SYLLABUS
FOR TWO YEAR

MASTER'S PROGRAMME
IN
PHYSIOLOGY

Based on guideline of UGC's Choice-Based-Credit system (CBCS) w.e.f. the Academic year 2014
(Revised as per regulation for Masters' Programme of the University since 2016)

(Revised for Inter-Departmental CBCS with effect from Academic Year 2017)

UNIVERSITY OF KALYANI
DEPARTMENT OF PHYSIOLOGY
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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. As per regulation for Masters' Programme of the University, 2016, the syllabus has been revised and redesigned 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; and 400 marks and 16 credits have been allotted for each semester. So, the total weightage of the syllabus for 4 semesters will be 1600 marks (4 X 400 = 1600 marks) and 64 credits (16x4 = 64 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 64 credits. Entire semester programme shall be comprised of three types of courses, namely Core Course (46.9%), Foundation Course (40.6%) [Compulsory and Elective] and Elective Course (12.5%) [Generic and Open]. Framework of the curriculum along with marks and credits for each semester have been given in the table. A option for three multidisciplinary foundation courses (Environmental Physiology, Ergonomics and Occupational Physiology, and Food and Nutrition) shall be given to the students to choose a foundation 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.

1st Semester Programme in Physiology
July to December (Odd semester)
Outline of courses and components
400 Marks
16 credits

	Course Components	Marks (Semester End Examination + Internal Assessment)	Lecture/ Practical hours I	Tutorial/ Assignment hours II	Total Credit (Credit for I +II)
Course 101 (Core)	101.1 Physiological Chemistry and Chemistry of Metabolism 101.2 Hematology and Cardiovascular Physiology	100 (80+20)	60	15	4+1=5
Course 102 (Foundation, Compulsory)	102.1 Cellular Physiology 102.2 Molecular Physiology 102.3 Nanophysiology	50 (40+10)	30		2
Course 103 (Core)	103.1Occupational Physiology and Exercise Physiology 103.2Application of Instrumentation in Physiology	50 (40+10)	30		2
Course 104 (Core, Practical)	104.1Physiological Chemistry 104.2 Environmental Chemistry	100 (80+20)	90		3
Course 105 (Core, Practical)	105.1Human Physiological Experiments 105.2 Environmental Experiments	50 (40+10)	60		2
Course 106 (Generic, Elective)**	106.1 Environmental Physiology 106.2 Ergonomics and Occupational Safety 106.3 Cancer Biology 106.4. Human Nutrition and Dietetics	50 (40+10)	30		2
		Total 400 Marks			**16 credits**

** Note: Any one course shall be chosen

2nd Semester Programme in Physiology

January to June (Even semester)

Outline of courses and components

400 Marks

	Course Components	Marks (Semester End Examination + Internal Assessment)	Lecture/ Practical hours I	Tutorial/ Assignment hours II	Total Credit (Credit for I +II)
Course 201 (Open elective)**	Fundamental in Physiology	100 (80+20)	60		4
Course 202 (Core)	201.1 Neuro-physiology 201.2 Muscle Physiology 201.3 Physiology of Special Senses	100 (80+20)	60	15	4 + 1=5
Course 203 (Core)	202.1 Respiratory Physiology and Renal Physiology 202.2 Endocrine Physiology and Stress Physiology	100 (80+20)	60	15	4+1=5
Course 204 (Core, Practical)	Experimental Physiology	50 (40+10)	30		1
Course 205 (Core, Practical)	Hematology	50 (40+10)	30		1
		Total 400 Marks			**16 Credits**

** Note: For inter-departmental students only.

3rd Semester Programme in Physiology

July to December (Odd Semester)

Outline of courses and components

400 Marks

16 Credits

	Course Components	Marks (Semester End Examination + Internal Assessment)	Lecture/ Practical hours I	Tutorial/ Assignment hours II	Total Credit (Credit for I+ II)
Course 301 (Core)	301.1 Gastro-intestinal Physiology 301.2 Neuro-endocrinology and GI Hormones 301.3 Reproductive Physiology, Population control and Embryology	100 (80+20)	75	15	5+1=6
Course 302 (Foundation, Compulsory)	302.1 Microbiology and Immunology 302.2 Chrono-physiology 302.3 Application of Biostatistics and Computer Science in understanding Physiology	100 (80+20)	60		4
Course 303 (Foundation-Compulsory, Practical)	303.1 Microbiology 303.2 Immunology	50 (40+10)	30		1
Course 304 (Core, Practical)	304.1 Histology 304.2 Histological Chemistry	50 (40+10)	60		2
Course 305 (Foundation-Compulsory, Practical)	305.1 Computer Applications 305.2 Physiological Statistics.	50 (40+10)	60		2
Course 306 (Open-Elective, Review)	Recent advances in Physiology	50 (40+10)	30		1
			Total 400 Marks		**16 Credits**

4th Semester Programme in Physiology

January to June (Even semester)

Outline of courses and components

400 Marks

	Course Components	Marks (Semester End Examination + Internal Assessment)	Lecture/ Practical hours I	Tutorial/ Assignment hours II	Total Credit (Credit for I +II)
Course 401 (Foundation, (Compulsory -Special)	401.1 Environmental Physiology 401.2 Ergonomics and Occupational Physiology 401.3 Food and Nutrition	100 (80+20)	60	15	4+1=5
Course 402 (Foundation, (Compulsory -Special)	402.1 Environmental Physiology 402.2 Ergonomics and Occupational Physiology 402.3 Food and Nutrition	100 (80+20)	60	15	4+1=5
Course 403 (Foundation Compulsory-Specaial Practical)	403.1 Environmental Physiology 403.2 Ergonomics and Occupational Physiology 403.3 Food and Nutrition	100 (80+20)	60		2
Course 404 Foundation (Compulsory -Special Practical)	401.1 Environmental Physiology 404.2 Ergonomics and Occupational Physiology 404.3 Food and Nutrition	50 (40+10)	60		2
Course 405 (Open Elective, Project work)	Project work and Seminar presentation on recent advances in the subject	50 (40+10)	60		2
		Total 400 Marks			**16 Credits**

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

Course-101 (100 Marks: Credits = 6)
(Core course)
Lectures = 75 hours
Tutorial / assignment = 15 hours

Course - 101.1 Physiological Chemistry and Chemistry of Metabolism (40)
101.2 Hematology and Cardiovascular Physiology (35)

101.1.1 Physiological Chemistry (20)

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 (20)

I. Introduction to Metabolism

a) Overview: trophic 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, stereospecificity 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 proenzymes 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 (20)

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+} (Ca^{2+} 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.

Course-102 (50 Marks: Credits = 2)
(Foundation-Compulsory course)
Lectures = 30 hours

Course - 102.1 Cellular Physiology (13)
102.2 Molecular Physiology (10)
102.3 Nanophysiology (7)

102.1 Cellular Physiology (13)

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, subthreshold 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.

102.2 Molecular Physiology (10)

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, nontranscribed DNA.
b) Regulation of prokaryotic gene expression: lac repression, attenuation-trp operon.
c) Regulation of eukaryotic gene expression.

102.3 Nanophysiology (7)

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.

Course-103 (50 Marks: Credits = 2)
(Core course)
Lectures = 30 hours

103.1 Occupational Physiology and Exercise Physiology (20)
103.2 Application of Instrumentation in Physiology (10)

103.1.1 Occupational Physiology (10)

I. Introduction to Occupational Health

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

II. Anthropometry

a) Static and dynamic anthropometry.
b) Application of anthropometric data in design.
c) Use of percentile value.
d) Somatotyping and body composition.
e) Kinathropometry.
f) Role of physique in sports.

III. System –design

a) Information: visual information, auditory information and information through other senses.
b) Display: Types.
c) Operation: types of control, distinction between different type of control.
d) Control display compatibility.
e) Relation between information and operation: expectation, user friendliness, cognitive abilities.

IV. Work Organization

a) Work study: basic procedure, human factors in the application of work study.
b) Method study: procedure, recording of facts, string diagram, activity chart, micromotion study.
c) Work measurement: work sampling, time study.

V. 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.

VI. Assessment of Physiological Work load

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

103.1.2 Exercise Physiology (10)

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 comsumption, VO_2 max, EPOC
c) Work, Power and Endurance: definition, measurement factors influence, exercise efficiency.

III. Training

a) Endurance training: design of training, effect of training on different body system.
b) Physiological effects of strength training.
c) Training effect of strength training.

d) Training to improve aerobic power.
e) Training to improve anaerobic power.
f) Physical-warm up.

IV. Ergogenic Aids

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

103.2 Application of Instrumentation in Physiology (10)

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.

III. 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.

Course-104 (100 Marks: Credits = 3)
(Core, Practical course)
Practical = 90 hours

Course - 104.1 Physiological Chemistry (60)
104.2 Environmental chemistry (30)

104.1 Practical on Physiological Chemistry (60)

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 (30)

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.

Course-105 (100 Marks: Credits = 2)
(Core, Practical course)
Practical = 60 hours

Course- 105.1 Human Physiological experiments (40)
105.2 Environmental Experiments (20)

105.1 Human Physiological Experiments (40)

a) Determination of heart rate in different conditions: by Ten beats method / Polar heart rate recorder.
b) Determination of diurnal variation of resting heart rate and body temperature: by standard Method.
c) Study of the effect of change of posture on blood pressure (three posture – supine, sitting and Standing): measurement of blood pressure by auscultatory method.
d) Study of the effect of exercise on blood pressure: by Auscultatory method.
e) Determination of hemoglobin concentration before and after exercise: by Sahli's acid hematin method.
f) Examination of motor functions – muscle tone, muscle power and co-ordination of muscle: by Standard method and grip strength by hand grip dynamometer.
g) Determination of visual acuity: by Snellen's chart and Jaeger's chart.
h) Examination of colour vision: by Ishihara's chart.
i) Anthropometric measurement: by Martin's anthropometric rod and measuring tape.
j) Determination of body density and fat percentage.
k) Pulmonary function tests: by Computerized Spirometer.
l) Study of the effect of posture on vital capacity.
m) Measurement of VO_2 max: by Queen College Test.
n) Study of ECG, EMG and EEG: by using Polyrite / other specific machine.

105.2 Environmental Experiments (20)

a) Determination of heat stress indices in working environment: WBGT and CET.
b) Determination of noise level in working environment: by Sound Level meter.
c) Determination of illumination level: by Luxmeter.

Course-106 (100 Marks: Credits = 2)
(Generic elective)
Lectures = 30 hours
(Any one course shall be chosen)

Course - **106.1 Environmental Physiology (30)**
106.2 Ergonomics and Occupational safety (30)
106.3 Cancer Biology (30)
106.4 Human Nutrition and Dietetics (30)

106.1 Environmental Physiology (30)

I. Man and Environment

a) Human environment: definition, types, components.
b) Physiological environment: physiological hierarchy, homeostasis-steady state controlling at limits by set point.
c) Basic concept on changes in the environment caused by man and his style of living.

II. Body Temperature Homeostasis

a) Normal core and skin temperature.
b) Mean Body temperature
c) Regulation of Body temperature: Role of central and peripheral thermoreceptors.
d) Hypothermia and hyperthermia.

