SYLLABUS
FOR TWO YEAR

MASTER'S PROGRAMME
IN
PHYSIOLOGY

Based on guideline of UGC's Choice-Based-Credit system (CBCS) and Learning –Outcome –Based –Curriculum- Framework (LOCF)

2021

UNIVERSITY OF KALYANI

DEPARTMENT OF PHYSIOLOGY

KALYANI – 741235

NADIA, WEST BENGAL, INDIA

(www.klyuniv.ac.in)

Preamble

Department of Physiology was established in 2005. The entire syllabus for 2 (two) year Master of Science (M.Sc.) programme in Physiology was first formulated under the part –I and Part –II framework. In 2009, the curriculum was designed with the adoption of semester wise evaluation system. The M.Sc. Programme in Physiology was re-structured in 2014, for adoption choice based credit system (CBCS) under the four semester frame work to facilitate students' mobility across institutions within and across countries. This system brought in the desired uniformity in grading system and method for computing the cumulative grade point average (CGPA) based on the performance of students in examinations. In 2016, the syllabus has been revised and redesigned. Now the syllabus is revised as per Learning Outcomes-Based Curriculum Frame work and placed for approval of University Authority.

About the Curriculum

The entire syllabus for 2 (two) year Master of Science (M.Sc.) curriculum in Physiology has been divided into 4 (four) semesters. The total weightage of the syllabus for 4 semesters will be 1050 marks and 84 credits. In each paper 80% marks shall be earmarked for term-end examination and remaining 20% marks shall be allotted for internal assessment. Students will be assessed internally by class test, proficiency in oral presentation, performance in group discussion, report submitted on assignment, and continuous evaluation based on performance in theoretical and practical classes.

Each credit will have 15 hours of work load in case of theoretical classes and 30 hours of work load in case of practical classes per semester. The M.Sc degree in Physiology will be awarded to the student who will complete a total of minimum 84 credits. Entire semester programme shall be comprised of five types of courses, namely Core Course (COR), Ability Enhancement compulsory Courses (AECC), Skill Enhancement Courses (SEC), Generic Elective Courses (GEC) and Discipline Specific Elective Course (DSE)]. Framework of the curriculum along with marks and credits for each semester have been given in the table. An option for three multidisciplinary DSE (Environmental Physiology, Ergonomics and Occupational Physiology, and Food and Nutrition) shall be given to the students to choose a course in order to enhance their knowledge in core physiology course(s) and develop skills in the subject for employability. This foundation course shall be called "special paper" in the curriculum of Physiology.

The learning outcomes based approach of this curriculum demonstrated achievement of outcomes expressed in terms of knowledge, understanding, skills, attitude and values. It specifies what students completing a particular course component of study are expected to know and be able to do at the end of their programme of study.

1st Semester Programme in Physiology

July to December (Odd semester)

Outline of courses and components

225 Marks

18 credits

Paper code	Course Components	Theory/ Practical	Credit	Marks (Semester End + Internal Assessment)
COR 101	101.1 Physiological Chemistry and Chemistry of Metabolism 101.2 Hematology and Cardiovascular Physiology	Theory	4	50
COR 102	102.1 Cellular Physiology and Cancer biology 102.2 Molecular Physiology 102.3 Nanophysiology	Theory	4	50
COR 103	103.1 Occupational Physiology and safety 103.2 Exercise Physiology 103.3 Instrumentation in Physiology	Theory	4	50
COR 104	104.1 Physiological Chemistry 104.2 Environmental Chemistry	Practical	4	50
AECC	Orientation for dissertation, review of literature and experiments done. Oral presentation of the same uses IT-pedagogy.	Practical	2	25
	Total		**18**	**225**

COR: Core Courses, AECC: Ability Enhancement Compulsory Courses

2nd Semester Programme in Physiology

January to June (Even semester)

Outline of courses and components

250 Marks

20 Credits

Paper code	Course Components	Theory/ Practical	Credit	Marks (Semester End + Internal Assessment)
COR 205	205.1 Neuro-physiology 205.2 Muscle Physiology 205.3 Physiology of Special Senses	Theory	4	50
COR 206	206.1 Respiratory Physiology and Renal Physiology 206.2 Endocrine Physiology and Stress Physiology	Theory	4	50
COR 207	Experimental Physiology	Practical	4	50
COR 208	208.1 Hematology 208.2 Human Physiological Experiments	Practical	4	50
GEC	Fundamentals in Physiology		4	50
	Total		**20**	**250**

COR: Core Courses, GEC: Generic Elective - Courses for Intradepartmental Students

3rd Semester Programme in Physiology

July to December (Odd Semester)

