

University of Mumbai



No. UG/20 of 2020-21

CIRCULAR:-

Attention of the Principals of the Affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Science & Technology Faculty is invited to the syllabus uploaded Academic Authority Unit which was accepted by the Academic Council at its meeting held on 27th February, 2013 - vide item No. 4.39 relating to the revised syllabus as per the (CBSGS) of M.Sc. in Course Zoology- Biotechnology – Oceanography and Fishery Science (Sem. III & IV).

They are hereby informed that the recommendations made by the Board of Studies in Zoology at its meeting held on 23rd March, 2020 and subsequently made by the Board of Deans at its meeting held on 20th July, 2020 vide item No. 50 have been accepted by the Academic Council at its meeting held on 23rd July, 2020 vide item No. 4.102 and that in accordance therewith, the revised syllabus as per the (CBCS) of M.Sc. Part-II (Sem. III & IV) in Zoology with specializations viz Animal Physiology, Entomology, Endocrinology and Reproductive Physiology, Environmental Science, Oceanography and Fishery has been brought into force with effect from the academic year 2020-21 accordingly. (The same is available on the University's website www.mu.ac.in).

MUMBAI – 400 032
(1st November, 2020
To


(Dr. Vinod Patil)
I/c REGISTRAR

The Principals of the affiliated Colleges, the Head University Departments and Directors of the recognized Institutions in Science & Technology Faculty. (Circular No. UG/334 of 2017-18 dated 9th January, 2018.)

A.C/4.102/23/07/2020

No. UG/ 20 -A of 2020-21

MUMBAI-400 032

11th November, 2020

Copy forwarded with Compliments for information to:-

- 1) The Dean, Faculty of Science & Technology,
- 2) The Chairman, Board of Studies in Zoology,
- 3) The Director, Board of Examinations and Evaluation,
- 4) The Director, Board of Students Development,
- 5) The Co-ordinator, University Computerization Centre,


(Dr. Vinod Patil)
I/c REGISTRAR

Copy to :-

- 1. The Director of Board of Student Development.,**
- 2. The Deputy Registrar (Eligibility and Migration Section)**
- 3. The Director of Students Welfare,**
- 4. The Executive Secretary to the to the Vice-Chancellor,**
- 5. The Pro-Vice-Chancellor**
- 6. The Registrar and**
- 7 The Assistant Registrar, Administrative sub-centers, Ratnagiri, Thane & Kalyan, for information.**

- 1. The Director of Board of Examinations and Evaluation**
- 2. The Finance and Accounts Officers**
- 3. Record Section**
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- 5. The Deputy Registrar, Enrolment, Eligibility and Migration Section**
- 6. The Deputy Registrar (Accounts Section), Vidyanagari**
- 7. The Deputy Registrar, Affiliation Section**
- 8. The Professor-cum- Director, Institute of Distance and Open Learning Education,**
- 9. The Director University Computer Center (IDE Building), Vidyanagari,**
- 10. The Deputy Registrar (Special Cell),**
- 11. The Deputy Registrar, (PRO)**
- 12. The Deputy Registrar, Academic Authorities Unit (1 copies) and**
- 13. The Assistant Registrar, Executive Authorities Unit**

They are requested to treat this as action taken report on the concerned resolution adopted by the Academic Council referred to in the above circular and that on separate Action Taken Report will be sent in this connection.

- 1. The Assistant Registrar Constituent Colleges Unit**
- 2. BUCTU**
- 3. The Deputy Accountant, Unit V**
- 4. The In-charge Director, Centralize Computing Facility**
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- 8. The Superintendent, Post-Graduate Section**
- 9. The Superintendent, Thesis Section**

for information.

UNIVERSITY OF MUMBAI



Program: M.Sc.

Course: Zoology **(Animal Physiology)**

Syllabus for Semester III & IV

(Choice Based Credit System
with effect from the academic year 2020-21)

M.Sc. Part II (Semester III and Semester IV): Zoology (Animal Physiology)
Syllabus Committee Members

Dr. Nisar Shaikh Chairman, G. M. Momin Women's College, Bhiwandi Dist. Thane, Maharashtra	Dr. Vasanti Katchi Mentor, Former Board of Chairperson in Zoology, University of Mumbai, Mumbai
Dr. Smita Durve Mentor, Former Board of Chairperson in Zoology, University of Mumbai, Mumbai	Dr. Kalpana Pai Mentor, Centre of Advanced Study, Department of Zoology, Savitribai Phule Pune University, Ganeshkhind, Pune – 411007
Dr. G. Gyananath Mentor, Former Director, School of Life Sciences, SRTM University, Nanded.	Dr. Arthur Frank Mentor, Professor and Chair Emeritus, Department of Environmental and Occupational health Dornsife School of Public Health, Drexel University, Philadelphia, PA, USA.
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CONTENTS

- 1. Preface**
- 2. Preamble**
- 3. Pedagogy**
- 4. Tables of Courses, Topics, Credits and Workload**
- 5. Theory Syllabus for Semester III
(Course codes: PSZOPHY301 – PSZOPHY304)**
- 6. Practical Syllabus for Semester III
(Course codes: PSZOPHY3P1 – PSZOPHY3P4)**
- 7. Theory Syllabus for Semester IV
(Course codes: PSZOPHY401 – PSZOPHY404)**
- 8. Practical Syllabus for Semester IV
(Course codes: PSZOPHY4P1 – PSZOPHY4P4)**
- 9. References (Semester III and Semester IV)**
- 10. Marking Scheme of Examination (Theory and Practical)**
- 11. Skeleton Practical Papers: Semester III and Semester IV**

PREFACE

The main objective of reconstructing the Post Graduate syllabus of Zoology for Semester III and Semester IV is to provide global level advanced and skill oriented deep knowledge to the stakeholders which is currently needed for their survival. The current research and teaching in Zoology includes diverse aspects with a balance of organismic and reductionist biology. It offers teaching and research programs in the diverse areas, such as, Animal Physiology, Entomology, Fish Biology, Immunology, Developmental Biology, Cell Signaling, Cell Biology, Radiation Biology, Reproductive Biology, Endocrinology, Genomics, Metagenomic, Cancer Biology, etc. Our vision is to provide Global Knowledge in education, training & research in the field of Zoology where teaching and research encrust detailed understanding from microbes to human. The broad skills and deeper knowledge in the field would make them highly successful and excellent researcher in advanced areas of research in the Biological sciences.

Therefore, the Board of Studies in Zoology aims to impart holistic understanding of Zoology by “redefining Zoology” to students of every age so that they develop interest in Science. It also aims to develop teaching and research programs that have relevance to society and employability. The M.Sc. program is being revised under CBCS scheme of UGC to meet the expectations of students.

To keep all of the above factors in mind, this syllabus was developed by the curriculum committee of Mentors, subject experts from other Universities and dedicated teachers. Their major role was to abridge, grow, augment and give a forward bearing to Zoology taught in undergraduate curriculum, with projections to future requirements. They have successfully completed this colossal task. I congratulate them.

Dr. Deelip L. Bharmal
Chairman Board of Studies in Zoology University of Mumbai

PREAMBLE

I am extremely happy to present this new syllabus of Semester III and Semester IV to the teachers and students of Post Graduate Course in Zoology of the specializations, Oceanography and Fishery Technology, Entomology, Endocrinology, Animal Physiology and Environmental Science. While constructing the syllabus, the relevant inputs have been considered from Mentors, subject experts from various fields of other Universities, teachers and stakeholders to make it more effective.

An attempt has been made to make post graduate courses competitive and on par with global standards, as per the directives of University Grant Commission for the implementation of choice based credit system. Hence as per the guideline of UGC the present syllabus is made more interesting with new, innovative topics as per need of the current situation of the world and stakeholders.

The M.Sc. Zoology program provides an appropriate blend of classical and applied aspects of the subject. This newly designed curriculum will allow students to acquire skills in handling scientific instruments planning and performing in the laboratory and exercising critical judgment, independent thinking and problem solving skills.

The utmost care has been taken to declare the final syllabus well in advance to enable the teachers to make preparations before commencement of the academic year and facilitating students to execute their right to know the details before admissions.

The draft of Syllabus was approved in meeting of the Board of Studies in Zoology held on 10th March 2020, and it was unanimously resolved to implement the revised syllabus of Zoology at M.Sc. Semester-III and IV and make it effective from the Academic Year 2020-2021 after approval from concerned authorities of the University.

The success of this revamped syllabus will depend totally on the enthusiasm and interest shown by the stakeholders.

Dr. Nisar Shaikh
Chairman, M.Sc. Part II
Syllabus Committee

PEDAGOGY

PSZOPHY301 deals with '**Systems' Physiology (Invertebrates) I**'. Any life process could be better understood, if the concept of cell physiology is clear, hence the course starts with the topic on cell physiology followed by physiological processes like Nutrition, Respiration, Circulation and Excretion with respect to invertebrates. Use of animated videos (ICT) will be a good help for the learner in understanding the concepts of membrane physiology. The students will get a clear insight and understand these topics with the help of lectures, demonstrations as well as observation of permanent slides or specimens and comparing the structures with that of the function.

PSZOPHY302 covers topics with respect to '**Systems' Physiology (Vertebrates) II**'. Life processes like Nutrition, Respiration, Circulation and Excretion in the vertebrates will be covered in this course. All the physiological processes that are to be studied in this unit will focus on structure and function analysis. The analytical skills of the students will be developed if the topics are taught by correlating the habitat and behaviour of the organism with that of the structure involved in maintenance of physiological processes. Life processes studied in the syllabus also include various disorders associated with it. These topics can be made more effective by indulging class room discussion, paper presentations and seminars wherein the recent studies and treatments involved with respect to a particular disorder can be understood by the students.

