



**Anekant Education Society's**

**Tuljaram Chaturchand College**  
**of Arts, Science & Commerce, Baramati**  
**(Autonomous)**

**Four Year B.Sc. Degree Program in Zoology**  
**(Faculty of Science & Technology)**

**CBCS Syllabus**

**F.Y. B.Sc. (Zoology) Semester -II**

**For Department of Zoology**

**Tuljaram Chaturchand College of Arts, Science & Commerce, Baramati**

**Choice Based Credit System Syllabus (2023 Pattern)**

**(As Per NEP 2020)**

**To be implemented from Academic Year 2023-2024**

**Title of the Programme: F. Y. B. Sc. (Zoology)****Preamble**

AES's Tuljaram Chaturchand College has made the decision to change the syllabus of across various faculties from June, 2023 by incorporating the guidelines and provisions outlined in the National Education Policy (NEP), 2020. The NEP envisions making education more holistic and effective and to lay emphasis on the integration of general (academic) education, vocational education and experiential learning. The NEP introduces holistic and multidisciplinary education that would help to develop intellectual, scientific, social, physical, emotional, ethical and moral capacities of the students. The NEP 2020 envisages flexible curricular structures and learning based outcome approach for the development of the students. By establishing a nationally accepted and internationally comparable credit structure and courses framework, the NEP 2020 aims to promote educational excellence, facilitate seamless academic mobility, and enhance the global competitiveness of Indian students. It fosters a system where educational achievements can be recognized and valued not only within the country but also in the international arena, expanding opportunities and opening doors for students to pursue their aspirations on a global scale.

In response to the rapid advancements in science and technology and the evolving approaches in various domains of Zoology and related subjects, the Board of Studies in Zoology at Tuljaram Chaturchand College, Baramati - Pune, has developed the curriculum for the first semester of **F. Y. B. Sc. Zoology**, which goes beyond traditional academic boundaries. The syllabus is aligned with the NEP 2020 guidelines to ensure that students receive an education that prepares them for the challenges and opportunities of the 21st century. This syllabus has been designed under the framework of the Choice Based Credit System (CBCS), taking into consideration the guidelines set forth by the National Education Policy (NEP) 2020, LOCF (UGC), NCrf, NHEQF, Prof. R.D. Kulkarni's Report, Government of Maharashtra's General Resolution dated 20th April and 16th May 2023, and the Circular issued by SPPU, Pune on 31st May 2023.

After completion of B.Sc. in Zoology enrolled students will acquire complete disciplinary knowledge as well as allied branches of Zoology. At the end of programme, students may possess expertise which will provide them competitive advantage in pursuing higher studies within India or abroad; and seek jobs in academia, civil administration, research or industries. Students will be able to define and explain major concepts in the

biological sciences. They will be able to correctly use biological instrumentation and proper laboratory techniques; to communicate biological knowledge in oral and written form; to identify the relationship between structure and function at all levels: molecular, cellular, tissue, organ, system and organismal.

Students should be able to identify, classify and differentiate diverse non-chordates and chordates based on their basic morphological, anatomical biochemical and molecular characters. They will also be able to describe economic, ecological and medical significance of various animals in human life. This programme will create a curiosity and awareness among students to explore the animal diversity and take up wild life photography or wild life exploration as a career option. The procedural knowledge about identification and classification of animals will provide students professional advantages in seeking the jobs in fields of teaching, research and taxonomy in various private & public organizations; including Zoological Survey of India and National Parks/Sanctuaries. Students will be able to apply the scientific methods to answer questions in biology by formulating testable hypotheses, gathering data that address these hypotheses, and analyzing those data to assess the degree to which their scientific work supports their hypotheses. Students will be able to present scientific hypotheses and data both orally and in writing in the conventional formats that are in practice. Students will be able to access the primary literature, identify relevant works for a particular topic, and evaluate the scientific content of these works. Acquired practical skills in biotechnology, biostatistics, bioinformatics and molecular biology can be used to pursue career as a scientist in drug development industry in India or abroad. The students will be acquiring basic experimental skills in various techniques in the fields of genetics; molecular biology; biotechnology; entomology, physiology, qualitative and quantitative microscopy; and analytical biochemistry. These methodologies will provide an extra edge to our students, who wish to undertake higher studies. Students will be able to use the evidence of comparative biology to explain how the theory of evolution offers the only scientific explanation for the unity and diversity of life on earth. They will be able to use specific examples to explicate how descent with modification has shaped animal morphology, physiology, life history, and behaviour. Students will be able to explain how organisms function at the level of the gene, genome, cell, tissue, organ and organ-system. Drawing upon this knowledge, they will be able to give specific examples of the physiological adaptations, development, reproduction and behaviour of different animals. Students will be able to analyse the ecological relationships of life on earth by tracing energy and nutrient flows through the ecosystems. They will be able to establish the relationship between the physical

features of the environment and the structure of populations, communities, and ecosystems. Students undertaking skill enhancement courses like aquaculture, sericulture and apiculture will inculcate skills involved in rearing fish, bees and silk moth which would help them to generate self-employment making them successful entrepreneurs. Acquired skills in diagnostic testing, haematology, histopathology, staining procedures etc. used in clinical and research laboratories will make them eligible to work in diagnostic or research laboratories. B.Sc. Zoology graduates will find opportunities in public services departments, NGOs, environmental agencies, universities, colleges, biotechnological, pharmaceutical, environmental / ecological fields. There are numerous career opportunities for candidates completing their B.Sc, M.Sc and Ph.D. in Zoology in public and private sector. Candidates may find jobs as Animal Behaviourist, Conservationist, Wildlife Biologist, Zoo Curator, Wildlife Educator, Zoology teacher, Forensic experts, Lab technicians, Veterinarians, etc.

Overall, revising the Zoology syllabus in accordance with the NEP 2020 ensures that students receive an education that is relevant, comprehensive, and prepares them to navigate the dynamic and interconnected world of today. It equips them with the knowledge, skills, and competencies needed to contribute meaningfully to society and pursue their academic and professional goals in a rapidly changing global landscape.

## Programme Specific Outcomes (PSOs)

- PSO1. *Disciplinary Knowledge:*** Understand the basic concepts of various branches of Zoology like Cell Biology, Genetics, Taxonomy, Physiology, Biochemistry, Molecular Biology, Embryology, Developmental Biology, Immunology, Ecology and Applied Zoology.
- PSO2. *Critical thinking and problem solving:*** Analyse the relationships of animals with abiotic factors and different biotic factors like plants and microbes. They will be able to interpret the pathogen based upon symptoms of disease.
- PSO3. *Individual and Teamwork:*** Sets up the experiments and performs the same as per laboratory standards in different fields of Zoology like Taxonomy, Physiology, Ecology, Cell biology, Genetics, Applied Zoology, Clinical science, tools and techniques of Zoology, Toxicology, Entomology, Nematology, Sericulture, Biochemistry, Ichthyology, Animal biotechnology, Immunology, Physiology and research methodology.
- PSO4. *Research related skills and scientific temper:*** Propose hypothesis, formulate tests, use various modern instruments for biological analysis, data collection and field surveys and interprets the data and find answers.
- PSO5. *Critical Thinking:*** Recognizes the relationships between structure and functions at different levels of biological organization (e.g., molecules, cells, organs, organisms, populations, and species) for animals.
- PSO6. *Development of Observation Skills:*** Distinguishes different ecosystems (e.g., terrestrial, freshwater, marine) based on biological, chemical, and physical features; Correlates the morphology, physiology, behaviour with the properties of habitat.
- PSO7. *Ethics and Effective Citizenship:*** Contributes the knowledge for sustainable development and nation building.
- PSO8. *Management Skills:*** Exhibits management skills in applied branches of Zoology like Apiculture, Sericulture, Aquaculture and Agriculture.
- PSO9. *Environmental Ethics and Sustainability:*** Explains the broad understanding of ecosystems, biodiversity and their conservation.
- PSO10. *Identification of critical problems and issues:*** Detect the causes and consequences of biodiversity depletion.

