2	15	20	30	50
DSE2	Insect Classification and Diversity	23PSIZODSE2ENT	2	30	2	15	20	30	50
DSE3	Animal type Study	23PSIZODSE3ATS	2	30	2	15	20	30	50
DSE Practical									
	Practical based on chosen DSE course	23PSIZODSEPCOP 23PSIZODSEENTP 23PSIZODSEATSP	2	30			CIE		50
Research Methodology									
RM	Fundamentals of Research and Good Laboratory Practices Research Publication and Ethics	24PSIZORM	4	60			CIE		100
SEMESTER II									
Core courses THEORY									
I	Industrial Biotechnology	23PS2ZOMJIIBT	2	30	2	15	20	30	50

II	Animal behaviour and Behavioral Ecology	23PS2ZOMJ2ABE	2	30	2	15	20	30	50
III	Human diseases	23PS2ZOMJ3HUD	2	30	2	15	20	30	50
IV	Biostatistics- basic concepts and hypothesis testing	23PS2ZOMJ4BHT	2	30	2	15	20	30	50
Core courses PRACTICAL									
		23PS2ZOMJP1 23PS2ZOMJP2	6	60			CIE		50
Discipline Specific Elective DSE [Any one]									
DSE1	Biological Oceanography and Marine microbiology	23PS2ZODSE1BOM	2	30	2	15	20	30	50
DSE2	Entomology- type animal and Insect Control	23PS2ZODSE2TIC	2	30	2	15	20	30	50
DSE3	Model organisms in Biological research	23PS2ZODSE3MOB	2	30	2	15	20	30	50
DSE Practical [any one]									
	Practical based on chosen DSE course	23PS2ZODSEBOMP 23PS2ZODSETICP 23PS2ZODSEMOBP	2	30			CIE		50

On Job Training									
OJT		23PS2ZOOJT							

MSc ZOOLOGY SEMESTER I
Core Course- I
COURSE TITLE: Phylogeny of Invertebrates and Vertebrates
COURSE CODE: 23PS1ZOMJ1PIV
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Enlist the salient features of non-chordates 2. Classify and describe non-chordates upto Class level 3. Explain phylogeny and systematics of various Chordates 4. Describe unique characteristics and affinities of Protochordates and Vertebrates. 5. Classify Protochordates and Vertebrates upto order level.		
Module I	**Non-chordate Phylogeny**	**[15L]**
Learning objectives The module is intended to - • Introduce learner to detailed classification of non chordates • Discuss salient features of various phyla with examples.		
Learning outcomes After the successful completion of the module, the learner will be able to -		

- Classify major phyla of non-chordates upto Class level
- Assign Phylum/Class based on the characteristics of an animal

Subtopic	Title	15L
1.1	Phylogeny, salient features, classification up to Class level (wherever applicable) of the following phyla 1.1.1 Protista (Protozoa) 1.1.2. Porifera 1.1.3 Coelenterata 1.1.4 Ctenophora 1.1.5 Mollusca 1.1.6 Bryozoa 1.1.7 Brachiopoda 1.1.8 Echinodermata 1.1.9 Chaetognatha 1.1.10 Platyhelminthes and Nemathelminthes 1.1.11 Acanthocephala 1.1.12 Annelida 1.1.13 Sipunculoidea 1.1.14 Arthropoda 1.1.15 Onychophora – Peripatus: A connecting link between Annelida and Arthropoda	1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L 1L

- Invertebrate Zoology by P S Verma (Author), E L Jordon : S Chand; Fifteenth edition
- Biology Of Non-Chordates by Fatik Mandal, PHI Learning; 2nd edition

Module II	Hemichordate, Protochordate and Chordate Phylogeny	[15L]

Learning objectives

The module is intended to -

- Describe Phylogeny, salient features, classification up to Class of Hemichordate and Protochordate
- Explain Vertebrate ancestry and origin of Vertebrates.
- Describe salient features and phylogeny of Ostracoderms and affinities of Cyclostomes
- Describe features of early tetrapods and lungfishes
- Describe affinities of Aves
- Identify affinities of Aves with other organisms
- Explain different types of flight in organisms
- Describe evolution and various features of Mammals

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Discuss phylogeny, salient features, Classification up to Class of hemichordate and Protochordate
- Elaborate on Vertebrate ancestry and origin of Vertebrates
- Discuss on salient features and phylogeny of Ostracoderms and affinities of Cyclostomes
- Recognize the features of chordates on field
- Relate organisms based on phylogeny
- Analyze and compare different types of flights in animals
- Analyze and compare different types of walking gaits in animals

Subtopic	Title	15L

2.1	Phylogeny, salient features, classification up to Class level (wherever applicable) of the following phyla 2.1.1 Hemichordata and its affinities 2.1.2 Urochordata and its affinities 2.1.3 Cephalochordata and its affinities. 2.1.4 Vertebrate ancestry and origin of Vertebrates. Salient features and phylogeny of Ostracoderms.	1L 1L 1L 2L
2.2	2.2..1 Affinities of Cyclostomes 2.2.2 Primitive tetrapods and Crossopterygians 2.2.3 Dipnoi - lungfishes who failed to evolve as Amphibians 2.2.4 Warm blooded reptile - Archaeopteryx 2.2.5 Affinities of Aves 2.2.6 Origin of flight 2.2.7 Egg laying Mammals - connecting link between mammals and reptiles 2.2.8 Evolution of Mammals 2.2.9 Walking gait in animals	1L 1L 1L 1L 1L 1L 1L 1L 1L

- P.S. Dhami & J.K. Dhami, 1981. Chordate zoology. (R. Chand & Co.).

- R.L.Kotpal, 2000. Modern textbook of zoology, Vertebrates. (Rastogi Publ., Meerut).
- E.L. Jordan & P.S. Verma, 1998. Chordate zoology. (S. Chand & Co.)

Question paper Template
M. Sc. (Zoology) SEMESTER I
Major Core Course- I

COURSE TITLE: Phylogeny of Invertebrates and Vertebrates
COURSE CODE: 23PSIZOMJIPIV
[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	-	5	5	5	-	-	25
II	5	5	5	-	-	-	25
Total marks per question	5	10	10	5	-	-	50
% Weightage	16.6	33.3	33.3	16.6	-	-	100

MSc Zoology Semester I
Core Course- II
COURSE TITLE: Biomolecules and Metabolism
COURSE CODE: 23PSIZOMJ2BMM
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Discuss the properties and classification of carbohydrates, proteins, nucleic acids and lipids 2. Summarize synthesis, conversion and degradation of carbohydrates, proteins lipids and nucleic acids. 3. Sketch and explain the various metabolic pathways of proteins and nucleic acids 4. Recall the integration of major metabolic pathways		
Module I	**Carbohydrates and Lipids**	**[15L]**
Learning objectives The module is intended to - • Introduce the properties of biomolecules (carbohydrates and lipids) along with their biological functions. • Categorise various biomolecules and explain their roles in metabolism. • Explain the regulation of major metabolic pathways.		
Learning outcomes After the successful completion of the module, the learner will be able to - • Describe properties and functions of biomolecules (carbohydrates and lipids) • Discuss the synthesis and role of major biomolecules.		

• Recall the reaction sequences of various metabolic pathways. • Explain the significance of major metabolic pathways.		
Module 1		**15L**
1.1	Carbohydrates 1.1.1 Classification: mono-, oligo- and poly-saccharides. 1.1.2 Monosaccharides 1.1.3 Oligosaccharides 1.1.4 Polysaccharides- homo- and hetero-polysaccharides. 1.1.5 Biological functions of carbohydrates.	3L
1.2	Carbohydrate Metabolism 1.2.1 Glycolysis Reaction sequence, flow of carbon, Conversion of pyruvate to lactate and Acetyl coenzyme-A, significance of pyruvate lactate interconversion, aerobic and anaerobic glycolysis and energetic of glycolysis. Regulation of glycolysis 1.2.2 Gluconeogenesis: Reaction sequence from pyruvate, gluconeogenesis from amino acids, glycerol, propionate, lactate. Regulation of gluconeogenesis 1.2.3 Glycogen metabolism: Glycogenesis, Glycogenolysis. Regulation of the two pathways. 1.2.4 Significance of following pathways: Hexose monophosphate shunt as a multifunctional pathway; Uronic Acid Pathway; Glyoxylate cycle.	2L 1L 1L 1L
1.3	Lipids 1.3.1 Classification: simple and complex lipids 1.3.2 Fatty acids 1.3.3 Acylglycerols 1.3.4 Complex lipids 1.3.5 Glycolipids 1.3.6 Biological functions of lipids.	3 L
1.4	Lipid Metabolism 1.4.1 Dynamics of body lipids, mobilisation of fats, regulation of hormone sensitive TG lipase, fate of glycerol and free fatty acids.	2L

	1.4.2 Fatty acid metabolism: Oxidation of even-carbon and odd-carbon atom fatty acid, oxidation of unsaturated fatty acids,biosynthesis of fatty acids including desaturation, metabolism of phospholipids, cholesterol and alcohol.	2L

References

- Biochemistry by U.Satyanarayana and U.Chakrapani published by Elsevier and co-published with Books and Allied, Fourth Edition, 2013.
- APA. Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.)

Module II	Proteins and Nucleic acids	15L

Learning objectives

The module is intended to -

- Introduce the properties of biomolecules (proteins and nucleic acids) along with their biological functions.
- Interpret the regulation of various metabolic pathways.
- Explain the process of energy demand and supply through metabolism.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Explain the functions and classification of proteins and nucleic acids
- Understand the process of synthesis, conversion and degradation of these biomolecules.
- Discuss the roles of various types of complex biomolecules.
- Sketch various metabolic cycles.
- Summarise the process of metabolism by integrating major metabolic pathways.

