KERALA PUBLIC SERVICE COMMISSION

SYLLABUS FOR THE POST OF

RANGE FOREST OFFICER IN

KERALA FOREST & WILDLIFE DEPARTMENT

Optional subject- Geology

Module 1 : PHYSICAL GEOLOGY AND GEOMORPHOLOGY   **(20 marks)**

Introduction to various branches of Earth Science, **Earth** : origin, internal structure, Age determination. Geologic time scale and units. Concept of plate tectonics, sea-floor spreading and continental drift. Palaeomagnetism

Endogenic processes: Earthquakes: types, causes and effects, seismic waves, focus and epicentre, seismograph and seismogram, intensity and magnitude, seismic belts of the world, seismic hazard zonation of India. Volcanoes: classification, distribution and products. Mountains: Types, concept of isostasy.

Exogenic Processes : Weathering- agents, types and products. Soil : Regolith, soil profile, factors affecting soil formation, types in India. Mass movements: process of downslope movements, classification. Landslides- causes, types, effects and mitigation,

Fluvial Processes : Streams : Drainage basin, drainage pattern, geological work, evolution of landforms. Oceans and Seas : Eustatic sea level changes, Ocean floor morphology: continental shelf, continental slope, continental rise, submarine canyons, abyssal plains, MORs, deep sea trenches, guyots, seamounts, coral reefs.

Glaciers: Formation, movement and morphology. Types of glaciers. Erosion, transportation and deposition by glaciers. Glacial landforms. Global warming and its effects on glaciers.

Wind : Geological activity, Aeolian Landforms, Desertification process.

Module 2 : MINERAL SCIENCE (20 marks)

Crystallography: Crystal : Concept of crystalline matter, morphology- faces, edges, vertex, forms, zones, crystal angles, law of constancy of interfacial angles, elements of symmetry, crystallographic axes, space lattices, Weiss parameters and Miller indices, classification of crystals into systems, Hermann Mauguin notation, basic concepts of spherical and stereographic projections in crystallography

Mineralogy : Classification of minerals, Silicate structures and types, Isomorphism, Polymorphism, Pseudomorphism, exsolution and solid solution. Physical properties of minerals- form, habit, cleavage, fracture, colour, diaphaneity, luminescence, fluorescence, phosphorescence, play of colours, luster, streak, hardness, specific gravity, electrical, magnetic, radioactive.

Optical Mineralogy : Ordinary and polarized light, polarization of light, refractive index, critical angle and total internal reflection. Polarization by reflection, absorption, and refraction. Isotropic and anisotropic substances. Uniaxial and biaxial minerals. Double refraction, construction of Nicol prism. Petrological microscope - parts and functions. Optical accessories - mica plate, gypsum plate and quartz wedge. Optical properties- Colour, relief, pleochroism, interference colour and its order, extinction and its types, birefringence and optic sign, Basic description of optical indicatrix

Module 3 : IGNEOUS AND METAMORPHIC PETROLOGY (20 marks)

Magma generation in the crust and upper mantle, Physical properties of magma, Bowen's reaction Series and its application, Magmatic differentiation- fractional crystallization, partial melting, assimilation and their role in magmatic differentiation, Phase rule and its application to eutectic, peritectic and solid solution system. Study of following binary systems: Diopside-Anorthite (Eutectic), Albite-anorthite (solid solution), Forsterite-silica (Incongruent).,

Igneous rocks : Modes of emplacement: volcanic, hypabyssal, plutonic, Forms of igneous rocks. Texture and Microstructure of Igneous rocks, classification of igneous rocks : IUGS /QAP/Chemical classification Petrography of common igneous rocks –granite, syenite, diorite, gabbro, dolerite, basalt, andesite, rhyolite, pegmatites, dunite, peridotite, anorthosite, granodiorite

Metamorphism : Factors and limits of metamorphism. Anatexis, palingenesis and migmatites. Types of metamorphism, metamorphic facies, mineralogical phase rule of closed and open system. Composition-paragenesis diagrams. Basic concept of ACF, AKF and AFM diagrams. Metamorphic structures and Textures, Metamorphism of pelitic, carbonate and mafic rocks.
Metamorphic rocks: Regional occurrence and tectonic significance, Petrography of Slate, Phyllite, Quartzite, Marble, Schists, Amphibolite, Gneisses, Eclogite, Blueschist, mylonite, Hornfels and Granulites – Charnockite (massive, incipient), Khondalite and Leptynite

Module 4 : SEDIMENTARY PETROLOGY (20 marks)

Sediment – Provenance, Lithification and Diagenesis. Texture - Clastic texture - concept of grain size (Udden-Wentworth and Phi scale of size determination), grain shape, fabric and packing. Non-clastic texture – different types of crystalline texture. A brief study of structures- primary, secondary and organic.