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**Board of Studies (BoS) in Zoology**

From 2022-23 to 2024-25

Sr. No.	Name	Designation
1.	<b>Mr. Sandip P. Chordiya</b>	Chairman
2.	<b>Dr. Vitthal B. Nale</b>	Member
3.	<b>Dr. Deepali M. Sangale</b>	Member
4.	<b>Dr. Sunil N. Pokale</b>	Vice-Chancellor Nominee
5.	<b>Dr. Gulab D. Khedkar</b>	Expert from other University
6.	<b>Dr. Sanjay K. Gaikwad</b>	Expert from other University
7.	<b>Dr. Yogesh A. Karpe</b>	Industry Expert
8.	<b>Mr. Kishor U. More</b>	Invitee member
9.	<b>Mr. Mayur S. Shitole</b>	Invitee member
10.	<b>Mr. Bipin B. Jagtap</b>	Meritorious Alumni
11.	<b>Ms. Rutuja R. Chavan</b>	Student Representative
12.	<b>Mr. Subodh M. Nikam</b>	Student Representative
13.	<b>Mr. Shubham R. Ghadage</b>	Student Representative
14.	<b>Ms. Tamanna S. Tamboli</b>	Student Representative

### Credit Distribution Structure for F.Y.B.Sc. -2023-2024 (Zoology)

Level	Semester	Major		Minor	GE/OE	VSC, SEC (VSEC)	AEC, VEC, IKS	OJT, FP, CEP, CC, RP	Cum. Cr./Sem.	Degree/ Cum.Cr.
		Mandatory	Electives							
4.5	<b>I</b>	<b>ZOO-101-MJM:</b> Animal Systematics & Diversity-I  <b>ZOO-102-MJM:</b> Fundamentals of Cell Biology  <b>ZOO-103-MJM:</b> Zoology Practical – I  <b>Credits-2+2+2</b>		--	<b>ZOO-116-OE:</b> <b>Fresh Water Fishery</b> (गोड्या पाण्यातील मत्स्य शेती.)  <b>ZOO-117-OE:</b> <b>Fresh Water Fishery(Practical)</b> (गोड्या पाण्यातील मत्स्यशेती (प्रात्यक्षक) Credit-2+2	<b>ZOO-121-VSC:- Biological Techniques-I</b>  <b>ZOO-126-SEC: Medical Laboratory Technology-I</b>  Credit-2+2	<b>ENG-131-AEC:</b> Functional English-I  <b>ZOO-135-VEC:</b> Environmental Science  <b>ZOO-137-IKS:</b> <b>Animal Diversity &amp; Conservation in Indian Culture</b> Credit-2+2+2	<b>US--CC1:</b> NSS/NCC/Yoga/Cultural Activity/Sports  Credit-2	22	<b>UG Certificate 44</b>
	<b>II</b>	<b>ZOO-151-MJM:</b> Animal Systematics & Diversity-II  <b>ZOO-152-MJM:</b> Genetics  <b>ZOO-153-MJM:</b> Zoology Practical – II <b>Credits-2+2+2</b>		<b>ZOO-161-MN:</b> Apiculture  Credits-2	<b>ZOO-166-OE:</b> <b>Crop pests: Types &amp; management</b> (पकावरील कड: प्रकार व व्यवस्थापन)  <b>ZOO-167-OE:</b> <b>Crop pests: Types &amp; management</b> (पकावरील कड: प्रकार व व्यवस्थापन) (प्रात्यक्षक) Credit-2+2	<b>ZOO-176-SEC: Medical Laboratory Technology-II</b>  <b>ZOO-171-VSC: Biological Techniques-II</b>  Credit-2+2	<b>ENG-181-AEC:</b> English – II  <b>ZOO-185-VEC:</b> Digital and Technological Solutions  Credit-2+2	<b>US--CC2:</b> NSS/NCC/Yoga/Cultural Activity/Sports  Credit-2	22	
	<b>Cum Cr.</b>	<b>12</b>	-	<b>2</b>	<b>8</b>	<b>8</b>	<b>10</b>	<b>4</b>	<b>44</b>	

### Course Structure for F.Y.B.Sc. Zoology (2023 Pattern)

Sem	Course Type	Course Code	Course Name	Theory / Practical	Credits
I	Major Mandatory	ZOO-101-MJM	Animal Systematics & Diversity – I	Theory	02
	Major Mandatory	ZOO-102-MJM	Fundamentals of Cell Biology	Theory	02
	Major Mandatory	ZOO-103-MJM	Zoology Practical – I	Practical	02
	Open Elective (OE)	ZOO-116-OE	Fresh Water Fishery (गोड्या पाण्यातील मत्स्य शेती.)	Theory	02
	Open Elective (OE)	ZOO-117-OE	Fresh Water Fishery (Practical) (गोड्या पाण्यातील मत्स्यशेती (प्रात्य क्षक)	Practical	02
	Vocational Skill Course (VSC)	ZOO-121-VSC	Biological Techniques-I	Theory	02
	Skill Enhancement Course (SEC)	ZOO-126-SEC	Medical Laboratory Technology-I	Practical	02
	Ability Enhancement Course (AEC)	ENG-131-AEC	Functional English-I	Theory	02
	Value Education Course (VEC)	ZOO-135-VEC	Environmental Science	Theory	02
	Indian Knowledge System (IKS)	ZOO-137-IKS	Animal Diversity & Conservation in Indian Culture	Theory	02
	Co-curricular Course (CC)	--	To be selected from the Basket	Theory	02
<b>Total Credits Semester-I</b>					<b>22</b>
II	Major Mandatory	ZOO-151-MJM	Animal Systematics & Diversity – II	Theory	02
	Major Mandatory	ZOO-152-MJM	Genetics	Theory	02
	Major Mandatory	ZOO-153-MJM	Zoology Practical – II	Practical	02
	Minor	ZOO-161-MN	Apiculture	Theory	02
	Open Elective (OE)	ZOO-166-OE	Crop pests: Types & management ( पकावरील कड: प्रकार व व्यवस्थापन)	Theory	02
	Open Elective (OE)	ZOO-167-OE	Crop pests: Types & management ( Practical) ( पकावरील कड: प्रकार व व्यवस्थापन) (प्रात्य क्षक)	Practical	02
	Vocational Skill Course (VSC)	ZOO-171-VSC	Biological Techniques-II	Practical	02
	Skill Enhancement Course (SEC)	ZOO-176-SEC	Medical Laboratory Technology -II	Practical	02
	Ability Enhancement Course (AEC)	ENG-181-AEC	Functional English-II	Theory	02
	Value Education Course (VEC)	ZOO-185-VEC	Digital and Technological Solutions	Theory	02
	Co-curricular Course (CC)	--	To be selected from the Basket	Theory	02
<b>Total Credits Semester-II</b>					<b>22</b>
<b>Cumulative Credits Semester I + Semester II</b>					<b>44</b>



**SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020  
(w. e. f. June, 2023)**

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Major (Mandatory) Theory**

**Course Code: ZOO-151-MJM**

**Course Name: Animal Systematics & Diversity-II**

**Number of Credits: 02**

**Number of Teaching hours: 30**

**Course Objectives:**

- Understand the diversity of animal life and their evolutionary relationships.
- To explore the evolutionary affinities and relationships of Hemichordata with other phyla.
- Describe the characteristics and classification of different subphyla and classes of animals.
- Explain the processes of metamorphosis in Urochordata and Neoteny in Amphibia.
- Analyze the various forms of fish migration and its ecological importance.
- Comprehend the anatomy and physiological systems of frogs, with a focus on *Hoplobatrachus tigerinus*.
- Develop practical skills in the identification and observation of external and internal structures of animals.

**Course Outcomes:**

Student will be able to-

CO 1: classify animals into different subphyla and classes, citing specific examples for each category.

CO 2: recognize the key characteristics of Hemichordata, Urochordata, and Cephalochordata.

CO 3: explain the concept of retrogressive metamorphosis in Urochordata and Neoteny in Amphibia.

CO 4: discuss the significance of migration in fish and its impact on aquatic ecosystems.

CO 5: analyze the anatomy and physiology of the digestive, circulatory, nervous, and reproductive systems in frogs.

CO 6: demonstrate the ability to identify external features and structures of various animals through practical exercises and observations.

CO 7: explore ethical use of animal abilities for environmental sustainability and own economic benefits.

**TOPICS:**

Unit No.	Subunit No.	Details	Teaching Hours
<b>1. General &amp; special characters and classification of following subphyla up to order with one Example</b>	1.1	Hemichordata	<b>07</b>
	1.2	Hemichordata: Affinities.	
	1.3	Urochordata	
	1.4	Urochordata: Retrogressive metamorphosis.	
	1.5	Cephalochordata	
<b>2. General &amp; special characters and classification up to</b>	2.1	Pisces - (Chondrichthyes and Osteichthyes )	<b>05</b>
	2.2	Migration in fish	

<b>order with one example of the following Classes</b>	2.3	Amphibia	
	2.4	Neoteny in Amphibia	
<b>3. Study of Frog (Hoplobatrachus tigrinus)</b>	3.1	Systematic position, Habit and habitat	<b>18</b>
	3.2	External characters and sexual dimorphism	
	3.3	Digestive system, food, feeding and physiology of digestion	
	3.4	Circulatory system: <b>Blood, heart, arterial and venous system</b>	
	3.5	Central Nervous system: <b>Brain and spinal cord</b>	
	3.6	Sense organs- <b>Tympanum, eyes, skin, tongue</b>	
	3.7	Reproductive systems (male & female)	

### REFERENCES

1. Kershaw, D. R. (2012). Animal Diversity. Redwood Burn Ltd., Trowbridge.
2. Nigam, H. C., & Sobti, R. (1995). Functional Organization of Chordates (Part I and II). S. Chand and Co., New Delhi.
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**Course Articulation Matrix of ZOO-151-MJM: Animal Systematics & Diversity-II**  
**Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	3	1	1	1	1	1	1
CO2	3	2	3	1	1	1	1	1	1
CO3	2	2	3	3	1	1	1	1	1
CO4	2	2	2	3	2	1	1	1	1
CO5	2	1	1	2	2	1	1	1	1
CO6	1	1	1	1	2	3	1	1	1
CO7	1	1	1	2	3	1	3	3	3

**PO1: Disciplinary Knowledge**

CO1 aligns with PO1 as it requires comprehensive knowledge of animal classification and the ability to apply this knowledge in a practical context.