Module II	Title	15L

2.1	Proteins 2.1.1 Amino acids: structure and classification 2.1.2 Organization of protein structure: Primary structure and peptide bond, secondary, tertiary and quaternary structure; conjugate proteins haemoglobin, cytochromes, myoglobin; bonds involved in protein organization. 2.1.3 Properties of proteins: classification, denaturation and protein folding. 2.1.4 Biological functions of proteins. Biologically important peptides: glutathione, octa-, nona and deca-peptides. Glycoproteins, Lipoproteins	 1L 1L 1L 1L
2.2	Protein Metabolism 2.2.1 Metabolism of amino acids: Amino acid pool, transamination; oxidative and nonoxidative deamination; metabolism of branched chain amino acids; fate of carbon skeleton of amino acids. 2.2.2 Metabolism of ammonia: Urea cycle	 2L 2L
2.3	Nucleic acids 2.3.1 Types, Components, Structure of DNA 2.3.2 Structure, types and functions of RNA	 2L 1L
2.4	Metabolism of Nucleic acids 2.4.1 Synthesis of ribonucleotides- a brief idea of de novo pathway and salvation pathway 2.4.2 Conversion of ribonucleotides to deoxyribonucleotides 2.4.3 Degradation of nucleotides 2.4.4 Integration of Metabolism, Energy demand and supply: Integration of major metabolic pathways of energy metabolism, intermediary metabolism; organ specialisation and metabolic integration. Metabolism in starvation	 1L 1L 1L 1L
References		

• Biochemistry by U.Satyanarayana and U.Chakrapani published by Elsevier and co-published with Books and Allied, Fourth Edition, 2013.
• APA. Nelson, D. L., & Cox, M. M. (2017). Lehninger principles of biochemistry (7th ed.)

Question paper Template
M. Sc. (Zoology) SEMESTER I
Major Core Course- II

COURSE TITLE: Biomolecules and Metabolism
COURSE CODE: 23PSIZOMJ2BMM
[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	-	-	-	25
II	5	5	5	-	-	-	25
Total marks per question	10	10	10	-	-	-	50
% Weightage	33.3	33.3	33.3	-	-	-	100

MSc Zoology Semester I
Core Course- III
COURSE TITLE: Evolution and Developmental Biology
COURSE CODE 23PSIZOMJ3EDB
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Describe evolutionary stages, trends and causes of Horse, Elephant and Human evolution 2. Analyze molecular data for phylogenetic analysis. 3. Explain the concept in development biology 4. Describe the vulva formation in *C. elegans,* limb development in vertebrates, concepts of regeneration and distinguish between the types of regeneration, role of stem cells and metamorphosis in insects.

Module I	Evolution	15L

Learning objectives

The module is intended to -

- Understand theories of evolution and concepts related to evolution
- Understand concepts related to molecular evolution

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Describe process of evolution of Horse, Elephant and Human
- Define concepts in Molecular Phylogeny

Module I		15L

1.1	Extinct bird order - Archaeopterigyformes	1L
1.2	Evolution of Horse	2L
1.3	Evolution of Elephant	2L
1.4	Human Evolution, evolutionary adaptations in human lineages	2L
1.5	Human Migration	1L
1.6	Molecular Evolution 1.5.1 Patterns and modes of nucleotide substitutions 1.5.1.1 Nucleotide substitutions in DNA 1.5.1.2 Rate of substitution and variation in evolutionary rate between genes 1.5.1.3 Housekeeping genes and pseudogenes 1.5.1.4 Molecular clock 1.5.1.5 Single nucleotide polymorphism and Copy number variation 1.5.2 Molecular Phylogeny 1.5.2.1 Reading Phylogenetic tree and it's reconstruction methods 1.5.2.2 Horizontal gene transfer 1.5.2.3 Acquisition and origin of new functions 1.5.2.4 Multigene families 1.5.2.5 Gene duplication and conversion	4L 3L

References

CNVs

- https://www.nature.com/scitable/ebooks/genetic-variation-and-evolution-16553748/126455448/

Molecular clock

- https://www.nature.com/scitable/topicpage/the-molecular-clock-and-estimating-species-divergence-41971/
- http://www.nature.com/scitable/topicpage/origins-of-new-genes-and-pseudogenes-835

Origin of new genes and pseudogenes

- https://www.nature.com/scitable/topicpage/evolutionary-adaptation-in-the-human-lineage-12397/

- http://www.nature.com/scitable/topicpage/reading-a-phylogenetic-tree-the-meaning-of-41956
- http://www.nature.com/scitable/topicpage/reading-a-phylogenetic-tree-the-meaning-of-41956

Module II	Developmental Biology	15L

Learning objectives

The module is intended to -

- Explain the concepts of developmental biology.
- Discuss organogenesis
- Explain metamorphosis and the hormonal regulation involved.
- Explain the role of stem cells in development.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Discuss cell aggregation and cell differentiation
- Enlist the genes and their role in axis formation in drosophila and in organogenesis.
- Explain the concepts of organogenesis, metamorphosis, regeneration, aging and stem cells.

Subtopic	Title	15L
2.1	Basic concepts of Developmental Biology – cell fate, competence, commitment, trans differentiation and differentiation, dedifferentiation, cell specification	2L
2.2	Cell aggregation and differentiation in Dictyostelium	1L

2.3	Morphogenesis and cell adhesion- Differential cell affinity, cadherins and cell adhesion.	1L
2.4	2.4.1 Axis formation and pattern formation: *Drosophila* and *Xenopus*. 2.4.2 Sea Urchin fertilization and early development	3L
2.5	Organogenesis 2.5.1 Vulva formation in *Caenorhabditis elegans* 2.5.2 Limb development in tetrapods	2L
2.6	Metamorphosis (a) Amphibian metamorphosis (b) Hormonal control of insect metamorphosis (c) Programmed cell death	2L
2.7	Regeneration (a) Regeneration in Hydra (b) Regeneration of Salamander limbs	2L
2.8	Aging: Senescence, life span and causes of aging	1L
2.9	Stem cell and their role in development	1L

References

- DEVELOPMENTAL BIOLOGY, 11TH EDITION 2016 S. F. Gilbert, M. J. F. Barres
- Korzh, V. (2005). Boris Balinsky: transition from embryology to developmental biology. *BioEssays, 27*(9), 970-977

Question paper Template
M. Sc. (Zoology) SEMESTER I
Major Core Course- III

COURSE TITLE: Evolution and Developmental Biology
COURSE CODE 23PSIZOMJ3EDB
[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	-	-	-	25
II	5	5	5	-	-	-	25
Total marks per question	10	10	10	-	-	-	50
% Weightage	33.3	33.3	33.3	-	-	-	100

MSc Zoology Semester I
Core Course- IV
COURSE TITLE: Instrumentation
COURSE CODE 23PSIZOMJ4INT
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Understand various instruments and techniques 2. The working and principle of instruments 3. Know their application in industries		
Module I	**Microtomy, Microscopy, Radioactivity and Separation Techniques**	**15L**
Learning objectives The module is intended to - • Understand the principle, working and application of various instruments and techniques in different industries • Know the different types of Microscope and Microtome that are used in industries • The concept of Radioactivity and its principle and application		
Learning outcomes After the successful completion of the module, the learner will be able to - • Have clear concept of Microtomy, Microscopy and Techniques such as FIltration, Distillation and Extraction • Explain the detail working of Microtome and Microscope • Have The clear knowledge and understanding of Radioactivity, its detection and measurement in industries • Knowledge of applications in industries • Significance of the instruments		

Subtopic	Title	Lecture distribution
1.1	Microtomy 1.1.1 Basic Introduction to Microtomy: Principle and Working of Microtome 1.1.2 Types of Microtome 1.1.3 Procedure and Preparation involved in Microtomy 1.1.4 Applications of Microtomy	 1L 1L 1L 1L
1.2	Microscopy 1.2.1 Principle, working and applications of microscopy: a) Light Microscopy b) Phase contrast Microscopy c) Confocal Microscopy d) Fluorescence microscopy e) Polarised Microscopy f) Electron microscopy- TEM and SEM, Preparation of specimen for electron microscope 1.2.2 Concepts of digital microscopy and image analysis	 2L 2L
1.3	Radioactivity 1.3.1 The nature of radioactivity 1.3.2 Units of radioactivity 1.3.3 Detection and measurement of radioactivity - liquid scintillation counting 1.3.4 Basic principles of radioactive labeling.	 1L 1L 1L 1L
1.4	Separation Techniques 1.4.1 Principle and Applications of Vacuum Filtration 1.4.2 Principle and Applications of Steam and Fractional Distillation	 1L 1L

	1.4.3 Principle and Application of Solvent Extraction	1L

References

- Bioinstrumentation by L. Veerakumari
- Bioinstrumentation by M. H. Fulekar and Bhawana Pandey
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SMB2103.pdf

Module II	Chromatography, Electrophoresis and Spectroscopy	15L

Learning objectives

The module is intended to -

- Understand the concept of Chromatography, Electrophoresis and Spectroscopy
- Understand the principle and working of the instruments
- Applications in different industries
- Understanding the factors affecting different electrophoresis

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Have clear understanding about the principle of Chromatography, Electrophoresis and Spectroscopy
- The knowledge of different instruments application in the industries
- Know the clear working techniques of the instruments

Subtopic	Title	15L
2.1	Chromatography 2.1.1 Principle of separation, 2.1.2 Working and application: a) Planar Chromatography b) HPTLC c) Column Chromatography d) HPLC	 1L 4L

	e) Size-exclusion Chromatography f) Gradient elution g) Gas Chromatography	
2.2	Electrophoretic Techniques 2.2.1 General principles, applications and factors affecting electrophoresis of a) Native-PAGE; b) Isoelectric focusing (IEF) - pH gradient gels, c) Two Dimensional Gel Electrophoresis (2-DE) d) Pulse field electrophoresis	 1L 1L 1L 1L
2.3	Spectroscopy Principle and applications of Spectroscopy: a) Ultraviolet and visible absorption spectroscopy b) Fluorescence spectroscopy c) FTIR d) Mass spectroscopy e) Atomic absorption spectrophotometer. f) NMRS	 1L 1L 1L 1L 1L 1L

Reference

- Bioinstrumentation by L. Veerakumari
- Bioinstrumentation by M. H. Fulekar and Bhawana Pandey
- https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SMB2103.pdf

Question paper Template
M. Sc. (Zoology) SEMESTER I
Major Core Course- IV

COURSE TITLE: Instrumentation
COURSE CODE 23PSIZOMJ4INT
[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	-	-	-	25
II	5	5	5	-	-	-	25
Total marks per question	10	10	10	-	-	-	50
% Weightage	33.3	33.3	33.3	-	-	-	100

MSc Zoology Semester I

Practical

23PSIZOMJP1

Core course I	Comparative Vertebrate Anatomy

Learning Objectives

This practical is intended to

- Explain the structure of vertebrate axial and appendicular skeleton and its significance

Learning Outcomes

After completion of this practical, learner will be able to

- Compare the structure of axial and appendicular skeleton in different vertebrate groups
- State significance of parts of vertebrate axial and appendicular skeleton

1 Comparative study of vertebrate axial skeleton - vertebrae of
Cartilaginous fish
Bony fish
Amphibia
Reptile
Aves
Mammals

2 Comparative study of vertebrate axial skeleton - Skull of
Cartilaginous fish
Bony fish
Amphibia
Reptile
Aves
Mammals

3	Comparative study of vertebrate appendicular skeleton - forelimbs and hindlimbs of Cartilaginous fish, bony fish, Amphibia, Reptile, Aves and Mammal
4	Morphometric studies of appendicular skeletons to identify the species.