Outline of courses and components

275 Marks

22 Credits

Paper code	Course Components	Theory/ Practical	Credit	Marks (Semester End + Internal Assessment)
COR 309	309.1 Gastro-intestinal Physiology 309.2 Neuro-endocrinology and GI Hormones 309.3 Reproductive Physiology, Population control and Embryology	Theory	4	50
COR 310	310.1 Microbiology and Immunology 310.2 Chrono-physiology 310.3 Application of Biostatistics and Computer Science in understanding Physiology	Theory	4	50
COR 311	311.1 Microbiology 311.2 Immunology	Practical	4	50
COR 312	312.1 Histology 312.2 Histological Chemistry	Practical	4	50
DSE 301	301.1 Environmental Physiology-T1 301.2 Ergonomics and Occupational Safety-T1 301.3 Human Nutrition and Dietetics-T1	Theory	4	50
SEC	Computer Applications Physiological Statistics	Practical	2	25
	Total		**22**	**275**

COR: Core Courses, SEC: Skill Enhancement Courses, DSE: Discipline Specific Elective

4th Semester Programme in Physiology

January to June (Even semester)

Outline of courses and components

300 Marks

24 Credits

Paper code	Course Components	Theory/ Practical	Credit	Marks (Semester End + Internal Assessment)
DSE 402	402.1 Environmental Physiology-T2 402.2 Ergonomics and Occupational Physiology-T2 402.3 Food and Nutrition-T2	Theory	4	50
DSE 403	403.1 Environmental Physiology-T3 403.2 Ergonomics and Occupational Physiology-T3 403.3 Food and Nutrition-T3	Theory	4	50
DSE 404	404.1 Environmental Physiology-P1 404.2 Ergonomics and Occupational Physiology-P1 404.3 Food and Nutrition-P1	Practical	4	50
DSE 405	405.1 Environmental Physiology-P2 405.2 Ergonomics and Occupational Physiology-P2 405.3 Food and Nutrition-P2	Practical	4	50
Project/Dissertation	Literature Review, Project work and Seminar presentation on recent advances in the subject	Practical	8	100
	Total		**24**	**300**
	Grand Total		**84**	**1050**

COR: Core Courses, AECC: Ability Enhancement Compulsory Courses, SEC: Skill Enhancement Courses, GEC: Generic Elective Courses, DSE: Discipline Specific Elective

Minimum Credit must be **84 points**.

1st Semester Programme in Physiology
July to December (Odd semester)
Detail of courses and components
225 Marks
18 credits

COR 101 (50 Marks: Credits = 4)
(Theory)
Lectures = 60 hours

Course - 101.1 Physiological Chemistry and Chemistry of Metabolism (30)
101.2 Hematology and Cardiovascular Physiology (30)

101.1.1 Physiological Chemistry (15)

I. Neural Chemistry

a) Biosynthesis and catabolism of acetylcholine.
b) Biosynthesis and catabolism of catecholamines: Biosynthesis of dopamine and epinephrine, catabolism of dopamine, catabolism of extracellular epinephrine and norepinephrine.
c) Biochemical events of cholinergic, noradrinergic and serotonergic endings.
d) Biosynthesis and catabolism of serotonin.
e) Synthesis of catabolism of histamine.
f) Formation and metabolism of glutamate and GABA.
g) Chemistry of tachykinins, opioid peptides, CGRP (calcitonin gene related peptide), cannabinoids, gases (CO, NO), prostaglandins.
h) Glutamate-glutamine cycle in glutaminergic neurons and astrocytes.
i) Physiochemical basis of LTP in Schaffer collaterals in the hippocampus.
j) Chemistry of phototransduction in rods.

II. Muscular Chemistry

a) Chemistry of cross-bridge cycle.
b) Energy sources and metabolism: phosphorylcreatine, carbohydrate and lipid breakdown, EPOC mechanism, rigor.

III. Hormonal Chemistry

a) Biosynthesis of protein hormones.
b) Biosynthesis of insulin.
c) Chemistry of glucagon.
d) Biosynthesis of thyroid hormones.
e) Chemistry and metabolism of TSH.
f) Steroid hormone biosynthesis.
g) Biosynthesis of adrenocortical and gonadal steroids: aldosterone, glucocorticoid, testosterone, estrogen and progesterone.
h) Formation and metabolism of melatonin.
i) Renin-angiotensin system.
j) Natriuretic peptides.
k) Chemistry of oxytocin and vasopressin.

l) Chemistry of G-I hormones.
m) Synthesis of vitamin D_3 dihydroxycholecalciferol.