**PO1: Disciplinary Knowledge**

CO2 aligns with PO1 as it involves understanding the characteristics of specific animal subphyla, which is a form of disciplinary knowledge.

**PO3: Social Competence**

CO3 aligns with PO2 as it requires students to explain complex concepts, demonstrating critical thinking and problem-solving skills.

**PO4: Research-related skills and Scientific temper**

CO4 relates to PO5 as it requires an understanding of the ecological impact of fish migration, which involves integration of different disciplines.

**PO5: Trans-disciplinary knowledge**

CO5 aligns with PO4 as it involves scientific skills and knowledge application through the analysis of the anatomy and physiology of various systems in frogs.

**PO6: Personal and professional competence**

CO6 aligns with PO6 as it involves practical work and the development of professional skills in animal observation and identification, contributing to personal and professional competence.

**PO7: Effective Citizenship and Ethics:**

CO7 addresses ethical considerations, social concern, and sustainability, aligning with both PO7 and PO8.

**PO8: Environment and Sustainability:**

CO7 This course outcome requires students to consider the environmental impact of using animal abilities for human benefit.

**PO9: Self-directed and Life-long learning:**

CO7 This course outcome requires students to explore new and innovative ways to use animal abilities for environmental sustainability and economic benefit.

**SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020  
(w. e. f. June, 2023)**

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Major (Mandatory) Theory**

**Course Code: ZOO-152-MJM**

**Course Name: Genetics**

**Number of Credits: 02**

**Number of Teaching hours: 30**

**Course Objectives:**

- To introduce students to the basic concepts of classical genetics.
- To provide students with a comprehensive understanding of Mendelian Laws of Inheritance and their practical applications.
- To enable students to learn about different types of gene interaction and their implications.
- To acquaint students with the concept of multiple alleles and polygenic inheritance, and their importance in human genetics.
- To provide students with an overview of chromosome structure, function, and aberrations.
- To familiarize students with the different mechanisms of sex determination and sex-linked inheritance in humans.

**Course Outcomes:**

Student will able to

CO1: define and explain the key concepts in classical genetics and applies Mendelian laws of inheritance to solve problems in genetics.

CO2: understand the different types of gene interaction and their effects on inheritance

CO3: explain the concept of multiple alleles and polygenic inheritance and their implications for human health and disease.

CO4: describe the morphology, composition, and classification of chromosomes.

CO5: identify and explain the different types of chromosomal aberrations and their effects on human development.

CO6: understand the chromosomal theory of sex determination and the different mechanisms of environmental sex determination.

CO7: describe the inheritance of sex-linked traits in humans.

**Topics:**

Unit No.	Subunit No.	Details	Teaching Hours
<b>1. Introduction to Classical Genetics</b>	1.1	Basic concepts in genetics	4
	1.2	Mendelian Laws of Inheritance and their practical applications	
	1.3	Tests of heredity: <b>Test cross &amp; Back cross</b>	
<b>2. Gene</b>	2.1	Concept of gene interaction, co-dominance and	4

<b>Interaction</b>		incomplete dominance	
	2.2	Complementary factors (9:7)	
	2.3	Supplementary factors (9: 3:4)	
	2.4	Inhibitory factors (13:3)	
<b>3. Multiple Alleles and Polygenic Inheritance</b>	3.1	Concept, characteristics and importance of multiple alleles, ABO & Rh-blood group system and its medico-legal importance	5
	3.2	Pleiotropism and sickle cell anaemia	
<b>4. Chromosomes</b>	4.1	Introduction to morphology and composition	10
	4.2	Classification based on the centromeric position	
	4.3	Types of chromosomes (autosomes and sex chromosomes); Lampbrush and polytene chromosome	
	4.4	Chromosomal aberrations: Structural and numerical changes	
	4.5	Study of human karyotype	
	4.6	Syndromes: a) Autosomal-Down's (Mongolism) b) Sex chromosomal abnormalities in human: Klinefelter's and Turner's syndrome	
	4.7	Inborn errors of metabolism: Albinism and Phenylketonuria	
<b>5. Sex determination</b>	5.1	Introduction	5
	5.2	Chromosomal theory of sex determination (XX-XY, ZZ-ZW, XX-XO & Haploid- Diploid method)	
	5.3	Parthenogenesis and Gynandromorphism.	
	5.4	Environmental Sex Determination	
<b>6. Sex linked inheritance in human</b>	6.1	Inheritance of Colour-blindness, Haemophilia and Hypertrichosis	2

### REFERENCES

1. Miadoková, E. (1977). Genetics: Strickberger, MW: Macmillan Publishing Company, Inc., New York, Collier Macmillan Publishers, London, 1976. Pp. 548, Figs. 548, Tabs. 139.
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**Course Articulation Matrix of ZOO-152-MJM: Genetics****Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	3	3	3	2	3	1	1	2
CO2	3	3	3	3	2	2	1	1	2
CO3	3	2	3	2	3	2	1	1	2
CO4	2	2	2	2	2	2	1	1	3
CO5	2	1	1	2	1	1	2	1	2
CO6	1	1	1	1	1	1	2	2	2
CO7	1	1	1	1	3	1	3	3	3

Each course outcome is mapped to one or more program outcomes based on the following criteria:

**Directly related:** The course outcome directly addresses a program outcome.

**Indirectly related:** The course outcome indirectly addresses a program outcome by providing students with the knowledge or skills necessary to achieve a program outcome.

**Supportive:** The course outcome supports students in achieving a program outcome by providing them with opportunities to practice or develop the skills and knowledge necessary to achieve that outcome.

**PO1: Disciplinary Knowledge**

This program outcome requires students to demonstrate a comprehensive knowledge of genetics. All the course outcomes in this course are directly related to the study of genetics.

**PO2: Critical Thinking and Problem Solving**

This program outcome requires students to be able to use critical thinking and problem-solving skills to analyze and interpret complex information. All the course outcomes in this course require students to use these skills to solve genetics problems.

**PO3: Social Competence:**

This program outcome requires students to be able to communicate effectively and work collaboratively with others. All the course outcomes in this course can be achieved through individual and group work, such as completing problem sets, conducting laboratory experiments, and writing research papers.

**PO4: Research-related Skills and Scientific Temper**

This program outcome requires students to be able to design and conduct experiments, interpret results, and establish hypotheses. All the course outcomes in this course provide students with the opportunity to develop these skills.

**PO5: Trans-disciplinary Knowledge**

This program outcome requires students to be able to integrate knowledge from different disciplines. Course Outcome 3 (CO3) requires students to explain the implications of multiple alleles and polygenic inheritance for human health and disease. This requires students to integrate their knowledge of genetics with their knowledge of human physiology and disease. Course Outcome 7 (CO7) requires students to describe the inheritance of sex-linked traits in humans. This requires students to integrate their knowledge of genetics with their knowledge of human reproduction and development.

**PO6: Personal and Professional Competence**

This program outcome requires students to be able to work independently and as part of a team to achieve common goals. All the course outcomes in this course can be achieved through individual and group work, such as completing problem sets, conducting laboratory experiments, and writing research papers.

**PO7: Effective Citizenship and Ethics**

This program outcome requires students to be able to make ethical decisions in a variety of contexts. Course Outcome 7 (CO7) requires students to consider the ethical implications of sex-linked inheritance.

**PO8: Environment and Sustainability**

This program outcome requires students to be able to understand the environmental impact of human activity. Course Outcome 7 (CO7) requires students to consider the implications of sex-linked inheritance for environmental sustainability.

**PO9: Self-directed and Life-long Learning**

This program outcome requires students to be able to learn independently and adapt to new situations. All of the course outcomes in this course require students to be able to learn new information and apply it to solve problems.

## SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020 (w. e. f. June, 2023)

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Major (Mandatory) Practical**

**Course Code: ZOO-153-MJM**

**Course Name: Zoology Practical-II**

**Number of Credits: 02**

**Number of Teaching hours: 60**

### Course Objectives:-

- Vertebrate classification system.
- Morphometric analysis & different types of tail fins of the fishes.
- Culturing of *Drosophila*
- Human genetic traits & human karyotype ABO blood group system
- Basic physiology in vertebrate animal
- To provide students with hands-on experience in the study of chordate animals, including their classification, morphology, anatomy, physiology, and genetics.
- To develop students' critical thinking and problem-solving skills by applying their knowledge of chordate biology to real-world examples.
- To prepare students for further study in chordate biology and related fields.

### Course Outcomes:

Student will able to

CO1: classify chordate animals into the appropriate subphyla and classes, and explain the reasons for their classification.

CO2: identify and describe the key morphological and anatomical features of different chordate animals, including fishes, amphibians, and humans.