PSZOPHY303, 'Biochemical adaptations and Instrumentation' covers topics Biochemical adaptations, Oxygen and Environmental radiations, Water, Temperature and Pressure, Instrumentation I and II. The concepts of environmental stress with respect to oxygen, temperature, pressure, and water can be elucidated with the help of simple laboratory experiments along with classroom teaching. The knowledge of instruments being essential in research, hence the learners should be encouraged to visit research institutes in order to understand the working and principles of various instruments that are used in research. Learners should be motivated to participate in workshops for hands on training in research institutes so that they can handle the instruments confidently and at the same time their interaction with the scientists and research scholars would enhance their analytical and reasoning skills

PSZOPHY304, 'Applied Physiology' deals with Cellular physiology, Human Immune response and Medical applications, Cancer cell biology, Exercise physiology. Learners have already comprehended the basics of Cell biology and immunology at the undergraduate level. Hence at post graduate level the syllabus involves various aspects of cell signaling, cell communication, immune response and related medical applications in healthcare. This topic will be well perceived by the students as the theoretical part of this topic is supported enough with the practical component. Cell signaling and communication can be explained with the aid of ICT, visit to pathology laboratory wherein medical tests involving immune responses are conducted will further help the learners in understanding the diagnostic tests. The learners being familiar with the concepts of cell cycle, the topic of Cancer cell biology will help them to relate the role of variations in cell cycle with that of the development of cancer. Recent advances in cancer treatment can be effectively understood by the learners with emphasis on reference of recent research papers. Exercise physiology a newly introduced topic in the syllabus highlights the basic physiology related to exercise. The learner will understand the importance of exercise though much needed in our present lifestyle. Learners can comprehend this concept easily as most of them enjoy strength training and they will be more conscious about the physiological changes that take place during and due to work outs. Avenues are available as fitness trainers and the knowledge of exercise physiology may benefit and allow the learner an added career option.

PSZOPHY401, 'Systems' Physiology III' deals with Locomotor system, Physiology of motility, Neurophysiology, and Sensory and Effector Physiology in animals. Locomotion is one of the characteristic features of the animal kingdom. The locomotory structures vary in different animals depending upon their habitat. Hence, study of locomotory structures and the mechanism of their

working may to be explained by conducting field visits. Neurophysiology and Sensory & effector physiology may be best elucidated with the help of ICT enabled teaching learning methodology along with regular class room teaching.

PSZOPHY402, 'Systems' Physiology IV' includes Endocrine Physiology I & II in invertebrates and the vertebrates respectively, Biological rhythms and Physiology of migration. Endocrine Physiology both in invertebrates and vertebrates may be made interesting to the learner not only by chalk and board or ICT method but also with the help of simple laboratory experiments. In 2017, Nobel Prize in Physiology was awarded to Hall, Rosbash and Young for their discoveries in molecular mechanisms controlling circadian rhythm. Such great discoveries and research work should be discussed in the class to motivate and encourage the learners to understand biological rhythms in animals. Having already studied the concept of migration at undergraduate level the learner can comprehend physiology of migration and adaptation in animals not only by lectures but more effectively by screening of various documentaries based on migratory routes of animals with geographical distribution.

PSZOPHY403, 'Recent Trends in Physiology' introduces the learners to the topics of Drug Designing & Modelling, Clinical trials, Clinical trial management & Guidelines and Stem Cell physiology. Drug designing, an integrated developing discipline in an era of tailored drug, involves the study of effects of biologically active compounds in animals whereas the topic on Clinical trials will make the learners understand various types and phases of clinical trials. The syllabus also focuses upon the guidelines to be followed during clinical trials and the management of clinical trials. The topics of this course being newly introduced would require the learner to understand the basic concepts aided with ICT tools, animation, video clips and visits to industry and pharmaceutical company. The concepts of stem cell physiology may be better comprehended by the learners with the help of class room discussions, review of recent research papers and invited talks from expertise of the subject.

PSZOPHY404 consists of '**Instrumentation and Presentation of Scientific data**' which help the students to choose suitable measuring instruments for their applications and understanding of limitations, principles and measurement errors. The students will aware the efficiency of the instruments. Similarly the course also has the unit of presentation of scientific data. Text, tables, and graphs for data and information presentation are very powerful communication tools. They can make scientific report easy to understand, attract and sustain the interest of beneficiary.

Convener and Committee Members

M. Sc. II Zoology Syllabus
Choice Based Credit System
To be implemented from the Academic Year 2020-2021

Animal Physiology: Semester III						
Course Name and Code	Unit	Topic Headings	Credit	Lecture/ Week	College Assessment Internal	University Assessment External
Paper I: Systems' Physiology (Invertebrates) I						
PSZOPHY301	1	Nutritive System	4	1	40	60
	2	Respiratory System		1		
	3	Circulatory System		1		
	4	Osmoregulation and Excretory System		1		
Paper II: Systems' Physiology (Vertebrates) II						
PSZOPHY302	1	Nutritive System	4	1	40	60
	2	Respiratory System		1		
	3	Circulatory System		1		
	4	Osmoregulation and Excretory System		1		
Paper III: Biochemical adaptation and Instrumentation						
PSZOPHY303	1	Biochemical adaptation, Oxygen and Environmental Radiation	4	1	40	60
	2	Water, Temperature and Pressure		1		
	3	Instrumentation I		1		
	4	Instrumentation II		1		
Paper IV: Applied Physiology						
PSZOPHY304	1	Cellular Physiology	4	1	40	60
	2	Human Immune Response and Applications		1		
	3	Cancer Cell Biology		1		
	4	Exercise Physiology		1		
		Total	16	16	160	240
Practicals						
PSZOPHY3P1	Practicals based on PSZOPHY301		2	4	–	50
PSZOPHY3P2	Practicals based on PSZOPHY302		2	4	–	50
PSZOPHY3P3	Practicals based on PSZOPHY303		2	4	–	50
PSZOPHY3P4	Practicals based on PSZOPHY304		2	4	–	50
	Total		8	16	–	200
	Grant Total		24	32	160	440

Animal Physiology: Semester IV						
Course Name and Code	Unit	Topic Headings	Credit	Lecture/ Week	College Assessment Internal	University Assessment External
Paper I: Systems' Physiology III						
PSZOPHY401	1	Locomotor System	4	1	40	60
	2	Physiology of Motility		1		
	3	Neurophysiology		1		
	4	Sensory and Effectors Physiology		1		
Paper II: Systems' Physiology IV						
PSZOPHY402	1	Endocrine Physiology - I	4	1	40	60
	2	Endocrine Physiology - II		1		
	3	Biological Rhythms		1		
	4	Physiology of Migration		1		
Paper III: Recent Trends in Physiology						
PSZOPHY403	1	Drug Designing & modelling	4	1	40	60
	2	Clinical trials		1		
	3	Clinical Trial Management and Guidelines		1		
	4	Stem Cell Physiology		1		
Paper IV: Instrumentation and Presentation of Scientific data						
PSZOPHY404	1	Instrumentation	2	1	40	60
	2	Presentation of Scientific data		1		
	3	Project		2		
		Total	16	16	160	240
Practicals						
PSZOPHY4P1	Practicals based on PSZOPHY401		2	4	–	50
PSZOPHY4P2	Practicals based on PSZOPHY402		2	4	–	50
PSZOPHY4P3	Practicals based on PSZOPHY403		2	4	–	50
PSZOPHY4P4	Practicals based on PSZOPHY404		2	4	–	50
	Total		8	16	–	200
	Grant Total		24	32	160	440

M. SC. PART 2: SEMESTER III (THEORY)
PAPER 1: PSZOPHY301
SYSTEMS' PHYSIOLOGY (INVERTEBRATES) I

Unit 1: Nutritive System

(15 L)

Objectives:

- *To familiarize the learner with nutritional physiology at various structural levels from membranes to systems.*

Desired Outcome:

- *The learner shall comprehend the molecular processes at membrane level and their significance in nutrition, food capture and processing, nutritive types and their correlation to variety of structures of nutritional apparatus in invertebrates.*

1.1 Nutritional Physiology at Cellular level

1.1.1 Membrane physiology

Functional consequences of molecular composition and arrangement of cell membrane

1.1.2 Transport across cell membrane

Diffusion, active transport, pump; uniports, symports and antiport, co-transport by symporters and antiporters

1.2 Physiology of Food Capture and Processing in Invertebrate

1.2.1 Nutritive Patterns – Origin of Nutritive types

1.2.2 Feeding patterns

a) Large particle feeding

b) Surface nutrient absorption

1.2.3 Modifications in the digestive system of invertebrates

a) Arthropoda

b) Mollusca

1.3 Dietary toxins and chemical defense strategies nematocyst, milk weed in monarch butterfly

Unit 2: Respiratory System

(15 L)

Objectives:

- *To familiarize the learner to different structural elements in respiratory process and their operational mechanism.*

Desired outcome:

- *The learner shall discern relationship of respiratory pigments, organization of membranes into structures like gills and trachea, mechanism of operation, patterns of respiration and their relationship to the habitat of invertebrates.*