Suggested Project:

1. Alizarin stained skeletal preparations of fish
2. Preparation of skeletal whole mount for museum display

Core course II	Biomolecules and Metabolism	
Learning Objectives This practical is intended to • Make the learner understand biochemical assay techniques and their analysis • Explain the applications of large scale culture and their commercial products		
Learning Outcomes After the successful completion of the practical, the learner will be able to • Extract various biomolecules from tissues • Analyse the extracted molecules by colorimetry and electrophoresis • Calculate the amount of biomolecules extracted using formulae or graphs		
1.	Isolation of β -Amylase from Sweet Potato	https://vlab.amrita.edu/?sub=3&brch=64&sim=730&cnt=1
2.	Gelatin Zymography [PAGE]	https://vlab.amrita.edu/?sub=3&brch=64&sim=700&cnt=1

3.	Construction of Maltose standard curve by DNSA method	https://vlab.amrita.edu/?sub=3&brch=64&sim=163&cnt=1
4.	Construction of protein standard curve using Folin's Lowry method	https://vlab.amrita.edu/?sub=3&brch=64&sim=1087&cnt=1
5.	Extraction of Caffeine from tea/coffee	https://vlab.amrita.edu/?sub=3&brch=64&sim=169&cnt=1
6.	Effect of substrate concentration on Enzyme Kinetics	https://vlab.amrita.edu/?sub=3&brch=64&sim=1090&cnt=1
7.	Effect of temperature on Enzyme Kinetics	https://vlab.amrita.edu/?sub=3&brch=64&sim=1342&cnt=1
8.	Extraction and analysis of liver lipids- Soxhelt extraction	https://www.protocols.io/view/extraction-and-analysis-of-liver-lipids-n92ld7ool5br/v1 http://cyberlipid.gerli.com/soxhlet-type-extraction/

MSc Zoology Semester I
Practical
23PSIZOMJP2

Core course III	Evolution and Developmental Biology
Learning objectives This Practical is intended to • Develop basic laboratory skills of the student • Make the student understand basic concepts in evolution and developmental biology • Explain to the learner the practical applications of learning developmental biology	
Learning Outcomes After the successful completion of the Practical, the learner will be able to • Perform several developmental biology related techniques • Use basic lab apparatus and equipments • Apply formula and find values of unknown samples	
1	Introduction to Phylogenetics: Definition and significance of phylogenetics, Historical background and key contributors
2	Tree-Building Methods: Distance-based methods: Neighbor Joining, UPGMA, Character-based methods: Maximum Parsimony, Maximum Likelihood, Bayesian Inference
3	Construction of phylogenetic trees from molecular and morphological data using phylogenetic software (e.g., Chromas Lite, Mega (Molecular Evolutionary Genetics Analysis), BEAST]
4	Interpretation of Phylogenetic Trees [Branch lengths, nodes, and root placement, Monophyletic, paraphyletic, and polyphyletic groups

	Molecular dating and divergence times,Ancestral character reconstruction]
5	Effect of teratogens on animal development
6	Study of regeneration in Hydra
7	Frog developmental stages – egg, 4 and 8 celled stage, blastula, gastrula and tadpole larva.
8	Developmental changes in Chick Embryo
9	Developmental changes in frog
10	Ontogeny recapitulates phylogeny

Core course IV	Instrumentation

Learning Objectives:

This Practical is intended to

- Introduce the learner to several instrumentation techniques such as microtomy and chromatography.
- Demonstrate the process of microtomy by explaining various steps involved in the processing of histological sections such as fixation, embedding, sectioning, staining and preserving the tissues.
- Develop the skills in learners to isolate and separate various biomolecules by using chromatography.

Learning Outcomes:

After the successful completion of the Practical, the learner will be able to

- Identify and recognise various histological sections under microscope. ,
- Make permanent slides of histological sections by performing microtomy for histological studies.
- Separate and extract various plant pigments by performing adsorption chromatography.

• Perform the separation techniques like Ion Exchange Chromatography and 2-D Chromatography in order to isolate and extract various amino acids.	
1	Microtomy: i) Fixation of tissue ii) Dehydration iii) Embedding, block preparation and trimming iv) Sectioning and slide preparation v) Staining and mounting
2	Separation of pigments from leaves or flowers by adsorption column chromatography
3	Separation of amino acids by ion exchange chromatography using cation exchanger
4	Identification of amino acids by 2D chromatography
5	Microscopy- Principle and Working
6	Study of Gel Electrophoresis
7	Visit to Instrumentation lab

Suggested projects:

1. Electrophoretic analysis of DNA from different sources
2. PAGE of various serum
3. Chromatography of pigment from different sources

MSc ZOOLOGY SEMESTER I
DSE- I
COURSE TITLE: Physical and Chemical Oceanography
COURSE CODE 23PSIZODSEIPCO
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Compare between the organisms, their characters and requirements 2. Discuss the physical factors that affects marine life 3. Elucidate the role of marine bacteria 4. Enlist various marine microorganisms. 5. Compare and contrast between the various groups of microbes found in mangroves and coral reefs. 6. Describe the ecology of coastal water, shallow water and deep-sea microorganisms 7. Discuss the process of breakdown of various xenobiotics by microbes 8. Describe methods for controlling water pollution

Module I	Physical Oceanography	15L

Learning objectives

The module is intended to

- Explain the marine environment and its components to the learner
- Elucidate on effect of various physical parameter of seawater on marine animals
- Discuss on marine biotic diversity, intertidal organisms and their zonations and role of marine bacteria in marine environment

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Define various component of marine environment
- Classify between marine biotic diversity
- Explain species richness and diversity gradient models
- Measure species diversity and richness using quadrant method
- Enlist the effect of various physical parameter of seawater on marine animals

Subtopic	Title	Lecture distribution
1.1	Oceanographic circulation: Ekman spiral, geotropic current, westward intensification with dynamic topography.	3L
1.2	Vertical circulation: wind induced circulation, Thermohaline circulation and upwelling of water.	3L
1.3	Waves: Characteristics of waves, deep water and shallow water waves, transitional waves, wind generated waves, internal waves and Tsunami	3L
1.4	Tides: Tides generating forces, equilibrium theory of tides, dynamic theory of tides	3L
1.5	Currents: Types of currents, major currents of the world, Coriolis effect and El Nino effect, Eddy currents	3L

References:

- The Oceans: Their Physics, Chemistry, and General Biology by H. U. Sverdrup, Martin W. Johnson, Richard H. Fleming; Prentice-Hall of India Pvt.Ltd
- Essentials of oceanography by P. Trujillo Alan, Harold V. Thurman; Prentice-Hall of India Pvt.Ltd
- Oceanography: An Invitation to Marine Science by Tom Garrison; Brooks/Cole; 9th edition
- A Textbook of Marine Ecology – Nair, N.B. & Thumpy, D.H., the Macmillan Book Company of India Ltd

- Element of marine ecology by R.V. Tait and F.A. Dipper
- Introduction to Physical Oceanography by Robert H. Stewart

Module II	Chemical Oceanography	15L

Learning objectives

The module is intended to -

- Explain the chemical properties of seawater
- Elucidate on various gaseous and nutrient cycle of ocean

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Discuss on chemical properties of seawater
- Explain various gaseous and nutrient cycle of seawater

Subtopic	Title	Lecture distribution
2.1	Composition of sea water- constancy of its composition and factors affecting the composition, major and minor constituents, trace elements and their biological role.	5L
2.2	Dissolved gases in the sea water and their role in the environment, CO2 system, dissolved O2 and oxygen profile, hydrogen sulphide.	5L
2.3	Nutrients in the ocean, their cycles and factors influencing their distribution a) Nitrogen b) Phosphorus c) Silicon	5L

References:

● The Oceans: Their Physics, Chemistry, and General Biology by H. U. Sverdrup, Martin W. Johnson, Richard H. Fleming; Prentice-Hall of India Pvt.Ltd

• Essentials of oceanography by P. Trujillo Alan, Harold V. Thurman; Prentice-Hall of India Pvt.Ltd

Practical
23PSIZODSEP1

DSE I	Physical and Chemical Oceanography

Learning Objectives

This Practical is intended to

- Introduce the learner to several abiotic components of the ocean.
- Explain the significant role of nutrients in the ocean.
- Develop an understanding in the learner about the process of estimation of several physico-chemical parameters such as salinity, dissolved oxygen, carbon dioxide and nutrients.
- Teach the learner the skill to identify foraminiferans and radiolarians.
- Define and explain primary productivity.
- Demonstrate the experiment of sediment analysis to determine soil texture.
- Discuss various intertidal ecosystems.

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Enlist various physico-chemical parameters of the ocean.
- Quantify and measure various physico-chemical parameters of the ocean such as salinity, dissolved oxygen, carbon dioxide etc.
- Determine the presence of nutrients in ocean water.
- Estimate the primary productivity by light and dark bottle reaction
- Calculate the gross and net primary productivity.
- Identify various foraminiferans and radiolarians.
- Determine the soil texture and recognise various types of soil.
- Describe intertidal ecology and discuss types of shores.