CO3: understand the basic physiological processes of chordate animals, such as digestion, circulation, and reproduction.

CO4: apply their knowledge of chordate biology to solve problems related to animal diversity, conservation, and human health.

CO5: conduct basic laboratory experiments in chordate biology, including morphometric analysis, dissection, and karyotyping.

CO6: interpret and analyze scientific data, such as images, graphs, and tables.

CO7: communicate their findings effectively in writing and orally.

Practical No.	Name of the practical	E/D	Teaching Hours
1	To study the classification with reasons of the following: a) Hemichordata- <i>Balanoglossus</i> b) Urochordata- <i>Hardmania</i> c) Cephalochordata- <i>Amphioxus</i> d) Cartilaginous fish- <i>Scoliodon</i> e) Bony fish- Sea horse	(D)	4



2	Study of fish scales and chromatophores.	(E)	4
3	Morphometric study of any freshwater fish: Measurements of total length, standard length, weight and length-weight relationship.	(E)	4
4	Study and demonstration of morphological and anatomical structures of preserved frog specimen a. External characters and sexual dimorphism. b. Digestive system and brain.	(D)	4
5	Study of male & female reproductive system of frog.	(D)	4
6	Study of sense organs in frog	(D)	4
7	Collection of any five <b>chordate</b> animals, photographic images and identification with morphological characters ( <b>Activity based learning</b> )	-	4
8	Study of human genetic disorders (any two) hereditary disorders / inborn errors of metabolism.	(D)	4
9	Profile of any two geneticists ( <b>Activity based learning</b> ).	-	4
10	Study of human blood groups: ABO and Rh- factor.	(E)	4
11	Genetical Problems: Based on monohybrid, dihybrid cross & ABO blood groups.	(E)	4
12	Study of Karyotype: Study of normal human karyotype and one abnormal karyotype (any one of Down's, Klinefelter's or Turner's from metaphase chromosomal spread picture (image based learning).	(E)	4
13	Study of human genetical traits: Tongue rolling, widow's peak, ear lobes, colour blindness and PTC tasters/ non tasters (video based practical).	(D)	4
14	Study of <i>Drosophila</i> : A) Culture of <i>Drosophila</i> B) External characters, sexual dimorphism and life cycle. C) Mutants: Eye and wing mutants (any two of each).	(D)	8
15	A visit to natural habitat for biodiversity study or Study visit to a research institute or a zoo and submission of report is essential.	-	4
<b>D- Demonstration; E- Experiment.</b>			

**Course Articulation Matrix of ZOO-153-MJM: Zoology Practical-II****Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	1	1	1	1	1	2	1
CO2	3	1	1	1	1	1	1	2	1
CO3	3	2	2	2	1	1	1	2	1
CO4	1	3	2	2	2	1	1	1	1
CO5	1	1	2	3	2	1	1	1	2
CO6	1	2	1	3	2	3	1	1	2
CO7	2	2	3	1	3	2	2	3	3

Each course outcome is mapped to one or more program outcomes based on the following criteria:

Directly related: The course outcome directly addresses a program outcome.

Indirectly related: The course outcome indirectly addresses a program outcome by providing students with the knowledge or skills necessary to achieve a program outcome.

Supportive: The course outcome supports students in achieving a program outcome by providing them with opportunities to practice or develop the skills and knowledge necessary to achieve that outcome.

**PO1: Disciplinary Knowledge**

CO1: Classify chordate animals into the appropriate subphyla and classes, and explain the reasons for their classification. This course outcome requires students to demonstrate their understanding of the different subphyla and classes of chordate animals, as well as the key features that distinguish them from each other. This aligns with the program outcome of disciplinary knowledge, which requires students to have a comprehensive understanding of the field of biology.

CO2: Identify and describe the key morphological and anatomical features of different chordate animals, including fishes, amphibians, and humans. This course outcome requires students to demonstrate their understanding of the key morphological and anatomical features of different chordate animals. This aligns with the program outcome of disciplinary knowledge, which requires students to have a comprehensive understanding of the field of biology.

CO3: Understand the basic physiological processes of chordate animals, such as digestion, circulation, and reproduction. This course outcome requires students to demonstrate their understanding of the basic physiological processes of chordate animals. This aligns with the program outcome of disciplinary knowledge, which requires students to have a comprehensive understanding of the field of biology.

**PO2: Critical Thinking and Problem Solving**

CO4: Apply their knowledge of chordate biology to solve problems related to animal diversity, conservation, and human health. This course outcome requires students to apply their knowledge of chordate biology to solve real-world problems. This aligns with the program outcome of critical thinking and problem solving, which requires students to be able to use their knowledge to solve complex problems.

**PO3: Social Competence**

CO7: Communicate their findings effectively in writing and orally. This course outcome requires students to develop their social competence by communicating their findings

effectively in writing and orally. This aligns with the program outcome of social competence, which requires students to be able to communicate and work effectively with others.

#### **PO4: Research-related Skills and Scientific Temper**

CO5: Conduct basic laboratory experiments in chordate biology, including morphometric analysis, dissection, and karyotyping. This course outcome requires students to develop their research-related skills and scientific temper. This aligns with the program outcome of research-related skills and scientific temper, which requires students to be able to design and conduct experiments, interpret and analyze data, and establish hypotheses.

CO6: Interpret and analyze scientific data, such as images, graphs, and tables. This course outcome requires students to develop their research-related skills and scientific temper. This aligns with the program outcome of research-related skills and scientific temper, which requires students to be able to interpret and analyze scientific data.

#### **PO5: Trans-disciplinary Knowledge**

CO7: Explore ethical use of animal abilities for environmental sustainability and own economic benefits. This course outcome requires students to integrate their knowledge of chordate biology with other disciplines, such as ethics and economics. This aligns with the program outcome of trans-disciplinary knowledge, which requires students to be able to integrate knowledge from different disciplines to solve complex problems.

#### **PO6: Personal and Professional Competence**

CO6: Demonstrate the ability to identify external features and structures of various animals through practical exercises and observations. This course outcome requires students to develop their personal and professional competence by demonstrating their ability to identify external features and structures of various animals through practical exercises and observations. This aligns with the program outcome of personal and professional competence, which requires students to be able to work independently and as part of a team to achieve common goals.

#### **PO7: Effective Citizenship and Ethics**

CO7: Explore ethical use of animal abilities for environmental sustainability and own economic benefits. This course outcome requires students to consider the ethical implications of using animal abilities for human benefit. This aligns with the program outcome of effective citizenship and ethics, which requires students to make ethical decisions in a variety of contexts.

#### **PO8: Environment and Sustainability**

CO7: Explore ethical use of animal abilities for environmental sustainability and own economic benefits. This course outcome requires students to consider the environmental impact of using animal abilities for human benefit. This aligns with the program outcome of environment and sustainability, which requires students to understand the environmental impact of human activity and to develop solutions to environmental problems.

#### **PO9: Self-directed and Life-long Learning**

CO7: Explore ethical use of animal abilities for environmental sustainability and own economic benefits. This course outcome requires students to think critically about the ethical implications of using animal abilities for human benefit. This aligns with the program outcome of self-directed and life-long learning, which requires students to be able to learn independently and adapt to new situations.

## SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020 (w. e. f. June, 2023)

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Minor**

**Theory Course Code: ZOO-161-MN**

**Course Name: Apiculture**

**Number of Credits: 02**

**Number of Teaching hours: 30**

### Course Objectives:

- To disseminate information on economic aspects of zoology like apiculture.
- To encourage young learners for self-employment.
- To comprehend the functioning of apiculture industry and its scope in India.
- To study the honey bee species and bee products
- To study the bee keeping industry.
- To encourage adoption of scientific Apiculture by supply of disease free bee colonies, bee health management, quality honey production and other bee products.
- To critically study the life history and rearing of honey bees, bee behavior and communication, bee diseases and enemies.

### Course Outcomes:

**Students will be able to-**

CO 1: Identify different honey bee species.

CO 2: Explain the tools & techniques used in apiculture.

CO 3: Illustrate the diseases of honey bee.

CO 4: Enumerate the methods of collecting, processing, and utilizing bee products, including honey, wax, bee venom, propolis, royal jelly, and pollen grains and thereby understands the economic importance of apiculture.

CO 5: Get acquainted about communication system among the casts in the colony.

CO 6: Understand the seasonal management of bees for bee keeping.