III. Physiological Toxicology

a) Toxicological principle: toxins, mode of action of toxins, factors affecting toxicity- dose and duration,dose response curves,LD_{50} ,LOD_{50},NOEL,biological effects of toxins.
b) Biomagnification of xenobiotics:health hazards of pesticides,dioxin,PCB, PAH and reproductive toxins.
c) Nerve gases:types and specific hazards.
d) Occupational health hazards:pneumoconiosis,asbestosis and silicosis.
e) Physiological actions of saxitoxin,tetrodotoxin,TEA,cobra toxin.

IV. Environmental pollution and Human health hazards:

a) Air pollution: definition, sources, air pollutants, effects of air pollution on human health; ETS and human health hazards; ozone layer depletion – causes and human health hazards; concept of ozone hole; enhanced greenhouse effect- global warming & human environment.
b) Water pollution: definition, types, water pollutants, health hazards, minamata, & Itai Itai disaster, ocean pollution, ground water pollution by arsenic – drinking water standard for arsenic, health hazards for chronic arsenic poisoning.
c) Soil pollution: definition, causes, health hazards, solid waste management – bioremediation.
d) Noise: definition, concept of noise, sources of noise, effects of noise pollution on human health, noise standards.
e) Radionuclide pollution: definition, types, ionizing radiations, effects of ionizing radiations on human health.

106.2 Ergonomics and Occupational Safety (30)

I. Introduction to ergonomics

a) Genesis, Multi-disciplinary nature of Ergonomics.
b) Different branches of ergonomics.
c) Its role in the society.

II. Man Machine Interface

a) Man as a system component.
b) Micro and Macro ergomic concept.
c) Control and Display.
d) Control display compatibility.

III. Man and Thermal work Ervironment

a) Normal core and skin temperature.
b) Mean Body temperature.
c) Regulation of Body temperature: Role of central and peripheral thermoreceptors.
d) Hypothermia and hyperthermia.
e) Heat stress indices.
f) Cold Stress Indices.
g) Ergonomic way to control heat stress Hazards.

I. Industrial Safety

a) Concept of occupational safety.
b) Analysis of Accident, Theories.
c) Types of Errors, Analysis of causes.
d) Six sigma and other management process of accident.

106.3 Cancer Biology (30)

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

II. Multi-step 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

106.4 Human Nutrition and Dietetics (30)

I. Human Nutrition

a) Essential dietary components.
b) Caloric intake and distribution.
c) Mineral requirements.
d) Vitamins and antioxidants: sources &physiologic actions.

II. Whole Body Metabolism

a) Energy metabolism: balance, energy input, energy output- BMR or RMR.
b) Energy generation: respiratory quotient.
c) Energy storage & transfers.
d) Carbohydrate metabolism; protein metabolism- nitrogen balance,Kwashiorkor; fat metabolism- LDL/HDL ratio.
e) Metabolic adaptations: fasting, exercise.
f) Regulation of energy stores: BAT, UCP-1,2 & 3, anorexia.

III. Dietetics

a) Dietetics in different stages of life cycle; infancy, childhood, adolescence adulthood and old-age.

b) Special dietetics: during pregnancy & lactation, space travel, obese and atherosclerotic individual, anemic individual.
c) Nutritional disease: obesity, protein-energy malnutrition, rickets, scurvy, osteoporosis, iodine deficiency goiter (endemic), anemia, atherosclerosis, hypertension, food allergy, food intolerance.

IV. Nutrition and Public Health

a) Food additives and adulterants.
b) Food borne diseases: food poisoning, bacterial poisoning, botulism, meat borne diseases, fish borne diseases, milk borne diseases.

2nd Semester Programme in Physiology
January to June (Even semester)
Detail of courses and components
400 Marks
16 credits

Course-201 (100 Marks: Credit = 4)
(Open Elective)
Lectures = 60
For Inter Departmental students

Course-201: Fundamentals in Physiology (60)

I. General Physiology

a) Concept of Homeostasis.
b) Ionic Equilibrium and Resting Membrane Potentials, Action Potentials.
c) Nerve Impulse Conduction, Mechanism of Synaptic Transmission.
d) Introduction to Membrane Receptors, Second Messengers, and Cell signaling.
e) Ageing and Apoptosis.
f) Elementary idea of Muscle and Nerve.
g) Concept of Human body clock.

II. Respiratory Physiology

a) Physiology of Breathing.
b) Oxygen and Carbon Dioxide transport.
c) Gas exchange at lungs and tissues.
d) Regulation of Respiration.
e) Pulmonary Function Test.

III. Hematology

a) Concept of Circulating Body Fluids.
b) Leukocytes : Ultra structure and Functions.
c) Thrombocyte (Platelet) and Hemostasis.
d) Erythrocyte (RBC).
e) Blood Types and Transfusion.
f) Basic concept of immunity.

IV. Cardiovascular Physiology

a) Anatomy of Heart.
b) Cardiac Pacemaker and Special junctional Tissue.
c) Cardiac Cycle.
d) ECG.
e) Cardiac Diseases.
f) Cardiovascular Regulatory Mechanisms.
g) Special Circulations.

V. Gastrointestinal Physiology

a) Anatomy of GI system.
b) Motor and secretory functions.
c) HCl secretion and Gastric ulcer.
d) Digestion and absorption of food staff, minerals and water.
e) Entero-hepatic circulation, Liver and gall bladder diseases.
f) Basic concept of human nutrition, Protein and energy Malnutrition.

VI. Nervous System

a) Central, Autonomic and Peripheral Nervous System.
b) Basic Structure and function of Brain and Spinal Cord.
c) Memory and Intelligence, Memory related disorders- Alzheimer disease.
d) Language functions- aphasias.
e) Hunger and Satiety.
f) Body temp Regulation.
g) Sleep and EEG.
h) Emotion
i) Control of body posture
j) Special sense organs: Structure and functions.

VII. Endocrine and reproductive Physiology

a) General principles of endocrine physiology.
b) Endocrine glands and their functions.
c) Structure and Functions of male and female reproductive organs.
d) Sex determination.
e) Infertility, Concept of test tube baby.
f) Family planning and control of population

IX. Renal Physiology

a) Overview of renal function
b) Formation of Urine
c) Role of kidney in fluid and mineral homeostasis.
d) Renal function test and renal disorders.

Course-202 (100 Marks: Credits = 5)
(Core course)
Lectures = 60 hours
Tutorial / Assignment = 15 hours

Course -202.1 Neurophysiolgy (30)
Course -202.2 Muscle Physiology (15)
Course -202.3 Physiology of Special Senses (15)

Course 202.1 Neurophysiology (30)

I. Neurohistology and Neuroanatomy

a) Cells of the nervous system: Glia-multifunctional cell and neuron-excitable nerve cell, dendritic spines, axon collaterals, molecular structure of myelin- MDL and IPL, axonal transport.
b) Nerves, ganglion and synapse: electrical and chemical synapse, simple chemical synapse-type I and type II, specialized chemical synapse, reciprocal and serial synapse, synaptic glomerulus.
c) Receptor organs.
d) Neuronal injury and repair.
e) Spinal and cranial nerves: organization and function.
f) Spinal cord: segments and roots; meninges, internal structure-cross section and structural variations in thoracic, lumbar, and sacral regions; grey matter nuclei; Rexed laminae; position of tracts in the spinal cord; course of ascending and descending tracts.
g) Internal structure of midbrain, pons and medulla.

II. The Somatosensory System

a) Sensory Pathways: first, second, third and higher order neurons.
b) Somatovisceral sensory receptors: cutaneous- mechanoreceptors, thermoreceptors, nociceptors, muscle, joint and visceral receptors; microneurography.
c) Spinal roots and dermatomes.
d) Somatosensory pathways of the dorsal spinal cord: dorsal column- medial lemniscus pathway, ancillary somatosensory pathways of the dorsal spinal cord, sensory functions of the dorsal spinal cord pathways-flutter-vibration, touch-pressure, proprioception, visceral sensations, graphesthesia, stereognosis.
e) Somatosensory pathways of the ventral spinal cord: spinothalamic tract, ancillary somatosensory pathways of the ventral spinal cord-spinoreticular tract, sensory functions of the ventral spinal cord pathway.
f) Sensation from the face: trigeminal tactile and proprioceptive pathways, trigeminal nociceptive and thermoreceptive system.
g) Pain: types of pain, inhibition of pain.
h) Higher processing of somatosensory information: thalamus, somatosensory cortex, association cortex, centrifugal control of somatosensation-endogenous analgesia system.

III. Organization of Motor Function

a) Decerebration: neurophysiological basis.

b) Sensory receptors responsible for eliciting spinal reflexes: Muscle spindle-structure nad function, responses of primary and secondary ending-static and dynamic responses, effect of γ-motor neuron on unloading of discharge; Golgi tendon organ.

c) Spinal reflexes: Myotatic (stretch) and inverse myotatic reflex, flexion reflexes.

d) Principle of spinal organization.

e) Descending pathways involved in motor control: topography about organization of the spinal and cranial nerve motor system; descending motor pathways- lateral corticospinal and corticobulbar tract; medial system-vestibulospinal, reticulospinal, tectospinal tract; monoaminergic pathways.

f) Brainstem control of posture and movement: postural reflexes, locomotion, control of eye position, gaza centers.

g) Motor control by cerebral cortex, cerebellum and basal ganglia:

Cerebral Cortex: cortical motor areas, connections of the motor regions of the cortex, role of supplementary motor and premotor areas in motor programming, activity of individual corticospinal neurons sensory feedback to corticospinal neurons.

Cerebellum: role of cerebellum in motor control; cerebellar organizations subdevisions of cerebellum; afferent pathways of the cerebellar divisions; cerebellar cortex- cellular organization, activity of purkinje cells, role of cerebellar purkinje cell in motor learning.

Basal Ganglia: organizations of basal ganglia and related nuclei, connections and operations of basal ganglia, direct pathway, indirect pathway, actions of neurons in the PC and SN on the striatum, role of basal ganglia in motor control, Parkinson's disease.

IV. Higher Functions of the Nervous system

a) **Cerebral Cortex:** lobes, function of lobes of cerebral cortex; Neocortical layering and subdivisions- archi-cortex, paleocortex and neocortex; cell types in neocortex, cytoarchitecture of cortical layers, myeloarchitecture of cortical layers, cortical afferent and efferent fibers , regional variation in neocortical structure; archicortex- hippocampal formation.

b) **Electroencephalogram (EEG):**Definition, types, electro-physiological basis, significance, evoked potential.

c) **Sleep-Wake Cycle:** circadian periodicity, characteristic changes in EEG during sleep-wake cycle , sleep stages in a night sleep, non-REM and REM sleep, physiological changes observed in nREM and REM sleep, mechanism of sleep (neuro-physiological basis of sleep), epilepsy, grand mal and petit mal seizures.

d) **Cerebral Dominance and Language:** dominant hemisphere, hemispheric specialization, language areas , mechanism of speech, aphasias, dyslexia.

e) **Interhemispheric Transfer.**

f) **Learning and Memory: Learning**-definition,types of learning, non-asssociative learning-habituation and sensitization, associative learning-classical and operant conditioning, molecular mechanism of learning, memory circuits-role of cerebellar Purkinje cells in conditioning trials.

Memory-definition , types- declarative and non declarative, short term and long term memory, molecular mechanism of memory, intercortical transfer of memory, amnesia, Alzheimer's disease and senile dementia.