IV. Blood Chemistry

a) Chemistry for the formation of platelet clot.
b) Chemistry of the blood clotting mechanism: activation of prothrombin, conversion of fibrinogen to fibrin, formation of fibrin polymer, fibrinolytic mechanism.

V. Histological Chemistry

a) Chemistry of tissue fixation.
b) Chemistry of dyeing and staining.
c) Histochemistry of biomolecules: starch, glycogen, lipids, amino acids, proteins, enzymes, and nucleic acids.
d) Immunohistochemistry.
e) Electronmicroscopic histochemistry.

101.1.1 Chemistry of Metabolism (15)

I. Introduction to Metabolism

a) Overview: tropic strategies, metabolic pathways, thermodynamic considerations, control of metabolic flux.
b) High energy compounds: ATP and phosphoryl group transfer, coupled reactions, other phosphorylated compounds, thioesters.
c) Oxidation-reduction reactions; NAD^+ and FAD, Nernst Equation, approaches to the study of metabolism: tracing metabolic fates, perturbing the system.

II. Carbohydrate Metabolism

i) **Carbohydrate Chemistry**

a) Isomerism of monosaccharides: optical, aldose, ketose, D-L stereoisomerism, pyranose-furanose isomerism.
b) Properties of monosaccharides: reducing action, osazone formation, mutarotation, and glycoside and ester formation.
c) Properties of sucrose, lactose, maltose and starch.

ii) **Glucose Catabolism**

a) Glycolysis: overview, reactions of glycolysis, fermentation-anaerobic fate of pyruvate, control of glycolysis-PFK and substrate cycling.
b) Metabolism of hexoses other than glucose: fructose, galactose and mannose.
c) Pentose phosphate pathway: oxidative reactions of NADPH production, isomerization and epimerization of Ribulose-5-phosphate, carbon-carbon bond cleavage and formation reactions, control of pentose-phosphate pathway, glucose-6-phosphate dehydrogenase deficiency and probable health hazards.

iii) Glycogen Metabolism and Gluconeogenesis

a) Glycogen breakdown.
b) Glycogen synthesis.
c) Control of glycogen metabolism: direct allosteric control of glycogen phosphorylase and glycogen synthase, covalent modification of phosphorylase and synthase, hormonal effects on glycogen metabolism.
d) Gluconeogenesis: pyruvate to phosphoenol pyruvate, hydrolytic reactions, regulation of gluconeogenesis.
e) Glycogen storage diseases.

iv) Citric Acid Cycle

a) Overview of citric acid cycle with enzymes, stereo specificity of citric acid cycle reactions.
b) Synthesis of Acetyl-COA: pyruvate dehydrogenase multienzyme complex and their reactions.
c) Regulation of Citric Acid Cycle: regulation of pyruvate dehydrogenase, rate-controlling enzymes of the citric acid cycle.
d) Reactions related to the citric acid cycle: pathways that use citric acid cycle intermediates, reactions that replenish citric acid cycle intermediates, the Glyoxylate Pathway.
e) Arsenic poisoning and cycle.

v) Electron Transport and Oxidative Phosphorylation

a) Mitochondrion: mitochondrial anatomy, mitochondrial transport systems.
b) Electron Transport: thermodynamics of electron transport, sequence of electron transport, complex I, II, III & IV.
c) Oxydative Phosphorylation: chemiosmotic theory, ATP synthase, P/O ratio, uncoupling oxidative phosphorylation.
d) Control of ATP production: control of oxidative phosphorylation, coordinated control of oxidative metabolism.
e) Physiological implication of aerobic metabolism: cytochrome P_{450}, reactive oxygen species, antioxidant mechanism.

III. Lipid Metabolism

i) Lipid Transport

ii) Fatty Acid Oxidation

a) Fatty acid activation.
b) Transport of fatty acyl COA across the mitochondrial membrane.
c) Beta-oxidation of fatty acyl-COA.
d) Oxidation of unsaturated fatty acids.
e) Oxidation of odd-chain fatty acids.
f) Peroxisomal beta-oxidation.

iii) Fatty Acid Biosynthesis

a) Transport of mitochondrial acetyl-COA into the cytosol.
b) Acetyl–COA carboxylase.
c) Fatty acid synthase.
d) Elongases and desaturases.
e) Synthesis of triacylglycerols.

IV. Regulation of Fatty Acid Metabolism

i) Membrane Lipid Synthesis

a) Glycerophospholipids.
b) Sphingolipid.

ii) Cholesterol Metabolism

a) Cholesterol biosynthesis.
b) Cholesterol transport.
c) Control of cholesterol metabolism.