Sedimentary rock : Formation, Characteristics, and Classification. Classification of Sandstone and Limestone (Folk & Dunham). Petrography of major sedimentary rocks: Sandstone, limestone (oolitic, fossiliferous), shale, conglomerate, breccia, arkose, greywacke, grit.

Brief study of depositional environments of sedimentary rocks and facies associations. An introduction to Sedimentary Basins and their formation. A brief study of sedimentary basins in India. Platetectonics and sedimentation.

Module 5 : STRUCTURAL GEOLOGY (20 marks)

Structural Planes : Attitude of planar and linear structures. Strike, dip, plunge and pitch. Width of outcrops, outlier and inlier, Rule of Vs. Primary and secondary structures. Use of primary structures in determining the top and bottom of beds.

Rock Deformation : Concept of Stress and strain, Stress and strain ellipsoids. Stages of rock deformation, Basic concepts of stereographic projections. Tectonites and its classification.

Folds: terminology, classification-genetic and geometric. Recognition of folds. Unconformities - types and their recognition in the field. **Fault** : terminology and classification. Fault mechanics. Recognition of faults. **Foliation** : tectonites, compositional, disjunctive, continuous, slaty cleavage, schistosity, flow cleavage, fracture cleavage, shear cleavage. Relationship of foliation with fold and shear zones. **Lineation** : discrete, constructional and mineral lineation. **Joints** : nature, origin, classification and geologic significance. Fractures and its types.

Module 6 : PALAEONTOLOGY AND STRATIGRAPHY (20 marks)

Palaeontology : scope and branches, Fossilization : conditions, processes and modes;

Fossils: morphology, classification, geological history and stratigraphic importance of Phylum Protozoa, Phylum Coelenterata - Class Anthozoa, Phylum Brachiopoda, Phylum Mollusca - Class Pelecypoda, Class Gastropoda, Class Cephalopoda, Phylum Arthropoda, Class – Trilobita. Phylum Echinodermata, Phylum Hemichordata – Class Graptolithina.

Microfossils and plant fossils: Introduction , general classification, uses and distribution of microfossils. Significance of microfossils in petroleum exploration. Brief introduction to Palynology. Brief account of the following plant fossils - Glossopteris, Gangamopteris, Ptilophyllum, Calamites, Lepidodendron and Sigillaria. Indian distribution of major plant fossils.

Stratigraphy : Branches, Concept of Plutonism, Neptunism, Catastrophism and Uniformitarianism, Stratigraphic principles, Elements of lithostratigraphic, chronostratigraphic and biostratigraphic classification. Type area, type section.

Stratigraphic correlation : criteria and methods, Breaks in stratigraphic succession-hiatus, diastem, non-sequences and their significance. Offlap and overlap. Significance of unconformity in stratigraphic studies.

Stratigraphy of India : Physiographic and tectonic subdivisions of India. Study of the stratigraphy, lithology, classification, age, structure and economic resources of Dharwar supergroup, Aravalli, Delhi Supergroup, Cuddapah Supergroup, Vindhyan Supergroup and Kurnool Group. Gondwana succession of Peninsular India, Cretaceous of Trichinopoly, Deccan Traps and associated sedimentaries. Tertiaries and Quaternary succession of Kerala

Module 7 : ECONOMIC GEOLOGY   (20 marks)

Mineral Resources : Ores, gangue minerals, tenor, grade, resources and reserves. Types of resources, Internal processes of ore formation : magmatic, hydrothermal, sedimentary ore forming processes, External ore forming processes : Evaporite deposits, sedimentary deposits: mechanical and residual concentration, Oxidation and supergene enrichment, Volcanic exhalative deposits.

Economic Minerals : Critical and Strategic Minerals. Materials for Abrasives, Refractories, Ceramics and Cement. Gemstones. Coal and Petroleum : Nature, origin and Indian distribution. Mineral Policy of India. Mineral resources of Kerala. Major mineral resources in India- Fe, Al, Cu, Pb, Zn and Mn

Module 8 : MINING AND ENVIRONMENTAL GEOLOGY   (20 marks)

Mining : Terminology, methods - opencast and under ground, Drilling, Surveying, Sampling, Assaying and ore reserve estimation., Social and environmental impacts of mining, sustainable use of mineral resources. Geological principles for mine stability and safety, mitigating hydrological impacts

Environmental Geology : scope, objectives, and aims. Global Climate change: Greenhouse effect, Global warming, Ozone depletion - causes and effects. Pollution and waste disposal – air, water and land pollution; brief ideas of causes and effects.