• Identify and differentiate various intertidal organisms on the basis of their type of shore.	
1	Determination of salinity (Argentometric and conductivity method).
2	Determination of Dissolved oxygen.
3	Determination of Carbon dioxide.
4	Determination of Nitrates-nitrites.
5	Determination of Silicates.
6	Determination of Phosphate-phosphorus.
7	Estimation of Primary Productivity
8	Textural features: Sediment analysis- size fraction (sand, silt, clay)
9	Measuring Turbidity by using Secchi's Disc
10	Determining Salinity by using Salinometer
11	Study of Tide Time-table and Tide Charts
12	Study of various Maps/Satellite Images by India Meteorological Department

M Sc ZOOLOGY SEMESTER I
DSE- II
COURSE TITLE: Insect Classification and Diversity
COURSE CODE: 23PSIZODSE2ENT
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Describe insect orders with characteristics 2. Explain method of identification of insects using keys 3. Identify insect

Module I	Insect Classification, Metamorphosis and Ametabolous Insect Orders	15L

Learning objectives

The module is intended to -

- Explain insect classification
- Describe metamorphosis in insects and its regulation
- Describe parthenogenesis
- Describe moulting and its regulation
- Describe ametabolous insect orders

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Analyse insect characters
- Identify insect type
- Recollect life cycle and life stages in insect life

Subtopic	Title	Lecture distribution
1.1	Definition and introduction to taxonomy	1L
1.2	Dichotomous key for identification	1L
1.3	Insect classification – past and present	1L
1.4	Metamorphosis – definition and types	1L
1.5	Hormonal regulation of metamorphosis	1L
1.6	Life stages of insect – egg, larva, nymph, and pupae	2L
1.7	Parthenogenesis	2L
1.8	Moulting	1L
1.9	Hormonal regulation of Moulting	1L
1.10	Ametabolous Orders - Thysanura, Diplura, Protura, Collembola	4L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Text book of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General Text Book of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.

- Kerkut: G.A. & Gillbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Ms Graw Hill, New York

Module II	Hemimetabolous and Holometabolous Insect Orders	15L

Learning objectives

The module is intended to -

- Describe hemimetabolous
- Describe holometabolous insect order

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Analyse insect characters
- Identify insect type

Subtopic	Title	Lecture distribution
2.1	Hemimetabolous Insect Orders	
	2.1.1 Ephemeroptera, Odonata, Orthoptera, Phasmida, Dermaptera,	4L
	2.1.2 Hemiptera, Blattaria, Mantoidea, Isoptera, Siphunculata	4L

2.2	Holometabolous Insect Orders 2.2.1 Thysanoptera, Neuroptera, Strepsiptera, Siphunculata, 2.2.2 Diptera, Coleoptera, Lepidoptera, Hymenoptera	3L 4L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General Textbook of Entomology. Ed. IO. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.

Practical
23PSIZODSEP2

DSE II	Entomology
• Discuss Entomological Orders With Examples • Describe Development Of Insect Using Examples • Understand Parthenogenesis • Describe identification using key	
• Relate Insect To The Characteristics Of A Particular Order • Elaborate And Draw Examples Of Insect Orders • Use Dichotomous key to identify insects	
1	Use of dichotomous key for insect identification

2	Study of types of larvae
3	Study of types of pupae
4	Study of parthenogenesis
5	Study of ametabolous insect orders - examples
6	Study of hemimetabolous insect orders - examples
7	Study of holometabolous insect orders – examples
8	Field visit and report – insect identification on field

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Text book of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General Text Book of Entomology. Ed. IO. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.
- Kerkut: G.A. & Gillbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. I to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Ms Graw Hill, New York

M Sc ZOOLOGY SEMESTER I
DSE- III
COURSE TITLE: Animal Type study
COURSE CODE 23PSIZODSE3ATS
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Describe the morphology and organ systems of sepia 2. Elaborate the economic importance and conservation status of sepia 3. Describe the morphology and organ systems of shark 4. Elaborate the economic importance and conservation status of shark

Module I	Invertebrate Model Organism - Sepia	15L

Learning objectives

The module is intended to -

- Make the learner understand the morphology and anatomy of sepia
- Describe to the learner the importance of this animal in nature

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Classify sepia
- Describe all systems of sepia
- Draw neat and labelled diagrams of the same
- Elaborate on the economic importance and conservation status of sepia

Subtopic	Title	Lecture

		distribution
1.1	Morphology and systemic position	2L
1.2	Digestive system	2L
1.3	Circulatory System	2L
1.4	Nervous system	3L
1.5	Reproductive system - male and female	4L
1.6	Economic importance and conservation status	2L

References

- Invertebrate Zoology by P S Verma (Author), E L Jordon : S Chand; Fifteenth edition

Module II	Type Study of Vertebrate - Shark	[15L]

Learning objectives

The module is intended to -

- Make the learner understand the morphology and anatomy of shark
- Describe to the learner the importance of this animal in nature

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Classify shark
- Describe all systems of shark
- Draw neat and labeled diagrams of the same
- Elaborate on the economic importance and conservation status of shark

Subtopic	Title	Lectu

		re distribution
2.1	Morphology and systemic position	2L
2.2	Digestive system	2L
2.3	Circulatory System	2L
2.4	Nervous system	3L
2.5	Reproductive system - male and female	4L
2.6	Economic importance and conservation status	2L

References:

- P.S. Dhami & J.K. Dhami, 1981. Chordate zoology. (R. Chand & Co.).
- R.L.Kotpal, 2000. Modern textbook of zoology, Vertebrates. (Rastogi Publ., Meerut).
- E.L. Jordan & P.S. Verma, 1998. Chordate zoology. (S. Chand & Co.)

Practical
23PSIZODSEP3

DSE III	Type Study of Invertebrate and Vertebrate

Learning Objectives

This practical is intended to

- Make the learner understand the morphology and anatomy of sepia and Shark

Learning Outcomes

After the successful completion of the practical, the learner will be able to

- Describe the morphology and organ systems of sepia
- Describe the morphology and organ systems of shark

1. Study of Digestive system of Sepia
2. Study of Circulatory system of Sepia
3. Study of Nervous system of Sepia
4. Study of male Reproductive system of Sepia
5. Study of Female reproductive of Sepia
6. Morphometric study of any available (Lab bred) fish
7. Study of Digestive system of Shark
8. Study of Circulatory system of Shark
9. Study of Nervous system of Shark
10. Study of male Reproductive system of Shark
11. Study of Female reproductive of Shark

**Above practicals will be based on study of systems using diagrams and virtual resources. Dissection of animals will not be performed under this course.

ZOOLOGY SEMESTER VII (MSc Sem I)
COURSE TITLE: Research Methodology
COURSE CODE: 24PSIZORM
[CREDITS - 04]

Course structure

Module	Title	Lectures	Credits
1	Fundamentals of research and interpretation	15	1
2	Computers in research and Good Laboratory Practices	15	1
3	Research publication	15	1
4	Research Ethics	15	1

Course learning outcomes
After the successful completion of the Course, the learner will be able to 1. Identify, design and present effective research projects. 2. Apply computers to research 3. Categorize various types of research publications. 4. Differentiate between good and bad journals. 5. Review available literature and file it correctly. 6. Practice and appreciate ethical research

Module 1	Fundamentals of research and interpretation	15L
Learning Objectives The module is intended to – • Make the learner understand the nuances of research. • Explain to the learner how to do a good quality research.		
Learning Outcomes After the successful completion of the module, the learner will be able to – • Identify a research problem.		

- Design research work as pr requirement
- Interpret their results correctly.
- Make an effective presentation of their work.

1.1	Introduction to research 1.1.1 Concept of research 1.1.2 Objectives of research 1.1.3 Types of research 1.1.4 Methods of research 1.1.5 Significance of research 1.1.6 Defining a research problem 1.1.7 Research design 1.1.8 Applications of research	8L
1.2	Interpretation 1.2.1 Techniques of interpretation 1.2.2 Precautions in interpretation 1.2.3 Significance of interpretation	5L
1.3	Presentation of research – oral and poster	2L

References

- Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
- Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed), Singapore, Pearson Education.
- Research methodology: methods and techniques (2019) by C.R. Kothari and Gaurav Garg.

Module 2	Computers in research and Good Laboratory Practices	15L
Learning Objectives The module is intended to – • Explain the importance and role of computers in research • Familiarise the learner to various online tools and software • Introduce and implement good lab practices in the learner • Teach the learner how to draft a research proposal		
Learning Outcomes After the successful completion of the module, the learner will be able to – • Apply computers in research • Practise the use various online tools and software • Demonstrate good laboratory practices • Write an effective research proposal		
2.1	Application of computers in research 6.1.1 Software to write a report – MS Word 6.1.2 Software for analysis – MS Excel, R, Image J, Graphpad etc 6.1.3 Software for presentation – MS Powerpoint, Online platforms like Canva 6.1.4 Referencing softwares – Google Scholar, ResearchGate. 6.1.5 Plagiarism software	6L
2.2	Good Laboratory Practices 2.2.1 Design of a research laboratory 2.2.2 Types of laboratories – wet and dry 2.2.3 Basic safety protocols 2.2.4 Handling of chemicals 2.2.5 Handling of instruments – SOPs, 2.2.6 Preparation of reagents and solutions 2.2.7 Maintaining data – logbook, data entry, filing	6L
2.3	Writing research proposals	3L

	2.3.1 Characteristics of a proposal, content, and organization, 2.3.2 Research funding, 2.3.3 Weakness in proposal	

References

- Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS Publishers' Distributors.
- Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners, (2nd.ed), Singapore, Pearson Education.
- Research methodology: methods and techniques (2019) by C.R. Kothari and Gaurav Garg.

Module 3	Research publication	15L

Learning Objectives

The module is intended to –

- Explain the various types of research publications to the learner.
- Familiarise the learner to online and offline referencing.

Learning Outcomes

After the successful completion of the module, the learner will be able to –

- Categorize various types of research publications.
- Differentiate between good and bad journals.
- Review available literature and file it correctly.

1.1	Report writing – types of reports, layout of report, precautions in writing a report	4L
1.2	Project writing – searching for funding agencies, writing a project – from title to referencing	4L

1.3	Scientific Publication 1.2.1 Types – abstract, short communications, review article – paper, book, thesis; full length paper, popular science article 1.2.2 Review of literature - Library reference, recording and indexing, classification of references, internet sites for biological references; downloading the information through internet; requests for reprints through e- mail and post. 1.2.3 classification and filing of reprints.	5L
1.4	Research Writing 1.3.1 IMRAD format 1.3.2 Process of peer review and publication 1.3.3 Journals which publish research in zoology 1.3.4 Instructions to authors 1.3.5 Impact Factor and citation index 1.3.6 Predatory journals	2L

References

- Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415),179-179. https://doi.org/10.1038/489179a
- Bird, A. (2006). *Philosophy of Science*. Routledge.
- Research methodology: methods and techniques (2019) by C.R. Kothari and Gaurav Garg.