V. Autonomic Nervous System (ANS):

a) Anatomic organization of autonomic outflow: sympathetic and parasympathetic division.

b) Chemical transmission at autonomic junctions: chemical divisions of the ANS, transmission in sympathetic ganglia.

c) Responces of the effector organs to autonomic nerve impulses: micturition reflex, defaecation reflex, autonomic influences on the rhythmic discharge of SA node, autonomic influences on respiratory and cardiovascular homeostasis, autonomic influences on gastro-intestinal functions.
d) Autonomic pharmacology.

202.2 Muscle Physiology (15)

202.2.1: Skeletal muscle Physiology

a) Anatomical organization: muscle, fascicle, fiber, fibril, filament.
b) Filament organization: thick filament and thin filament in sarcomere.

I. Molecular Structure of Thick and Thin Filament Proteins
a) Thick filament protein: myosin, tinin, myomesin, C-protein.
b) Thin filament protein: actin , nebulin, tropomyosin, troponin, tropomodulin, α-actinin, Cap Z.

II. Molecular Organization of Proteins in Thick and Thin Filament
a) Polymerization of myosin molecules in tail-tail configuration in thick filament.
b) Organization of thin filament proteins.

III. Orientation and Receptor Structure of Sarcotubular System
a) Sarcoplasmic reticulum (SR)
b) T-tubules.
c) Triad.
d) Molecular structure of DHPR and RYR.

IV. Control of Skeletal Muscle activity
a) Motor nerves and motor units.
b) Excitation –contraction coupling: role of DHPR (dihydropyridine receptor) andRYR (ryanodine receptor).
c) Actin-myosin interaction: cross-bridge formation.
d) Cross-bridge cycle-sarcomere shortening.

V. Skeletal muscle types
a) Fast twitch and slow twitch muscle.
b) Fast fibers and slow fibers.

VI. Modulation of force of Contraction
a) Recruitment.
b) Tetany.

VII. Modulation of Force
a) Stretch reflex.
b) Golgi tendon organ.
c) Skeletal muscle tone.

VIII. Energy Sources During Contraction
a) ATP, creatine phosphate, carbohydrates, fatty acids and triglycerides.
b) Oxygen debt.
c) Fatigue.

IX. Growth and Development

X. Denervation, Reinnervation and Cross innervations

XI. Response to Exercise
a) Learning.
b) Endurance.

c) Strength Training.

XII. Biophysical properties of skeletal muscle

a) Length-tension relationship.
b) Force-velocity relationship.

202.2.2: Smooth Muscle Physiology

I. Overview of Smooth Muscle: Types

a) Single unit and multi –unit.
b) Phasic and Tonic.

II. Structure of smooth Muscle Cells

a) Cell-to-cell contacts.
b) Cells and membranes.
c) Cytoskeleton.

III. Control of Activity of Smooth Muscle

IV. Innervation of Smooth Muscle

V. Regulation of Contraction

a) Phasic Versus tonic contraction: covalent regulation.
b) Energetics and metabolism.

VI. Regulation of Myoplasmic Calcium concentration

a) Sarcoplasmic reticulum.
b) Sarcolemma.

VII. Development and Hypertrophy

VIII. Synthetic and Secretary Functions

IX. Biophysical Properties of Smooth Muscle

a) Length-tension relationship.
b) Force-velocity relationship.

202.3 Physiology of Special Senses

202.3.1 Physiology of Vision (15)

I. Photoreceptors

a) Rods and cones.
b) Types of cones: spectral sensitivity.
c) Ultra structure of rods and cones.

II. Retinal circuitry

a) Cells involved in circuitry.
b) Basic retinal circuitry.
c) Ganglion cell types: P cells, M cells and W cells.

III. Receptive fields for retinal ganglion cells

a) On- center, off- surround.
b) Off-center, on- surround.

IV. Visual pathway and Striate cortex

a) Optic tract, LGN of thalamus, Meyer's Loop and striate cortex interactions.
b) Parvocellular and magnocellular layers of LGN.
c) Striate cortex, extrastraite cortex and other visual pathways.

V. Image Forming Mechanism

a) Visual transduction: ionic basis of dark current and depolarizing (resting) potentials in photoreceptors; photon induced second messenger cascades and hyperpolarization in photoreceptors- photo pigments, transducin and phosphodiesterase interactions.
b) Synaptic interactions in retinal circuitry.
c) Ganglion cell receptive actions; and interaction between ganglion cells and LGN layers.

d) Roles of striate cortex; stripe of Gennari; ocular dominance columns; orientation and direction selectivity; roles of simple , complex and hyper complex cells; P and M cell pathways; stereopsis.

IV. Color Vision

a) Three types of cone cells and their functions.
b) Roles of neurons in the visual pathway that show spectral opposition.
c) Roles of retinal ganglion cells and LGN neurons: interactions of P and M ganglion cells with P and M layers of LGN.
d) Roles of visual cortical neurons: single opponent and double opponent cells.
e) Role of P cells displaying spectral opponent properties.

202.3.2 Physiology of Hearing and Equilibrium

I. Sound
a) Sound Pressure Level (SPL) and its unit (dB).
b) Sound frequency.
c) Noise and white noise.
d) Presbycusis.

II. The Ear
a) External and middle ear.
b) Inner ear; cochlea- microstructure of organ of Corti.

III. Sound transduction
a) Mechanical activation of hair cells of organ of Corti by shear forces: displacement of the basilar membrane by travelling waves.
b) Discharge of primary afferent fibers of the cochlear nerves.
c) Encoding of acoustic stimulus in the discharge of cochlear nerve fibers.
d) Central auditory pathway.
e) Function of central auditory system: receptive fields and tonotopic maps, binatural interactions, cortical function.
f) Audiometry, audiogram and weber test.

IV. The Vestibular apparatus
a) Structure of the vestibular labyrinth.
b) Innervations of sensory epithelia of vestibular apparatus.
c) Vestibular transduction.
d) Semicircular ducts: Meniere's disease.
e) Otolith organs.

V. Central vestibular pathways

VI. Vestibular function
a) Response to rotational acceleration.
b) Response to linear acceleration.
c) Space motion sickness.

202.3.3 Physiology of Gustation

I. Taste Receptors
a) Chemoreceptor in the taste bud.
b) Structure and type of chemoreceptor.

II. Taste bud
a) Structure of taste buds.
b) Distribution and innervations of taste buds.

III. Central taste pathways

a) Cranial nerves: VII, IX and X.
b) Medulla: NOTS.
c) VPMpc of thalamus.
d) Gustatory areas of cerebral cortex.

VII. Gustatory transduction

a) Gustatory molecules.
b) Signal transduction at the receptor sites; role of α-gusducin.
c) Coding of 4 primary taste qualities in the taste afferents.
d) Cortical interpretation.

202.3.4 Physiology of Olfaction

I. Marcosomatic and Micro somatic Animals

II. Olfactory Receptors

a) Olfactory mucous membrane.
b) Olfactory chemoreceptors.

III. Central Pathways

a) Olfactory bulb: olfactory glomerulus.
b) Olfactory tarct: lateral and medial striae.
c) Primary olfactory receiving area: prepiriform cortex; and amygadaloid nucleus.

IV. Olfactory Threshold and Discrimination

V. Signal Transduction

a) Odorant molecules.
b) Signal transduction at the receptor site: role of $G_{olf.}$
c) Cortical interpretation.

Course-203 (100 Marks: Credits = 5)
(Core course)
Lectures = 60 hours
Tutorial / assignment = 15 hours

Course - 203.1 Respiratory Physiology and Renal Physiology (30)
203.2 Endocrine Physiology and Stress Physiology (30)

203.1.1 Respiratory Physiology (15)

I. Cells of the Airways

a) Cillated cells.
b) Mechanism of mucus production.
c) Cells of the alveoli: type I, II and III.

II. Surfactant

a) Function (surfactant and surface tension interaction).
b) Composition of mature surfactant.
c) Mechanism of production.
d) Respiratory distress syndrome (RDS).

III. Innervation of lungs and airways

a) Autonomic innervation.
b) Somatic innervations.

IV. Mechanics of respiration

a) Lung compliance.
b) Inspiration and expiration.
c) Lung volumes: measurement by helium dilution technique, spirometry and body plethysmography; dead space- types; measurements of anatomic dead space by single-breath N_2 washout technique; uses of spirometry and plethysmography.

V. Oxygen transport

a) Hemoglobin as transport molecules: mechanism of oxygen binding cooperativity- Perutz mechanism (role of T and R state).
b) Function of myoglobin.
c) Sickle cell anemia and methemoglobinemia.
d) Oxygen bound to hemoglobin and oxyhemoglobin dissociation curve.
e) Factors that shift the oxyhemoglobin dissociation curve: Ph and CO_2- the **Bohr effect**, 2,3 BPG, fetal hemoglobin, CO, temperature, clinical significance.
f) Oxygen saturation and oxygen content of blood.
g) Oxygen delivery and consumption .
h) Tissue hypoxia: types, causes and mechanism.

VI. Carbon Dioxide Transport

a) CO_2 production, metabolism and diffusion
b) CO_2 transport: Hamburger phenomenon (chloride shift) and role of Band 3 protein.
c) CO_2 dissociation curve: **Haldane effect.**

VII. Ventilatory Response to CO_2

a) Dose- response effect of arterial Pco_2 on ventilation.
b) The effects of hypoxia and hypercapnia on ventilation.

VIII. Control of Ventilation

a) Control by medullary respiration center: role of DRG and VRG.
b) Control of ventilation by central and peripheral chemorecptors.
c) Control by lung and chest wall reflexes: Hering- Breuer reflex, role of pulmonary stretch receptors, J receptors etc.

IX. Abnormal ventilation

a) Obstructive sleep apnea.
b) Central sleep apnea.
c) Cheyne-stokes breathing.
d) Apneustic breathing.

203.1.2 Renal Physiology (15)

I. Elements of Renal Function

a) Overview of renal function.

b) Functional anatomy of kidney: gross anatomy; utrastructure of nephron, renal corpuscle, and Juxtaglomerular apparatus; innervations of kidney.

II. Anatomy and Physiology of Lower Urinary Tract

a) Gross anatomy and histology.
b) Innervation of Bladder.
c) Passage of urine from kidney to bladder: nephrolithiasis (kidney stones).
d) Micturation: micturation reflex, cytometrogram.

III. Assessment of renal function

a) GFR.
b) Renal clearance.
c) GFR: clearance of inulin.

IV. Glomerular Filtration

a) Determinants of ultrafiltrate composition.
b) Dynamics of ultrafiltration.

V. Renal Blood Flow (RBF)

a) Autoregulation.
b) Myogenic and tubuloglomerular feedback mechanism for autoregulation.

VI. Regulation of RBF and GFR: by

a) Nerves, b) Hormones c) Angiotensin-II d) PG e) NO f) ANP and g) dopamine.

VII. Tubular Function

a) Soluble and water reabsorption by proximal tubule, Henle's loop: Bartter's syndrome, distal tubule and collecting duct: Liddle's syndrome and role of **Amilorede**.
b) Regulation of NaCl and Water reasorption: by hormones and nerves.