Environmental Awareness - Environmental Protection and Planning. Environmental consequences of natural hazards- Earthquakes, Storms, Floods, Tsunamis, Volcanic activity and Landslides. Soil erosion and its impact on environment . Beach erosion – sedimentation – coastal zone protection & Management – coastal engineering constructions – their effects remedial measures..

Environmental Planning and Management. Environmental Assessment. Environmental Impact of urbanization. Geology and urban planning. Role of Geologist in conservation of environment. Environmental awareness and environmental laws. Environmental Management Plan, Environment protection- legislative measures in India.

Module 9 : GROUNDWATER AND ENGINEERING GEOLOGY   (20 marks)

Water bearing characteristics : Hydrological cycle, vertical zonation of ground water, Properties of water bearing formations porosity, permeability, specific yield, specific retention, storativity. Aquifer types-Confined and unconfined aquifers, aquitard, aquiclude, aquifuge. Darcy's law.

Groundwater investigation   - geophysical exploration methods with special emphasis on electrical resistivity method, well logging, tracer techniques. Pumping test and determination of safe yield, water conservation methods - check dams, ponds, sub surface dykes, concept of artificial recharging of groundwater. Hydrogeological provinces of India. Groundwater status in India. Major aquifers and groundwater exploitation in Kerala.

Engineering Geology: Introduction , major man-made structural features. Weathering and its significance in engineering, soil profile, Engineering properties of rocks: strength, hardness, elasticity, porosity and specific gravity; rock mass and its characteristics; Rock discontinuities. Mechanical properties of rocks and soils. Engineering classification of soils. Determination of water content in soils, specific gravity of soils, void ratio, porosity. Particle size analysis of soils Geological considerations involved in the construction of dams and reservoirs, tunnels, roads, airways, bridges and buildings. Mass Movements with special emphasis on landslide and causes of hill slope instability; stability of slopes. Geological materials used in construction -building stones, roofing and facing materials. Physical characters of building, ornamental stones and concrete aggregates.

Module 10 : REMOTE SENSING AND GIS   (20 marks)

 Photogeology -types and acquisition of aerial photographs; Scale and resolution; Principles of stereoscopy, relief displacement, vertical exaggeration and distortion elements of aerial photo interpretation, Image Errors, Rectification and Restoration, FCC, Image Enhancement, Filtering, Image Rationing, Image classification and accuracy assessment, study of lithology, geological structures and geomorphology from aerial photos

Remote sensing – basic principles, . Electromagnetic spectrum and interaction with Earth's surface. Types of remote sensing platforms (satellites, aerial platforms, UAVs), Characteristics of remote sensing sensors (optical, thermal, radar). Geostationary and sun-synchronous satellites. Global Positioning System. Digital image processing. Remote sensing in landform and land use mapping, structural mapping, hydrogeological studies and mineral exploration.

Geographical Information System – Introduction, definition, components of GIS – GIS software – Raster and Vector data – Spatial data – Introduction – Maps and GIS – thematic

characters of spatial data – Different sources of spatial data. Spatial data modelling – Entity – definition – spatial data models – spatial data structures, Concepts of GPS, Integrating GPS data with GIS applications in earth science

Optional subject- Horticulture

Module 1: Fundamentals of Horticulture (20 marks)

Horticulture- Importance, divisions, classification, nutritive value, area and production, Horticultural zones in India, Commercial orchards and plantations- selection of site, planning and layout, Systems of planting, Tree forms and functions- training systems, pruning techniques, Growth and development, Bearing habits, Fruit set and fruit drop- factors affecting and measures to overcome, Causes of unfruitfulness, Seedlessness- significance and induction, Plant growth regulators- preparation and methods of application. Plant propagation- types, advantages and disadvantages, Potting and repotting- containers and media. Seed propagation- dormancy, types and methods to overcome, Asexual propagation- apomixis, polyembryony, bud sport, chimera, Propagation- by cutting, layering, grafting, budding, Stock- scion relationship, incompatibility. Plant propagation structures- green house/ glass house, hot bed, cold frame, lath house, net house, mist chamber, Nursery- site selection, layout, components, Commercial propagation of selected horticultural plants, micropropagation.

Module 2: Fruit crops (40 marks)

Importance and scope of fruit crops in India with special reference to Kerala, Classification of fruits, Cultivation practices of important tropical (banana, mango, pineapple, papaya, sapota, guava, pomegranate), subtropical (Citrus, grapes, mangosteen, avocado, litchi, Moraceous and Annonaceous fruits) and temperate (apple, pear, peach, plum, strawberry, cherry, minor fruits) fruit crops- origin, soil and climate, botany, cultivars, plant propagation, planting aftercare and management, nutrient deficiencies, cultivation problems, major pests and disease and control measures, Hi-Tech innovative practices in fruit production- Biotechnology, HDP, fertigation, protected cultivation, organic farming.