V. Amino Acid Metabolism

a) Intracellular protein degradation.
b) Amino acid deamination, transamination, oxidative deamination.

c) Urea cycle: reactions of urea cycle, regulation of urea cycle.
d) Breakdown of amino acids.
e) Amino acid biosynthesis: essential and nonessential amino acids.
f) Nitrogen fixation.
g) Phenylketonuria and Alkaptonuria.
h) Other products of amino acid metabolism; biosynthesis and degradation of heme, biosynthesis of physiologically active amines, nitric oxide.

VI. Mammalian Fuel Metabolism: Integration and Regulation

a) Inter organ metabolic pathways: Cori cycle, Glucose-alanine cycle, glucose transporters.
b) Mechanism of hormone action (signal transduction): hormone regulation of fuel metabolism, adenylate cyclase signaling system, receptor tyrosine kinases, phosphoinositide pathway.
c) Disturbances of fuel metabolism: starvation, diabetes mellitus, obesity.
d) Oncogenes and cancer, effect of drugs and toxins on cell signaling, response of beta-cells to blood glucose level.

VII. Nucleotide Metabolism

a) Synthesis of purine ribonucleotides.
b) Synthesis of pyrimidine ribonucleotides.
c) Formation of deoxyribonucleotides.
d) Nucleotide degradation: catabolism of purines, fate of uric acid, catabolism of pyrimidines.

101.2.1 Hematology (15)

I. Concept of Circulating Body Fluids

a) Blood: overview of composition, concept of plasma and serum, physiological function of plasma proteins, complement system and clotting pro-enzymes present in plasma.
b) Lymph: Composition, formation, circulation and function.

II.Leukocytes: Ultastructure and Functions

a) Neutrophil: Phagocytosis of opsonized bacteria, killing of bacteria by O^{2-}, H_2O_2, defensins and NADPH oxidase by neutrophil, role of myeloperoxidase.
b) Monocyte: Role of monocytes in tissue macrophage system.
c) Lymphocyte: Lymphocyte population: B lymphocyte-plasma and memory B cells; T-lymphocytes-helper T cells (T_4 Cells), Suppressor and Cytotoxic T Cells (T_8 Cells) and memory T cells; interleukins and cytokines; antigen presentation, T-Cell receptors, humoral immunity and cell mediated immunity.

III. Thrombocyte (Platelet) and Hemostasis

a) Ultrastructure of Platelets.
b) Homeostasis: local vasoconstriction, platelet activation, platelet adhesion, platelet aggregation, activation of prothrombin and role of factor X_a and gamma-carboxylase (activated by Vit. K), formation of fibrin monomer and polymer, stabilization of fibrin polymer.
c) Abnormalities in homeostasis: hemophilia A, Von Willebrand's disease, thrombosis.

d) Anticlotting mechanism: role of thrombomodulin, heparin, antithrombin-III and plasmin.
e) Anticoagulants: heparin, antithrombin III, chelating agents.

IV. Erythrocyte (RBC)

a) Ultrastructure of RBC plasma membrane.
b) RBC size: normocytic, macrocytic and microcytic cell.
c) Red cell fragility: role of G6PD in normal red cell fragility, osmotic fragility, hereditary spherocytosis.
d) Feedback control of erythropoiesis, role of erythropoietin, role of IL-1, 3, 6 and GM-CSF in the development of erythroid stem cells, erythroblasts and reticulocytes-structure and function.
e) Hemoglobin (Hb): molecular structure, types – HbA and HbF, R & T state of hemoglobin, abnormalities in Hb production – hemoglobinopathies, thalassaemias (α and β); sickle RBC.
f) Function of RBC: transport of O_2 and CO_2.

V. Blood Types and Transfusion

a) The ABO system.
b) Transfusion reactions.
c) Inheritence of A and B antigens.
d) Rh- group: D antigen, Rh +ve and Rh -ve individual.
e) Hemolytic disease of the newborn: erythroblastosis fetalis, hydrops fetalis.

101.2.2 Cardiovascular Physiology (15)

I. Functional Anatomy of Cardiac Muscle

a) Myocardial cell, intercalated discs, electrical synapse (nexi) present in intercalated disc, orientation of T- tubule along 'Z' line, organization of sarcoplasmic reticulum with diad, sarcolemma with glycocalyx.
b) Organization of myofillaments in cardiac myofibrils, sarcomere - structural and functional unit, organization of thick and thin filaments during systole and diastole, molecular organization of contractile proteins in thick and thin filaments of sarcomere.

II. Excitation- Contraction Coupling in Cardiac Muscle

a) The primary source of extracellular Ca^{2+}: role of cAMP dependent protein kinase and glycocalyx.
b) Release of Ca^{2+} from SR trigger Ca^{2+} ($Ca2^{+}$ induced Ca^{2+} release).
c) Ca^{2+} activated contraction of myofilaments (systole).
d) Relaxation (Diastole): role of phospholamban.
e) Action of cardiac glycosides in heart failure.
f) Starling's law of the heart.