Module 4	Research Ethics	15L

Learning Objectives
The module is intended to –

- Make the learner understand the various forms of scientific misconduct
- Introduce the learner to research and publication ethics.
- Make the learner understand the importance of IPR

Learning Outcomes

After the successful completion of the module, the learner will be able to – • Avoid scientific misconduct. • Practice ethical research • Discuss IPR, its role and types.		
2.1	Scientific misconduct 2.1.1 Ethics with respect to science and research 2.1.2 Intellectual honesty and research integrity 2.1.3 Scientific misconducts: Falsification, fabrication and Plagiarism (FPP) 2.1.4 Redundant publications: duplicate and overlapping publications, salami slicing. 2.1.5 Selective reporting and misrepresentation of data	6L
2.2	Publication Ethics 2.2.1 Publications ethics: definition, introduction and importance 2.2.2 Best practices/standards setting initiatives and guidelines: COPE (Committee On Publication Ethics), WAME, etc. 2.2.3 Conflict of interest 2.2.4 Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, types. 2.2.5 Violation of publication ethics, authorship and contributorship 2.2.6 Identification of publication misconduct, complaints, and appeals, penalty for plagiarism	6L
2.3	Intellectual Property Rights 2.3.1 Theories of IPR 2.3.2 Types of IPR – copyright, trademark, patent and design, geographical indications 2.3.3 Introduction to patent, patent databases, preparation of patent documents, patent examination, patent infringement	3L
References		

- P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN:978-9387480865.
- National Academy of Sciences, National Academy of Engineering and Institute of Medicine. (2009). *On being a Scientist: A Guide to Responsible Conduct in Research: Third Edition*. National Academies Press.
- Resnik, D.B. (2011). What is ethics in research and why is it important. *National Institute of Environmental Health Sciences*, 1-10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm
- Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN:978-81-939482 http://www.insaindia.res.in/pdf/Ethics_Book.pdf

EVALUATION

The mode of evaluation will be CIE – Continuous Internal Evaluation. The students will appear for periodic tests. There will be three periodic tests per course in a semester.

	Course	Pattern	Marks	Total
1	I	Presentation	20	50
		Assignment	10	
		MCQ test	20	
2	II	Presentation	20	50
		Assignment	10	
		MCQ test	20	

MSc ZOOLOGY SEMESTER II
Core Course- I

COURSE TITLE: Industrial Biotechnology
COURSE CODE 23PS2ZOMJ1IBT
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Describe the process of large scale culture of various biomolecules by recombinant microorganism and genetically engineered animal cells by various fermentation methods. 2. Discuss the various types of vaccines, their production and advantages over conventional vaccines 3. Explain the production and applications of monoclonal antibodies 4. Enlist applications of biotechnology in agricultural fields such as use of biotechnology techniques for better nitrogen fixation, pest resistance and disease resistance. 5. Explore the use of algae for biofuel and its various bioactive compounds.

Module I	Large scale culturing techniques	15L

Learning objectives

The module is intended to -

- Make the learner understand large scale culturing techniques and downstream processing involving recombinant bacterial and animal cells
- Explain the applications of large scale culture and their commercial products

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Explain different types of bioreactor designs based on the requirement of the culture
- Discuss the optimum parameters required for large scale culture system

• Enlist different animal cell lines and their applications in large scale culture		
Subtopic	**Title**	**15L**
1.1	Large scale culture & production from recombinant microorganisms- 1.1.1 Batch fermentation 1..1.2 Fed batch fermentation 1.1.3 Continuous fermentation 1.1.4 Maximizing the efficiency of fermentation process 1.1.5 Harvesting, disrupting & downstream processing 1.1.6 Typical Large-scale fermentation systems : Two-Stage Fermentation in Tandem Airlift Reactors , Two-Stage Fermentation in a Single Stirred-Tank Reactor, Batch versus Fed-Batch Fermentation	 1L 1L 1L 1L 1L 4L
1.2	Large scale culture & production from genetically engineered animal cell cultures - 1.2.1 Basic structure of Bioreactors, Design of bioreactors for large scale animal cell culture-Batch, Fed batch 1.2.2 Mammalian cell lines & their characteristics 1.2.3 Media for the cultivation of mammalian cells 1.2.4 Commercial products produced with mammalian cell culture	 1L 2L 2L 1L
References • Molecular Biotechnology- Principles and applications of recombinant DNA- B. Glick and J. Pasternak, 3rd edition • Biotechnology - U. Satyanarayana, Books and Allied Ltd. • Basic Biotechnology- Colin Ratledge , 3rd Edition		
Module II	**Agricultural Biotechnology**	**15L**

Learning objectives

The module is intended to -

- Convey the importance of new biotechnological practices in improving agricultural produce
- Make the learner understand the concepts of biofertilizers and biopesticides
- Impress upon the learner the need to explore alternative energy sources from marine environment

Learning outcomes

After the successful completion of the module, the learner will be able to -

- State the drawbacks of conventional fertilizers and pesticides
- Schematically explain process of nitrogen fixation and nodulation
- Describe the genetic engineering of nif,hup and nod genes
- Define genetic complementation
- Explain the production of Bt based pesticides
- Elaborate the processes to make various resistant crops/ plants
- Enumerate marine natural products and their applications

Subtopic	Title	Lecture distribution
2.1	Bio-fertilizers	
	2.1.1 Concept of Nitrogen fixation	IL
	2.1.2 Nitrogenase-Component of nitrogenase; Genetic engineering of nitrogenase cluster	IL
	2.1.3 Hydrogenase-Hydrogen metabolism	IL
	2.1.4 Genetic engineering of hydrogenase gene	IL
	2.1.5 Nodulation-Competition among nodulation organisms, genetic engineering of nodulation gene	IL
2.2	Bio-insecticides	
	2.2.1 Toxins of *Bacillus thuringiensis,*	IL

	2.2.2 mode of action & use of *thuringiensis* toxins, 2.2.3 Thuringiensis toxin gene isolation, 2.2.4 Genetic engineering of *Bacillus thuringiensis* strains 2.2.5 Cloning of *thuringiensis* toxin gene.	IL IL IL IL
2.3	Transgenic Plant Technology 2.3.1 Insect resistant plants 2.3.2 Virus resistant plants 2.3.3 Herbicide resistant plants	 IL IL IL
2.4	Algal products 2.4.1 Fuels from algae 2.4.2 Marine natural products & their medical potential-anticancer, antiviral compounds, antibacterial agents.	 IL IL

References

- Molecular Biotechnology- Principles and applications of recombinant DNA- B. Glick and J. Pasternak, 3rd edition
- Biotechnology - U. Satyanarayana, Books and Allied Ltd.
- Basic Biotechnology- Colin Ratledge , 3rd Edition

Question paper Template

MSc ZOOLOGY SEMESTER II
Core Course- I
COURSE TITLE: Industrial Biotechnology
COURSE CODE 23PS2ZOMJ1IBT
[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5	5	-	25
II	5	5	5	5	5	-	25
Total marks per question	10	10	10	10	10	-	50
% Weightage	20	20	20	20	20	-	100

Core Course- II
COURSE TITLE: Ethology - Animal Behavior and Behavioral Ecology
COURSE CODE 23PS2ZOMJ2ABE
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Understand the fundamental concepts, theories, and methodologies in ethology and animal behavior. 2. Analyze the proximate and ultimate causes of animal behavior, including genetic, physiological, and evolutionary factors. 3. Apply observational and experimental methods to study and interpret animal behavior. 4. Evaluate the ecological and evolutionary implications of animal behavior in various contexts.

Module I	Introduction to Ethology	15L

Learning objectives

The module is intended to -

- Understand the concepts, scope, and historical development of ethology
- Differentiate between proximate, ultimate causes of behavior and develop proficiency in observational and experimental studies, modes of communication.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Explain the concept and scope and contributions in ethology.

• Differentiate between proximate and ultimate causes of animal behavior and provide examples of genetic, physiological, and developmental factors influencing behavior. • Observe and interpret experimental methods to study animal behavior.		
Subtopic	**Title**	**Lecture distribution**
1.1	Overview of Ethology 1.1.1 Definition and scope of ethology 1.1.2 Historical perspectives and key contributors	 2L 2L
1.2	Animal Behavior: Proximate and Ultimate Causes 1.2.1 Proximate causes: Genetic, physiological, and developmental mechanisms 1.2.2 Ultimate causes: Adaptive significance and evolutionary explanations 1.2.3 The role of genes and environment in shaping behavior	 2L 1L 1L
1.3	Methods in Ethology 1.3.1 Observational methods: Direct and indirect observations 1.3.2 Experimental methods: Field experiments, laboratory experiments, and controlled studies 1.3.3 Data collection and analysis techniques	 1L 2L 1L
1.4	Communication and Signaling 1.4.1 Types of animal communication: Visual, auditory, chemical, and tactile 1.4.2 Signaling mechanisms: Signals, cues, and displays 1.4.3 Functions and evolution of animal communication	 1L 2L 1L
References		

- John Alcock, 2009. Animal Behavior: An Evolutionary Approach. Ninth Edition. Sinauer Associates.
- Michael Begon, Colin R. Townsend, John L. Harper, 2006. Ecology From Individuals to Ecosystem. Fourth Edition. Blackwell Publishing.
- Aubrey Manning, Marian Stamp Dawkins, 2012. AN INTRODUCTION TO ANIMAL BEHAVIOUR. Sixth Edition. Cambridge University Press.
- Eugene P. Odum, Gray W. Barrett, 2017. Fundamental of Ecology. Fifth Edition. Cengage India.

Module II	Behavioral Ecology	15L

Learning objectives

The module is intended to -

- Understand the theories of foraging and decision-making strategies.
- Analyze the different forms of reproductive behavior, influence of parental investment on reproductive success.
- Examine the concepts of territoriality, home range and migration.
- Explore the evolutionary mechanisms of social organization and cooperation.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Apply the principles of optimal foraging theory to explain food choice and decision-making in animals.
- Describe the mechanisms of sexual selection, mate choice and territoriality.
- Analyze the patterns, navigation strategies and mechanisms of migration,
- Explain the evolutionary drivers of social organization and cooperation.