Module 3: Vegetable crops (40 marks)

Importance and scope of vegetable crops in India with special reference to Kerala, Classification of vegetables, Factors affecting vegetable production- Temperature, light, moisture, soil and nutrients, Types of vegetable gardens, Systems of vegetable cultivation- traditional and specialized, Protected cultivation, Precision farming, Cropping systems, Basic principles in vegetable production- nursery, sowing and transplanting, care and management, Irrigation management, Nutrient management, Growth regulators, Seed production, Post harvest handling, Packing and transport, Marketing, Production technology of warm season (Solanaceous, Cucurbitaceous, Leguminous, okra, amaranth, perennial vegetables and tubers) and cool season vegetables (Cole crops, Root crops, Bulb crops, Potato, Peas& Beans, salad crops& leafy vegetables)- importance, origin, taxonomy, varieties, cultivation, problems and prospects.

Module 4: Floriculture and Landscaping (40 marks)

Introduction to Landscaping and gardening- components of landscapes and gardens, History of gardening, Garden styles- formal and informal, types of gardens- Mughal, Japanese, Persian, French, Italian, English. Principles of landscaping- designing and preparation of landscape and garden plans. Garden adornments, Lawn- types, methods of establishing, maintenance. Annuals and herbaceous perennials- use, selection, design, cultural practices. Shrubs and trees- trees for landscape, avenue planting. Climbers and creepers, cacti and succulents, ferns and palms. Specialized gardening techniques- rock garden, water garden, bonsai, terrace garden, sunken garden. Indoor plants- types, display, terrarium. Commercial Floriculture- status of cut flower industry in India, problems and prospects. Cut flowers (Rose, Orchids, Anthurium), Loose flowers (Jasmine, chrysanthemum), bulbous plants, minor commercial flowers- Importance, classification, varieties, cultivation practices. Flower arrangement- principles, styles, designs, tools, containers, vase solutions, flower shows and exhibitions

Module 5: Plantation crops, Spices, Medicinal& Aromatic crops (40 marks)

Plantation crops (coconut, arecanut, oil palm, rubber, cashew, tea, coffee and cocoa), Spices (Pepper, cardamom, ginger, turmeric, cinnamon, nutmeg, clove, vanilla and allspice)- Introduction, importance, area, origin and distribution, botany, varieties, climate, soil, site selection, propagation, cultivation practices and harvesting. Seed and herbal spices and minor essential oil yielding plants. Medicinal (*Rauvolfia, Catharanthus,* Opium, *Digitalis, Dioscorea*, solanum, acorus, senna, neem, cinchona, *Kaempferia*, long pepper, Plumbago, *Indigofera* and Ocimum) and aromatic plants (lemon grass, palmarosa, citronella, vetiver), jasmine, tuberose, rose, geranium, patchouli, eucalyptus, sandal wood and other minor essential oil yielding crops- History, importance, problems and scope, cultivation practices, active principles and uses

Module 6: Post Harvest Management (20 marks)

Importance of post harvest management of fruits, vegetables and other horticultural produce, present status and future scope, Post harvest losses, physiology of maturity, ripening and senescence. Harvesting, handling, curing, grading and pre-cooling of horticultural produce, pre and post harvest treatment for extending storage life, Principles and methods of storage for fruits and vegetables- storage at ambient, low temperature and controlled atmosphere. Packing of fresh and processed products. Principles and methods of preservation-dehydration, thermal processing, chemical preservatives, fermentation, ionizing radiation. Govt. policies, regulations and specifications for fresh and processed products. Export promotion agencies and their role in export of fresh and processed products. Post harvest technology of plantation crops, spices and cut flowers.

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Optional subject- Botany

Module	Topic	Marks
I	**Angiosperm anatomy and Embryology**	20
II	**Phycology and Mycology**	12
III	**Microbiology and Plant Pathology**	12
IV	**Bryology, Pteridology, Gymnosperms and Paleobotany**	20
V	**Taxonomy and Economic Botany**	20
VI	**Environmental Studies**	16
VII	**Cell biology and Genetics**	12
VIII	**Molecular Biology**	12
IX	**Plant Physiology and Biochemistry**	20
X	**Biotechnology**	20
XI	**Horticulture and Plant breeding**	16
XII	**Forestry**	20
	TOTAL	200

Module I. Angiosperm anatomy and Embryology

Angiosperm Anatomy: Tissues-Meristems - Classification based on origin, position, growth patterns/. Apical organization of shoot apex, Permanent tissues – Definition, classification – simple, complex and secretory tissues. Tissue systems. Primary structure – Root, stem and leaf (Dicot & Monocot). Secondary growth- Root and stem, annual rings, heart wood and sap wood, periderm formation – phellum, phellogen and phelloderm; lenticels, Bark.