2.1 Invertebrate transition from water to land

2.2 Respiratory mechanisms in aquatic invertebrates

2.2.1 Respiration across the cell membrane

2.2.2 Ostia

2.2.3 Gills – Crustacean and Echinoderms

2.2.4 Plastron

2.2.5 Aquatic insects

2.3 Tracheal system

2.3.1 Millipedes, Centipedes and insects

2.3.2 Tracheal ventilation

2.3.3 Gas exchange across tracheolar walls

- 2.3.4 Spiracle and its movement
- 2.4 Discontinuous or cyclic respiration
- 2.5 Regulation of respiration
- 2.6 Respiratory pigments
 - a) Chlorocruorin
 - b) Haemerythrin
 - c) Haemocyanin

Unit 3: Circulatory System

(15 L)

Objectives:

- *To familiarize the learner to circulation of body fluids and types of circulation in various phyla of invertebrates*

Desired outcome:

- *The learner shall study variety of circulatory fluids, patterns of circulation and physiological types of hearts in invertebrates.*

- 3.1 Evolution of Invertebrate circulatory system
- 3.2 Circulating Fluids
 - 3.2.1 Cytoplasm
 - 3.2.2 Hydrolymph
 - 3.2.3 Haemolymph
 - 3.2.4 Lymph
 - 3.2.5 Blood
- 3.3 Circulation of external fluid through an open body cavity – Sponge
- 3.4 Circulation of internal fluid through an open circulatory system – Cockroach
- 3.5 Open circulatory system in Mollusca
- 3.6 Circulatory mechanism and fluid compartments, movements of body fluids by somatic muscle
- 3.7 Physiological types of hearts with special reference to Arthropods, Annelids, Mollusca
- 3.8 Circulation in Cnidarians, Nemertean worms, Nematods, Annelids, Echinoderms, Molluscs, Arachnids

Unit 4: Osmoregulation and Excretory System

(15 L)

Objectives:

- *To familiarize the learner to organizational levels of osmo-regulatory and excretory structures in invertebrates and types of molecules generated as excretory product.*

Desired outcome:

- *The learner shall appreciate the relationship between increasing complexity of structure of excretory systems, the metabolic pathways generating the excretory waste products and the habitat of the invertebrates.*

- 4.1 Invertebrate excretory organs and physiology
 - 4.1.1 Epithelial exchange
 - 4.1.2 Coelom
 - 4.1.3 Coelomoducts
 - 4.1.4 Malpighian tubules
 - 4.1.5 Protonephridia and metanephridia
 - 4.1.6 Molluscan kidney
 - 4.1.7 Antennal gland in crustacean
- 4.2 Multifunctional aspects of nitrogen excretory pathways in the Molluscs
- 4.3 Channelling of the flow of nitrogen towards uric acids or urea in the Molluscs
- 4.4 Significance of ammonia production in crustaceans,
- 4.5 Ammonotelic-Uricotelic transition in insects, formation of urine in insects

PAPER 2: PSZOPHY302

SYSTEMS' PHYSIOLOGY (VERTEBRATES) I

Unit 1: Nutritive System

(15 L)

Objectives:

- *To familiarize the learner to different feeding patterns, variety of nutritional apparatus, process of digestion in the vertebrates and digestive system in human beings.*

Desired outcome:

- *The learner shall comprehend the comparative and specialized aspects of nutritional type, digestive systems, digestion as a metabolic process and neuro-hormonal regulation of nutrition.*
- *Role of microbes in digestion, balanced diet and disorders of digestive function are applied aspects of nutrition, the study of which is an important take away for learners, which will help them in healthcare.*

1.1. Feeding mechanism in vertebrates

1.1.1 Filter feeding

- a) Pisces
- b) Flamingoes
- c) Tadpoles of frog

1.1.2 Reptiles (Jacobson's organ)

1.2. Specialized compartmentalization of digestive system in vertebrates

1.2.1 Intestinal modification in herbivore and carnivore

1.2.2 Intestine in fish, bird and mammal

1.3. Comparative study of mechanical or physiological digestion – gill rakers, Dentition in Pisces, Amphibians, Reptiles, Birds and Mammals

1.4. Comparative study of Chemical digestion

1.5. Absorptive adaptation of the Gut

1.6. Micro-biome of human gut and its significance

1.7. Metabolic transition between meals

1.7.1 Hormonal control postprandial regulation of nutrient stores

1.7.2 Effect of prolonged food deprivation

1.8. Balanced diet- a human perspectives

1.9. Disorders of digestive system:

1.9.1 Acid reflux

1.9.2 Gall stones

1.9.3 Haemorrhoids

1.9.4 Dental Acidity

1.9.5 Acidity and its impact

1.9.6 Stress and hunger drive

Unit 2: Respiratory System

(15 L)

Objectives:

- *To introduce the learner to physico-chemical parameters of respiration in the vertebrates.*

Desired outcome:

- *The learner shall comprehend change in physiology as an adaptive process in transition of vertebrates between aquatic and terrestrial mode of life.*
- *The learners shall realize the clinical significance of simple diagnostic tests for estimation of blood parameters.*

2.1 Transition of vertebrates from water to land

- 2.2 Comparative study of Respiratory system in vertebrates:
 - 2.2.1 Aquatic, terrestrial, gas exchange in terrestrial eggs
 - 2.2.2 Respiration in lungfish
- 2.3 Chemistry of respiration
 - 2.3.1 Composition of atmospheric and expired air
 - 2.3.2 Aerodynamic Sub-division of air in the lungs
 - 2.3.3 Regulation of lung breathing
 - 2.3.4 Transport of gases in the blood
 - 2.3.5 Diffusion of gases in the lungs
 - 2.3.6 Transport of CO₂ in the blood
 - 2.3.7 Haldane effect- Partial pressure of gases
- 2.4 Dissociation of Oxyhaemoglobin and factors affecting it (temperature, electrolytes, CO₂ and Carboxyhaemoglobin)
- 2.5 Acid-base balance:
 - 2.5.1 Measurements
 - 2.5.2 Causes of disturbances
 - 2.5.3 Metabolic Acidosis
 - 2.5.4 Respiratory Acidosis
 - 2.5.5 Metabolic, Alkalosis
 - 2.5.6 Respiratory Alkalosis
- 2.6 Role of medulla oblongata in respiration
 - 2.6.1 Chemoreceptor
 - 2.6.2 Mechanoreceptor and Ventilation reflexes
 - 2.6.3 Chemical factors regulating respiration
 - 2.6.4 Oxygen equilibrium curve and its significance
- 2.7 Manifestation of variation in haemoglobin saturation
 - 2.7.1 Oxygen toxicity
 - 2.7.2 Carbon monoxide poisoning
 - 2.7.3 Clinical significance

Unit 3: Circulatory System

(15 L)

Objectives:

- *To introduce the learner to functional dynamics of circulatory systems in the vertebrates.*

Desired outcome:

- *The learner shall gauge the evolutionary adaptations of the circulatory system and understand the control and coordination of circulation in the vertebrates.*
- *The learner shall comprehend the applied aspects of circulatory system in the context of human health.*

- 3.1 Rheology:
 - 3.1.1 Viscosity, Poiseuille
 - 3.1.2 Hagen flow formula
 - 3.1.3 Laminar and turbulent flow Resistance
 - 3.1.4 Pressure, velocity and gravity
- 3.2 Chordate circulatory system:
 - 3.2.1 Arterial system
 - 3.2.2 Venous System
 - 3.2.3 Lymphatic System
- 3.3 Circulatory patterns in Vertebrates
 - 3.3.1 Lung fish
 - 3.3.2 Amphibians
 - 3.3.3 Reptiles
 - 3.3.4 Birds

- 3.3.5 Mammals
- 3.4 Regulation of cardiovascular system
 - 3.4.1 Heart
 - 3.4.2 Cardiac output
 - 3.4.3 Blood pressure
- 3.5 The buffer system of the blood
 - 3.5.1 Haemoglobin buffer
 - 3.5.2 The Chloride shift
- 3.6 Selective distribution of blood flow
- 3.7 Circulatory disorders in humans – Varicose veins

Unit 4: Osmoregulation and Excretory System

(15 L)

Objectives:

- *To enable the learner to become well versed with patterns of nitrogen metabolism, excretion of wastes, osmoregulation and applied aspects renal function in human beings.*

Desired outcome:

- *The learner shall discern the variations in metabolic waste products and their relationship to habitat, metabolic pathways of nitrogen metabolism in the vertebrates, role of renal functions in electrolyte balance, blood pressure and acid-base balance.*
- *The learner shall be introduced health effects of compromised kidney functions.*

- 4.1 Variation in vertebrate kidneys
- 4.2 Nitrogen Metabolism: Formation of nitrogenous excretory products
 - 4.2.1 Amino-N Metabolism
 - 4.2.2 Nucleic Acid Metabolism
 - 4.2.3 Other nitrogenous waste products
- 4.3 Regulation of Urine formation
 - 4.3.1 Urine concentration,
 - 4.3.2 Micturition,
 - 4.3.3 Relationship of regulation of water balance with reference to blood volume, blood pressure, electrolyte balance, acid-base balance.
- 4.4 Kidney failure and diseases in human:
 - 4.4.1 Acute kidney injury,
 - 4.4.2 Causes of kidney failure,
 - 4.4.3 Chronic kidney disease
 - a) Causes,
 - b) Kidney stone
 - c) Dialysis (renal and peritoneal dialysis)

PAPER 3: PSZOPHY303

BIOCHEMICAL ADAPTATION AND INSTRUMENTATION

Unit 1: Biochemical Adaptation, Oxygen and Environmental Radiation

(15 L)