CO 7: Acquire knowledge about structure of bee colony, functions of each casts in colony

### TOPICS:

Unit No.	Subunit No.	Details	Teaching Hours
<b>1. Introduction, habit, habitat and nesting behavior</b>	1.1	An introduction to Apiculture	<b>05</b>
	1.2	Study of habit, habitat and nesting behavior of <i>Apis dorsata</i> , <i>Apis indica</i> , <i>Apis florea</i> <i>Apis mellifera</i>	
<b>2. Honey bee life cycle, behaviour and</b>	2.1	Life cycle of honey bee	<b>06</b>
	2.2	Colony organization and division of	

<b>communication.</b>		labour, Polymorphism	
	2.3	Bee behaviour	
	2.4	Bee communication	
<b>3.Bee keeping equipments</b>	3.1	Bee box (Langstroth type)	<b>04</b>
	3.2	Honey extractor	
	3.3	Smoker	
	3.4	Bee-veil	
	3.5	Gloves	
	3.6	Hive tool	
	3.7	Bee Brush	
<b>4.Bee products (collection methods, composition and uses)</b>	3.8	Comb foundation Sheet	<b>06</b>
	4.1	Honey	
	4.2	Wax	
	4.3	Bee Venom	
	4.4	Propolis	
	4.5	Royal jelly	
<b>5.Diseases and enemies of Bees</b>	4.6	Pollen grains	<b>07</b>
	5.1	Bee diseases – Protozoan, Bacterial, Fungal – with two examples	
	5.2	Bee pests – Wax moth (Greater and Lesser), Wax beetle	
	5.3	Bee Enemies – Bee eater, King crow, Wasp, Lizard, Bear, Man	
<b>6. Bee keeping and seasonal management.</b>			<b>02</b>

### REFERENCES

1. Destructive and useful Insects, their habit and Control, 1973. C.L.Metcalf and W. p. Flint, Tata McGraw Hill Publications, New Dehli.
2. A Text Book Of Entomology, 1974. V.K. Mathur and K.D. Upadhayay, Goel Printing Press, Barani.
3. Imm's Text Book of Entomology, Vol I & II, Richard and Owen.
4. Biology of Insects, 1992. S.C. Saxena. Oxford and IBH Publishing Co., New Dehli. Bombay, Calcutta.
5. Bee and Bee Keeping, 1978, Roger A. Morse, Conell University Press, London.
6. The Behaviour & Social Life of Honey Bees, C.R. Ribbandas, Dover Publication inc. Mandal, GoM, Mumbai.

### Course Articulation Matrix of ZOO-161-MN: Apiculture

**Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	1	2	1	2	1	1	2
CO2	3	1	1	2	1	3	1	1	1
CO3	1	1	1	3	1	1	3	2	1
CO4	1	2	1	1	3	1	2	3	1
CO5	1	3	1	2	1	3	1	1	1
CO6	1	1	1	1	2	3	1	1	3
CO7	3	1	1	1	2	3	2	1	1

Each course outcome is mapped to one or more program outcomes based on the following criteria:

Directly related: The course outcome directly addresses a program outcome.

Indirectly related: The course outcome indirectly addresses a program outcome by providing students with the knowledge or skills necessary to achieve a program outcome.

Supportive: The course outcome supports students in achieving a program outcome by providing them with opportunities to practice or develop the skills and knowledge necessary to achieve that outcome.

### **PO1: Disciplinary Knowledge**

CO 1: Identify different honey bee species. Identifying different honey bee species requires comprehensive knowledge of bee taxonomy and characteristics specific to each species. This aligns with the program outcome of disciplinary knowledge.

CO 2: Explain the tools & techniques used in apiculture. Understanding apiculture tools and techniques is a part of the specific knowledge related to beekeeping, aligning with PO1.

CO 7: Acquire knowledge about the structure of the bee colony, functions of each caste in the colony. Understanding the structure and functions of a bee colony involves disciplinary knowledge specific to apiculture.

### **PO2: Critical Thinking and Problem Solving**

CO 5: Get acquainted with the communication system among the castes in the colony. Understanding the communication system in a bee colony involves critical thinking to comprehend complex social behavior in bee castes.

### **PO3: Social Competence**

CO5: CO 5: Get acquainted with the communication system among the castes in the colony. This knowledge contributes to social competence by understanding the intricate social structure of a bee colony and implementing that principle in human social life.

### **PO4: Research-related Skills and Scientific Temper**

CO 3: Illustrate the diseases of honey bee. Understanding and illustrating bee diseases involves research-related skills and scientific knowledge, as it requires a systematic understanding of diseases affecting honey bees.

### **PO5: Trans-disciplinary Knowledge**

CO 4: Enumerate the methods of collecting, processing, and utilizing bee products, including honey, wax, bee venom, propolis, royal jelly, and pollen grains and thereby understands the economic importance of apiculture. Understanding the economic importance of apiculture involves integrating knowledge about different bee products and their utilization, which is a trans-disciplinary approach.

### **PO6: Personal and Professional Competence**

CO 2: Explain the tools & techniques used in apiculture. Explaining these tools and techniques also demonstrates the development of professional skills and competence, which is in line with PO6.

CO 5: Get acquainted with the communication system among the castes in the colony. This knowledge also contributes to personal and professional competence by understanding the intricate social structure of a bee colony.

CO 6: Understand the seasonal management of bees for beekeeping. Understanding the

seasonal management of bees is a practical aspect of beekeeping and contributes to personal and professional competence.

**PO7: Effective Citizenship and Ethics**

CO 3: Illustrate the diseases of honey bee. Being knowledgeable about bee diseases aligns with demonstrating empathy for bee populations and ethical concerns regarding beekeeping.

**PO8: Environment and Sustainability**

CO 4: Enumerate the methods of collecting, processing, and utilizing bee products, including honey, wax, bee venom, propolis, royal jelly, and pollen grains and thereby understands the economic importance of apiculture. Recognizing the economic value of bee products relates to the sustainability of apiculture and its impact on society and the environment.

**PO9: Self-directed and Life-long Learning**

CO 6: Understand the seasonal management of bees for beekeeping. Seasonal management skills can be applied in various contexts, promoting the ability for self-directed and lifelong learning as beekeeping practices evolve.

**SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020  
(w. e. f. June, 2023)**

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Open Elective (Theory)**

**Course Code: ZOO-166-OE**

**Course Name: Crop pest- types and management (पिकांवरील कीड: प्रकार व व्यवस्थापन)**

**Number of Credits: 02**

**Number of Teaching hours: 30**

**Course Objectives:-**

- शेतातील वेगवेगळ्या कीड नियंत्रणाच्या पद्धती अभ्यासणे.
- तृणधान्य आणि कडधान्यच्या कीड नियंत्रणाच्या पद्धती अभ्यासणे.
- नगदी पिकांच्या कीड नियंत्रणाच्या पद्धती अभ्यासणे.
- साठविलेल्या धान्याला होणारी किडी समजून घेणे.
- आहारामध्ये वापरल्या जाणाऱ्या शाकभाजावरील किडीचा प्रादुर्भाव अभ्यासणे.
- टोळ आणि गवती टोळचा अभ्यास करणे.
- पिकांचे ईतर शत्रूचा अभ्यास करणे.

**Course Outcomes:-**

सदर विषयाचा अभ्यास केल्यावर विद्यार्थी-

CO1: वेगवेगळ्या कीड नियंत्रणाच्या पद्धती आत्मसात करेल.

CO2: कीड नियंत्रणाच्या माध्यमातून तृणधान्य आणि कडधान्याचे उत्पन्नात वाढ करू शकतो.

CO3: नगदी पिकांसाठी कीड नियंत्रणाच्या योग्य पद्धती शेतात अवलंबू शकतो.

CO4: टोळ आणि गवती टोळ मुळे होणारे नुकसान टाळू शकतो.

CO5: शाकभाजांवरील किडीचा प्रादुर्भाव रोखू शकतो.

CO6: साठविलेल्या धान्याला होणारी किडीचा प्रादुर्भाव रोखू शकतो.

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो

**Topics:**

अनु. क्र.	घटक आणि उपघटक	तास
1	शेतामध्ये घेतली जाणारी वेगवेगळी पिके आणि त्यावरील कीड नियंत्रणाच्या पद्धती	1L
	1.1 तृणधान्य: ज्वारी, बाजरी आणि गहू या पिकांवरील कीड नियंत्रण.	3L
	1.2 ऊसावरील कीड नियंत्रण.	3L
	1.3 कडधान्य : तूर, हरभरा आणि वाटाणा या पिकांवरील कीड नियंत्रण.	3L
	1.4. तेलबिया : भुईमूग आणि सुर्यफुल या पिकांवरील कीड नियंत्रण.	2L



	1.5. फळझाडे : आंबा, डाळिंब, पेरू, द्राक्षे आणि नारळ या पिकांवरील कीड नियंत्रण.	5L
2	साठविलेल्या धान्यातील कीड नियंत्रण. : <ul style="list-style-type: none"> <li>• तांदळामधील सोंडा, कोठारातील सोंडा नियंत्रण.</li> <li>• धान्य पोखरणारा भुंगेरा, पिठातील भुंगेरा, पिठातील लांबशीर्ष भुंगेरा, कडधान्याचा भुंगेरा नियंत्रण.</li> <li>• धान्याची साठवण व किडीचे नियंत्रण.</li> </ul>	4L
3	टोळ आणि गवती टोळ: <ul style="list-style-type: none"> <li>• टोळ, टोळधाड आणि जीवनक्रम.</li> <li>• टोळधाडीच्या नियंत्रणाचे उपाय.</li> <li>• गवती टोळ व तिचे नियंत्रण.</li> </ul>	3L
4	वाळवी: 1) वाळवीमुळे होणारे नुकसान आणि त्याचे नियंत्रण.	1L
5	उंदीर: <ul style="list-style-type: none"> <li>• उंदरांचे प्रकार, शेतातील उंदीर.</li> <li>• वास्तव्य आणि सवयी</li> <li>• खाद्य व जीवनक्रम</li> <li>• नुकसान व त्याचे प्रकार.</li> <li>• उंदरांचा बंदोबस्त आणि प्रतिबंधात्मक उपाय.</li> </ul>	3L
6	पिकांचे इतर शत्रू: <ul style="list-style-type: none"> <li>• कृमी</li> <li>• खेकडे</li> <li>• पक्षी</li> <li>• रानडुक्कर</li> <li>• वटवाघुळ</li> <li>• चिंकारा</li> </ul>	2L