Angiosperm embryology: Microsporogenesis- Structure and functions of wall layers. Male gametophyte- Dehiscence of anther. Megasporogenenesis –Female gametophyte – Embryo sac-development and types. Pollination- Germination of pollen grains, Fertilization, double fertilization, Barriers of fertilization. Structure of embryo – Dicot and Monocot. Endosperm. Pollen structure, aperture morphology, pollen allergy. Economic importance of pollen.

Module II Phycology and Mycology

Algae : Structure, reproduction and life cycle of Nostoc, Chlorella, Volvox, Oedogonium, Chara, Vaucheria, Pinnularia, Sargassum and Polysiphonia

Commercial products of algae – Agar, Alginates, Carrageenin, Diatomaceous earth, biofuels. Medicinal aspects, algal blooms and red tide.

Fungi: Structure, reproduction, life cycle, of Rhizopus, Penicillium, Saccharomyces, Agaricus, Puccinia, Xylaria and Cercospora. Economic importance of Fungi.

Module III : Microbiology and Plant Pathology

Microbiology –Ultra structure of bacteria, Reproduction, Economic importance.

Mycoplasma and Actinomycetes. Virus- Structure, Chemical composition, reproduction of bacteriophages. Soil microorganisms, the rhizosphere. Microbiology of sewage. Food spoilage and preservation methods. Role of microbes in soil fertility, Nitrogen fixation, Biofertilizers.

Plant Pathology: Classification of plant diseases on the basis of causative organisms and symptoms. Hostparasite interaction. phytoalexins. Symptoms, disease cycle and
control measures. Brief account of the following fungicides- Bordeaux mixture, Lime
sulphur, Tobacco decoction, Neem cake and oil.

Module IV: Bryology, Pteridology, Gymnosperms and Paleobotany

Bryophytes: Habit, thallus organization, vegetative and sexual reproduction and alternation of generation of the following types - *Riccia, Marchantia, Anthoceros, Funaria.* Economic importance of Bryophytes.

Pteridophytes: General characters. Study of the habitat habit, internal structure, reproduction and life cycle of the following types Psilotum, Selaginella, Equisetum and Pteris. Stelar evolution in Pteridophytes - Economic importance of Pteridophytes.

Gymnosperms : General characters and classification of Gymnosperms. Study of the habit, anatomy, reproduction and life cycle of Cycas, Pinus and Gnetum. Evolutionary trends in gymnosperms, Economic importance of Gymnosperms.

Palaeobotany: Geological time scale, Fossil formation, types of fossils. Fossil Pteridophytes- *Rhynia, Lepidodendron, Lepidocarpon*. Fossil gymnosperms- *Lyginopteris.*

Module V: Taxonomy and Economic Botany

Taxonomy: Types of inflorescence. Flower -symmetry of flower, aestivation types, placentation types. Fruit types: simple, aggregate and multiple. Seeds: albuminous and exalbuminous

Systems of classification - Artificial- Linnaeus, Natural - Bentham and Hooker, Phylogenetic- Engler and Prantl. Basic rules of Binomial Nomenclature and International Code of Nomenclature for algae, fungi, and plants (**ICN**); Importance of herbarium, Herbarium techniques and Botanical gardens.

Morphological peculiarities and economic importance of the members of the families Annonaceae, Nymphaeaceae, Malvaceae, Rutaceae, Myrtaceae, Cucurbitaceae, Rubiaceae, Asteraceae, Sapotaceae Solanaceae , Acanthaceae, Euphorbiaceae , Orchidaceae ,Poaceae
Economic Botany: Cereals–Millets, Pulses, Spices, Beverages, Fibre yielding plants, Dye Yielding plants; Resins, Oil yielding plants; Latex yielding plants; Medicinal plants.