III Electrical Activity of the Heart

a) Ionic basis of resting potential.
b) Action potential: types- fast response and slow response, ionic basis of fast response and slow response action potential.
c) Membrane potential of pacemaker tissue: prepotential (pacemaker potential), slow response action potential, ionic basis of pacemaker membrane potential,

effect of sympathetic and vagal stimulation on the pacemaker membrane potential.

d) Normal electrocardiograms.
e) Myocardial infarction.

IV Hemodynamics

a) Velocity of the blood stream.
b) Relationship between velocity and pressure.
c) Relationship between pressure and flow: application of Poiseuille's law, resistance to flow, resistance in series and in parallel, laminar and turbulent flow- Reynold's number, shear stress on the vessel wall.
d) Rheologic properties of blood.

V. Cardiovascular Regulatory Mechanism

a) Local regulation: autoregulation, local vasoconstriction, vasodialation by metabolites.
b) Endothelial regulation: role of prostacyclin and thromboxane A_2, NO, and endothelins.
c) Systemic regulation by hormones: role of kinins and ANP.
d) Systemic regulation by nervous system: cardiac innervations and heart rate, medullary control of blood pressure- role of baroreceptors and buffer nerves, Bainbridge reflex and coronary chemo reflex.
e) Hypertension: essential and malignant.

VI. Special Circulation

a) Coronary circulation: regulation, acute coronary artery occlusion, myocardial ischemia and angina pectoris.
b) Cerebral circulation: regulation.

(Learning outcome: The students will able to understand biochemical process occurs in human body and it's implication in health and wellbeing. It will also help to understand the role of body fluids and cardiovascular system in health and disease.)

COR102 (50 Marks: Credits = 4)
(Theory)
Lectures = 60 hours

Course - 102.1 Cellular Physiology and Cancer Biology (30)
102.2 Molecular Physiology (20)
102.3 Nanophysiology (10)

102.1.1 Cellular Physiology (20)

I. Cellular Membranes and Transmembrane Transport of Solutes and Water

a) Cellular membranes.
b) Membrane structure.
c) Membrane composition: lipid composition, membrane proteins, asymmetry of membrane proteins and lipids.
d) Membranes as permeability barriers.
e) Transport across, but not through membranes: endocytosis, exocytosis, fusion of membrane vesicles.
f) Transport of molecules through membranes: diffusions (including roles of aquaporins), osmosis.

g) Protein mediated membrane transport : facilitated transport; active transport ; other membrane transport processes- ion transporting ATPases (Type- P,V, and F), Calcium ATPases, Na^+-Ca^{2+} exchange, Na^+ - H^+ exchange, anion exchange facilitated transport of glucose, ABC transporters, transport across epithelia.

II. Ionic Equilibria and Resting Memrane Potentials

a) Ionic equilibria: electrochemical potentials of ions, electrochemical equilibrium and the Nernst equation, Gibbs-Donan equilibrium, regulation of cell volume.
b) Resting membrane potentials : distribution of ions across plasma membranes, active ion pumping and resting potential and role of cardiac glycosides, generation of resting membrane potential by ion gradients, chord conductance equation, roles of Na^+, K^+-ATPase in establishing resting membrane potential—direct versus indirect.

III. Generation and Conduction of Action Potentials

a) Membrane potentials: observation of membrane potentials, sub-threshold responses: the local response, action potentials.
b) Ionic mechanisms of action potentials: action potential in squid giant axon, ion channels and gates – role of tetrodotoxin (TTX) and saxitoxin, behaviour of individual ion channels – patch electrodes, action potential in cardiac and smooth muscle.
c) Properties of action potentials- primary hyperkalemic paralysis.
d) Conduction of action potentials: local response, action potential as self-reinforcing signal, conduction velocity.

IV. Synaptic Transmission

a) Synapse: electrical and chemical.
b) Neurotransmitter Junction: structure, overview of neurotransmitter transmission- end plate potential (EPP), synthesis of acetylcholine, quantal release of transmitter- miniature EPP (MEPP), action of cholinesterase and reuptake of choline, acetylcholine receptor protein action of alpha-toxin in cobra venoms, autoimmune disease- myasthenia gravis and Lambert-Eaton myasthenic syndrome.
c) Electrical synapse- gap junctions.
d) Chemical synapse between neurons, excitatory and inhibitory postsynaptic potentials (EPSP & IPSP), summation of synaptic inputs and postsynaptic potentials, modulation of synaptic activity.
e) Neurotransmitters and neuromodulators: neurotransmitters, neuroactive peptides- opioid peptides.
f) Neurotransmitter receptors.
g) Cellular and molecular mechanisms of neurotransmitter release- docking, priming and release; role of botulinum toxins – B, D, F and G.