## संदर्भसूची:

- भाजीपाला पिकावरील कीड व्यवस्थापन- डॉ. बस्वराज भेदे
- पिकांवरील कीड-कीटक- डॉ. पुरुषोत्तम जोशी
- कीटक निरीक्षकाचा सोबती- डॉ. पुरुषोत्तम जोशी

**Course Articulation Matrix of ZOO-166-OE: Crop pest- types and management (पिकांवरील कीड: प्रकार व व्यवस्थापन) Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	1	1	1	1	1	1	1
CO2	1	3	1	1	1	1	1	1	1
CO3	1	1	3	1	1	1	1	1	1
CO4	1	1	1	3	1	1	1	1	1
CO5	1	1	1	1	3	1	1	1	1
CO6	1	1	1	1	1	3	1	1	1
CO7	1	1	1	1	1	1	3	2	2

Each course outcome is mapped to one or more program outcomes based on the following criteria:

**Directly related:** The course outcome directly addresses a program outcome.

**Indirectly related:** The course outcome indirectly addresses a program outcome by providing students with the knowledge or skills necessary to achieve a program outcome.

**Supportive:** The course outcome supports students in achieving a program outcome by providing them with opportunities to practice or develop the skills and knowledge necessary to achieve that outcome.

**PO1: Disciplinary Knowledge**

CO1: वेगवेगळ्या कीड नियंत्रणाच्या पद्धती आत्मसात करेल. This course outcome requires students to demonstrate their knowledge of the different methods of pest control. This aligns with the program outcome of disciplinary knowledge, which requires students to have a comprehensive understanding of the field of agriculture.

**PO2: Critical Thinking and Problem Solving**

CO2: कीड नियंत्रणाच्या माध्यमातून तृणधान्य आणि कडधान्याचे उत्पन्नात वाढ करू शकतो. This course outcome requires students to apply their knowledge of pest control to improve crop yield. This aligns with the program outcome of critical thinking and problem solving, which requires students to be able to apply their knowledge to solve real-world problems.

**PO3: Social Competence**

CO3: नगदी पिकांसाठी कीड नियंत्रणाच्या योग्य पद्धती शेतात अवलंबू शकतो. This course outcome requires students to be able to apply their knowledge of pest control to specific crops in the field. This aligns with the program outcome of social competence, which requires students to be able to work effectively in a variety of contexts.

**PO4: Research-related Skills and Scientific Temper**

CO4: टोळ आणि गवती टोळ मुळे होणारे नुकसान टाळू शकतो. This course outcome requires students to be able to identify and mitigate the damage caused by specific pests. This aligns with the program outcome of research-related skills and scientific temper, which requires students to be able to conduct research and apply scientific principles to solve real-world problems.

**PO5: Trans-disciplinary Knowledge.**

CO5: शाकभाजांवरील किडीचा प्रादुर्भाव रोखू शकतो. This course outcome requires students to integrate their knowledge of pest control with their knowledge of vegetable production. This aligns with the program outcome of trans-disciplinary knowledge, which requires students to be able to apply their knowledge from different disciplines to solve complex problems.

**PO6: Personal and Professional Competence**

CO6: साठविलेल्या धान्याला होणारी किडीचा प्रादुर्भाव रोखू शकतो. This course outcome requires students to be able to independently apply their knowledge of pest control to protect stored grain. This aligns with the program outcome of personal and professional competence, which requires students to be able to work independently and as part of a team to achieve common goals.

**PO7: Effective Citizenship and Ethics**

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो. This course outcome requires students to consider the ethical implications of using pest control methods to increase crop yield. This aligns with the program outcome of effective citizenship and ethics, which requires students to make ethical decisions in a variety of contexts.

**PO8: Environment and Sustainability**

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो. This CO requires students to consider the environmental impact of pest control. This aligns with the PO of environment and sustainability, which requires students to understand the impact of their actions on the environment.

**PO9: Self-directed and Life-long Learning**

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो. This CO requires students to be able to learn new methods of pest control as they become available. This aligns with the PO of self-directed and life-long learning, which requires students to be able to learn independently throughout their lives.

**SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020  
(w. e. f. June, 2023)**

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Open Elective (Practical)**

**Course Code: ZOO-167-OE**

**Course Name: Crop pest- types and management (पिकांवरील कीड: प्रकार व व्यवस्थापन)**

**(प्रात्यक्षिक)**

**Number of Credits: 02**

**Number of Teaching hours: 60**

**Course Objectives:-**

- शेतातील कीड नियंत्रणाच्या पद्धती समजून घेणे.
- फळझाडांवरील कीड नियंत्रणाच्या पद्धती अभ्यासणे.
- तृणधान्य आणि कडधान्याना होणारी कीड अभ्यासणे.
- ऊस या प्रमुख नगदी पिकांच्या कीड नियंत्रणाच्या पद्धती अभ्यासणे.
- घरामध्ये साठविलेल्या धान्याला होणारी किडी समजून घेणे.
- आहारामध्ये वापरल्या भाजांवरील किडीचा प्रादुर्भाव रोखणे.
- शेतातील वेगवेगळ्या कीड प्रकारांची माहिती करून घेणे.

**Course Outcomes:-**

सदर विषयाचा अभ्यास केल्यावर विद्यार्थी-

CO1: वेगवेगळ्या कीड नियंत्रणाच्या पद्धतीचे अवलोकन करेल.

CO2: कीड नियंत्रणाच्या माध्यमातून फळझाडांचे संगोपन आणि उत्पन्न घेऊ शकतो.

CO3: तृणधान्य आणि कडधान्याचे संगोपन आणि उत्पन्न घेऊ शकतो.

CO4: ऊस या प्रमुख नगदी पिकांच्या कीड नियंत्रणाच्या पद्धती शेतात अवलंबू शकतो.

CO5: घरामध्ये साठविलेल्या धान्याला होणारी किडी रोखू शकतो.

CO6: आहारामध्ये वापरल्या भाजांवरील किडीचा प्रादुर्भाव रोखून जास्त उत्पन्न घेऊ शकतो.

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळऊ शकतो.

प्रात्यक्षिके:

अनुक्रमांक	प्रात्यक्षिकाचे नाव	E/D	Teaching hours
1	शेतातील कीड नियंत्रणाच्या वेगवेगळ्या पद्धती अभ्यासणे.	D	04
2	तृणधान्यावर होणारे किडीचे रोग, त्याची लक्षणे आणि उपायांचा अभ्यास करणे.	D	08
3	कडधान्यावर होणारे किडीचे रोग, त्याची लक्षणे आणि उपायांचा अभ्यास करणे.	D	08

4	फळझाडांवर होणारे किडीचे रोग आणि त्यावरील उपायांचा अभ्यास करणे.	D	08
5	शाकभाज्यांवर होणारे किडीचे रोग आणि त्यावरील उपायांचा अभ्यास करणे.	D	04
6	साठविलेल्या धान्यातील किडी आणि त्यांच्या नियंत्रणाचे उपाय अभ्यासने.	D	08
7	टोळधाडमुळे होणारे नुकसान आणि नियंत्रणाचे उपाय अभ्यासने.	D	04
8	शेतातील उंदीरांमुळे होणारे नुकसान आणि त्याचे प्रतिबंधात्मक उपाय अभ्यासने.	D	04
9	पिकांचे इतर शत्रू त्यांच्यामुळे होणारे नुकसान आणि त्यावरील उपाययोजना अभ्यासने.	D	04
10	तुमच्या घराच्या आसपासच्या शेतातील वेगवेगळ्या पिकांवर होणाऱ्या किडीचा आणि त्यावर केल्या जाणाऱ्या उपायांचा सर्वे करा आणि त्याचा एक अहवाल तयार करा.	E	08

## संदर्भसूची:

- भाजीपाला पिकावरील कीड व्यवस्थापन- डॉ. बस्वराज भेदे
- पिकांवरील कीड-कीटक- डॉ. पुरुषोत्तम जोशी
- कीटक निरीक्षकाचा सोबती- डॉ. पुरुषोत्तम जोशी

**Course Articulation Matrix of ZOO-167-OE: Crop pest- types and management (पिकांवरील कीड : प्रकार व व्यवस्थापन) Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	1	1	1	1	1	1	1
CO2	1	3	1	1	1	1	1	1	1
CO3	2	1	3	1	1	1	1	1	1
CO4	2	1	1	3	1	1	1	1	1
CO5	2	1	1	1	3	1	1	1	1
CO6	2	1	1	1	1	3	1	1	1
CO7	1	2	1	1	1	1	3	2	2

Each course outcome is mapped to one or more program outcomes based on the following criteria:

Directly related: The course outcome directly addresses a program outcome.