VIII. Control of Body Fluid Osmolality: Urine Concentration and Dilution

a) Normal routes of water gain and loss in adults in room temperature.
b) Osmotic and hemodynamic control of Antidiuretic hormone (ADH) secretion.
c) ADH actions on the kidney: nephrogenic diabetes insipidus.
d) Thirst.
e) Renal mechanism for diluton and concentration of urine: single effect of countercurrent multiplication process.
f) Control of extracellular fluid volume and regulation of renal NaCl excretion: concept of effective circulating volume, volume-sensing system, volume sensor signals-rennin-angiotensin-aldosterone system, control of Na+ excretion during euvolemia, volume expansion, and volume contraction.

IX. Role of kidney in Potassium, Calcium and Phosphate Homeostasis

X. Role of Kidneys in the Regulation of Acid- Base Balance

a) HCO_3- buffer system.
b) Dietary and metabolic production of acid and alkali.
c) Overview of renal acid secretion.
d) HCO_3 – reabsorption along the nephron.
e) Regulation of HCO_3- reabsorption.
f) Formation of new HCO_3- : role of ammonium.
g) Renal defense against the acid-base disorders.

203.2 Endocrine Physiology and Stress Physiology

203.2.1 Endocrine Physiology (25)

I. General Principle of Endocrine Physiology

a) Types of hormones: amines-thyroid hormones, catecholamines, and melatonin; steroids-adrenal cortical, reproductive gland hormones and active metabolites of Vit D; **prostanoids, proteins** and **peptides.**

b) Hormone synthesis and hormone release, release of peptide and catecholamine hormone by exocytosis-role of GTP binding protein, microtubule and microfilament and cAMP.

c) Cellular receptors and hormone action: Number, affinity and ligand specificity of hormone receptors, receptor kinetics-**Scatchard plot**, Binding assay.

d) Receptor regulation.

e) Plasma membrane hormone receptor system: receptor structure and coupling by G protein, second messengers and membrane receptor signal transduction.Action of peptide hormones.

f) Nuclear hormone receptors, intracellular receptor systems, actions of steroid hormones-genomic and non-genomic.

g) Nongenomic steroid actions: prostanoids, endocrine and target cell turn over.

h) Hormone action and termination of hormone action: Permissive, additive and synergistic action of hormones.

i) Regulation of hormone secretion: feedback mechanisms -positve and negative, neuronal and chronotropic.

j) Estimates of hormone secretion: secretion rate, production rate, plasma levels, urinary excretion.

k) Hormone transport and disposal.

II. Hormones of the Pancreatic Islets

a) Anatomy of pancreatic islets.
b) Insulin; structure and synthesis, insulin secretion, regulation of insulin secretion, insulin actions-action on cells and action on fuels; carbohydratetes,fats and proteins.(Other beta cell products-functions of Amylin and Pancreastatin)
c) Glucagon: structure and synthesis, regulation of secretion, hormone actions, insulin-glucagon ratio, GLP-1.
d) Somatostatin and pancreatic polypeptide: secretion and function.

III. Endocrine Regulation of calcium and Phosphate Metabolism

a) Overview of calcium and phosphate metabolism: calcium, calcium sensing, phosphate.
b) Bone dynamics: bone formation, bone resorption, coordination of resorption and formation in remodeling.
c) Vitamin D: Vitamin D production, vitamin D action.
d) Parathyroid hormone(PTH):synthesis and release, PTH actions, PTH-related protein.
e) Calcitonin: synthesis and release, calcitonin actions.
f) Integrated hormonal regulation of calcium and phosphate.

IV. Thyroid Gland

a) Microanatomy of thyroid gland: thyroid gland follicle and follicular cells, parafollicular cells ('C' cells).
b) Synthesis and release of thyroid hormones: chemical pathway, iodide accumulation by NIS(sodium-iodide-symporter),T_4 and T_3 synthesis-role of TPO, retrieval of stored hormone-endocytosis of colloid by megalin (TG receptor) and intracytoplasmic proteolysis, deiodination of MIT and DIT.
c) Regulation of thyroid gland activity.
d) Metabolism of thyroid hormones.
e) Relationship between hormone metabolism and hormone action.
f) Intracellular actions of thyroid hormone.
g) Whole body action of thyroid hormone on metabolism; general effects, respiratory effects, cardiovascular effects, metabolic effects.
h) Thyroid hormones and the sympathetic nervous system.
i) Effects on growth and tissue development.
j) Effects on bone.
k) Effects on the nervous system.
l) Goiter: exopthalmic and iodine deficiency goiter.
m) Antithyroid drugs and natural goitrogens.

V. Adrenal gland

a) The adrenal glands.
b) Adrenal cortex: histology and zonations; hormones secreted.
c) Synthesis of adrenocortical hormones and role of cytochrome P450 enzymes: glucocorticoids, androgens and estrogens, mineralocorticoids.
d) Regulation of zona fasciculate and zona reticularis functions.
e) General actions of glucocorticoids: intracellular actions and effects on metabolism, role in reproduction, nervous system, anti-inflammatory and immunosuppressive action.
f) Action of adrenal androgens.
g) Regulation of zona glomerulosa function: role of ANP.

h) Action of mineralocorticoid.
i) Adrenal medulla: synthsis and storage of catecholamine hormones, regulation of adrenomedullary secretion, actions of catecholamines- intracellular action and systemic actions.
j) Integration of the response to stress- General Adaptation Syndrome

203.2.2 Stress Physiology (5)

I. Description of Stress

a) Stress: definition, effects of stress on homeostasis, strain.
b) Types of stress: stress due to invading organisms; behavorial, social, physiological stress; stress due to injury and diseases; environmental- thermal stress (hot & cold), oxidative stress.

II. Integration of the Response to Stress

a) Role of Sympathetic Nervous System (SNS).
b) CRH-ACTH-Cortisol axis.
c) Immune response and cytokines.
d) Stress minimizing drugs.

Course-204 (50 Marks: Credits = 1)
(Core, Practical)
Practical = 30 hours

204: Experimental Physiology Practical (30)

A) Amphibian Experiments

A-1: Nerve- Muscle Experiments

a) Study of the effect of increasing strength of stimuli on isotonic muscle contraction of load.
b) Study of the genesis of tetanus in a sciatic (nerve)- gastrocnemius (muscle) preparation of toad.
c) Study of the isometric muscle contraction of toad.
d) Study of the conduction velocity of nerve in toad.

A -2: Experiments on Perfused Heart

a) Study of the effects of stimulation of vagosypathetic trunk on the perfused heart of toad.
b) Study of the effects of stimulation of vago- sympathetic trunk on the perfused heart of toad before and after the application of nicotine.
c) Study of the effects of stimulation of vago- sympathetic trunk before and after the application of atropine.
d) Study of the effects of drugs and ions on the perfused heart of toad.

Drugs :

(a) Graded doses of adrenaline hydrochloride (1 in 100,000 dilutions).
(b) Graded doses of acetylcholine (1 in 10,00,000 dilutions).

Ions :

(a) 1ml of 1% $CaCl_2$ (Ca^{++})
(b) 1ml of 1% KCl (K^+)
(c) 2ml of 1% NaCl (Na^+)

B. Mammalian Experiments

a) Study of the effects of drugs and ions on the isolated perfused heart of rabbit: by Langendroff's method.

Drugs : (a)Adrenaline
(b)Acetylcholine

Ions : (a) NaCl (Na^+)
(b) KCl (K^+)
(c) $CaCl_2$ (Ca^{++})
(d) Study of the effects of Drugs* and Ions* on the motility of isolated mammalian intestine (rat/rabbit/ guineapig): by Dale's method.

* Study in graded effects of the following drugs/ chemicals by taking 0.5-1 ml of each solution in a pipette and putting directly and mixing the solution in the central organ bath:

Acetylcholine	: 1 in 1000000
Adrenaline	: 1 in 100000
Atropine	: 0.01%
Histamine	: 50µg (microgram)
KCl solution	: 1%
$CaCl_2$ solution	: 1%
Barium chloride	: 2 %

(e) Study of the effects of Drugs*on isolated mammalian uterine (rat/rabbit/ guineapig): by Dale's method.

* Study in graded effects of Oxytocin, estrogen, progesterone, acetylcholine, and adrenaline on uterine contraction.

Course-205 (50 Marks: Credits = 1)
(Core, Practical)
Practical = 30 hours

Course 205: Hematology (30)

A) Experiments on Human Blood

a) Determination of RBC indices.
b) Differential leucocyte count: in a blood film stained with Leishman stain.
c) Determination of ESR: by Westergren method.
d) Determination of blood group: by rapid slide or test tube method using anti-A and anti-B sera.
e) Study of the osmotic fragility of RBC: by using hypo and hypertonic saline.
f) Determination of bleeding and clotting time: bleeding time by **Duke method** and clotting time by **capillary tube method**.
g) Platelet count: staining by brilliant cresyl blue and counting by hemocytometry.
h) Reticulocyte count: by using supravital stains (brilliant cresyl blue/ new methylene blue).

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3rd Semester Programme in Physiology
July to December (Odd semester)
Detail of courses and components
400 Marks
16 credits

Course-301 (100 Marks : Credits = 6)
(Core course)
Lectures = 75 hours
Tutorial / assignment = 15 hours

Course- **301.1 Gastro- intestinal Physiology (25)**
301.2 Neuro-endocrinology and GI Hormones (20)
301.3 Reproductive Physiology, Population control and Embryology (30)

301.1 Gastro-intestinal Physiology

I. Gastro-intestinal Regulation and Motility

a) Structure of the gastrointestinal (GI) tract.
b) Regulation of GI tract functions : GI hormones, paracrine mediators in the GI tract, innervation of GI tract- sympathetic, parasympathetic, enteric nervous system, reflex control, neural control of GI functions.
c) GI smooth muscle: electrophysiology of GI smooth muscle.
d) Gastric motility: structure and innervation of stomach, responses to gastric filling, mixing and emptying of gastric contents, fed versus fasted state, electrical activity and gastric contractions, regulation of gastric emptying.
e) Vomiting: physiology of vomiting- vomiting reflex.
f) Motility of small intestine: electrical activity of small intestinal smooth muscle, contractile behaviour of the small intestine, intestinal reflexes, migrating myoelectric complex, contractile activity of the muscularis mucosae, emptying of ileum.

II. Mechanism and Cellular Control of Salivary and Pancreatic Secretion

III. Gastric Secretion

a) Structure of gastric mucosa.
b) Gastric acid secretion: ionic composition of gastric juice, rate of secretion of gastric acid, morphological changes that accompany gastric acid secretion, cellular mechanisms of gastric acid secretions, stimulation of parietal cell to secrete H^+ and Cl^-.
c) Secretion of pepsin.
d) Secretion of intrinsic factors.
e) Secretion of mucus and bicarbonate.
f) Control of gastric acid secretion: control of HCl secretions at the level of parietal cell, cellular mechanisms of parietal cell agonists, endogenous antagonists of acid secretion, in vivo control of acid secretion- cephalic phase, gastric phase and intestinal phase.
g) Gastric and duodenal ulcers: peptic ulcer- hyper secretion of HCl and infection by H. pylori, treatment of peptic ulcers- antibodies and H_2 blockers.

IV. Functions of Liver and Gall Bladder

a) Structure and function of liver.
b) Bile: fractions secreted by hepatocytes, phospholipids and cholesterol in bile, secretion of bile duct epithelium, cellular mechanisms of bile secretion, bile concentration and storage in gall bladder, emptying of gall bladder, enterohepatic circulation of bile acids, gallstones.