Objectives:

- Learner shall reinforce concepts of homeostasis and understand environmental stress and physiological adaptations to withstand the stress.*

Desired outcome:

- The learner shall comprehend metabolic strategies and physiological adaptations to withstand environmental stress in the form of ambient oxygen availability and environmental radiation.*

1.1 Environmental Stress, Homeostasis and strategies of biochemical adaptations:

1.1.1 Basic concept of environmental stress

- Plastic and elastic strain
- Stress resistance, stress avoidance and stress tolerance

1.1.2 Homeostasis and biochemical adaptation:

- External and internal environment
- Multiple control system
- Strategies of biochemical adaptations

1.2 Oxygen as an environmental factor:

1.2.1 Oxygen and Origin of life

1.2.2 Oxygen dependencies in living organism

1.2.3 Anoxia adaptations in invertebrates

1.2.4 Adaptations of vertebrates during prolonged diving

1.2.5 Oxygen debt in vertebrate muscle

1.3 Radiation as an environmental factor:

1.3.1 Biomolecules involved in perception and trapping of solar radiations:

- Chlorophyll
- Bacterio-rhodopsin
- Rhodopsin
- Vitamin A

1.3.2 Adaptations of animals to absence of solar radiations

Unit 2: Water, Temperature and Pressure

(15 L)

Objectives:

- Learner shall reinforce concepts of homeostasis and understand environmental stress and physiological adaptations to withstand the stress.*

Desired outcome:

- The learner shall comprehend metabolic strategies and physiological adaptations to withstand stress in the form of water, temperature and pressure as environmental factors.*

2.1 Water and Solute problem:

2.1.1 Preservation of intracellular solvent capacity

2.1.2 ATPase the model regulatory enzyme

2.1.3 Key role of GDH reaction

2.2 Temperature as environmental factor

2.2.1 Thermal limits of survival

2.2.2 Temperature and Structural effects with response to Biological molecules and biological membranes

- 2.2.3 Temperature and rate effects:
 - a) Temperature dependent E~S affinity
 - b) Lipoprotein enzymes
- 2.3 Thermal resistance of dormant and active cells
 - 2.3.1 Ectothermy and endothermy
 - 2.3.2 Endothermy in invertebrates
 - 2.3.3 Biochemical adaptations of Ectothermy:
 - a) Antifreeze substances
 - b) Heat shock proteins
- 2.4 Pressure as an environmental factor:
 - 2.4.1 Fundamental effects of pressure on biological system
 - 2.4.2 Effect of pressure on weak bonds and the consequences for higher orders of molecular structures and process (transcription, translation and gene regulation)
 - 2.4.3 Strategies of enzyme adaptations to pressure in marine organisms:
 - a) FDPase
 - b) PK

Unit 3: Instrumentation – I

(15 L)

Objectives:

- To familiarize the learner with various tools and techniques required to study animal physiology.

Desired outcome:

- The learner will be acquainted with principles and procedures necessary to prepare samples for physiological studies and learn experientially through observing demonstration or hands on experience of instruments.

- 1.1 Histochemical and Immunotechniques
 - 1.1.1 Detection of molecules using
 - a) ELISA
 - b) RIA
 - c) Western blot
 - d) Immunoprecipitation
 - e) Fluocytometry
 - f) Immunofluorescence microscopy
 - 1.1.2 Detection of molecules in living cells, in situ localization by techniques such as FISH and GISH
- 3.2 Chromatographic techniques: Principles and applications
 - 3.2.1 Column Chromatography
 - 3.2.2 Ion exchange chromatography
 - 3.2.3 HPTLC
 - 3.2.4 HPLC
 - 3.2.5 Gas chromatography

Unit 4: Instrumentation – II

(15 L)

Objectives:

- To familiarize the learner with various tools and techniques required to study animal physiology.

Desired outcome:

- The learner will be acquainted with principles and protocols necessary to operate instruments for estimations and analyses of samples for physiological studies and learn experientially through observing demonstration or hands on experience of analytical instruments.

- 4.1 Biophysical Method: Molecular analysis
 - 4.1.1 UV/visible
 - 4.1.2 Fluorescence,
 - 4.1.3 Circular dichroism
 - 4.1.4 NMR
- 4.2 ESR spectroscopy Molecular structure determination using X-ray diffraction and NMR
- 4.3 Molecular analysis using light scattering
- 4.4 Different types of mass spectrometry and surface plasma resonance methods
- 4.5 Radiolabeling techniques:
 - 4.5.1 Detection and measurement of different types of radioisotopes normally used in biology
 - 4.5.2 Incorporation of radioisotopes in biological tissues and cells
 - 4.5.3 Molecular imaging of radioactive material, safety guidelines

PAPER 4: PSZOPHY304 APPLIED PHYSIOLOGY

Unit 1: Cellular Physiology

(15 L)

Objectives:

- *To initiate the learner in the process of cellular signaling and communication as well as protein sorting.*

Desired outcome:

- *The learner shall envisage molecular processes involved in cellular signaling and communication.*
- *The learner shall be able to trace the transport of proteins from their site of synthesis to the site of their action.*

1.1 Cell signaling:

- 1.1.1 Hormones and their receptors
- 1.1.2 Cell surface receptor,
- 1.1.3 Signaling through G-protein coupled receptors
- 1.1.4 Signal transduction pathways
- 1.1.5 Second messengers
- 1.1.6 Regulation of signalling pathways

1.2 General principles of cell communication

- 1.2.1 Cell adhesion and roles of different adhesion molecules
- 1.2.2 Gap junctions
- 1.2.3 Extracellular matrix
- 1.2.4 Integrins
- 1.2.5 Neurotransmission and its regulation

1.3 Protein sorting and transportation

Unit 2: Human Immune Response and Medical Application

(15 L)

Objectives:

- *To familiarize the learner to immune response and defence mechanisms in human systems.*

Desired outcome:

- *The learner shall comprehend various molecular defence mechanisms and immune response and their applications in healthcare in terms of therapeutics and organ transplantation.*

2.1 Major Histocompatibility complex, antigen processing and presenting cells

2.2 Tolerance and Autoimmunity

2.3 Immunity to pathogens and vaccines

2.4 The Complement System

- 2.4.1 Functions
- 2.4.2 Components
- 2.4.3 Activation and regulation of the complement
- 2.4.4 Biological consequences of the complement activation

2.5 Lymphocyte Ontogeny and Membrane Markers

2.6 Transplantation Immunology

- 2.6.1 basis of graft rejection
- 2.6.2 Clinical manifestation of graft rejection
- 2.6.3 General and specific immunosuppressive therapy

- 2.6.4 Immune tolerance to allograft
- 2.6.5 Clinical transplantation
- 2.7 Organ-Specific Autoimmune Diseases
 - 2.7.1 Systemic Lupus Erythematosus
 - 2.7.2 Rheumatoid Arthritis
 - 2.7.3 General account of Immunodeficiency diseases

Unit 3: Cancer Cell Biology

(15 L)

Objectives:

- *To introduce the learner to development of cancer in terms of cell cycle and apoptosis.*

Desired outcome:

- *The learner shall comprehend factors responsible for apoptosis, variations in cell cycle and their role in development of cancer.*

- 3.1 Components of cell cycle and control system, Mitotic catastrophe
- 3.2 Extracellular control of cell division
 - 3.2.1 Cell growth and apoptosis
 - 3.2.2 Morphological and biochemical features of apoptosis
 - 3.2.3 Necroptosis
- 3.3 Caspases (effector molecules)
 - 3.3.1 Executioners of the apoptosis process
 - 3.3.2 Extrinsic and intrinsic apoptotic pathway
- 3.4 Role of mitochondria in cell death
 - 3.4.1 Mechanism of mitochondrial outer membrane permeabilization (MOMP)
 - 3.4.2 Cell death effectors released from mitochondria
- 3.5 Poly – ADP –ribose Polymerase (PARP) proteolysis as an indicator of cell death
- 3.6 Senescence and cancer
- 3.7 Chemoresistance and cancer
- 3.8 Immunogenicity of cancer cell death
- 3.9 Autophagy and Role of autophagy in tumour survival, oncogenic genes that regulate Autophagy
- 3.10 Cancer treatment: Immunotherapy

Unit 4: Exercise Physiology

(15 L)

Objectives:

- *To initiate the learner to fundamentals of exercise physiology.*

Desired outcome:

- *The learner shall comprehend effect of exercise on various physiological parameters for molecular to systems level.*

- 4.1 Exercise and Immune system:
 - 4.1.1 Exercise and resistance to infections
 - 4.1.2 Risks of infections due to high intensity workout and environmental extremes
- 4.2 Cell signaling and Hormonal response to exercise:
 - 4.2.1 Blood hormone concentration
 - 4.2.2 Hormone receptor interaction
 - 4.2.3 Muscle glycogen utilization
 - 4.2.4 Blood glucose homeostasis during exercise
 - 4.2.5 Hormone substrate interaction
- 4.3 Circulatory responses to exercise:
 - 4.3.1 Organization of circulatory system

- 4.3.2 Cardiac cycle
- 4.3.3 Changes in oxygen delivery to muscles during exercise
- 4.4 Role of nervous system exercise:
 - 4.4.1 Control and coordination of movements during exercise
 - 4.4.2 Joint and muscle proprioceptors
 - 4.4.3 Muscle chemoreceptors
 - 4.4.4 Motor functions of the spinal cord

M. Sc. Part 2: Semester III Practical

Practical 1: PSZOPHY3P1

1. Study of Mouth parts in different insects, observe the modifications and write the adaptations – Biting, chewing, piercing and sucking.
2. Study of digestive system of earthworm.
3. Study of nephridia of earthworm and Malpighian tubules of cockroach.
4. Study of Digestive system of cockroach, earthworm / crab.
5. Study of Nervous system of cockroach.
6. Study of heartbeat in *Daphnia*, effect of heavy metals / nicotine on heartbeat of *Daphnia*.
7. Study of Respiratory quotient (R.Q.) of cockroach.
8. Study of transport of glucose across a semi-permeable membrane (egg membrane).