V. Membrane Receptors, Second Messengers, and Signal Transduction Pathways

a) Types of Signal Transduction Pathways- protein kinases and Phosphatases in signal transduction pathways.
b) G-protein linked membrane receptors, G-protein mediated signal transduction pathways,
c) Membrane phospholipid and signal transduction pathways.
d) Heterotrimeric G-protein – monomeric GTP binding proteins, second messenger dependent ion channels.
e) Protein tyrosine kinases.

f) Second messenger dependent protein kinases –cyclic AMP dependent protein kinase, protein kinase C, calmodulin dependent protein kinases.
g) Tyrosine kinases –receptor associated tyrosine kinases.
h) Protein phosphatases and their modulation-protein tyrosine phosphatases, serine-threonine protein phosphatases.
i) Atrial natriuretic peptide receptor-guanylyl cyclases.
j) Nitric oxide.
k) Down regulation and desensitization of receptors.
l) Defects in signaling pathways that lead to diseases.

VI. Cell Death

a) Types of cell death- Apoptosis and necrosis.
b) Apoptosis: definition and event.
c) Cellular and molecular basis of apoptosis.

102.1.2 Cancer Biology (10)

I. An overview of the nature of cancer- Terminologies in cancer, evolution and cancer.

II. Multistep Tumorigenesis

a) Self sufficiency in growth signals-oncogenes,
b) Insensitivity to growth-inhibitory signals- tumor suppressor genes,
c) Evasion of apoptosis,
d) Acquisition of limitless replicative potential,
e) Sustained angiogenesis,
f) Ability to invade and metastasize.

III. Tumor microenvironment and Tumor immunology.

IV. Rational treatments of cancer

102.2 Molecular Physiology (20)

I. Realm of Molecular Physiology

II. Biomolecules

a) Definition.
b) Types: nucleotides and nucleic acids, amino acids, protein, carbohydrate, lipids and biological membranes.
c) Biomolecules and physiological importance.

III. Nucleotides and Nucleic Acids

a) Nucleotide structure and function
b) Nucleic acid structure: base composition of DNA, double helix ,single stranded nucleic acids.
c) Function of nucleic acid: Genetic information, protein synthesis, RNA world.
d) Nucleic acid sequencing: restriction endonucleases, electrophoresis and restriction mapping, chain terminator method of sequencing.
e) Recombinant DNA technology: cloning techniques, genomic libraries, DNA amplification by Polymerase Chain Reaction, applications of recombinant DNA technology, RFLPs, ethical aspects of recombinant DNA technology.

IV. Amino Acids

a) Amino acid structure.
b) Stereochemistry.

c) Nonstandard amino acids.

V. Proteins

a) Polypeptide diversity.
b) Protein purification: general approach, protein solubility, chromatography, electrophoresis of protein, ultracentrifugation.
c) Protein sequencing: preliminary steps, polypeptide cleavage, Edman degradation, reconstructing the proteins sequence.
d) Three-dimensional structure of protein: secondary, tertiary and quaternary structure of protein; protein folding, collagen diseases, protein structure determinations by NMR, disease related to protein folding.
e) Functions of protein: basic function of hemoglobin, myosin and actin, antibody.

VI. DNA Replication and Repair

a) Overview of replication.
b) Prokaryotic DNA replication: DNA polymerases, initiation of replication, synthesis of leading and lagging stand, termination of replication, fidelity of replication.
c) Eukaryotic DNA replication: eukaryotic DNA polymerases, initiation of eukaryotic DNA replication, telomerase.
d) DNA mutation and repair.

VII. Transcription and RNA Processing

a) RNA polymerase. Transcription in eukaryotes: eukaryotic RNA polymerases, promoters, transcription factor.
b) Post transcriptional processing: mRNA, rRNA, and tRNA.

VIII. Translation

a) Genetic code.
b) Transfer RNA and its aminoacylation.
c) Ribosomes.
d) Polypeptide synthesis; chain initiation, elongation, and termination; translation accuracy.
e) The effect of antibiotics on protein synthesis.

IX. Regulation of gene Expression

a) Genome: gene number, gene clusters, non-transcribed DNA.
b) Regulation of prokaryotic gene expression: lac repression, attenuation-trp operon.
c) Regulation of eukaryotic gene expression.

102.3 Nanophysiology (10)

I. Nanotechnology

a) Nanoparticles: characteristics.
b) Nanotechnology: Contribution of Eric Drexler, 1986 & 2006.