V) Digestion and Absorption

a) Digestion and absorption of carbohydrates: digestion of carbohydrates, absorption of carbohydrates- role of SGLT1, GLUT2, GLUT5, carbohydrate mal-absorption syndrome-lactose intolerance.
b) Digestion and absorption of proteins.
c) Intestinal absorption of salts, water.
d) Cellular mechanism of absorption of calcium and other ions.
e) Cellular mechanism of absorption of water soluble vitamins- B_{12}, fat soluble vitamins.
f) Digestion and absorption of lipids: digestion of lipids, absorption of the products of lipid digestion - roles of MVM-FABP, I-FABP, L-FABP, SCP-I & II; chylomicrons.

301.2 Neur-endocrinology and GI hormones (20)

301.2.1 Neuro-endocrinology (15)

I. Hypothalamus

a) Anatomy: proximity and functional relationship between the hypothalamus, pituitary and their blood supply.
b) Function of the endocrine Hypothalamus.

II. Pituitary Gland

a) Anatomy of pituitary.
b) Anterior pituitary hormones.
c) TSH: synthesis, secretion, TSH action.
d) ACTH: synthesis, secretion, ANH and ACTH secretion, ACTH actions.
e) LH and FSH: secretion of LH and FSH, feedback regulation of gonadotropins, actions of gonadotropins.
f) GH(Somatotropin): synthesis, secretion and actions of GH, mechanism of GH action.
g) Prolactin: regulation of prolactin secretion, biological effects of prolactin-mechanism of prolactin action.
h) Control of hypothalamic/ hypophysial hormone secretion.
i) Posterior pituitary hormones – circulation and metabolism.
j) ADH (AVP); secretion, regulation of secretion, action of ADH.
k) Oxytocin: secretion and actions.
l) Control of neurohypophysial hormone secretion.
m) Pathophysiology of hypothalamic and pituitary dysfunction.

301.2.2 GI Hormones (05)

I. Gastrointestinal Hormones

a) Gastrin: sources (G or APUD cells) and physiological actions.
b) Sources and physiological actions of seretin, CCK-PZ, GIP, VIP etc.

301.3 Reproductive Physiology, Population control, Embryology (30)

301.3.1 Reproductive Physiology (20)

I. Sex Determination, Differentiation and Development

a) Genetic sex (roles of SRY, SOX-9,WT-1,DAX-1 and SOX-3 gene), gonadal sex, genital (phenotypic) sex.
b) Abnormalities of sexual differentiation.

II. Common Aspects of gonadal Function

a) Pathways of gonadal steroid hormone synthesis.
b) Other gonadal products.
c) Gonadotropin actions in the gonads.

III. Age Related Changes in Gonadotropin Secretion

a) Intrauterine and childhood patterns.
b) Puberty.
c) Climactic.
d) Germ cell development.

IV. Male Reproductive System and Hormones

a) Microanatomy of the Testes.
b) Biology of spermatogenesis and spermiogenesis.
c) Endocrine control of testicular function- Hypothalamic-Pituitary-Testicular Axis of hormones.
d) Hormonal regulation of spermatogenesis.
e) Sertoli cell function and its regulation.
f) Secretion and metabolism of androgen.
g) Androgen actions.
h) Male puberty.

V. Female Reproductive System and Hormones

a) Reproductive cycles.
b) Microanatomy of the ovaries.
c) Stage of development and regression of follicle during the reproductive years.
d) Biology of oogenesis.
e) Hormonal patterns during menstrual cycle.
f) Ovarian steroid hormone biosynthesis.
g) Hormonal regulation of oogenesis and the stages of follicular development.
h) Luteal phase, hormonal regulation of luteal phase and biosynthesis of progesterone.
i) Gonadal steroid hormone effects: intracellular actions, effects on fallopian tubes, vagina, breasts,and other puberty.
j) Neuroendocrine control of ovarian function.
k) Female puberty.
l) Menopause.

VI. Pineal Gland and Gonads

a) Effects of melatonin on gonadal function.
b) Pineal and sexual precocity.

VII. Pregnancy

a) Fertilization and implantation.
b) Infertility: in vitro fertilization.
c) Function of the placenta.
d) Hormones of pregnancy.
e) Physiological changes associated with pregnancy, Maternal – fetal metabolism.
f) Parturition: endocrine regulation.

VIII. Lactation

a) Development of breasts.
b) Secretion and ejection of milk.
c) Initiation of lactation after delivary: colostrums.
d) Effects of lactation on menstrual cycle.

301.3.2 Population Control (5)

a) Requirement of population control.
b) Methods of control – hormonal, sterilization, IUD, modern methods.
c) Measures of control and its effect.

301.3.3 Embryology (5)

a) Development of Blastula- Formation of morula from Zygote, Formation of blastula: development of bilaminar germ disc.
b) Development of trilaminar Germ Disk: Gastrulation.
c) Organogenesis.
d) Birth defects: role of teratogens.
e) Molecular basis of Embryo Development.
f) Respiratory Distress Syndrome (RDS).
g) Fetal circulation.
h) Fetal respiration.

Course-302 (100 Marks: Credits = 4)
(Core course)
Lectures = 60 hours

Course- **302.1 Microbiology and Immunology (30)**
302.2 Chrono-physiology (10)
302.3 Application of Biostatistics and Computer Science in understanding Physiology (20)

302.1 Microbiology and Immunology (30)

302.1.1 Microbiology (15)

I. Science of Microorganisms: Outline Concept

a) Scope and history of microbiology.
b) Classification of microorganisms: fungi, algae, protozoa, bacteria and viruses.
c) Historical perspectives on development of microscopic identification of microorganisms.

II. Science of bacteria

i) Morphology and fine structures of bacteria
a) Size, shape and arrangement of bacterial cells.
b) Bacterial structures: structures external to the cell wall, cell wall- structures and chemical composition, structures internal to the cell wall, spores and cysts.

ii) Bacterial reproduction and growth
a) Reproduction: modes.
b) Growth: normal growth cycle (growth curve) of bacteria, transitional periods between growth phases, synchronous growth, continuous culture.
c) Quantitative measurement of bacterial growth.

iii) Bacterial genetics
a) Study of bacterial genetics.
b) Inheritance of characters and variability.
c) Phenotypic changes due to environmental alterations.

d) Genotypic changes.
e) Bacterial recombination.
f) Transduction and transformation.
g) Regulation and expression of gene activity.
h) Genetic engineering.

iv) World of bacteria

a) Ordinary gram positive bacteria.
b) Ordinary gram negative bacteria.
c) Bacteria with unusual properties.
d) Gram positive, filamentous bacteria of complex morphology.
e) Nitrogen fixing bacteria: mechanism of nitrogen fixation – half-cell reactions.

III. Microbial physiology

a) Enzymes and their regulation.
b) Microbial metabolism: energy production, utilization of energy and biosynthesis.
c) Control of microorganisms by physical, chemical and chemotherapeutic agents.
d) Development of resistance to chemotherapy.

IV. Microorganisms: Fungi, Algae and Protozoa

V. Viruses

a) Bacteriophages: general characteristics, discovery and significance.
b) Morphology and structures.
c) Classification and nomenclature of bacteriophages.
d) Replication of bacterial viruses: adsorption, penetration, transcription, assembly and release
e) Viral multiplication (replication) cycle.
f) Lysogeny: mechanism.

VI. Viruses of animals (including insects) and plants

a) History.
b) Structure and composition.
c) Virus replication.
d) Effects of virus infections on cells.
e) Progressive and fatal diseases associated with virus in animals: classic slow viral diseases, cancer and viruses HIV (AIDS virus), influenza virus-molecular basis of flu epidemic, herpes viruses, hepatitis B virus, and retro viruses.
f) Viroids.

VII. Environmental and industrial microbiology

a) Microbiology of soil.
b) Aquatic microbiology.
c) Microbiology of domestic water and waste water.
d) Microbiology of foods (milk, fish, meat, etc.).
e) Industrial microbiology: microorganism used in industrial processes, genetic engineering of microorganisms and benefits from genetic engineering, production of vaccines, hormones, alcohol, steroids, lactic acid, vinegar, yeasts, etc.

VIII. Microorganisms and Diseases

a) Microbial flora of healthy human host.
b) Host -microbe interaction: the process of infection.
c) Epidemiology of infectious diseases.
d) Microbial agents of diseases: bacteria, virus, fungi and protozoa.

302.1.2 Immunology (15)

I. Overview of the immune system

a) Historical perspectives.
b) Early studies of humoral and cellular immunity.
c) Infection and immunity.
d) Innate and adaptive immunity.

II. Cellular and organs of the immune system

i) Cells of the immune system

a) Lymphoid cell.
b) B lymphocytes (B cells).
c) T Lymphocytes (T cells).
d) b and t cell population.
e) Natural killer cell.
f) Mononuclear phagocytes, Granulocytic cells, Mast cells, Dendritic cells, Follicular dendritic cells.

ii) Organs of the immouno system

a) Primary lymphoid organs.
b) Secondary lymphoid organs.

III. Innate Immunity

a) Anatomical barriers.
b) Connections between innate and adaptive immunity.
c) Inflammation.
d) Soluble molecules and membrane associated receptors.
e) Toll-like receptor.
f) Cell types of innate immunity: neurotrophils, macrophages, NK cells, dendritic cells.
g) Signal transduction pathways: TLR signaling.
h) Physiological factors of innate immunity.

IV. Generation of B cells and T cells responses

i) Antigens and antibodies

a) Immunogenicity versus antigenecity.
b) Epitopes, paratopes and idiotopes.
c) Basic structures of antibody.
d) Antibody binding site.
e) Antibody mediated effector functions.
f) Antibody classes and biological activities.
g) Antigenic determinants on immunoglobulin.
h) B cell receptor.
i) Immunoglobulin super family.
j) Monoclonal antibodies.

ii) Organization and expression of immunoglobulin genes

a) Organization and expression Ig gene.
b) Mechanism of variable-region gene rearrangements.
c) Generation of antibody diversity.
d) Synthesis, assembly and secretion of immunoglobulins.
e) Regulation of Ig gene transcription.

iii) Antigen-antibody interaction: Principles and applications

a) Strength of antigen antibody inter-reactions.
b) Cross – reactions.
c) Surface Plasmon resonance.

d) Precipitation reactions.
e) Agglutination reactions.
f) Radioimmuno assay, enzyme-linked immunosorbent assay, Western blotting.

iv) Complement system

a) Components and functions of complement.
b) Complement activation.
c) Regulation of complement system.
d) Biological consequence of complement activation.
e) Complement deficiencies.

v) Major histo-compatibility complex and antigen presentation

a) General organization and inheritance of MHC.
b) MHC molecules and genes.
c) MHC and immunoresponses.
d) Role of antigen presenting cells.
e) Endogenous and exogenous antigens.
f) Presentation of non-peptide antigens.

vi) T-Cell receptor

vii) T-cell maturation, activation, and differentiation

a) T-cell maturation and the thymus.
b) Thymic selection of T-Cell receptors.
c) T-cell activation.
d) T-cell differentiation.
e) Cell death and T –cell population.

viii) B-Cell generation, activation, and differentiation

a) B-cell maturation.
b) B-cell activation and proliferation.
c) Humoral response.
d) In vivo sites for induction humoral responses.
e) Germinal centers and antigen-induced B cell differentiation.
f) Regulation of immune effect or responses.

ix) Immuno effector mechanism

a) Cytokines.
b) Leukocytes activation and migration.
c) Cell-mediated cytotoxic responses.
d) Hypersensitivity reactions;
    1. Gell and Coombs classification.
    2. Ig E-mediated (Type I) hypersensitivity.
    3. Antibody-mediated cytotoxic (Type II) hypersensitiivity.
    4. Immune-complex mediated (Type III) hypersensitivity.
    5. Delayed- type hypersensitivity (DTH, Type IV).