Module VI: Environmental Studies

Natural resources - Renewable and Non-renewable. Degradation of natural resources - Causes. Conservation of Natural resources - Renewable resources. Reforestation. Ecosystems - components- biotic andabiotic; Energyflow. Food chains -Food web and ecological Pyramids, biogeochemical cycles - Carbon and Phosphorous cycle. Ecological succession. Adaptations of – Hydrophytes, Xerophytes, Halophytes, Epiphytes, Parasites. Characteristic features of different ecosystems. Biodiversity and its conservation - Genetic, species and ecosystem diversity; Hot-spots of biodiversity; Threats to biodiversity: Red data Book; Extinct and Threatened species-endangered & Rare; Endemic species of Western Ghats. Conservation of biodiversity: In-situ and Ex-situ conservation. Global initiatives in biodiversity conservation.
Environmental pollution - Air pollution, Water pollution, Soil pollution, Noise pollution, Thermal pollution. Solid Waste Management. Environmental Organisations –UNEP, IPCC, WWF, Central Pollution Control Board. Global warming and sea level rise, Acid rain, Ozone layer depletion.
Disaster management - Natural and Environmental disasters- Earth quake, flood, coastal disasters, landslides, tsunami, cyclone, dam collapse, nuclear disaster, chemical disaster, biological disaster. Disaster management –mitigation, preparedness, responses, recovery. Emergency procedures and warning systems, application of GIS.

Module VII. Cell biology and Genetics

Cell biology: Ultra structure and functions of the cell components and organelles. The chromosomes- Chromatin -Nucleosome model of DNA organization. Special types of chromosomes- Salivary gland, Lamp brush and B chromosomes. Variation in Chromosome number (Numerical aberrations). Variation in Chromosome structure (Structural aberrations) - Mitosis and Meiosis. cell cycle : Significance of mitosis and meiosis

Genetics: Mendelian principles, monohybrid and dihybrid crosses, back cross and testcross. Incomplete dominance; Interaction of genes- Comb pattern in poultry. Recessive and Dominant epistasis. Complementary genes. Duplicate gene with cumulative effect. Duplicate dominant genes; Inhibitory factor. Multiple alleles- ABO blood group in man. Rh factor. Quantitative characters- polygenic inheritance. Linkage and crossing over.

Module VIII Molecular Biology:
DNA as genetic material- experimental evidence. DNA- Chemical Composition. Watson & Crick's Double Helical Model of DNA. A, B and Z forms. Satellite and repetitive DNA. Replication of DNA in prokaryotes. Semiconservative model- Meselson and Stahl experiment;. DNA repairing mechanism. Replication of DNA in eukaryotes. RNA structure and types. Genetic code. Synthesis of protein. Transcription and Post transcriptional modification of mRNA. Translation in Eukaryotes; Modern concept of gene. Regulation of gene expression in prokaryotes and eukaryotes- lac operon; transcriptional gene regulation in eukaryotes-promoters, enhancers, transcription factors; RNA interference. Transposable genetic elements.

Module IX: Plant Physiology and Biochemistry

Physiology
Water relations: Absorption and translocation of water. Loss of water from plants. Significance of transpiration - guttation, anti-transpirants. Mineral nutrition: Macro and micro elements, role of essential elements and their deficiency symptoms. Culture methods - hydroponics and aeroponics. Mechanism of mineral absorption. Photosynthesis: Photosynthetic apparatus, structure and function of chloroplast, Fluorescence and phosphorescence; Red drop, Emerson effect; Light reaction - cyclic and non cyclic photophosphorylation; Hill reaction - Calvin cycle; C4 and CAM plants; Photorespiration. Respiration: Respiratory substrate, types of respiration-aerobic and anaerobic. Glycolysis, Krebs's cycle, terminal oxidation. Anaerobic respiration – fermentation. Translocation of solutes: Path way of movement, phloem transport, mechanism of stransport - Munch hypothesis. Nitrogen metabolism: Biological nitrogen fixation – symbiotic and asymbiotic. Nif genes -Leghaemoglobin. Growth: Plant growth regulators. Senescence and abscission, Photoperiodism, Photoreceptors – Phytochrome and Cryptochrome. Vernalization - Physiology of bud and seed dormancy, germination. Plant movements: Tropic and nastic movements. Circadian rhythm and biological clock. Stress physiology: water stress, salt stress.

Biochemistry
Carbohydrates, Amino acids, Proteins – Structure, classification, properties and function. Lipids-fats & oils, waxes; phospholipids, sphingolipids and glycolipids; Cholesterol and terpenes; Fatty acids –Alpha- oxidation and Beta-oxidation; Enzymes - structure, classification and nomenclature; Mechanism of enzyme action - coenzymes and cofactors.
Secondary Plant Products -- Alkaloids, terpenoids, phenolics, flavonoids

Module X: Biotechnology

Plant Tissue culture – Totipotency- dedifferentiation, redifferentiation and Cytodifferentiation. Culture media. Micropropagation, Callus and suspension culture, Somaclonal variation- Somatic embryogenesis and organogenesis. Production of haploids, Protoplast culture – somatic hybrids – cybrids - Synthetic seeds
Recombinant DNA technology: Cloning vectors, Restriction endonucleases, ligases – Gene library. Gene transfer methods - *Agrobacterium* mediated, electroporation- Biolistics.