Practical 2: PSZOPHY3P2

1. Determination of activities of digestive enzymes viz. amylase, trypsin etc. in different animals (human saliva for amylase, Intestine of goat or chicken for trypsin).
2. Study of effect on activity of salivary/ pancreatic amylase enzyme on various factors substrate concentration, pH, temperature, activator, inhibitor (enzyme) and determination of K_m of a given enzyme.
3. Study of pathological report and interpretation of report with respect to human physiology
 - a. Renal function test
 - b. Liver function test
 - c. Stress test
 - d. Polycythemia
 - e. Various scans – X rays / CT Scan or any other scan images interpretation
4. Effect of different concentrations of sodium chloride on the diameter of RBCs and determination of concentration isotonic to blood.
5. Determination of urea, uric acid and creatinine in blood – human / goat.
6. Determination of blood cholesterol content – human / goat.
7. Routine urine tests. Prepare a report as provided by pathological laboratory.
8. Influence of sub lethal concentration (50-60ppm) ammonia (as liquor ammonia / ammonium hydroxide / ammonium chloride) on a suitable fish exposed to ammonia stress for 3 / 7 / 15 days with reference to the following parameters:
 - a. Level of excretory ammonia
 - b. Level of activity of hepatic and brain glutamate dehydrogenase
 - c. Level of amino acid content of muscle, gill, brain and liver

Practical 3: PSZOPHY3P3

1. Observation of decreasing PO_2 of water on the respiratory rate of a fish.
2. Effect of decreasing PO_2 of water on lactic acid in the fish muscle.
3. Estimation of salt loss and gain in an aquatic animal when transferred to a salt free medium and to natural medium.
4. Effect of temperature on opercula movement of suitable fish.
5. Study of effect of temperature on development of chick embryo.
6. Study of effect of electrolyte stress on angiogenesis using chick embryo.
7. Separation of plasma proteins by PAGE electrophoresis.
8. Separation of serum globulins by PAGE electrophoresis.
9. Immobilize Yeast cells in calcium alginate and prepare a bioreactor column to demonstrate invertase activity in the bioreactor column.

Practical 4: PSZOPHY3P4

1. Performance of Ouchterlony technique to demonstrate immune-diffusion.
2. Demonstration of single radial immune-diffusion of antibody and antigen.
3. Study of counter-current immune-electrophoresis.
4. Study of Agglutination Reaction:
 - a) Tube Agglutination Reaction
 - b) Slide Agglutination Reaction
 - c) Indirect Agglutination Inhibition Reaction
5. Separation of Lymphocytes.
6. Study of Phagocytosis.
7. Identification of histological slides of lymphoid tissue:
 - a) Spleen
 - b) Thymus
 - c) Lymph node
 - d) Bone marrow

M. SC. PART 2: SEMESTER IV (THEORY)
PAPER 1: PSZOPHYN401
SYSTEMS' PHYSIOLOGY III

Unit 1: Locomotor System

(15 L)

Objectives:

- *To familiarize the learner with various types of locomotory structures in invertebrates.*

Desired outcome:

- *The learner shall understand the functional and operating mechanisms of various locomotory structures and organs in invertebrates.*

1.1 Functions of locomotory organs

1.1.1 Pseudopodia

- Lobopodia
- Reticulopodia
- Filopodia
- Axopodia

1.1.2 Cilia

1.1.3 Flagella

1.1.4 Tentacles

1.1.5 Foot

1.1.6 Tube feet

1.1.7 Setae

1.2 Locomotion in Arthropods

1.2.1 Legs

1.2.2 Wings

1.3 Pyloric rhythm of the crustacean

1.4 Comparative physiology of invertebrate muscles

1.4.1 Polyneuronal innervation in arthropod muscle

1.4.2 Insect non-oscillatory postural muscle

1.4.3 Resonant flight and tymbal muscle in insects

1.4.4 Catch muscle and delayed relaxation

Unit 2: Physiology of Motility

(15 L)

Objectives:

- *To familiarize the learner to intracellular and extracellular processes involved in movement and locomotion in the vertebrates.*

Desired outcome:

- *The learner shall discern molecular and supra-molecular structures and processes responsible for movement and locomotion in the vertebrates.*

2.1 Physiology of movement and locomotion:

2.1.1 Biochemistry of contractile proteins

2.1.2 Physiology of non-muscular contractile elements:

- a) Axoplasmic movement
- b) Chromosome involvement

2.1.3 Physiology of skeletal muscle fibre:

- a) Actomyosin complex
- b) Source of energy for muscle contraction
- c) Sliding filament theory

- d) Excitation of contraction and mechanism of regulation of contraction by calcium ions
- e) Mechanism of relaxation

Unit 3: Neuro Physiology

(15 L)

Objectives:

- *To familiarize the learner to structural and functional aspects of neurophysiology.*

Desired outcome:

- *The learner shall comprehend molecular, structural and functional dimensions of neurophysiology in the animal kingdom.*

- 3.1 Excitable membranes
 - 3.1.1 Membrane potential
 - 3.1.2 Ions as current carriers
 - a) Protons
 - b) Calcium
 - c) Potassium
 - 3.1.3 structure of Cation
 - a) Permeable channels
 - b) Chloride channels
- 3.2 Primitive nervous system
 - 3.2.1 Nerve nets
 - 3.2.2 Central pattern generators in invertebrates
 - 3.2.3 Motor control in Arthropods
- 3.3 Nervous tissue
 - 3.3.1 Neurons
 - 3.3.2 Glial cells
- 3.4 Integrative neurophysiology:
 - 3.4.1 Interneurons
 - 3.4.2 Neural circuits
- 3.5 Neurotransmitters
 - 3.5.1 Acetylcholine
 - 3.5.2 Dopamine
 - 3.5.3 Catecholamine
 - 3.5.4 GABA
 - 3.5.5 ATP
 - 3.5.6 Adrenaline
 - 3.5.7 Noradrenaline
 - 3.5.8 FMRF amide family
 - 3.5.9 Neuropeptide
- 3.6 Central Nervous system processing
- 3.7 Memory and learning
- 3.8 Neurophysiological disorders
 - 3.8.1 Alzheimer
 - 3.8.2 Parkinson
 - 3.8.3 Dementia

Unit 4: Sensory and Effector Physiology

(15 L)

Objectives:

- *To familiarize the learner to sensory and effector systems in the animal kingdom.*

Desired outcome:

- *The learner shall understand the organizational aspects of sensory structures at the molecular, membrane and organ level and their functioning as transducers in reception of sensory stimuli.*
- *The learner shall understand physiology of effectors.*

4.1 Sensory and effector system in invertebrates

- 4.1.1 Specificity, membrane bound receptor system, cytosolic receptor system
- 4.1.2 Mechanisms of insect olfactory reception
- 4.1.3 Organs of Equilibrium – statocyst, insect ear
- 4.1.4 Habituation and sensitization in *Aplysia*
- 4.1.5 Physiological effectors – Cnidoblast, Chromatophores, Bioluminescent system

4.2 Sensory and effector system in the vertebrates:

- 4.2.1 Organs of Equilibrium – statocyst, internal ear of vertebrate
- 4.2.2 Sensory modalities of animals: Sensory coding and transduction of sensory stimuli:
 - a) Chemoreception (Gustation and olfaction)
 - b) Hygroreception
 - c) Thermoreception
 - d) Mechanoreception
 - e) Echolocation
 - f) Electroreception
 - g) Magnetoreception
 - h) Photoreception

PAPER 2: PSZOPHY402 SYSTEMS' PHYSIOLOGY IV

Unit 1: Endocrine Physiology – I

(15 L)

Objectives: *To introduce to the learner various Endocrine systems in Invertebrates.*

Desired outcome: *The learner shall understand various molecular and structural aspects of invertebrate endocrine systems, the effect of endocrine secretions on various life-processes and development as well as the mechanism of action of hormones in invertebrates.*

- 1.1 Invertebrate endocrine system
 - 1.1.1 Lower invertebrates in general
 - 1.1.2 Annelids
 - 1.1.3 Arthropods
 - 1.1.4 Molluscs
 - 1.1.5 Echinoderms
- 1.2 Hormonal action in invertebrates
 - 1.2.1 Feed-back substance (polychetes)
 - 1.2.2 Prothoracicotropic hormone
 - 1.2.3 Juvenile hormone
 - 1.2.4 Ecdysone
 - 1.2.5 Trypsin modulating oostatic factor (TMOF)
 - 1.2.6 Allomones
 - 1.2.7 X and Y Organs
 - 1.2.8 Epitracheal glands (Inka cells)
 - 1.2.9 Methyl farnesoate (MF)
 - 1.2.10 Gonadotropic hormone in gastropods and cephalopods
 - 1.2.11 1- Methyl – adenine (meiosis inducing substance) endocrine disruptors
 - 1.2.12 Gamete shedding substance (GSS) in Star fish
- 1.3 Mechanism of hormone action in invertebrates