V. Tolerance and Autoimmunity

a) Establishment and maintenance of tolerance.
b) Organ- specific autoimmune diseases.
c) Systemic autoimmune diseases.
d) Animal models for autoimmuno disease.
e) Evidence for implicating the CD^{4+} T Cell, MHC, and TCR in autoimmunity.
f) Treatment of autoimmune diseases.

VI. Immune System in Health and Disease

i) Transplantation immunology

ii) Immune response to infectious diseases

a) Viral infections.

b) Bacterial infections.
c) Parasitic diseases.
d) Fungal diseases.
e) Emerging infectious diseases: SARS

iii) Vaccines

a) Active and passive immunization.
b) Designing vaccines for active immunization.
c) Live, attenuated vaccines.
d) Inactivated or "killed" vaccines.
e) Subunit vaccines: toxoids, bacterial polysaccharides, viral glycoproteins, pathogen proteins, synthetic peptides.
f) Conjugate vaccines.
g) DNA vaccines: recombinant vector vaccines.

iv) AIDS and other immunodeficiencies

a) Primary immunodeficiency.
b) AIDS and other acquired or secondary immunodeficiency.

v) Cancer and the Immune system

a) Cancer: origin and terminology.
b) Malignant transformation of cells.
c) Oncogenes and cancer induction.
d) Tumors of the immune system.
e) Tumors evasion of the immune system.
f) Cancer immunotherapy.

302.2 Chronophysiology (10)

I. Overview of Chronophysiology

a) Physiological rhythms: outline concept.
b) Types of physiological rhythms: circadian, ultradian, and infradian.
c) Outline concept on circannual, nycthemeral, seasonal rhythms.
d) Zeitgeber, time-zone transitions and shift work.

II. Circadian Rhythm (Circadian Periodicity)

a) Circadian pacemakers: suprachiasmatic nuclei (SCN)-the main circadian pacemaker.
b) Physiological circadian rhythms: sleep-wake cycle, circadian variation of the secretion of ACTH, glucocorticoids, prolactin, GH and melatonin, human body temperature rhythms, functions of pineal gland-photoperiods and pineal function, role of physiological master clock.

III. Ultradian Rhythms/Periodicity

a) Ultradian pacemakers.
b) Physiological ultradian rhythms: cardiac rhythmicity, respiratory rhythm, and nerve impulse discharge.

IV. Infradian Rhythms /Periodicity

a) Infradian pacemakers.
b) Physiological infradian rhythms: menstrual rhythm, seasonal rhythm and life time.

302.3 Application of Statistics and Computer Science in Understanding Physiology (20)

302.3.1 Application of statistics in Understanding Physiology (10)

I. Uses of Statistics in Physiology

II. Definition of Statistical Terms:

a) Observation and Observational unit.

b) Data, Population.
c) Sample, Sampling Unit.
d) Parameter.

III. Sampling

a) Representative sample, precision (sample size), sample techniques, simple random sampling.

IV. Significance of Difference in Means

a) SEM: application and uses.
b) Standard error of difference between two means of age samples.
c) Small samples, t-tests, unpaired and paired.
d) Analysis of variance test.

V. Significance of Difference in Proportions of Large Samples

a) Standard error of proportion (SEP): application and uses.
b) Standard error of difference between two proportions [se (P1-P2)].

VI. Chi-square test

a) Alternate test to find the significance of difference in two or more than two proportions.
b) As a test of association between two events in binomial or multinomial samples.
c) As a test of goodness fit.
d) Calculation of X^2 value.
e) Restriction in application of X^2 test, Yates' correction.

VII. Correlation and Regression

a) Calculation of correlation coefficient from ungrouped series.
b) Regression, calculation of regression coefficient (b), regression line.
c) Standard deviation of the Y measurements for the regression line.

VIII. Designing and Methodology of an Experiment or a Study.

a) Steps and methodology.
b) Format for presentation of any research work.

IX. Graphical Presentation of Data

a) Quantitative data: histogram, frequency curve and polygon, line chart or graph, cumulative frequency diagram, scatter or dot diagram.

b) Qualitative data: bar diagram, pie or sector diagram, pictogram or picture diagram, map diagram or spot map.

X. Demography and Vital Statistics

a) Demography: static and dynamic demography, collection of demographic data, population census.

b) Records of vital statistics: sample registration system (SRS), survey of causes of death, definition of vital events.

XI. Measures of population and vital statistics

a) Measures of population, growth of population, population density, population distribution by age and sex in India.

b) Measure of vital statistics, measures of fertility rates, reproduction rates, measures of marital status, measures of morbidity, measures of mortality, monitoring of family planning programme.

XII. Life table

a) Uses and application.
b) Construction of life table.
c) Modified life table.

302.3.2 Application of Computer Science in understanding Physiology (10)

I. Computer: Characteristics
a) Definition of computer.
b) Computer versus brain.
c) Characteristics of computer.
d) Impact and versatility of computer.

II. Historical Evolutions of Computer
a) Evolution from abacus to first generation of computer.
b) Computer generations.
c) Ages of computeronics.
d) Computer dynasty: digital analog and hybrid computer.
e) Classification of computer based on memory size: micro, mini, super mini, midi, mainframe, maxi or super computers; laptop.

III. Anatomy of Computer
a) Input device.
b) Central processing unit (CPU).
c) Output device.
d) Arithmetic and logic unit (ALU).
e) Storage devices; primary and secondary.
f) Control unit.
g) Anatomy of micro computer.
h) Memory: ROM, RAM, PROM, EPROM, EEPROMS, CAM, SAM, DAM.

IV. Architecture of Computer
a) Architecture of micro computer.
b) Architecture of mini computer.
c) Main frame computer's organization.

V. Data Presentation and Number System
a) Data type and number system-binary and decimal.
b) Conversion from decimal to binary, and conversion of fractional decimal to binary.
c) Conversion of binary to decimal.
d) Hexadecimal number system: hexadecimal to binary conversions, hexadecimal to decimal conversions.
e) Words, bytes and bits.

VI. Binary Operations
a) Binary operations.
b) Binary additions, subtraction, multiplication and division.

VII. Boolean Algebra and Logic Gates
a) Boolean algebra.
b) The OR, XOR, AND, NOT, NOR, NAND Gates.

VIII. Communication with a Computer
a) Management of computer.
b) Hardware.
c) Software: system software, application of software.
d) Computer languages: machine languages, symbolic languages, high level languages.

IX. Computer Networking

a) LAN system.
b) Internet: operation and downloading.
c) Library searching technique.

X. Orientation to software packages

a) Operating system: Window, DOS, etc.
b) PowerPoint preparation for scientific presentation.
c) MS Word: preparation of text, table and others.
d) Excel: managing database, calculation and graphs.
e) Statistical packages: statistical calculation of experimental data.

XI. Programming with C^{++}

XII. Computers in physiology: simulation and modeling of physiological problems, application of computer graphics for solving the problems, molecular modeling and drug designing.

Course-303 (50 Marks: Credit = 1)
Foundation –Compulsory Practical
Practical = 30 hours

Course- 303.1 Microbiology (15)
303.2 Immunology (15)

303.1 Practical on Microbiology (15)

I. Microbiological Experiments

a) Preparation of media for culture of bacteria , molds and yeasts.
b) Study of morphology by staining : Gram staining , acid fast staining , spore staining , mole and yeast staining.
c) Isolation, purification and identification of E, Coli by using selective media.
d) Isolation of pure culture from mixed bacterial culture by streaking, pour plate and spread plate technique.
e) Determination of bacterial growth curve by O.D.
f) Bacterial count in saliva , throat swab and tongue swab.
g) Staining and identification of bacterial found in polluted water (source like sewage , lake water) and soil after their growth in the culture media in the laboratory.
h) Determination of minimum concentration (MIC) of antibiotics.
i) Determination of sensitivity of bacteria to different antibiotics.
j) Estimation of antibiotic and vitamin.
k) Preparation of plasmids and chromosomal DNA.
l) Observation of DNA by autoradiography (demonstration).
m) Southern, Northern , and Western blotting techniques (demonstration).
n) Polymerase chain reaction (PRC) (demonstration).

303.2 Immunological Experiments (15)

a) Identification of B and T-cells by resetting.
b) Measurement of respiratory burst response of neutrophils – enzyme release assay.

c) Agglutination tests: blood groupings , preparation tests.
d) Hemolytic plaque assay.
e) Experiments on phagocytosis and chemo taxis.
f) Ouchterlony double diffusion and single radial immunodiffusion (SRID).
g) Immunoelectrophoresis and counter current electrophoresis.
h) Enzyme linked immunosorbent assay (ELISA) (demonstration).

Course-304 (50 Marks: Credits = 2)
(Core, Practical)
Practical = 60 hours

Course - 304.1 Histology (40)
304.2 Histological Chemistry (20)

304.1 Histology (40)

I. Study of estrus cycle in rat : Proestrus , estrus , metestrus and diestrus

II. Histological Techniques for the Preparation of Paraffin Tissue / Organ sections
a) Isolation and collection of specific tissue / organ mass from sacrificed animal.
b) Fixation of tissue mass.
c) Dehydration, Clearing , Embedding and Paraffin blocking of tissue masses .
d) Cutting of paraffin sections by microtome and preparation of paraffin tissue sections(s) on glass slide.

III. Frozen Tissue Section (For diagnostic and enzyme histo-chemistry , and non-enzyme histochemistry e.g. lipids and glycogen)

IV. Staining of Paraffin Tissue / Organ Sections
i) Histological Staining
a) Hematoxylin-Eosin.
b) Iron- Hematoxylins.
c) Weigert's iron Hematoxylin (for connective tissue).
d) Hematoxylin-eosin (for glycogen).

304.2 Histological chemistry

a) PAS method / Best's carmine method (for glycogen).
b) Oil red method [for fats (degenerating myelin)].
c) PAS & Sudan Black B method (for Glycolipids, neutral fat and myelin).
d) Feulgen & Rossenbeck Nuclear Reaction method (for DNA / deoxyribose).
e) Methylgreen – pyronin method (for RNA).
f) Perl's Prussian blue reaction method (for endogenous ferric iron).
g) Millon reaction method (for tyrosine).
h) Gomori calcium method / Azo dye coupling method (for alkaline phosphatase).
i) VanGieson Trichrome (for connective tissue staining).

Course-305 (50 Marks: Credit = 2)
(Foundation-Compulsory: Practical)
No. of Hours in Practical course = 60

Course- 305.1 Computer Applications (30)
305.2 Physiological statistics (30)

305.1 Computer Applications

a. Binary operations.
b. Boolean algebra.
c. Computer operations and data entry.
d. Computer programming and file management.
e. Microsoft Office.
f. Programming on physiological problems.
g. Computer graphics.