II. Physiological Application of Nanoparticles

a) Nanoparticles used to understand the homeostasis of physiological variables.
b) Routes for the entry of nanoparticles in the body.
c) Physiological application of: Gold nanoparticles (AuNp), and carbon nanostructures fullerenes (e.g. C_{60}) and nanotubes.

III. Nanotoxicology

a) Nanotoxicology.
b) Human health hazards imparted by nanoparticles: mechanism of toxicity.
c) Possible control of nanotoxicology.

(**Learning outcome:** Students will be able to learn the fundamentals of human body, molecular mechanism and genetic basis and its implication in diseases. They will also know the application of nanotechnology in physiological system.)

COR-103 (50 Marks: Credits = 4)
(Theory)
Lectures = 60 hours

103.1 Occupational Physiology and safety (25)
103.2 Exercise Physiology (20)
103.3 Application of Instrumentation in Physiology (15)

103.1 Occupational Physiology and safety (25)

I. Introduction to Occupational Physiology

a) Concept of health and Well being.
b) Man as a system component.

II. Assessment of Work load

a) Classification of Work load.
b) Determination of work stress: Heart rate, oxygen consumption, and catecholamine secretion.
c) Mental work load and

III. Occupational Health Problems

Epidemiological assessment of occupational health problem. Work-related musculoskeletal disorders (WRMSDs); Cumulative trauma disorder, Repetitive strain injury, Standardized questionnaire, Prevention.

a) Diseases due to physical agents.
b) Diseases due to chemical agents.
c) Diseases due to biological agents.

IV. Ergonomics for safety and loss prevention

a) Concept of Ergonomics
b) Accident**:** Definition, Classification, Cost of accident, Theories.
c) Unsafe acts and unsafe conditions.
d) Analysis of Risk

V. Anthropometry

a) Static and dynamic anthropometry.
b) Application of anthropometric data in design.
c) Use of percentile value.

VI. Environmental Factors

a) Noise: definition, measurement, physiological effects, effects of noise on performance, noise reduction methods, and overall control of noise.
b) Vibration: definition, measurement, effects of vibration, preventive measures.
c) Illumination: standard illumination for specific work environments, glare, effect on visual performance.

103.2 Exercise Physiology (20)

I. Bioenergetics

a) Biological energy transformation.

b) Fuels for exercises.
c) Phosphagen systems.
d) Anaerobic system.
e) Aerobic system.
f) Interaction between the systems.

II. Physiological Response to Exercise

a) Cardiovascular response to exercise: autonomic influences on cardiovascular changes- rhythmicity of heart, pressure changes in cardiac events in a cycle, cardiac output, blood pressure, circulation in heart and muscle; cardiac metabolism, dynamic of blood circulation, inherent and supraspinal control of cardiovascular reflex .
b) Respiratory response to exercise: autonomic influences on ventilation, lung compliance, ventilation-perfusion ratio, oxygen and carbon-dioxide transport, oxygen consumption, VO_2 max, EPOC
c) Work, Power and Endurance: definition, measurement factors influence, exercise efficiency.

III. Selection of events and Training

a) Role of anthropometry and somatotyping.
b) Endurance training: design of training, effect of training on different body system. Intermittent training.
c) Physiological effects of training.
d) Training to improve aerobic power.
e) Training to improve anaerobic power.
f) Event specific training methodology.
g) Physical-warm up and warm down.

IV. Ergogenic Aids

a) Nutritional supplements –benefit and precautions.
b) Aerobic performance enhancing dope: oxygen, blood doping.
c) Anaerobic performance enhancing dope: blood buffers.
d) Drugs: anabolic steroids, caffeine, nicotine, etc.

103.3 Application of Instrumentation in Physiology (15)

I. Principle and use of physiological instruments.

a) Principle and use of light microscope, phase contrast microscope, polarized light microscope, fluorescence microscope.
a) Principle and use of rotary microtome, cryostat and embedding bath.
b) Principle and use of micro centrifuge, micro homogenizer, orbital shaking incubators, refrigerated centrifuge, photoelectric colorimeters, spectrophotometer, electrophoretic apparatus, PCR, gas analyzer.
c) Principle and use of kymograph, perfusion and Dale's apparatus, nerve stimulator, polyrite with software and transducers (force and volume)
d) Principle and use of sphygmomanometer, spirometer (mechanical and digital), portable ECG machine, sound level meter, audiometer, perimeter, anthropometric rods, handgrip dynamometer, peak flow meter.