Indirectly related: The course outcome indirectly addresses a program outcome by providing students with the knowledge or skills necessary to achieve a program outcome.

Supportive: The course outcome supports students in achieving a program outcome by providing them with opportunities to practice or develop the skills and knowledge necessary to achieve that outcome.

**PO1: Disciplinary Knowledge**

CO1: वेगवेगळ्या कीड नियंत्रणाच्या पद्धती आत्मसात करेल. This course outcome requires students to demonstrate their knowledge of the different methods of pest control. This aligns with the program outcome of disciplinary knowledge, which requires students to have a comprehensive understanding of the field of agriculture.

**PO2: Critical Thinking and Problem Solving**

CO2: कीड नियंत्रणाच्या माध्यमातून फळझाडांचे संगोपन आणि उत्पन्न घेऊ शकतो. This course outcome requires students to apply their knowledge of pest control to improve crop yield. This aligns with the program outcome of critical thinking and problem solving, which requires students to be able to apply their knowledge to solve real-world problems.

**PO3: Social Competence**

CO3: तृणधान्य आणि कडधान्याचे संगोपन आणि उत्पन्न घेऊ शकतो. This course outcome requires students to be able to apply their knowledge of pest control to specific crops in the field. This aligns with the program outcome of social competence, which requires students to be able to work effectively in a variety of contexts.

**PO4: Research-related Skills and Scientific Temper**

CO4: ऊस या प्रमुख नगदी पिकांच्या कीड नियंत्रणाच्या पद्धती शेतात अवलंबू शकतो. This course outcome requires students to be able to identify and mitigate the damage caused by specific pests. This aligns with the program outcome of research-related skills and scientific temper, which requires students to be able to conduct research and apply scientific principles to solve real-world problems.

**PO5: Trans-disciplinary Knowledge.**

CO5: घरामध्ये साठविलेल्या धान्याला होणारी किड रोखू शकतो. This course outcome requires students to integrate their knowledge of pest control with their knowledge of vegetable production. This aligns with the program outcome of trans-disciplinary knowledge, which requires students to be able to apply their knowledge from different disciplines to solve complex problems.

**PO6: Personal and Professional Competence**

CO6: आहारामध्ये वापरल्या भाजांवरील किडीचा प्रादुर्भाव रोखून जास्त उत्पन्न घेऊ शकतो. This course outcome requires students to be able to independently apply their knowledge of pest control to protect stored grain. This aligns with the program outcome of personal and professional competence, which requires students to be able to work independently and as part of a team to achieve common goals.

**PO7: Effective Citizenship and Ethics**

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो. This course outcome requires students to consider the ethical implications of using pest control methods to

increase crop yield. This aligns with the program outcome of effective citizenship and ethics, which requires students to make ethical decisions in a variety of contexts.

**PO8: Environment and Sustainability**

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो. This CO requires students to consider the environmental impact of pest control. This aligns with the PO of environment and sustainability, which requires students to understand the impact of their actions on the environment.

**PO9: Self-directed and Life-long Learning**

CO7: पिकांचे कीडनियंत्रण करून जास्तीत जास्त उत्पन्न मिळवू शकतो. This CO requires students to be able to learn new methods of pest control as they become available. This aligns with the PO of self-directed and life-long learning, which requires students to be able to learn independently throughout their lives.

## SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020 (w. e. f. June, 2023)

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Vocational Skill Courses (Practical)**

**Course Code: ZOO-171-VSC**

**Course Name: Biological Techniques-II**

**Number of Credits: 02**

**Number of Teaching hours: 60**

### Course Objectives: -

- Understand and apply Good Laboratory Practices (GLP) to ensure safety, accuracy, and reliability in laboratory work.
- Develop the skills necessary for laboratory sterilization procedures to maintain aseptic conditions.
- Gain knowledge of basic laboratory tools and glassware and learn to select and use them appropriately.
- Demonstrate proficiency in the sterilization of laboratory glassware and equipment to prevent contamination.
- Acquire the ability to prepare normal (N) solutions with precise concentrations for various laboratory applications.
- Master the techniques for preparing molar (M) solutions to work with different chemicals effectively.
- Learn to prepare and work with percent solutions for specific laboratory experiments.

### Course Outcomes: -

Student will able to:

- CO1: Apply Good Laboratory Practices (GLP) consistently to ensure safety, precision, and reliability in laboratory work.
- CO2: Demonstrate proficiency in laboratory sterilization techniques to maintain sterile conditions and minimize contamination risks.
- CO3: Identify, select, and effectively utilize basic laboratory tools and glassware, adhering to best practices for their care and maintenance.
- CO4: Successfully sterilize laboratory glassware and equipment, creating a contamination-free environment for experiments.
- CO5: Prepare and work with normal (N) and molar (M) solutions, accurately calculating concentrations and volumes for specific applications.
- CO6: Create and utilize percent solutions, showing a sound understanding of their preparation and application in laboratory experiments.
- CO7: Perform serial dilution methods and conduct acid-base titrations with precision, achieving accurate results in chemical analyses.

Practical No	Title of practical	E/D	Teaching Hours
1.	Good Laboratory Practices (GLP)	D	04
2	To perform laboratory sterilization	D	04
3.	To study the basic tools and glassware's of laboratory	D	04



4.	Sterilization of laboratory glassware and equipment	D	08
5.	Preparation of normal (N) solution	E	04
6.	Preparation of molar (M) solution	E	04
7.	Preparation of percent solution	E	04
8.	Study of serial dilution method	E	04
9.	Preparation of PPM and PPB solutions	E	04
10.	Acid-base titration	E	04
11.	To study the camera lucida	D	04
12.	To study the working mechanism of laminar air flow	D	04
13.	To Study the principal and working of pH meter	E	04
14.	To Study the principal and working of Centrifugation	D	04
15.	To Study the principal and working of Colorimeter	E	04
<b>D- Demonstration; E- Experiment.</b>			

#### References:

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2. Christopher.F Forster, D.A. John Wase, (1987) Environmental Biotechnology, Ellis Harwood.
3. Arms, K. (1990) Environmental Science, Saunders College Publishing
4. Cheesbrough, M. 1998. District Laboratory Practice in Tropical Countries. Part I. Cambridge University Press, UK.
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6. Cappuccino, J.G. and Sherman, N. (1996) Microbiology a Laboratory Manual. The Benjamin Cummings Publishing Co. Inc., San Francisco.
7. Dubey, R.C. and Maheshwari, D.K (2002) Practical Microbiology S.Chand & Company Ltd.
8. Principles and Techniques of Biochemistry and Molecular Biology, 6th edition (2008), Keith Wilson and John Walker, Publisher–Cambridge University Press.

#### **Course Articulation Matrix of ZOO-171-VSC: Biological Techniques-II** **Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	1	2	2	1	1	1	1	1
CO2	2	3	1	2	1	1	1	1	1
CO3	2	1	3	1	1	1	1	2	1
CO4	2	1	1	3	1	1	1	2	1
CO5	2	1	1	2	3	1	2	1	2
CO6	2	1	1	2	1	3	2	1	1
CO7	2	2	1	2	2	1	3	3	3

Each course outcome is mapped to one or more program outcomes based on the following criteria:

Directly related: The course outcome directly addresses a program outcome.

Indirectly related: The course outcome indirectly addresses a program outcome by providing students with the knowledge or skills necessary to achieve a program outcome.

Supportive: The course outcome supports students in achieving a program outcome by providing them with opportunities to practice or develop the skills and knowledge necessary to achieve that outcome.

**PO1: Disciplinary Knowledge**

All of the COs in this example require students to demonstrate their knowledge of laboratory practices and techniques. For example, CO1 requires students to apply Good Laboratory Practices (GLP), CO2 requires students to demonstrate proficiency in laboratory sterilization techniques, and CO3 requires students to identify, select, and effectively utilize basic laboratory tools and glassware.

**PO2: Critical Thinking and Problem Solving**

All of the COs in this example require students to think critically and solve problems. For example, CO1 requires students to apply GLP to ensure the safety, precision, and reliability of their work, CO2 requires students to select the appropriate sterilization technique for a given situation, and CO7 requires students to troubleshoot problems that may arise during serial dilutions or acid-base titrations.

**PO3: Social Competence**

CO1 requires students to apply GLP, which includes best practices for teamwork and communication. CO3 requires students to identify, select, and effectively utilize basic laboratory tools and glassware, which requires them to be able to communicate effectively with other laboratory workers.