Unit 2: Endocrine Physiology II

(15 L)

Objectives:

- *To familiarize the learner to vertebrate endocrine cellular structures, organs and glands and types of their secretions.*

Desired outcome:

- *The learner shall comprehend various types of endocrine organs, glands, types of their secretions, neurohormones; and effects of these hormones on life processes including reproduction and development.*

- 2.1 Introduction to Endocrine systems (Neurosecretion and classical endocrine glands) – an overview
- 2.2 Synthesis and Release of Hormone, Transport and Metabolism of Hormones, Mechanism of endocrine diseases
- 2.3 Mechanism of Hormone action in the vertebrates
- 2.4 Chordate endocrine systems
 - 2.4.1 Hypothalamo-hypophyseal axis
 - 2.4.2 Pineal gland
 - 2.4.3 Thyroid gland
 - 2.4.4 Parathyroid gland
 - 2.4.5 Ultimobranchial gland
 - 2.4.6 Corpuscles of stannous

- 2.4.7 Gastroenteropancreatic cells
- 2.4.8 Maunthner cells
- 2.4.9 Chromaffin tissues
- 2.4.10 Steroid hormones
- 2.5 Endocrine disorders due to alteration in receptor number and functions
- 2.6 Endocrine regulation during sex differentiation

Unit 3: Biological rhythms

(15 L)

Objectives:

- *To introduce the learner to temporal aspects of biological systems.*

Desired outcome:

- *The learner shall understand the various types of rhythms encountered in biological systems and their manifestations through various activities.*

- 3.1 Physiology of Biological Rhythms and timings:
 - 3.1.1 Temporal organization of the cells
 - 3.1.2 Circadian Rhythms. Synchronization of circadian rhythms
 - 3.1.3 Dormancy in fresh water and terrestrial animals
 - a) Preparatory phases
 - b) Induction of dormancy
 - c) Arousal from dormancy Entrainment and dormancy
 - 3.1.4 Diapause in insects
 - a) Induction
 - b) Factors affecting and termination of diapause,
 - c) Diapause and endocrine functions
 - 3.1.5 Photoperiodism
 - 3.1.6 Biological clocks (circadian rhythms, lunar rhythms and circannual rhythms)

Unit 4: Physiology of Migration

(15 L)

Objectives:

- *To familiarize the learner to various aspects of animal migration.*

Desired outcome:

- *The learner shall be able to discern causative, temporal, spatial, energetic and metabolic aspects of animal migration and its adaptive value to the migrating animal species.*

- 4.1 Physiological stimulus of Migration
- 4.2 Orientation and Navigation
- 4.3 Energetic
- 4.4 Timing
- 4.5 Synthesis
- 4.6 Migration for food, reproduction, territory
- 4.7 Migration as factor in life cycle
- 4.8 Adaptations for Migration
- 4.9 Communication during Migration

PAPER 3: PSZOPHY403 RECENT TRENDS IN PHYSIOLOGY

Unit 1: Drug Designing & Modelling

(15 L)

Objectives:

- *To introduce the learner to the fundamental concept of drug discovery and designing.*

Desired outcome:

- *The learner will comprehend steps involved in discovery and identification of new potential therapeutic molecules using combination of computational and experimental processing drug development.*

- 1.1 Introduction to Drug Design and Development
 - 1.1.1 Drug Discovery as a Process
 - 1.1.2 Target Identification and Validation
 - 1.1.3 Target Validation and Drug Validation Practical
- 1.2 Drug targets
- 1.3 Targets: Membrane Proteins, DNA, RNA, Enzymes
- 1.4 Lead Identification and Modification:
 - 1.4.1 Lead Identification and High Throughput Screening
 - 1.4.2 Sources of active compounds, Biologics
- 1.5 Computer-Aided Drug Design:
 - 1.5.1 Molecular Modelling
 - 1.5.2 Ligand-based Drug Design
 - 1.5.3 Structure Determination
 - 1.5.4 Structure-based Drug Design
- 1.6 Drug Delivery: Bioavailability, Pro-drugs and Drug Delivery

Unit 2: Clinical trials

(15 L)

Objectives:

- *To introduce the learner to different steps involved in clinical trials.*

Desired outcome:

- *The learner will comprehend types of clinical trials, designing of clinical trials, ethics in clinical trials and its application in health care.*

- 2.1 Pre-clinical Toxicology: In vivo
- 2.2 Pre-clinical Toxicology: In vitro
- 2.3 Clinical Trials: Clinical Trial Design
- 2.4 Ethics of Human and Animal Experimentation
- 2.5 Commercial Considerations in Drug Development
- 2.6 Introduction to artificial intelligence and its application
 - 2.6.1 Clinical trials
 - 2.6.2 Toxicology
 - 2.6.3 Healthcare

Unit 3: Clinical Trial Management and Guidelines

(15 L)

Objectives:

- *To introduce the learner to operation and management in clinical trials.*

Desired outcomes:

- *The learner will comprehend the monitoring and regulatory affairs with defined guidelines used in clinical trials.*

- 3.1 Project Management; protocol in clinical research; quality assurance & clinical data management
- 3.2 Informed consent; Case report form; investigator's brochure (Ib)
- 3.3 Ethical and regulatory submission; roles and responsibilities of clinical research professionals
- 3.4 Retention of Clinical trial subjects; monitoring visits; Documentation of clinical trials
- 3.5 Introduction to OECD
 - 3.5.1 Guidelines for the testing of chemicals
 - 3.5.2 Description of the method
 - 3.5.3 Selection of animal species
 - 3.5.4 Housing and feeding conditions, preparation of animals for experiment, preparation of doses
 - 3.5.5 Administration of doses
 - 3.5.6 Limit test and main test
 - 3.5.7 Observations:
 - a) Body weight
 - b) Pathology
 - c) Data and Reporting
 - d) Calculation of LD50 for the main test
 - e) Test report

Unit 4: Stem Cell Physiology**(15 L)****Objectives:**

- *To introduce the learner to the fundamentals of stem cell physiology.*

Desired outcome:

- *The learners shall comprehend the physiological aspects of stem cells and their functions in homeostasis of tissues, embryonic and somatic stem cells, cancer stem cells and stem cell therapy.*

- 4.1 Introduction to stem cell
- 4.2 Differentiation, dedifferentiation and redifferentiation
- 4.3 Wnt Signaling pathway
- 4.4 Orchestrating Wnt / B-catenin signaling
- 4.5 Somatic and cancer stem cells
- 4.6 Role of stem cells in physiology, pathophysiology and therapy
- 4.7 Future of stem therapy as an alternative to organ transplant

PAPER 4: PSZOPHY404

INSTRUMENTATION AND PRESENTATION OF SCIENTIFIC DATA

Unit 1: Instrumentation

(15 L)

Objective

- *To learn how to design and build instruments for laboratory measurement.*
- *To understand fundamental principles of operation.*

Desired Outcome

- *The learner will understand methods for operation of instruments and data analysis.*
- *The learner will understand how instrumentation can advance scientific research.*

1.1 Centrifugation:

- Principle and applications of Centrifugation
- Differential and density gradient Centrifugation

1.2 Electrophoresis:

- Principle
- Structural components
- Applications

1.3 Chromatography:

- Principle and applications
- Adsorption
- Ion exchange
- Gel permeation
- Affinity

1.4 Spectrophotometer:

- Principle
- Applications

1.5 pH meter

- Principle
- Applications

1.6 Microscopy

- Binocular
- Trinocular

Unit 2: Presentation of Scientific data

(15 L)

Objective

- *To aware the students for good practice in data presentation.*
- *To aware the students to use different data presentation formats.*

Desired Outcome

- *The students will familiarize to explain their research data by using different techniques for presenting their scientific data.*

2.1 Types of presentation:

- Oral
- Poster
- Written
- Audio-visual

Aids for presentation

2.2 Preparing the manuscript

- Guidelines for authors
- The IMRAD format

2.3 Title, Byline, Abstract and Summary, Keywords

2.4 Introduction:

- Defining the problem
- Literature survey
- Justification of study

2.5 Materials and Methods:

- Contents
- Sources
- Procedures
- Techniques
- Reproducibility
- Significance

2.6 Results:

- Text
- How to present data
- Tables and illustrations
- Writing captions
- Labels and legends

2.7 Discussion:

- Components and Sequence
- Analysis, Comparison and Integration of Data
- Likely Sources of Errors in Results

2.8 Conclusions and significance

Unit 3: Project

(30 L)

Objective

- *To familiarize learner for analyzing a scientific occurrence with an investigation or to solve a problem with an invention.*

Desired Outcome

- *Research expands the current state of knowledge (at a certain cost) of the learners.*
- *Experimental findings that may yield new insights or lead to other research among the learners.*

- 1. Dissertation 60 Marks**
- 2. Examination 50 Marks**

Guidelines to the Project:

1. The Project shall include:

- Title of the Project
- Aims, Objectives and Rationale
- Materials and Methods
- Observation and / Results
- Interpretation of Observation / Results and Discussion
- Conclusion and / Recommendation
- Relevance of Work / Justification of Work with Project title
- Relevant References

2. The project must be type-written using computer and printed for binding.

3. No minimum or maximum limit of the number of pages is defined since the volume of the proposal is dependent on the scope of the selected topic.

4. Name of the mentor may be reflected on the first page of the project along with the student's names.

5. The hard copy of proposal must be retained and submitted along with the dissertation in the examination for the reference of the external examiner/s.