Isolation of DNA. Agarose gel electrophoresis. PCR, DNA sequencing-Sanger's method, Southern blotting, ELISA. Molecular markers – RAPD, RFLP. Genetically modified crops .
Microbial and Industrial Biotechnology - Microbes in Biotechnology. Bioreactor – Chemostat and Turbidostat. Industrial microbiology: Production of alcohol, vinegar, bread, dairy products & single cell protein.

Module XI: Horticulture and Plant breeding

Principles of garden making. Potting media, Soil types, Soil preparation. Irrigation methods. Vegetative propagation methods. Manures and fertilizers- Foliar sprays. Irrigation Methods– Components of Garden- Landscaping principles; Bonsai. Flower Arrangement- Free style, Shallow and Mass arrangement- Japanese- Ikebana. Dry flower arrangement.
Objectives in plant breeding- - Important national and international plant breeding Institutes. Plant introduction. Selection - Genetic basis of selection and methods. Hybridization. Composite and synthetic varieties. Heterosis and inbreeding depression. Male sterility. Mutation breeding. Polyploidy breeding.

Module XII: Forestry

Silviculture- concept and scope of study of natural and artificial regeneration of forests. Clear felling, uniform shelter, wood selection, coppice and conservation systems. Silviculture of some of the economically important species in India such as *Azadirachta indica, Tectona grandis, Eucalyptus indica, Swietenia mahagoni, Dalbergia sisso and Santalum album, Artocarpus heterophyllus, Hevea brasiliensis.*
Social and agro forestry. Selection of species and role of multipurpose trees. Food, fodder and energy. Social forest- Avenue plantation. Sacred plants- definition, importance of sacred trees like *Ficus religiosa, Emblica officinalis, Aegle marmelos.* Principles of forest management. Sustained yield principle and its limitations. Rotation - factors influencing length of rotations. Normal forest, regular and irregular forests. Working plans. Joint forest management. Forest policies in India, Forest Laws and Acts, The Wildlife (Protection) Act 1972, Forest (Conservation) Act 1980, Environment (Protection) Act 1986. International Treaties like CITES, CBD, RAMSAR. The Biological Diversity Act, 2002. Forest resources and utilization. Plantation forestry in India. Choice of species. Fertilization in plantations. Clonal plantations. Forest products- timber, pulp wood, secondary timbers, non timber forest products (NTFPs). Definition and scope (brief outline) - Gums, resins, fibers, oil seeds, nuts, rubber, canes and bamboos, medicinal plants, charcoal. Lac collection and marketing.

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Optional subject- Agriculture

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MODULE 1- Fundamentals of Agronomy and agriculture heritage   (20 marks)

Crops – classification- agronomic, botanical, ontogenic, growth habit – growth – definition and factors affecting growth – methods of sowing/planting- vegetative propagation of crops – setts, slips, tubers, rhizomes, etc. – Tillage and tillage implements-modern concepts of tillage-soil fertility and productivity -Crop nutrition- Mineral nutrition of plants- functions and deficiency symptoms of nutrients– methods of fertilizer application- methods for improving nutrient use efficiency, biological nitrogen fixation and biofertilizers -seed testing- - foliar nutrition and hydroponics-crop rotation-Plant ideotypes- yield contributing characters – harvest index

Agriculture scope- Importance of agriculture and agricultural resources available in India; Origin of agriculture- branches of agriculture- agricultural systems in the world- Green revolution and its impact- National agriculture setup in India; ICAR and SAUsCurrent scenario of Indian agriculture; Indian agricultural concerns and future prospects-CGAIR and international institutions-Introduction of Indian agricultural heritage- Ancient agricultural practices- Relevance of heritage to present day agriculture-Journey of Indian agriculture and its development from past to modern era; Natural calamities and famines- Plant production and protection through indigenous traditional knowledge; Crop voyage in India and world; Introduction to gender perspectives in agriculture-gender concepts- multiples roles of women Women in agriculture- multifaceted roles and tasks of farm women- gender, poverty and livelihoods -Gender equity and strategies for rural women's empowerment- self- help groups. Farm mechanization and women- Occupational health hazards-Women friendly agricultural technology-Ergonomical approaches- Technological options

MODULE 2 Fundamentals of Plant breeding and genetics-plant physiology-Seed Technology-Intellectual property rights   (15 marks)