**PO4: Research-related skills and Scientific temper**

All of the COs in this example require students to develop research-related skills and scientific temper. For example, CO1 requires students to apply GLP, which is essential for conducting rigorous scientific research. CO2 requires students to demonstrate proficiency in laboratory sterilization techniques, which is essential for preventing contamination and producing reliable results. CO4 requires students to successfully sterilize laboratory glassware and equipment, which is essential for creating a contamination-free environment for experiments. CO5 requires students to prepare and work with normal (N) and molar (M) solutions accurately, which is essential for conducting a variety of chemical calculations and experiments. CO6 requires students to create and utilize percent solutions accurately, which is essential for conducting a variety of chemical and biological experiments. CO7 requires students to perform serial dilution methods and conduct acid-base titrations with precision, which is essential for analyzing solutions and generating accurate data.

**PO5: Trans-disciplinary knowledge**

CO5 requires students to prepare and work with normal (N) and molar (M) solutions accurately, which is essential for conducting a variety of chemical calculations and experiments.

**PO6: Personal and professional competence**

CO6 requires students to create and utilize percent solutions accurately, which is essential for conducting a variety of chemical and biological experiments.

**PO7: Effective Citizenship and Ethics**

CO7 requires students to perform serial dilution methods and conduct acid-base titrations with precision, which is essential for analyzing solutions and generating accurate data. Serial dilution methods and acid-base titrations are two important techniques that are used in a variety of chemical and biological experiments. By mastering these techniques, students are able to develop their skills in independent learning and to prepare themselves for a career in science.

**PO8: Environment and Sustainability**

CO1: Apply Good Laboratory Practices (GLP) consistently to ensure safety, precision, and reliability in laboratory work. GLP is a set of principles and practices that ensure the quality and

integrity of nonclinical laboratory studies. By following GLP, scientists can conduct their work in a safe and ethical manner, and to produce reliable data that can be used to improve public health and safety.

CO2: Demonstrate proficiency in laboratory sterilization techniques to maintain sterile conditions and minimize contamination risks. Sterilization is a critical process for preventing contamination in the laboratory. By sterilizing their equipment and glassware, scientists are able to protect the environment from harmful microorganisms and to ensure that their experiments are conducted in a controlled environment.

**PO9: Self-directed and Life-long learning**

CO7 requires students to perform serial dilution methods and conduct acid-base titrations with precision, which is essential for analyzing solutions and generating accurate data. Serial dilution methods and acid-base titrations are two important techniques that are used in a variety of chemical and biological experiments. By mastering these techniques, students can develop their skills in independent learning and to prepare themselves for a career in science.

## SYLLABUS (CBCS) FOR F. Y. B. Sc. ZOOLOGY as per NEP 2020 (w. e. f. June, 2023)

**Name of the Program: B.Sc. Zoology**

**Program Code: ZOO**

**Class: F.Y. B.Sc.**

**Semester: II**

**Course Type: Skill Enhancement Course Practical**

**Course Code: ZOO-176-SEC**

**Course Name: Medical Laboratory Techniques-II**

**Number of Credits: 02**

**Number of Teaching hours: 60**

### Course Outcomes

- To introduce students to the essential equipment and techniques used in hematology laboratories and to provide hands-on experience in the preparation of different staining solutions and the observation of blood smears.
- To develop practical skills in estimating blood normal and abnormal concentrations of sugar, cholesterol, uric acid, and creatinine.
- To familiarize students with the morphology of red blood cells, their osmotic fragility and characteristics of common hematological disorders.
- To educate students about the anticoagulants commonly used in hematology.
- To instruct students in the technique of determining packed cell volume (PCV) using Wintrobe's method.
- To teach the principles and methods for determining erythrocyte sedimentation rate (ESR).
- To enable students to perform a comprehensive analysis of urine samples and identifies normal and abnormal constituents.

### Course Outcomes

**After completion of this course, student will be able to**

CO 1: operate hematology laboratory equipment and prepare staining solutions for blood smears effectively.

CO 2: accurately estimate blood concentrations of sugar, cholesterol, uric acid, and creatinine, distinguishing between normal and abnormal levels.

CO 3: recognize red blood cell morphology, assess osmotic fragility, and identify common hematological disorders.

CO 4: explain the use and impact of common anticoagulants in hematology.

CO 5: proficiently determine packed cell volume (PCV) using Wintrobe's method.

CO 6: understand and execute the principles and methods for erythrocyte sedimentation rate (ESR) determination.

CO 7: perform a comprehensive analysis of urine samples, precisely identifying normal and abnormal constituents.

Practical No	Title of practical	E/D	Teaching Hours
1.	Demonstration of haematology equipment	E	04
2	Preparation of Leishman, Acetocarmine & Giemsa stain.	E	04
3.	Preparation of haemin crystals using human blood.	E	04
4.	Estimation of blood sugar by GOD-POD method	E	04

5.	Estimation of serum cholesterol	D	08
6.	Estimation of serum uric acid	E	04
7.	Estimation creatinine in serum	E	04
8.	Study of normal and abnormal constituents of blood	E	04
9.	Morphology of Red Blood Cells	E	04
10.	Osmotic fragility test of RBCs	E	04
11.	Demonstration of slides of various disorders of anaemia and leukemia	D	04
12.	Study of anticoagulants used in Haematology	E	08
13.	Determination of Erythrocyte sedimentation rate by Wintrobe's method	D	04
14.	Urine analysis – normal & abnormal constituents of urine.	D	04
15.	Determination of PCV by Wintrobe's method	E	04
<b>D- Demonstration; E- Experiment.</b>			

**Course Articulation Matrix of ZOO-176-SEC: Medical Laboratory Technology-II**  
**Weightage: 1: Partially related, 2: Moderately related, 3: Strongly related**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9
CO1	3	2	1	1	1	1	1	1	2
CO2	1	3	2	1	2	1	1	2	1
CO3	2	3	2	3	2	1	1	1	1
CO4	3	2	1	1	3	1	1	1	1
CO5	1	1	2	2	1	1	1	3	1
CO6	3	1	1	1	1	1	1	1	1
CO7	1	2	2	2	1	2	1	3	1

**PO1: Disciplinary Knowledge**

CO1 directly mapped to PO1 because they require students to demonstrate knowledge of the disciplinary concepts and skills relevant to medical laboratory technology. For example, CO1 requires students to operate hematology laboratory equipment and prepare staining solutions for blood smears effectively, which demonstrates their knowledge of the principles and practices of hematology.

**PO2: Critical Thinking and Problem Solving**

All of the COs are also directly mapped to PO2 because they require students to apply critical thinking and problem-solving skills to real-world scenarios in the field of medical laboratory technology. For example, CO2 requires students to accurately estimate blood concentrations of sugar, cholesterol, uric acid, and creatinine, distinguishing between normal and abnormal levels. This requires students to be able to analyze the data and make sound judgments about the patient's health status.

**PO3: Social Competence**

All of the COs are also directly mapped to PO3 because they require students to interact with others in a professional and effective manner. For example, CO7 requires students to perform a comprehensive analysis of urine samples, precisely identifying normal and abnormal constituents. This may involve communicating the results of the analysis to other healthcare

professionals, such as doctors and nurses.

#### **PO4: Research-related skills and Scientific temper**

All of the COs are also directly mapped to PO4 because they require students to apply the principles of scientific research to their work. For example, CO3 requires students to recognize red blood cell morphology, assess osmotic fragility, and identify common hematological disorders. This requires students to be able to understand and interpret scientific data.

#### **PO5: Trans-disciplinary knowledge**

All of the COs are also directly mapped to PO5 because they require students to apply knowledge from different disciplines to solve problems in the field of medical laboratory technology. For example, CO4 requires students to explain the use and impact of common anticoagulants in hematology. This requires students to have knowledge of both hematology and chemistry.

#### **PO6: Personal and professional competence**

All of the COs are also directly mapped to PO6 because they require students to demonstrate the personal and professional skills that are essential for success in the field of medical laboratory technology. For example, CO5 requires students to proficiently determine packed cell volume (PCV) using Wintrobe's method. This requires students to be able to follow instructions accurately and precisely.

#### **PO7: Effective Citizenship and Ethics**

All of the COs are also directly mapped to PO7 because they require students to uphold the ethical standards of the medical laboratory profession. For example, CO6 requires students to understand and execute the principles and methods for erythrocyte sedimentation rate (ESR) determination. This requires students to be aware of the potential risks and benefits of the procedure and to obtain the patient's consent before performing it.

#### **PO8: Environment and Sustainability**

All of the COs are also directly mapped to PO8 because they require students to be aware of the environmental and sustainability implications of their work. For example, CO7 requires students to perform a comprehensive analysis of urine samples, precisely identifying normal and abnormal constituents. This may involve using hazardous chemicals, so students need to be aware of the proper safety procedures and how to dispose of waste safely.

#### **PO9: Self-directed and Life-long learning**

All of the COs are also directly mapped to PO9 because they require students to develop the skills necessary for self-directed and lifelong learning. For example, CO1 requires students to operate hematology laboratory equipment and prepare staining solutions for blood smears effectively. This requires students to be able to read and understand technical instructions and to learn new procedures as needed.