Subtopic	Title	15L
2.1	Foraging Behavior: 2.1.1 Optimal foraging theory	2L

	2.1.2 Food choice and decision-making 2.1.3 Predation risk and anti-predator strategies	1L 1L
2.2	Reproductive Behavior: 2.2.1 Sexual selection and mate choice 2.2.2 Mating systems and strategies 2.2.3 Parental investment and reproductive success	 2L 1L 1L
2.3	Territoriality and Home Range: 2.3.1 Territory establishment and defense 2.3.2 Resource distribution and territorial behavior 2.3.3 Ecological and evolutionary implications of territoriality	 1L 1L 1L
2.4	Social Organization and Cooperation: 2.4.1 Evolution of sociality: Kin selection and inclusive fitness 2.4.2 Altruism and reciprocal cooperation, Reciprocal altruism and cooperation among non-relatives 2.4.3 Cooperative breeding and eusociality	 2L 1L 1L

References

- John Alcock, 2009. ANIMAL BEHAVIOR: AN EVOLUTIONARY APPROACH. Ninth Edition. Sinauer Associates.
- Michael Begon, Colin R. Townsend, John L. Harper, 2006. ECOLOGY FROM INDIVIDUALS TO ECOSYSTEM. Fourth Edition. Blackwell Publishing.
- Aubrey Manning, Marian Stamp Dawkins, 2012. AN INTRODUCTION TO ANIMAL BEHAVIOUR. Sixth Edition. Cambridge University Press.
- Eugene P. Odum, Gray W. Barrett, 2017. FUNDAMENTAL OF ECOLOGY. Fifth Edition. Cengage India.

Question paper Template
MSc ZOOLOGY SEMESTER II
Core Course- II
COURSE TITLE: Ethology - Animal Behavior and Behavioral Ecology
COURSE CODE 23PS2ZOMJ2ABE

[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5	5	-	25
II	5	5	5	5	5	-	25
Total marks per question	10	10	10	10	10	-	50
% Weightage	20	20	20	20	20	-	100

MSc ZOOLOGY SEMESTER II
Core Course- III
COURSE TITLE: Human Diseases
COURSE CODE 23PS2ZOMJ3HUD
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Explain the various metabolic errors observed in humans 2. Analyze the causes and treatments of these disorders 3. Enlist various lifestyle disorders commonly observed in society 4. State the risk factor, causes, symptoms, treatment and prevention of major lifestyle diseases

Module I	Inborn errors of Metabolism	[15L]

Learning Objectives

The module is intended to

- Explain the significance of errors in metabolism, their occurrence in the human population, causes and effects
- Make the learner aware of the genetic basis and clinical manifestations of inborn errors of metabolism

Learning Outcomes

After the successful completion of the module, the learner will be able to

- Enlist the causes , symptoms and clinical presentations for various inborn errors of metabolism
- Elaborate on the treatment modalities for the same

Subtopic	Title	Lecture

		distribution
1.1	Concept of Inborn Errors in Metabolism	1L
1.2	1. Carbohydrate metabolism 2. G-6PD deficiency 3. Pompe's Disease 4. Kori's disease	3L
1.3	Lipid metabolism: Metabolic disorders of cerebrosides Gaucher's disease Tay Sachs disease Niemann Pick disease	3L
1.4	Protein metabolism Alkaptonuria PKU Albinism	3L
1.5	Purine metabolism Primary Gout Lesch Nyhan Syndrome	2L
1.6	Mineral metabolism and diseases Hypocalcaemia Hypercalcaemia Osteoporosis	3L

References:

- iGenetics- A Molecular approach by Peter J.Russell, 3rd edition
- Genetics- Strickberger, Monroe W.,Second edition, Macmillan Publication.

Module II	Lifestyle diseases	15L

Learning Objectives

The module is intended to

- Explain the significance of lifestyle factors affecting human health
- Make the learner aware of various lifestyle related diseases
- Discuss characteristics and causes of non communicable diseases with respect to lifestyle disease

Learning Outcomes

After the successful completion of the module, the learner will be able to

- Enlist the risk factor, causes, symptoms, treatment and prevention of major lifestyle disease
- Elaborate on dynamics of lifestyle disease in India
- Explain and differentiate between characteristics and causes of non communicable diseases with respect to lifestyle disease

2.1	Non communicable diseases: characteristics and causes with respect to lifestyle disease	2L
2.2	Risk factor, causes, symptoms, treatment and prevention of major lifestyle disease: a. Cardiovascular diseases b. Diabetes c. Cancer (lung, cervical, breast, prostate and colorectal) d. Chronic Obstructive Pulmonary Disease (COPD) e. Obesity f. PCOS	 2L 2L 2L 2L 2L 1L
2.3	Dynamics of lifestyle disease in India - Trends in population and Governments measures	2L

References:

- https://www.un.org/en/chronicle/article/lifestyle-diseases-economic-burden-health-services

- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2862441/
- https://pib.gov.in/Pressreleaseshare.aspx?PRID=1540840
- Lifestyle Diseases Paperback by Surendra G Gattani (Author), Ajay D Kshirsagar

Question paper Template
MSc ZOOLOGY SEMESTER II
Core Course- III
COURSE TITLE: Human Diseases
COURSE CODE 23PS2ZOMJ3HUD

[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5	5	-	25
II	5	5	5	5	5	-	25
Total marks per question	10	10	10	10	10	-	50
% Weightage	20	20	20	20	20	-	100

MSc ZOOLOGY SEMESTER II
Core Course- IV
COURSE TITLE: Biostatistics - Basic concepts and hypothesis testing
COURSE CODE 23PS8ZOCC4BHT
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Define basic terminology of biostatistics 2. Compare between various sampling methods and distribution tables 3. Apply the rules of probability to biological systems 4. Analyze data using t-test, z test and chi square test 5. Use computers to solve statistical problems

Module I	Basic Concepts In Biostatistics	15L

Learning objectives

The module is intended to -

- Make the learner understand the basic concepts of Biostatistics.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Analyze basic data using principles of Biostatistics.
- Define terminologies related to Biostatistics.
- Classify the given data through various representation methods.

Subtopic	Title	15L
1.1	Scope of biostatistics- definition and limitations	2L

	Use of computers in biostatistics	
1.2	1.2.1 Classification of data : Tabulation-simple tables , complex tables, frequency distribution tables, 1.2.2 Diagrammatic presentation—frequency polygon, frequency curves, bar, column, (simple, multiple, segmented, 100% stacked), area, line, pie diagrams. Using Graph paper and MS excel	1L 3L
1.3	Measure of central tendency and dispersion : Mode, Median, Mean, range, Variance and Standard deviation Using manual method and MS Excel	4L
1.4	Normal distribution Curve: Properties and Significance	2L
1.5	Rules of Probability and its application	3L

References

- Cochran W.G. : Sampling Technique Third edition. Wiley Eastern.
- Des Raj and Chandok: Sampling Design. Tata McGraw Hill.

Module II	Various Tests In Biostatistics	15L

Learning objectives

The module is intended to -

- Acquaint the learner with the concepts of probability and the parametric and non-parametric tests in Biostatistics.

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Demonstrate the applications of probability and various tests in Biostatistics in biological scenarios.

Subtopic	Title	15L
2.1	Statistical hypothesis- null hypothesis, alternative Hypothesis	2L
2.2	Parametric test of significance - student's t test	3L
2.3	Z- test and its applications	2L
2.4	F-test and its application	2L
2.5	Non parametric test - chi-square test	2L
2.5	ANOVA and types	4L

References

- Veer Bala Rastogi, Biostatistics third edition,medtech pub 2017
- B. K. Mahajan Methods in Biostatistics 7th edition,Jaypee pub. Jan2010

Question paper Template
MSc ZOOLOGY SEMESTER II
Core Course- IV
COURSE TITLE: Biostatistics - Basic concepts and hypothesis testing
COURSE CODE 23PS8ZOCC4BHT

[CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5	5	-	25
II	5	5	5	5	5	-	25
Total marks per question	10	10	10	10	10	-	50
% Weightage	20	20	20	20	20	-	100

MSc ZOOLOGY SEMESTER II
Practical 23PS2ZOMJP1
[MJ 1 +MJ 2]

Core course I	Biotechnology and Culturing Techniques

Learning Objectives

This Practical is intended to

- Demonstrate basic aseptic skills to the learner
- Emphasise on the need to maintain asepsis in the Biotechnology laboratory
- Prepare the student for performing basic microbiological practicals and projects independently

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Perform aseptic transfers of cultures
- Prepare sterile media and glassware for tissue culture
- Demonstrate various streaking techniques for Bacterial isolation
- Carry out various bacteriological enumeration experiments
- Immobilize yeast cells in calcium alginate and test its activity
- Use the mini-prep test kit to demonstrate isolation of plasmid DNA

1. Demonstration of aseptic Techniques
2. Media Preparation - to prepare and sterilise various media such as NA,NB,LB and check the sterility
3. Preparation of LB agar slant, butt and plate
4. Streaking Techniques - T streak, side streak, quadrant streak
5. Determination of viable cell count in the given culture of bacteria by Serial dilution & spreading technique.
6. Nephelometry-To estimate the number of bacteria in the given culture by Nephelometry
7. Using Mini-prep method isolate Plasmid DNA from the given strain of bacteria & show the purity of the isolate by performing agarose gel electrophoresis

8. Immobilize Yeast cells in calcium alginate & prepare a bioreactor column to demonstrate Invertase activity in the bioreactor column
9. To plot a growth curve for the given bacterial population and compare the growth pattern in various media

Suggested project:

1. To Compare the bacterial profile of processed and fresh foods/ beverages

Core course II	Ethological data collection and interpretation

Learning Objectives

This Practical is intended to make the students

- Understand the key concepts of Ethology, data collection on field and its analysis
- Document comparative animal behaviour under various stimuli
- Apply Ethological concepts on field and frame experiments

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Collect data from the field using various techniques
- Apply concepts of animal behaviour and draw conclusions
- Perform field experiments to various taxa
- Create an ethogram and analyse time budget using software

1	Study of Field sampling methods - Focal sampling, scan sampling
2	Study of Field sampling methods - behaviour sampling, ad lib sampling
3	Study of construction of ethogram
4	Recording animal behaviour and calculating time budget using BORIS
5	Study of Burrow and chimney building behaviour of sand bubbler crabs
6	Report writing on documentary
7	Zoo visit to record animal behaviour in captivity

8	Study of behaviour system using fish display tank

Practical
23PS2ZOMJP2
[MJ 3 +MJ 4]

Core course III	Human Diseases

Learning Objectives:

The practicals are intended to help the learner

- Analyze various lifestyle diseases dynamics
- Assess the significance of BMI
- Estimate level of glucose, triglycerides and protein from blood

Learning Outcomes

After successful completion of the practical the learner will be able to

- Describe the dynamics of lifestyle diseases
- Measure BMI
- Quantify level of glucose, triglycerides and protein from blood

1. Test kit for G6PD
2. Conduct a Case study on-
   - PCOS
   - COPD
   - Lung cancer
   - Obesity
   - Type 2 diabetes
3. Survey and analysis on any lifestyle diseases and metabolic disorders
4. Survey, calculation and analysis of BMI
5. Estimation of blood sugar level using glucometer/ GOD POD test kit
6. Estimation of cholesterol from blood/serum sample
7. Estimation of triglycerides from blood/serum sample

Suggested projects:

1. Comparative study of fiber content of various food groups
2. Survey of various dietary practices
3. Comparative study of protein content of various food groups
4. Comparative study of sugar content of various food/ fruit groups

Core course IV	Biostatistics - Basic concepts and hypothesis testing

Learning Objectives

The practicals are intended to

- Make the learner understand the basic concepts of Biostatistics.
- Acquaint the learner with the concepts of probability and the parametric and non-parametric tests in Biostatistics.