II. Methodology

a) Microscopy (light, polarized, phase contrast and electron).
b) Embedding, block preparing and microtomy.
c) Centrifugation, homogenization.

d) Spectrophotometry.
e) Radioimmuno assay.
f) Polyacrylamide gel electrophoresis (PAGE),
g) DNA finger printing.
h) Gas and gel chromatography, high pressure liquid chromatography (HPLC) and thin layer chromatography (TLC).
i) Measurement of DO.
j) Recording and analysis of the activity of perfused heart of animal and *in vitro* movement of visceral parts of the animal.
k) Recording and analysis of ECG, EMG, EEG, BP, isometric muscle contraction.
l) Anthropometry, audiometry, perimetry and Galvanic Skin response.
m) Measurement of sound intensities by SLM.
n) Haemocytometry.
o) Echocardiography and Ultrasonography, positron emission tomography (PET) and magnetic resonance imaging (MRI).
p) X-Ray diffraction technique.

(Learning outcome: Students will be able to understand the application of physiological principles, and assessment processes in sports. They will also be able to analyze different physiological factors associated with occupational health and safety. The student will also be able to know the theoretical basis of different instrumentation.)

Course-104 (50 Marks: Credits = 4)
(Practical)
Practical = 120 hours

Course - 104.1 Physiological Chemistry (80)
104.2 Environmental chemistry (40)

104.1 Practical on Physiological Chemistry (80)

I. Preparation of Serum and Plasma.

II. Collection of Blood for different biochemical analysis.

III. General Techniques for Analysis
a) Colorimetric methods: photoelectric colorimeters.
b) Spectrophotometric method.

IV. Special Techniques for Analysis
a) Electrophoresis: paper electrophoresis, gel electrophoresis.
b) Chromatography: paper chromatography.

V. Practical on carbohydrates
a) Determination of blood glucose (true) : by Hugget & Nixon , and Hjelm and De Verdier Method.
b) Determination of blood sugar (true) : by (i) modified Nelson and Somogyi; and (ii) Hagedorn and Jenson Method.
c) Determination of reducing blood sugar (total): by modified Folin and Wu Method.

VI. Practical on Lipids

a) Determination of total cholesterol in serum: by Zlathis and Henly's Ferric Chloride Method.
b) Determination of total cholesterol in whole blood or serum: by the method of Nath & Ghosh.
c) Determination of serum triglyceride: by the method of Neri and Fringe.
d) Determination of serum lipoprotein.
e) Determination of serum total lipids: by Frings and Dunn method.

VII. Practical on Proteins

a) Determination of total protein, albumin and globulin in serum: by Biuret method.
b) Fractionation and identification of serum proteins: by paper and polyacrylamide-gel Electrophoresis (PAGE).
d) Separation and identification of amino acid: by paper chromatography.

VIII. Practical on Mineral Nutrients

a) Determination of serum calcium: by the method of Kramer and Tisdall and EDTA titration Method.
b) Determination of acid soluble phosphate of blood: by Fisk and Subba Row Method.

IX. Practical on Enzymes

a) Determination of Serum Aspartate Amino-transferase (SGOT): by Reitman and Frankel Method.
b) Determination of Serum Alanine Amino-transferase (SGPT): by Reitman and Frankel Method.
c) Determination of G-6P dehydrogenase : by Kornberg and Horecker method.

X. Practical on Liver Function

a) Determination of Serum bilirubin (total & conjugated): by Malloy and Evelyn method.
b) Determination of Serum alkaline phosphatase: by the method of Stolbach and Nath.

XI. Practical on Renal Function

a) Determination of total blood NPN.
b) Determination of creatine and creatinine in blood.

104.2 Practical on Environmental Chemistry (40)

a) Determination of chloride in natural water by titrimetric method.
b) Determination of dissolve oxygen (DO) in natural water by Azide modification method.
c) Determination of Chemical Oxygen Demand (COD) in natural water by titrimetric Method.
d) Determination of nitrate in natural water by PDA method.
e) Determination of phosphate in natural water by colorimetric method.
f) Determination of arsenic in natural water by standard analytical method using Spectrophotometer.

(Learning outcome: This would provide hands on experience on different biochemical methods related body function and pathophysiological implications. They will be able to monitor different environmental chemical constituents.)

AECC (25 Marks: Credits = 2)
(Practical)
Practical = 60 hours

Orientation for dissertation, review of literature and experiments done. Oral presentation of the same, using IT-pedagogy.

The students will read the latest research articles on topic assigned to them. They will submit a Review Report on a topic of physiological importance under the supervision of a teacher of the department. Marks will be awarded to the examinee on the basis of their performance in the seminar, on the report and oral presentation on it.

(Learning outcome: Student will be learn to read, understand, write and be able to present the scientific facts and scientific writing skill will also develop.)