6. Student should prepare individual power point presentation (PPT) on the project and must present it in front of examiners at the time of examination.

7. The project will be prepared individually by students.

M. Sc. Part 2: Semester IV Practical

Practical 1: PSZOPHY4P1

1. Water and ionic regulation of freshwater animal in different osmotic media.
2. Estimation of sugar from blood plasma.
3. Extraction of glycogen from muscle and liver.
4. Estimation of liver glycogen content.
5. Preparation of glycerinated muscle fibre and study of its properties.
6. Study of nerve cells and neurosecretory cells of cockroach.
7. Study of various types of invertebrate physiological effectors.
8. Study of irritability in *Paramecium*.
9. Study of different sense organs in the vertebrates.

Practical 2: PSZOPHY4P2

1. Study of hormones in invertebrates.
2. Study of endocrine gland of vertebrates.
3. Effect of insulin /adrenalin on fish scales.
4. Effect of insulin/ adrenaline on rate of heart beat in *Daphnia* and chick embryo.
5. Effect of light and dark phase on *Drosophila*.
6. Study of X and Y organs in crab.
7. Study of estrous cycle of rat using histological slides or photographs.
8. Study of menstrual cycle.
9. Study of migration in animals in relation to food, reproduction and environment.
10. Study of migratory routes in birds and fishes.

Practical 3: PSZOPHY4P3

1. Estimation of LC₅₀ or LD₅₀ of an organo-phosphorous pesticide on *Artemia* cysts.
2. Designing protocols for toxicity experiments such as acute, sub-acute toxicity, reproduction toxicity, dermal toxicity.
3. Determination of pesticide residues in soil or water.
4. Effect of administration of carbon tetra chloride in rat/mice with reference to the following parameters:
 - a) Total lipid and free fatty acid content of liver
 - b) Free fatty acid content of plasma
 - c) Level of activity of the following enzymes:
 - i. AspAT
 - ii. AlaAT
 - iii. AICP
 - iv. ACP
 - v. LDH
 - vi. SDH
5. Study of stem cells in animals.
6. Visit to an animal house/clinical trial laboratory. Prepare a report on its role and significance.

Practical 4: PSZOPHY4P4

The practical of Semester 4 paper 4 comprises the Research Project for which students will have to take up a particular topic based on which they will be doing research applying the ethics of research, methods and methodology, etc. They are expected to abide rules of Scientific Research and if possible derive at a conclusion for the same. This will help the learners to build a strong foundation for pursuing research. Learners will acquaint about preparation of lay out, structure and language of typical reports, illustrations and tables. Learners will gain knowledge about how to write bibliography, referencing and footnotes in reports and thesis or in research articles.

Further, learners will be oriented to presentation of data through effective communication with the help of advanced visual technology. In addition to that they will be aware about the application of results, environmental impacts, conservation of biodiversity, ethical issues and ethical committees. The practical should be organized in such a manner that learners can be trained to manage large data sets generated via multiple observations, arrange them in a proper format and present them in relevant graphs/charts by adopting a hands-on in silico approach.

References

- 1) A. G. Giese: "Cell Physiology" (3rd Ed) Saunders, Toppan
- 2) Gerald Karp: "Cell Biology" McGraw Hill Kogakusha Ltd.
- 3) Biology of Animals --- Cleveland P. Hickman JR Larryds. Roberts
- 4) Darnell, Lodish, Baltimore: "Molecular Cell Biology" Scientific American Books.
- 5) C. A. Keil, E. Neil & E.N. Jobe (1982): "Samson Wright, Applied Physiology" Oxford Univ. \ Press.
- 6) R. Eckert & D. Randall (1982): "Animal Physiology: 2nd Ed." W. H. Freeman & Co.
- 7) W. A. Hoar (1982): "General & Comparative Animal Physiology 3rd Ed." Prentice Hall Inc.
- 8) C. L. Prosser (1973): "Comparative Animal Physiology" W. B. Saunders.
- 9) C. Ladd Prosser Ed. (1991): "Neural & Integrative Animal Physiology" "Comparative Animal Physiology", 4th Ed. Wiley – Liss Publ.
- 10) C. Ladd Prosser Ed. (1991): "Environmental & Metabolic Animal Physiology" "Comparative Animal Physiology" 4th Ed. Wiley – Liss Publ.
- 11) Withers, P.C. (1983): "Comparative Animal Physiology" International Ed. Saunders College Publishing.
- 12) K. Schmidt – Niel (1983): "Animal Physiology: Adaptation & Environmental" 3rd Ed. Cambridge Univ. Press.
- 13) R. W. Hill (1978): "Comparative Physiology of Animals – An Environmental Approach" Harper & Row Publ.
- 14) P. W. Hochachka & G. M. Somero (1973): "Strategies of Biochemical Adaptation".
- 15) J. G. Philips (1975): "Environmental Physiology" Blackwell Scientific Publ.
- 16) J. R. Bernstein (1972): "Biochemical Responses to Environmental Stress" Academic Press
- 17) Harold Harper: "Review of Physiology Chemistry" 4th Ed. Maruzen Asian Ed. Lang Medical Publ
- 18) OECD guideline for testing of chemicals - https://www.oecd-ilibrary.org/environment/test-no-425-acute-oral-toxicity-up-and-down-procedure_9789264071049-en
- 19) Kerns, E.H.; Di, L. Drug-Like Properties: Concepts, Structure Design and Methods: from ADME to Toxicity Optimization, Academic Press, Oxford, 2008
- 20) Burger's Medicinal Chemistry and Drug Discovery, 5th Edition, Vol. 1. Principles and
- 21) Practice, edited by M. E. Wolff, John Wiley & Sons: New York, 1995.
- 22) Principles of Medicinal Chemistry, 4th Edition, edited by W.O. Foye, T.L. Lemke, and
- 23) D. A. Williams, Williams and Wilkins: Philadelphia, 1995
- 24) Artificial intelligence – a modern approach, third edition, Stuart J. Russell and Peter Norvig, Pearson India Education services pvt. Ltd. 2015
- 25) Animal Physiology ----- Samson & Writy
- 26) Animal Physiology ----- Nelsion & Nelsion
- 27) Animal Physiology ----- Medical Physiology-Guiton
- 28) Text book of Animal Physiology ----- Nagbhushenen
- 29) Text book of Animal Physiology ----- Geise
- 30) Text book of Animal Physiology ----- A.K. Berry
- 31) Essentials Of Research Methodology and Dissertation Writing" by Yelikar
- 32) A Practical Approach to Pg Dissertation" by B Gitanjali and R Raveendran
- 33) Synopsis Dissertation And Research To Pg Students" by Prabhakara
- 34) A Practical Approach to Postgraduate Dissertation" by Raveendran
- 35) Exercise Physiology – Theory and Applications to fitness and performance, Scott K. Powers and Edward T. Howley, 10th edition, McGraw Hill Publication, 2015
- 36) Textbook of Endocrine Physiology -----James E. Griffin and Sergio R. Ojeda, Oxford University
- 37) Handbook of Neuroendocrinology --- Mandal A.(1994). EMKY Publication
- 38) Comparative Endocrinology of the Invertebrates-- Kenneth C. Highnam
- 39) Invertebrate Endocrinology ----- Tambhare D.B. (2012), Himalaya Publication
- 40) Invertebrate Endocrinology ----- Tombes, Academic Press.
- 41) Insect Endocrinology --- Lawrence I Gilbert, Academic Press
- 42) Sharma V.K. (1991) - Techniques in microscopy and cell biology, Tata-McGrawHill.

- 43) Bisen & Mathew - Tools and Techniques in Life Sciences – CBS Publishers & distributors.
- 44) Robert Braun - Introduction to Instrumental Analysis. McGraw Hill International Editions
- 45) Wilson and Walker – Principles and Techniques of Practical Biochemistry. Cambridge Univ.Press.
- 46) C. R. Kothari – Research Methodology, Methods and Techniques. Wiley Eastern Ltd. Mumbai.

University of Mumbai
M.Sc. ZOOLOGY (Animal Physiology) Semester III and
Semester IV EXAMINATIONS
Modality of Assessment

A. Internal Assessment 40%

Sr. No.	Evaluation type	Total Marks
1	One Assignments / Case study	25
2	Active participation in routine class instructional deliveries	05
3	Attendance – (0-25% = 0 marks, 25-50% = 1mark, 50-75% = 3 marks and 75-100%= 5 marks)	05
4	Overall conduct as a responsible student, manners, skill in articulation, leadership qualities demonstrated through organizing co-curricular, etc.	05

B. External Assessment 60%

a. Semester End Examination 60 Marks

- Duration – These examinations shall be of two and half hours duration for each paper.
- Theory Question Paper Pattern:
 - ❖ There shall be five questions each of 12 marks. On each unit there will be one question and the first one will be based on entire syllabus.
 - ❖ All questions shall be compulsory with internal choice within the questions. Each question will be of 18 to 30 marks with options.
 - ❖ Question may be subdivided into sub questions a, b, c... and the allocation of marks depend on the weightage of the topic.

b. Practicals: 50 Marks

c. Project in Semester IV: Internal Examination 40 Marks

Dissertation: 60 Marks

External Evaluation: 50 Marks

***Note - The practicals may be conducted by using specimens authorized by the wild life and such other regulating authorities though it is strongly recommended that the same should be taught by using photographs / audio-visual aids / simulations / models etc. as recommended by the UGC and as envisaged in the regulation of the relevant monitoring bodies. No new specimens, however, shall be procured for the purpose of conducting practicals mentioned here-in above.**

N.B:

I) It is pertinent to note that we have to adhere strictly to the directions as given in the UGC Circular F14-4/2006 (CPP-II).