305.2 Physiological statistics Physiological Statistics

a. Preparation of frequencies of a variable : by tabulation (frequency distribution table) and drawing (presentation of quantitative data by histogram, frequency curve, polygon, scatter diagram and qualitative data by bar diagram , pie diagram , pictogram etc.).
b. Calculation of range, mean, standard, deviation (SD) and coefficient of variation from the physiological observations.
c. Calculation of standard error of mean (SEM) from the physiological observations.
d. Calculation of probability from parametric tests.
e. Application of paired and unpaired "t" tests in different physiological observations.
f. Calculation of correlation and regression co-efficient from physiological observations.
g. Application X^2 test to find the significance in different physiological observations.
h. Utility of vital statistics in practice of community medicine and public health administration.

Course-306 (50 Marks: Credits = 1)
(Open Elective Review)
Practical = 30 hours

306. Review work and Seminar on Recent Advances in Physiology

Examinees are to submit a Review Report on a topic of physiological importance under the supervision of a teacher of the department. Marks will be awarded of the examinee on the basis of their performance in the seminar on the report and oral presentation on it.

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4th Semester Programme in Physiology
July to December (Odd semester)
Outline of courses and components
400 Marks
16 credits

Course-401 (100 Marks: Credits = 5)
(Foundation Compulsory Special)
Lectures = 60 hours
Tutorial / assignment = 15 hours

Course- **401.1 Environmental Physiology (60)**
401.2 Ergonomics and Occupational Physiology (60)
401.3 Food and Nutrition (60)

401.1 Environmental Physiology (60)

I. Human and Environment

a) Definition and types: natural, domesticated, fabricated, and social.
b) Components of human environment.
c) Biological and Physiological environment.
d) Basic concept on changes in the environment caused by human.

II. Human population and its Physiological Control

a) Position of human in biological environment.
b) Evolution and features of modern man.
c) Human population : definition, population growth rate, factors controlling population growth rate, World distribution of population, growth curves, survival curves of human, family planning- hormonal and immunological.
d) Population genetics and society.

III. Principles of Ecosystem

a) Ecosystem: definition and anatomy, habitat, niche, ecological equivalents, food chain, food webs, flow of matter and energy.
b) Terrestrial biomes: taiga, tundra, tropical rain forest, savanna, and deserts.
c) Marine biomes.
d) Biogeochemical cycle: carbon cycle- major sinks for CO_2; N_2 -cycle: biological fixations (Half cell reaction), denitrifications.

IV. Natural Resources

a) Air: components, human interactions: respiration, concept of atmosphere, atmospheric division, stratopheric ozone layer and its importance.
b) Water: fresh water- sources and uses, acquifers, oceans and rivers as beneficial resources to mankind.
c) Top soil: definition, components, types, origin and importance.
d) Minerals: nature and types, mineral resources of India.
e) Living resources: biodiversity – plants and animal resources and their use, wild life, medicinal plants, petrocrops.

V. Energy Resources

a) Conventional: non-renewable- coal, petroleum, natural gas; renewable- hydel power, atomic energy; fission and fusion atomic technologies.
b) Non-conventional: renewable- solar energy, wind energy, geothermal energy , tidal energy, OTEC.
c) Biofuels.
d) Petrocrops.

VI. Body Temperature Homeostasis

a) Normal core and skin temperature.
b) Mean body temperature.
c) Balance between factors affecting heat production and heat loss.
d) Regulation of body temperature: role of peripheral and central thermo receptors.
e) Hyperthermia: heat stroke and heat exhaustion.
f) Hypothermia: cold illness, myocardial fibrillation.

VII. Respiration in Unusual Environments

a) Respiration in low oxygen environments.
b) Respiration in deep sea diving.
c) Effects of high pressure on respiration.
d) Respiration in high- oxygen environments: atelectasis, free radicals induced toxic effects, retrolental fibrosis.
e) Respiration in unusual gaseous environnments: high concentration of CO_2 and respiration, CO and respiration.
f) Respiration in space travel: high G forces and the human body, weightlessness and respiration.

401.2 Ergonomics and Occupational Physiology (60)

I. Human and work environment

a) Human characteristics, capability and limitations.
b) Interface between man, machine and environment.
c) Macro- ergonomics and Micro-ergonomics.

II. Physical and chemical aspect of work environment

a. Thermal work environment**:** Normal core and skin temperature, Mean body temperature, Regulation of body temperature, Thermal comfort and discomfort, Heat stress indices, Heat tolerance, Control of thermal environment.
b. Noise and work**:** Units of noise, Effect of noise on man, Noise induced hearing loss (NIHL), Measurement and control.
c. Vibration and electromagnetic wave: Units, Effect of vibration on human body, Measurement and control. Effect of different types of electromagnetic wave.
d. Light and Colour**:** Light intensity and Luminance, Effect of Illumination on visual performance, glare, effect of colour, visual fatigue.
e. Ionizing and non- ionizing radiations in the work environment**:** Long term and short term effect, Method of control.
f. Dust, fumes, vapours, gases, chemicals, etc**:** Effect of respiratory and other body systems; Maximum allowable concentration, Threshold Limit Value.

III. Occupational ergonomics

a. **Manual material handling:** Lifting and carrying load, Personal and job risk factors, Biomechanics of spinal loading, NIOSH guideline and equation, Method for manual material handling task, Recommended weight limit (RWL).

b. **Posture:** Fundamental aspect of static and dynamic posture, assessment of working posture, OWAS, REBA, RULA, LUBA, PATH, etc.
c. **Work organization**: Macroergonomics, Sociotechnical systems theory, Work study.
d. Method Study, Work measurement, Motion study, Participatory ergonomics.

IV. Anthropometry: It's applications

a. Static and dynamic anthropometry.
b. Kinanthropometry.
c. Use of anthropometric data, Percentile value.
d. Application of anthropometry in design.
e. Work station design and reach, Use of Mannequins.
f. Somatotyping, Measurement of body composition, BMI and BSA.

V. User interface and principles of design

a. Man – machine interface.
b. Principles of product design.
c. Design characteristics of controls.
d. Design characteristics of displays.
e. Compatibility and population stereotypes.

VI. Ergonomics for safety and loss prevention

a. Accident**:** Definition, Classification, Cost of accident, Theories.
b. Unsafe acts and unsafe conditions.
c. Ergonomic interventions.

VII. Principles of management in ergonomics

a. Selection, Placement, Training.
b. Job evaluation, Cost benefit analysis, Motivation.

401.3 Food and Nutrition (60)

I. Nutrition and its requirements

a. Nutritive value of principal constituents of diets.
b. Mineral, Vitamins and Dietary fibres.
c. Antioxidants.
d. Nutritive requirements during growth and development, infancy and childhood, adolescent and youth, pregnancy and lactation, geriatric age and starvation.

II. Digestion and Absorption

a) **Digestion and absorption of Carbohydrates**
   i. Carbohydrate with diet.
   ii. Digestion of carbohydrates.
   iii. Absorption of Carbohydrate.
   iv. Carbohydrate malabsorption syndromes.
b) **Digestion and absorption of proteins**
   i. Digestion of proteins
   ii. Absorption of the products of protein digestion.
   iii. Defects of amino acid digestion and absorption.
c) **Intestinal Absorption of Salts and Water**
   i. Absorption of water
   ii. Absorption of sodium (Na^+)
   iii. Absorption of Cl^- and HCO_3^-
   iv. Absorption and secretion of K^+
   v. Mechanism of salts and water transport by the intestine.

d) Absorption of Calcium.
e) Absorption of other Ions: Magnesium, Phosphate, Copper.
f) Absorption of water soluble Vitamins: absorption of Vitamin $B_{12.}$
g) Digestion and Absorption of Lipids
i. Digestion of lipids.
ii. Absorption of the products of lipid digestion.
iii. Absorption of Bile salts.
iv. Malabsorption of lipids.
v. Absorption of Fat soluble Vitamins: A, D, E, and K.

III. Transducing and storing energy
a. Metabolism: Basic concepts and design.
b. Glycolysis and Gluconeogenesis.
c. The Citric Acid Cycle.
d. Oxidative phosphorylation.
e. The Light reaction of photosynthesis.
f. The Calvin Cycle and the Pentose Phosphate Pathway.
g. Glycogen Metabolism.
h. Fatty acid metabolism.
i. Protein turnover and Amino Acid catabolism.

IV. Food Science and Food Technology
a. Food types, calorie. Thermodynamics, food processes.
b. Food Fortification- principles and applications, food preservation, food additives and food color, food adulteration
c. Food quality control and legal procedures.
d. Food faddism, food intolerance and toxicity, food allergy and hypersensitivity, food myth and prejudices.
e. Fast food, convenient food.

V. Interactive interaction of nutrition
a. Nutrients and nutrients.
b. Drug and nutrients.
c. Hormone and nutrients.
d. Nutrient and genes.
e. Nutrient and infection.
f. Nutrition and immunity.
g. Nutrition and sports.
h. Nutrition and addiction.

VI. Modern Trends in Nutrition
a. Development of genetically engineered foods.
b. Role of neutraceuticals and phytochemicals as nutritional supplements.
c. Nutrition and Cancer.
d. Role of nutrients in detoxication mechanism.

VII. National and International Bodies and Research Organizations related to Nutrition
a. Policies and programmes.
b. Future trends in nutritional Research and Development.

Course-402 (100 Marks: Credits = 5)
(Foundation Compulsory Special)
Lectures = 60 hours
Tutorial / assignment = 15 hours

Course- **402.1 Environmental Physiology (60)**
402.2 Ergonomics and Occupational Physiology (60)
402.3 Food and Nutrition (60)

402.1 Environmental Physiology (60)

I. Physiological Toxicology

a) Principle of toxicology: toxins, mode of action of toxins, factors affecting toxicity: dose and duration, dose- response curve, LD_{50}, LOD_{50}, threshold level, NOEL; biological effects; acute and chronic- mutation , cancer, birth defects (teratogenicity).
b) Bio-accumulation and biomagnifications of xenobiotics.
c) Health hazards of pesticides, dioxin, PCB and PAH.
d) Occupational health hazards: pneumoconiosis, asbestosis, silicosis.
e) Reproductive toxins.
f) Nerve gases: examples and health hazards.

II. Environmental and Public Health

a) Definition: hygiene, health and public health.
b) Air, water, food borne diseases: causes, symptoms, and control.
c) Food additives and adulterants: definition, examples and human health hazards.
d) Vector borne epidemic diseases: malaria and plague- etiology and control.

III. Environmental pollution and human health hazards

a) Air Pollution: definition, sources, air pollutants, effects of air pollution on human health, indoor air pollution, environmental tobacco smokes (ETS) and human health hazards, phenomenon of photochemical smog, acid rain; ozone layer depletion- causes and human health hazards, concepts of ozone hole; enhanced green house effects and global warming; consequences of global warming on human environment.
b) Water Pollution: definition, types, health hazards, water pollutants, eutrophication, biochemical oxygen demand (BOD), thermal pollution, chemical pollution- Minamata and Itai- Itai disaster, oil pollution, plastic pollution, concept of safe drinking water standards, biomagnifications of xenobiotics in aquatic food chains.
c) Soil Pollution: causes, health hazards, solid waste managments- bioremediation, phytoremediation.
d) Sound Pollution: definition, concept of noise, sources of sound pollution, effects of sound pollution on human health, noise index (noise standards).
e) Radionuclide Pollution: radiation types sources, ionizing radiations, effects of ionizing radiation on human health, permissible doses.
f) Arsenic Pollution: sources, sources of arsenic in ground water, drinking water standard for arsenic (WHO, USEPA), health effects of chronic arsenic poisoning.
g) Legal and technological control measures for pollution.