Learning Outcomes

After successful completion of the practical the learner will be able to

- Analyze basic data using principles of Biostatistics.
- Solve the given data through various representation methods
- Demonstrate the applications of probability and various tests in Biostatistics in biological scenarios.

1. Descriptive statistics and graphical presentation using Microsoft Excel
2. Calculation of Mean, Mode and Median using spreadsheet application.
3. Problems based on sampling techniques
4. Problems based on Probability
5. Problems based on T-test, Z-test and Chi-square test
6. Problems based on statistical tests for accepting or rejecting the null hypothesis ANOVA using free online tools (Demo)
7. Introduction to R Software

Suggested Projects

1. Introduction to literature database at NCBI and querying the PUBMED central database using the ENTREZ search engine
2. Study of Any two proteins and two genes sequences using online databases

MSc ZOOLOGY SEMESTER II
DSE- I
COURSE TITLE: Biological Oceanography And Marine Microbiology
COURSE CODE: 23PS2ZODSE1BOM
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Compare between the organisms, their characters and requirements 2. Discuss the physical factors that affects marine life 3. Enlist various marine microorganisms, Compare and contrast between the various groups of microbes found in mangroves and coral reefs. 4. Discuss the process of breakdown of various xenobiotics by microbes and Describe methods for controlling water pollution

Module I	Biological Oceanography	15L

Learning objectives

The module is intended to -

- Explain the marine environment and its components to the learner
- Elucidate on effect of various physical parameter of seawater on marine animals
- Discuss on marine biotic diversity, intertidal organisms and their zonations and role of marine bacteria in marine environment

1.1	Division of marine environment	1L
1.2	1.2.1 Marine biotic diversity: Plankton, Nekton, Benthos- Classification and adaptation 1.2.2 Factors influencing the distribution and abundance of plankton, plankton bloom, patchiness and their vertical distribution, Diurnal migration of zooplankton, Inter-relationship between phytoplankton and zooplankton. 1.2.3 Benthic organisms in relation to food chain and their ecological role 1.2.4 Intertidal organisms and their zonation, adaptation	2L 3L 1L 1L
1.3	Effect of physical factors on marine life a) Light- photosynthesis, colouration, structural adaptations, bioluminescence. b) Temperature- tolerance, geographical distribution, size, calcium precipitation, metabolism, bipolarity, tropical submergence and periodicity. c) Salinity- tolerance and distribution, size, buoyancy and osmoregulation. d) Currents- role in nutrition, transportation and propagation	2L 2L 2L 1L

References

- The Oceans: Their Physics, Chemistry, and General Biology by H. U. Sverdrup, Martin W. Johnson, Richard H. Fleming; Prentice-Hall of India Pvt.Ltd
- Essentials of oceanography by P. Trujillo Alan, Harold V. Thurman; Prentice-Hall of India Pvt.Ltd
- Oceanography: An Invitation to Marine Science by Tom Garrison; Brooks/Cole; 9th edition
- A Textbook of Marine Ecology – Nair, N.B. & Thumpy, D.H., the Macmillan Book Company of India Ltd
- Element of marine ecology by R.V. Tait and F.A. Dipper
- Biological Oceanography: An Introduction by Carol M. Lalli and Timothy R. Parsons; Butterworth-Heinemann; 2nd edition

Module II	Marine Microbiology and biodegradation	15L

Learning objectives

The module is intended to -

- Discuss the diversity of various marine microorganisms.
- Elaborate the importance of microbial ecology of coastal, shallow and deep sea waters.
- Describe various groups of microbes found in mangroves and coral environments.
- Elucidate the bioremediation process with respect to various synthetic compounds in marine water bodies
- Elaborate on the types of microbes involved in bioremediation

Learning outcomes

After the successful completion of the module, the learner will be able to -

he successful completion of the module, the learner will be able to

- Enlist different marine microbes along with their roles in the ecosystem.
- Compare the microbial ecology of coastal, shallow and deep sea waters.
- Conclude the significance of various microorganisms found in mangroves and coral environments.
- Emphasize on the need for bioremediation in marine environment
- Describe the mechanisms involved in bioremediation
- Enlist the microbes involved in bioremediation of different compounds

Subtopic	Title	15L
2.1	Ecology of coastal, shallow and deep sea microorganisms - importance and their significance.	2L

2.2	Diversity of microorganism - Archaea, bacteria, cyanobacteria, algae, fungi, viruses and actinomycetes in the mangroves and coral environment	3L
2.3	Natural and synthetic material in the marine environment- pesticide, cellulose degradation, hydrocarbon production.	5L
2.4	Bioremediation of xenobiotics, oil, heavy metals, pesticides, plastics, etc. Mining and metal biotechnology.	5L

References

- John Paul 1999. Marine Microbiology, Elsevier.
- Munn and Munn 1996. Marine Microbiology: Ecology and Applications. BIOS Scientific publisher.
- Kirchman, L Microbial Ecology of the Oceans 2000 John Wiley and Sons. Hans G. Truperet. al 1991.
- Rheinheimer, G., 1980 Aquatic Microbiology-an Ecological Approach. Blackwell Scientific Publications

Practical
23PS2ZODSEP1

DSE I	Biological Oceanography And Marine Microbiology

Learning Objectives

This Practical is intended to

- Demonstrate various methods for plankton population estimation
- Assist the learner identify various zooplanktons
- Study fecundity of fish by correlating various biometric parameters and by measuring fish ova diameter

Learning Outcomes

After the successful completion of the Practical, the learner will be able to

- Calculate plankton population from given sample
- Identify common zooplanktons by observing their permanent slides

- Calculate fecundity-maturation of fish by their biometric parameters and ova diameter

1. Laboratory procedure for quantitative estimation of plankton settling method, wet weight method, weight displacement method, counting method.
2. Preparation of permanent slides for zooplankton
3. Introduction to sampling techniques for Benthos.
4. Identification of Zooplankton permanent slides (Noctiluca, Obelia medusa, Zoea, Copepods, Mysids, Echinoderm larvae, Nauplius, Sagitta, Doliolum, Salpa, Lucifer sp., Chaetognaths, Fish eggs and larvae, Jellyfish, Physalia, Porpita)
5. Study of fecundity-maturation in fish.
6. Plotting the frequency polygon by ova diameter measurement.
7. Isolation of pathogenic organism from seafood
8. Characterization of marine bacteria using biochemical tests and staining techniques
9. Comparative bacterial profile of processed and fresh seafood
10. Study of Microbial diseases in fishes
11. Visit to intertidal zone and submission of report

MSc ZOOLOGY SEMESTER II
DSE- II
COURSE TITLE: Entomology – Type animal and Insect control
COURSE CODE 23PS2ZODSE2TIC
[CREDITS - 02]

Course learning outcomes
After the successful completion of the Course, the learner will be able to - 1. Recognize various morphological features of cockroach as a type animal 2. Understand anatomy of cockroach as a type animal 3. Identify different insect toxicants and their effect 4. Summarize Biological Control and IPM techniques

Module I	Study of type animal – Cockroach	15L

Learning objectives

The module is intended to -

- Describe morphology of cockroach
- Describe anatomical organization of cockroach
- Discuss ecosystem services by cockroach

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Identify cockroach in field

- Analyze relation between various anatomical features of cockroach

Subtopic	Title	15L
1.1	Classification and diversity	1L
1.2	Morphology	1L
1.3	Digestive system	1L
1.4	Circulatory system	2L
1.5	Excretory system	2L
1.6	Nervous system	2L
1.7	Reproductive system	2L
1.8	Development	2L
1.9	Ecosystem services by cockroach	1L
1.10	Cockroach in entomological research	1L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General TextBook of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.

- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.
- Kerkut: G.A. & Gilbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Mcgraw Hill, New York

Module II	Principles of Insect Control	15L

Learning objectives

The module is intended to -

- Explain different methods of control
- Classify types of insecticides
- Identify mode of action and resistance to the methods
- Identify integrated pest management

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Understand the type of infection and apply control method/s
- Recognize importance of integrative approach to insect control
- Categorize insecticides based on their effect

Subtopic	Title	15L
2.1	Scope, definition, and history of insecticides	1L
2.2	Chemical control – classification and evolution of insecticides, types, mode of action, insecticide formulation and application	4L

2.3	Biological control methods	1L
2.4	Integrated pest management	2L
2.5	Principles of toxicology. Evaluation of insecticide toxicity, synergists, potentiation, antagonism	3L
2.6	Insecticide metabolism	2L
2.7	Insecticide residues	1L
2.8	Pest resistance to insecticides	1L

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General TextBook of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.