II) Apart from the Institutional Animal Ethics Committee (IAEC) and any other Committee appointed by a Competent Authority / Body from time to time, every college should constitute the following Committees:

- 1) A Committee for the Purpose of Care and Supervision of Experimental Animals (CPCSEA) and
- 2) A Dissection Monitoring Committee (DMC) to ensure that no dissections are done.

Composition of DMC shall be as follows:

- i) Head of the Concerned Department (Convener / Chairperson)
- ii) Two Senior Faculty Members of the concerned Department
- iii) One Faculty of related department from the same College
- iv) One or two members of related department from neighbouring colleges.

Use of animals for any experiment / dissection /mounting is banned. Simulations, authorized permanent specimens / slides, charts, models and other innovative methods are encouraged.

University of Mumbai
M.Sc. ZOOLOGY (Oceanography and Fishery Technology)
Paper Pattern of
Semester III (Papers 1, 2, 3, 4) / IV (Papers 1, 2, 3) Examination

Maximum Marks: 60

Duration: 2.5 Hours

Marks Option: 90

Question 1. Based on Unit I to IV (Mixed Questions)

Question 2. Based on Unit I

Question 3. Based on Unit II

Question 4. Based on Unit III

Question 5. Based on Unit IV

Instructions:

- a. All questions are compulsory.
- b. All questions carry equal marks.
- c. Draw neat and labelled diagrams wherever necessary.

1. Answer any **four questions** from the following: (Based on all 4 Units) **(12)**
 - a)
 - b)
 - c)
 - d)
 - e)
 - f)
2. Answer any **two questions** from the following: (Based on Unit I) **(12)**
 - a)
 - b)
 - c)
3. Answer any **two questions** from the following: (Based on Unit II) **(12)**
 - a)
 - b)
 - c)
4. Answer any **two questions** from the following: (Based on Unit III) **(12)**
 - a)
 - b)
 - c)
5. Answer any **two questions** from the following: (Based on Unit IV) **(12)**
 - a)
 - b)
 - c)

Semester IV Examination
Paper IV: Instrumentation and Presentation of Scientific data
Internal (Theory) Paper Pattern of PSZOOCN404

Maximum Marks: 40

Duration: 1.15 Hours

Marks Option: 60

Instructions:

- a. All questions are compulsory.
 - b. Draw neat and labeled diagrams wherever necessary.
-
1. Fill in the blank by choosing the correct option given in the brackets (Based on both Units) Four sub-questions from each unit. **(08)**
 2. Answer any **two questions** from the following: (Based on Unit I) **(16)**
 - a)
 - b)
 - c)
 3. Answer any **two questions** from the following: (Based on Unit II) **(16)**
 - a)
 - b)
 - c)

Skeleton of Practical Examination Question Paper

Practical Paper 1: PSZOPHY3P1

Time: 10:00 am to 3:00 pm

Total Marks: 50

- 1. Major Question** **18**
Dissect Earthworm / Crab / Cockroach so as to expose its digestive system.
OR
Dissect Cockroach so as to expose its Nervous system.
- 2. Minor question**
Demonstrate the transport of glucose across semi-permeable membrane (egg membrane). **09**
OR
Demonstrate the effect of suitable toxicant (heavy metal / nicotine) on the heartbeat of *Daphnia*. **09**
OR
Calculate the respiratory quotient of cockroach with the help of respirometer. **09**
- 3. Identify and mention the parts of invertebrate excretory organs. (Any two)** **07**
- 4. Identification**
Identify the insect mouth parts with respect to their modifications and adaptations. (Two spots). **06**
- 5. Viva- voce.** **05**
- 6. Journal.** **05**

Practical 2: PSZOPHY3P2

Time: 10:00 am to 3:00 pm

Total Marks: 50

- 1. Major question** **18**
Determination of activities of Amylase / Trypsin from suitable source (human saliva for amylase, Intestine of goat or chicken for trypsin) and Determination of K_m of a given enzyme.
OR
Determination of effect of pH / Temperature / Activator / Inhibitor on the activity of salivary / pancreatic amylase enzyme.
OR
Determination of isotonic concentration to blood by studying the effect of different concentrations of sodium chloride on the diameter of RBCs.
OR
Show the influence of sublethal concentration of ammonia (50-60 ppm) on suitable fish exposed to ammonia stress for 3/7 days with reference the following parameters:
 - i. Level of excretory ammonia **08**
 - ii. Level of activity of hepatic and brain glutamate dehydrogenase. **10****OR**
 - ii. Level of amino acid content of muscle / gill / brain / liver. **10**
- 2. Determine the cholesterol / urea / uric acid / creatinine content in the given blood sample.** **08**
- 3. Prepare a report from the given**
Parameters of routine test: renal function/liver function/ Stress test/Polycythemia/ urine. **12**
OR
X-ray / CT scan images. Interpret the result and submit the report. **12**
- 4. Viva- voce.** **05**
- 5 Journal.** **05**

Practical 3: PSZOPHY3P3

Time: 10:00 am to 3:00 pm

Total Marks: 50

1. Major question

18

Set up an experiment to demonstrate the effect of decreasing PO_2 of water on the respiratory rate of a fish / lactic acid content of fish muscle. Compare it with control fish and submit the report.

OR

Estimate the salt loss and salt gain in an aquatic animal when it is transferred to a salt free and natural medium.

2. Minor question

a) Separate from the given sample serum globulin / plasma proteins by PAGE electrophoresis.

12

b) Demonstrate the effect of temperature on development of chick embryo / opercula movement of fish.

10

3. Viva-voce.

05

4. Journal.

05

Practical 4: PSZOPHY3P4

Time: 10:00 am to 3:00 pm

Total Marks: 50

1. Major question

18

Demonstration of immune-diffusion by Ouchterlony technique.

OR

Demonstration of single radial immune-diffusion of antigen and antibody.

OR

Demonstration of counter current immune electrophoresis.

2. Minor question

a) Study of phagocytosis / Separation of lymphocytes.

09

b) Perform Agglutination Reaction: Tube Agglutination Reaction / Slide Agglutination Reaction / Indirect Agglutination Inhibition Reaction. Submit a report.

07

3. Identify lymphoid tissue and lymph node/bone marrow. (Any two slides)

06

4. Viva- voce.

05

5. Journal.

05

Practical 4: PSZOPHY4P1

Time: 10:00 am to 3:00 pm

Total Marks: 50

- 1. Major question** **18**
 - a) Demonstrate water and ionic regulation in the given freshwater fish in different osmotic media. (Any 3 media).

OR

 - b) Estimate the blood sugar level / liver glycogen in the given sample. Interpret the result and submit the report.
- 2. Prepare a setup to show the properties of glycerinated muscle fibre.** **10**
- 3. Identification:** **12**
 - a) Sense organs (vertebrates)
 - b) Physiological effectors (invertebrates)
- 4. Viva- voce.** **05**
- 5. Journal.** **05**

Practical 4: PSZOPHY4P2

Time: 10:00 am to 3:00 pm

Total Marks: 50

1. Major Question

18

Set up an experiment to demonstrate the effect of insulin / adrenaline on rate of heartbeat In *Daphnia*. Compare with control *Daphnia* and submit the report.

OR

Set up an experiment to show the effect of light and dark phase on *Drosophila*. Submit the report.

2. Identification:

12

- a) The endocrine glands (vertebrates) and
- b) The hormones (invertebrates)

OR

From the given data identify the migratory routes birds / fishes. Interpret the reason for migration.

3. Identify stage of:

10

- a) estrous cycle
- b) menstrual cycle

4. Viva voce.

05

5. Journal.

05

Practical 4: PSZOPHY4P3

Time: 10:00 am to 3:00 pm

Total Marks: 50

1. Major Question

Show the toxicity effect of carbon tetra chloride in rat / mice with reference to the following parameters: **18**

Level of enzyme activity:

- i. AspAT and AlAT
- ii. ACP / ALP, SDH, LDH

OR

a) Total lipid and free fatty acid content of liver. **09**

b) Free fatty acid content of plasma. **09**

2. Design protocol for toxicity experiment from the data provided. **12**

- a) Acute and sub-acute toxicity
- b) Reproduction toxicity
- c) Dermal toxicity

3. Submit a report of visit to animal house/clinical trial laboratory and viva based on it. **10**

4. Viva voce. **05**

5. Journal. **05**

Practical 4: PSZOPHY4P4

Evaluation of Project: 60 Marks

- | | | |
|----|--|------|
| 1. | Title of the Project | (01) |
| 2. | Aim, Objectives and Rationale | (04) |
| 3. | Materials and Methods | (05) |
| 4. | Observations and / Results | (10) |
| 5. | Interpretation of Observations / Results and Discussion | (10) |
| 6. | Conclusion and / Recommendation | (10) |
| 7. | Relevant work / Justification of work with Project title | (10) |
| 8. | Relevant References | (05) |
| 9. | Certified Dissertation | (05) |

External Evaluation: 50 Marks

- | | | |
|----|--|------|
| 1. | Content of Presentation | (10) |
| 2. | Quality of Presentation | (10) |
| 3. | Presentation Skill | (10) |
| 4. | Quality of Work | (10) |
| 5. | Viva based on Proposal / Question Answer Session | (10) |