IV. Environmental Management

a) Environmental ethics.
b) GIS, remote sensing to monitor environmental degradation.
c) Sustainable use of natural resources: water, topsoil, minerals, living resources.

d) Conservation of topsoil, ground water and wild lives; rain water harvesting; sanctuary, national park; biosphere reserve; wildlife (conservation) act 1992.
e) Environmental conflicts.

402.2 Ergonomics and Occupational Physiology (60)

I. Physiological job demand

a) **Physiological Energetics:** Muscle contraction and fuel for muscular contraction, aerobic and anaerobic power, cardiorespiratory change during exercise.
b) **Physical work capacity:** Measurement, Factors affecting, Absolute and relative cardiac cost, Energy cost of different activities, Classification of workloads.
c) **Fatigue:** Neuro-physiological model of fatigue and alertness, Mechanism of development, Measurement and prevention.
d) **Work – Rest Cycle:** Work load, Rest allowances, Organization of work, working time.

II. Psychological job demand and cognitive ability

a) **Stress:** Causes, effects and preventive measures; Physiological changes, Psychological aspects of stress.
b) **Cognitive ability:** Learning time, Mental fatigue and loading, Reaction time, Virtual environments, Sensory perception, Information processing, Attention, Human error, Reliability analysis.
c) **Job Demand:** Psychological load, Rating of perceived exertion (RPE), Borg scale, Error analysis.

III. Working hours and shift Work

a) Problems of shift work, Night work.
b) Chronophysiological aspect, Ergonomics organization of shift work.
c) Shift rotation and Flexible working hours.

IV. Human performance in adverse condition

a) Effect of high and low barometric pressure.
b) Physiological adaptation and acclimatization in high altitude.
c) Physiology of deep – sea diving.
d) Effect of performance in desert and Arctic climates.
e) Space travel.
f) Protection against climatic extremes.

V. 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.

VI. National and International Regulations

a) Factories Act, Workman Compensation Act.
b) The Employees' State Insurance Act.
c) Coal Mines Labour Welfare Act.
d) Occupational health and safety management system standards (OSHA).

402.3 Food and Nutrition (60)

I. Principles of Toxicology

a) Toxins and Toxicology.
b) Factors Effecting Toxicity.
c) LD_{50}, LOD $_{50}$, ED_{50}, NOEL, LOEL.

d) Concept of Acute and Chronic Effects.
e) Birth defects and Teratogens.
f) Concept of biomagnification and Bioconcentration.
g) Food additives and Food adulterants.
h) Prevention of Food adulteration Act 1954.
i) Other Food Toxicants: BPA, BPS, Pesticides, PAH, Dioxin, PCB, **Heavy Metals**: Pb, Hg, Cd, As etc.

II. Environment and Public Health

a) Food –Borne disease.
   i. Food poisoning.
   ii. Cause of Food Poisoning.
   iii. Bacterial poisoning: Botulism.
b) Meat Borne Diseases.
c) Fish- Borne Diseases.
d) Milk- Borne Diseases.
e) Preventive Measures for food Poisoning.

III. Basic Concept of Diet Therapy

a) Therapeutic adaptation of normal diet.
b) Principles of therapeutic diet.
c) Classification of therapeutic diet.
d) Therapeutic management.
e) Strategies in under nutrition.
f) Over nutrition.
g) Metabolic diseases and systemic diseases.

IV. Therapeutic Nutrition Management Strategies : -in illness, acute illness like fever, burn, cancer, HIV infection and degenerative diseases.

V. Therapeutic Nutrition Management Strategies in Space Flights and Sports

VI. Community Nutritional Survey, Assessment of Nutritional States and Nutritional Counseling

a) Principles of Diet survey.
b) Methods of Diet survey
c) Ethics related to diet survey of Human population.
d) Anthropometry in the assessment of nutritional states.
e) Nutritional Counselling- Basic principles and application, Epidemiology.

VII. Nutritional economics

Policies, laws and global interaction.

Course-403 (100 Marks: Credits = 2)
(Foundation Compulsory Special -Practical)
Practical = 60 hours

Course- 403.1 Environmental Physiology (60)
403.2 Ergonomics and Occupational Physiology (60)
403.3 Food and Nutrition (60)

403.1 Environmental Physiology (60)

I. Bio- chemical Experiments

a) Estimation of serum calcium by Kramer and Tisdall method of the animals exposed by ETS, and smoker and non-smoker humans.

b) Estimation of blood glucose by Nelson Somogy method after chronic exposure of the animals by tobacco smoke/smokers and non- smokers.
c) Estimation of SGOT and SGPT values.
d) Measurement of Dissolved oxygen (DO) and Biochemical Oxygen Demand (BOD) in water samples.
e) Measurements of chloride in water samples by Silver nitrate method.
f) Measurements of nitrate in water sample by PDA method.
g) Biochemical identification of food additives in some common foods.

II. Micro- Biological Experiments

a) Testing of potability of water by coliform count.
b) Staining and observation of bacteria and fungi in food (curd, milk, bread, fruit juices, sweets etc.) and water samples (tube well water, river water, tap water etc.)-
i. preparation of Media.
ii. Inoculation.
iii. Staining and Identification.

403.2 Ergonomics and Occupational Physiology (60)

I. Experiment on Environmental Ergonomics

a) Measurement of noise levels at different working areas.
b) Measurement of illumination level by Lux meter in different working areas.
c) Measurement of heat stress indices; WBGT, ET, CET, P_4SR; Measurement of relative humidity.
d) Measurement of dust particles in working environment by air sampler.

II. Experiment on Design ergonomics

a. Anthropometric measurement – Static and Dynamic, Measurement of BMI, BSA, Somatotyping, etc, Anthropometric measurements for different design considerations.
b. Determination of muscular strength by hand grip dynamometer.
c. Determination of visual acuity by different charts.

III. Occupational Ergonomics

a) Determination of center of gravity of human body under resting and working condition.
b) Postural analysis- Angular measurement by goniometer. Videography and photography. Different postural analytical methods viz, OWAS, REBA, RULA, LUBA, PATH, etc.
c) Time study and Motion study, Activity analysis.
d) NIOSH equation of lifting heavy materials, Lifting index, etc.
e) Audio-visual reaction time.

403.3 Food and Nutrition (60)

I. Protein chemistry and Molecular Biology

a) Chromatographic separation of proteins.
-Paper and Thin layer
-HPLC (Demonstration).
b) Electrophoretic separation of protein
-Paper, Agarose gel and SDS- PAGE (Demonstration).
c) Genomic DNA isolation.
d) Gel electrophoresis of DNA.
e) Western Blot.
f) PCR and its application (Demonstration).

II. Blood Analysis

a) Serum constituents (glucose, cholesterol, urea, uric acid, bilirubin etc.).
b) Enzymes (Estimation of serum amylase, transaminase, phosphatase, LDH, CPK etc.).

c) Minerals (Na, K, Ca, Mg, Phosphate etc).
d) Vitamins (Vitamin C, E).

III. Food Analysis

a) Food analysis (Na, K, Ca, Mg, PO_4 etc).
b) Food vitamins (vitamin C and E).

IV. Experimental Animal Models

Hepatotoxicity, Gastric ulcer, diarrhea, diabetes mellitus.

V. Nutritional Assessment and Diet Survey

a) Diet survey of community, submission of a report.
b) Visit to any Research organization related to Food, Nutrition and Dietetics.

Course-404 (50 Marks: Credits = 2)
(Foundation Compulsory Special -Practical)
Practical = 60 hours

Course-

404.1 Environmental Physiology (60)
404.2 Ergonomics and Occupational Physiology (60)
404.3 Food and Nutrition (60)

404.1 Environmental Physiology (60)

I. Physiological (Experimental) Experiments

a) Kymographic recording of the effects of Hg, Pb, and As compounds; and food additives (Metanil yellow, Rhodamin B, and TOCP) on
   i. The contraction of perfused heart of toad.
   ii. The contraction (isometric) of isolated Gastrocnemius muscle of toad.
   iii. The motility of intestinal movements of rats in Dale's bath.
b) Lung Function Tests in smokers, non –smokers and occupational exposed individuals in hazardous environment.
c) Studies of the effect of:
   i. Temperature on thyroid status.
   ii. Light gonads.
   iii. Iodine on thyroid status.
d) Measurement of MBT in hypothermic and hyperthermic conditions.
e) Studies of blood parameters in individuals exposed to occupationally hazardous environment.
   i. TC,DC,ESR
   ii. Reticulocyte count
   iii. Estimation of Hb
f) Measurement of noise levels at different zones and studies of the effect of noise on some physiological variables (BP, light refkex,auditory reflex etc.).

II. Histo-chemical Experiments

Histo-chemical studies regarding chronic effects of food additives and arsenic compounds on liver, kidney, intestine, brain, muscle and lung tissues in rat.

404.2 Ergonomics and Occupational Physiology (60)

I. Experiments on Occupational Physiology

a) Measurement of heart rate, blood pressure at rest and at different working conditions. Classification of work load.

b) Determination of maximal heart rate, cardiac cost and cardiac efficiency by Polar heart rate monitor.
c) Determination of VO_2 max by direct and indirect methods (Queen college test),
d) Evaluation of lung function (spirometric method) - Estimation of FVC, SVC FEV_1, MVV and PEFR.
e) Determination of hearing loss of different groups of workers by audiometric method.
f) Recording and Interpretation of ECG.
g) Recording and Interpretation of EMG.

II. Experiment on Occupational Physiological Chemistry

a) Estimation of Hematological parameter like Hb (By Shali's method or Drabkin method) and RBC count before and after exercise.
b) Estimation of Blood glucose level before and after work.
c) Estimation of Creatine Kinase level before and after work (Kit method).
d) Estimation of Lactate Dehydrogenase (Kit Method).
e) Qualitative and quantitative tests of sputum; staining and morphological assessment of macrophages.
f) Estimation of SGOT and SGPT values.
g) Estimation of oxidative stress enzymes, Lipid peroxidase, SOD and Catalase.

404.3 Food and Nutrition (60)

I. Qualitative tests for identifying food adulterants in some food samples:
Metanil yellow, Rhodamin B, Saccharin, Monosodium glutamate, Aluminium foil, Starch, Chicory, Bisphenol A and Bisphenol S, Margarine, Pb, Hg, As, PCB, Dioxin, etc.

II. Quantitative tests for identifying food additives in some food samples:
Metanil yellow in turmeric powder, besan, laddoo, and amriti, etc.

III. Experimental study:
Effect of Metanil yellow, Bisphenol A, Bisphenol S, Monosodium glutamate on the movement of intestine and uterus of the rat and heart of toad.

Course-405 (50 Marks: Credits = 2)
(Open Elective- Project work)
Practical = 60 hours

Course 405: Project work and Seminar Presentation on Recent Advances in the Subject

Under the supervision of a teacher of the Department, each student in the 4th semester session will carry out a **project** on a topic of his/her special paper for a period of 6-8 weeks. Students will be evaluated on the basis of the **reports** submitted and oral presentation on the report in a seminar on the schedule date of examination. Project reports and oral presentation will be evaluated by the examiners conducting the special practical examination.

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