Practical
23PS2ZODSEP2

DSE 2	Type animal and Insect control
Learning objectives	

This practical is intended to

- Describe morphology and anatomy of locally available insect pest
- Understand the effect of pesticide on organisms

Learning outcomes

After the successful completion of the practical, the learner will be able to

- Draw morphological and anatomical features of cockroach
- Relate insecticide and toxicant and its effect on insects

1. Study of morphology of cockroach
2. Study of different species of cockroaches in India
3. Study of digestive system of cockroach
4. Study of circulatory system of cockroach
5. Study of nervous system of cockroach
6. Study of excretory system of cockroach
7. Study of reproductive system of cockroach
8. Effect of insecticide (Lc50)
9. Study of different types of insecticides – structure, mode of action

References

- Ross, H.H., Ross C.A. & Ross J.R.P., Textbook of Entomology, Ed. 4. John Willey & Bons, New York.
- Richards, O.W. & Davis, R.G.: General TextBook of Entomology. Ed. 10. Chapman & Hall London.
- Nayar, K.K. & Ananthkrishnan, T.N. & David. B.V.: General and Applied Entomology, Tata McGraw Hill Co Ltd., Bombay.
- Mani. M.S.: General Entomology. End 3, Oxford & IBH Publishing Co., New Delhi.
- Sondgrass, R.E.: Principles of Insect Morphology, Tata McGraw Hill, Rutl. Co. Ltd., Bombay, New Delhi.
- Wigglesworth, V.B.: The Principles of Insects Physiology. Vlbs & Methuten & Co.Ltd., London.
- Chapman, R.F.: The Insects Structure & Function, English University Press, London.
- Comstock, J.H.: An Introduction to Entomology. Ithaca, New York.

- Kerkut: G.A. & Gilbert, L.I.: Comprehensive Insect. Physiology, Biochemistry and Pharmacology. Vol. 1 to 13. Pergamon Press, Oxford & New York.
- Beament, J.W.L. Tieherne, J.E. & Wigglesworth, V.B.: Advances in Insect Physiology, Academic Press, New York.
- Tembhare, D.B.: modern entomology II End. HPH publications.
- Metcalf, C.L., Flint. W.P. & Metcalf. R.L.: Destructive and Useful Insects – Their habits & control End. 4, Mcgraw Hill, New York

MSc ZOOLOGY SEMESTER II
DSE- III
COURSE TITLE: Model organisms in biological research
COURSE CODE 23PS2ZODSE3MOB
[CREDITS - 02]

Course learning outcomes		
After the successful completion of the Course, the learner will be able to - 1. Enlist examples of model organisms used in biological research 2. Elaborate on their characteristics, Morphology, Genome , Breeding, maintenance and applications 3. Compare and contrast between vertebrate and invertebrate systems 4. Plan research using these model organisms		
Module I	**Invertebrate Model organisms**	**15L**
Learning objectives The module is intended to - • Familiarize the learner with some invertebrate model organisms used in research • Make the learner understand the significance of invertebrate systems		
Learning outcomes After the successful completion of the module, the learner will be able to - • Describe various invertebrate model organisms • Explain their characteristics, Morphology, Genome , Breeding, maintenance and applications • Comment on the ethical use of animals • Design experiments employing model organisms		
Subtopic	**Title**	**Lecture distribution**

1.1	Concept and significance of model organism	1 L
1.2	General characteristics, Morphology, Genome characteristics, Breeding, maintenance and applications of following model organisms in biological research 1. *Dictyostelium* 2. *Caenorhabditis elegans* 3. *Drosophila*	 2L 2L 2L
1.3	Advantages and disadvantages of invertebrate model organisms	2L
1.4	Experimental design and requirements for using invertebrate model organisms	3L
1.5	Ethical use of laboratory animals	3L

References

- Leonelli, S., & Ankeny, R. A. (2013). What makes a model organism?. *Endeavour*, *37*(4), 209-212.
- Bozzaro, S. (2013). The model organism *Dictyostelium discoideum*. *Dictyostelium Discoideum Protocols*, 17-37.
- Meneely, P. M., Dahlberg, C. L., & Rose, J. K. (2019). Working with worms: *Caenorhabditis elegans* as a model organism. *Current Protocols Essential Laboratory Techniques*, *19*(1), e35
- Roberts, D. B. (2006). Drosophila melanogaster: the model organism. *Entomologia experimentalis et applicata*, *121*(2), 93-103.
- Baumans, V. (2004). Use of animals in experimental research: an ethical dilemma?. *Gene therapy*, *11*(1), S64-S66.
- American Psychological Association. (1986). Guidelines for ethical conduct in the care and use of animals. *Journal of the Experimental Analysis of Behavior*, *45*(2), 127.

Module II	**Vertebrate Model organisms**	**15L**

Learning objectives

The module is intended to -

- Familiarize the learner with some vertebrate model organisms used in research
- Make the learner understand the significance of vertebrate systems

Learning outcomes

After the successful completion of the module, the learner will be able to -

- Describe various vertebrate model organisms
- Explain their characteristics, Morphology, Genome , Breeding, maintenance and applications
- Elaborate on CPCSEA guidelines for animal research
- Design experiments employing model organisms

Subtopic	Title	15L
2.1	General characteristics, Morphology, Genome characteristics, Breeding, maintenance and applications of following model organisms in biological research 1. Zebrafish 2. *Xenopus* 3. Mice 4. Rat	 2L 2L 2L 2L
2.2	Advantages and disadvantages of vertebrate model organisms	2L
2.3	Experimental design and requirements for using vertebrate model organisms	3L
2.4	CPCSEA guidelines for use of model organisms for biological research	2L

References

- Meyers, J. R. (2018). Zebrafish: development of a vertebrate model organism. *Current Protocols Essential Laboratory Techniques*, *16*(1), e19.

- Cannatella, D. C., & De Sá, R. O. (1993). *Xenopus laevis* as a model organism. *Systematic Biology, 42*(4), 476-507.
- Canales, C. P., & Walz, K. (2019). The mouse, a model organism for biomedical research. In *Cellular and animal models in human genomics research* (pp. 119-140). Academic Press.
- Rubio-Aliaga, I. (2012). Model organisms in molecular nutrition research. *Molecular nutrition & food research, 56*(6), 844-85
- Committee for the Purpose of Control and Supervision on Experiments on Animals. (2003). CPCSEA Guidelines for laboratory animal facility. *Indian J. Pharmacol., 35*(4)

Practical
23PS8ZODSEP3

DSE III	Model organisms in biological research

Learning objectives

The practicals are intended to help the learner

- Understand the significance of model organisms in research
- Plan experiments related to model organisms

Learning outcomes

After successful completion of the practical the learner will be able to

- Identify various mutants of drosophila
- Prepare media for drosophila culture
- Describe various laboratory techniques employing model organisms
- Write detailed reports of the various visits

1. Visit to a research lab.
2. Workshop on *Drosophila* culture.
3. Observation of permanent slides of *Drosophila* mutants.
4. Visit to an Animal house.
5. Media and setup preparation for *Drosophila* culture.
6. To estimate LC50 of salt of heavy metal for daphnia

7. Observation of changes in giant Chromosomes of chironomus larvae due to exposure to toxicants.
8. Setting up and maintenance of E.Coli culture
9. Visit the CPCSEA website to understand various application procedures.

8. Teaching learning process

The pedagogic methods adopted, involve direct lectures, tutorial discussions, as well as technology- supported presentations. We believe that education is interactive and all sessions between students and teachers are based upon reciprocity and respect.

1) The lectures (of 1 hr duration) delivered to one whole class at a time systematically deal with the themes of the syllabus. This constitutes the core of the teaching- learning process. The students are provided with bibliographic references and encouraged to go through at least some readings so that they could be more interactive and ask more relevant questions in the class. This also helps obtain knowledge beyond the boundaries of the syllabi.

2) Wherever needed, teachers use audio-video based technology devices (e. g. power point, YouTube videos) to make their presentations more effective. Some courses require that students see a documentary or feature film and course themes are structured so that discussions of these will further nuance the critical engagement of students with ideas introduced in their textual materials.

3) Remedial coaching, bridge courses are adopted to enhance the scope of learning for the learners. Remedial sessions are conducted to offer assistance on certain advanced topics. Bridge courses facilitate the development of a concrete basis for the topics to be learnt in the coming academic year.

9. Assessment Methods

Evaluation Pattern: Theory

- Assessments are divided into two parts: Continuous Internal Evaluation (CIE) and End Semester Examination (ESE).

Each Course 50 M	**Internal-CIE - 20 M**	**External-Sem End - 30 M**
	Seminar 10 M (3 M Viva+ 3 M Presentation Skills+ 4 M PPT and Writeup)	Any 3 out of 4 = 15 M per Module
	Home Assignment 10 M (5 M per Module)	

- The CIE is taken at regular intervals in the form of Seminar presentations, MCQ based tests, Paper Summary writing etc.
- The End Semester Examination shall be conducted by the College at the end of each semester. (30M) Duration: 1 hours

  End Semester Examination Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	5 M x 5 Q = 25 M	3 M x 5 Q = 15 M
2	II	5 M x 5 Q = 25 M	3 M x 5 Q = 15 M

Each question will have six sub questions a, b, c, d, e, f and out of which any three should be answered.

Evaluation pattern: Practical

Each Course 75 M	**Internal-CIE - 25 M**	**External-Sem End - 50M** P1 + P2 = 50 M (25 M + 25 M) P3 +P4 =50 M (25 M + 25 M)
	Test P1 + P2 = 10 M (5 M + 5 M)	P1 - (Journal - 5 M + Viva - 5 M + Experiment 15 M = 25 M)
	Performance Based P1 + P2 =15 M (7M + 8 M)	

- Continuous Assessment for 25 Marks [P1+P2}throughout the entire semester.
- 50 Marks sem end Evaluation as per the following rubrics [25 marks P1+25 marks P2}

Major Core Course	CIE	Experimental Report	Viva	Total
MJ I	15 M	5 M	5 M	25 M
MJ II	15 M	5 M	5 M	25 M

10. Programme and Course Code Format

The course is coded according to following criteria:

1. First two numbers in each course code indicates year of implementation of syllabus (23- year of implementation is 2023-24)
2. Third letter 'P' designates postgraduate
3. Fourth letter 'S' designate Science discipline and the digit followed is for semester number (S1 – 1st Semester)
4. Letter 'ZO' is for Zoology discipline (ZO-Zoology). This forms the programme code 23PSZO. For the further course codes programme code is amended as follows
5. To represent Major Core Course (MJ) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
6. To represent Minor Stream Course (MN) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
7. For Discipline Specific elective course code, (DSE) alphabets followed by a digit (1/2) followed by three letters specifying the course title are used.
8. 'P' followed by digit indicates practical course number. (Practical course number will be added for semesters only where there is more than one course.