Breeding methods in asexually propagated crops, clonal selection and hybridization; Participatory plant breeding; Plant Breeders and & Farmer's Rights. Major breeding objectives and procedures including conventional and modern innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional); Ideotype concept and climate resilient crop varieties for future.
Crop physiology and its importance in agriculture; Crop water relations, water potential and its components, diffusion and osmosis, absorption of water; Transpiration and stomatal physiology,

water use efficiency. Mineral nutrition of plants- functions and deficiency symptoms of nutrients–nutrient uptake mechanisms- foliar nutrition and hydroponics. Photosynthesis - Light and dark reactions C3, C4 and CAM plants, photorespiration: Plant respiration- glycolysis, TCA cycle and Electron transport chain, Alternate respiration in plants; Plant growth regulators – physiological roles and agricultural uses; Physiological aspects of growth and development of major crops; Photoperiodism and vernalisation; Growth analysis, role of physiological growth parameters in crop productivity.

.Procedure for seed certification, field inspection. Foundation and certified seed production of important cereals, pulses, oilseeds, fodder and vegetables. Seed Act and Seed Act enforcement. Central Seed Committee, Central Seed Certification Board, State Seed Certification Agency, Central and State Seed Testing Laboratories. Synthetic seeds and terminator gene technology. Detection of genetically modified crops. Transgene contamination in non-GM crops, GM crops and organic seed production. Seed dormancy, internal and external factors affecting dormancy in seeds. Seed drying-seed processing -Seed treatment, Seed storage and seed marketing.

Introduction to GATT, WTO, TRIPs and WIPO, Treaties for IPR protection: Madrid protocol, Berne onvention, Budapest treaty, etc. Types of Intellectual Property and legislations covering IPR in India:-Patents, Copyrights, Trademark, Industrial design, Geographical indications, Integrated circuits, Trade secrets. Patents Act 1970 and Patent system in India, patentability, process and product patent, filing of patent, patent specification, patent claims, Patent opposition and revocation, infringement, Traditional knowledge-meaning and rights of TK holders. Indian Biological Diversity Act, 2002 and its salient features, access and benefit sharing.

MODULE 3-Fundamentals of soil science- soil fertility and problem soil management
(15 marks)

Weathering - soil formation - factors and processes - soil profile. Soil physical properties - soil texture - textural classes - particle size analysis.- Soil structure Classification - soil aggregates – significance. Soil consistency - soil crusting. Bulk density and particle density of soils and porosity - their significance and manipulation. Soil compaction - soil Colour- soil classification (elementary). Soils of India - geological formations – characterization of soils of Kerala. Soil water - retention and potentials - soil moisture constants - movement of soil water – infiltration – percolation – permeability – drainage - methods of determination of soil moisture. Thermal properties of soils - soil temperature - soil air - gaseous exchange - influence of soil temperature and air on plant growth. Soil colloids – properties – nature - types and significance. Layer silicate clays - their genesis and sources of charges. Adsorption of ions - ion exchange - CEC and AEC - factors influencing ion exchange and its significance. Concept of pH - soil acidity - overview of saline, sodic and calcareous soils- Soil organic matter – composition – decomposability – humus - fractionation of organic matter- Carbon cycle - C: N ratio. Soil biology – biomass - soil organisms and their beneficial and harmful roles.

Importance of organic manures, properties and methods of preparation of bulky and concentrated manures. Green/leaf manuring. Fertilizer recommendation approaches. Integrated nutrient management. Chemical fertilizers: classification, composition and properties of major nitrogenous, phosphatic, potassic fertilizers, secondary & micronutrient fertilizers, Complex fertilizers, nano fertilizers Soil amendments, specialty fertilizers –cutomised fertilizers and 100 per cent water soluble fertilizers; Fertilizer Storage, Fertilizer Control Order.History of soil fertility and plant nutrition. criteria of essentiality. role, deficiency and toxicity symptoms of essential plant nutrients, Mechanisms of nutrient transport to plants, factors affecting nutrient availability to plants. Chemistry of soil nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and

micronutrients. Soil fertility evaluation, Soil testing. Critical levels of different nutrients in soil. Forms of nutrients in soil, plant analysis, rapid plant tissue tests. Indicator plants. Methods of fertilizer recommendations to crops. Factor influencing nutrient use efficiency (NUE), methods of application under rainfed and irrigated conditions.

MODULE 4-Environment studies and disaster management   (30 marks)

Environmental studies- nature, definition, scope and importance-type and segments of environment. - Natural Resources: Renewable and non-renewable resources- Forest, water, food, mineral, energy and land resources. Forest resources: Use and over-exploitation, deforestation-Water resources: Use and over-utilization of surface and ground water, - Mineral resources: Use and exploitation. Food resources: World food problems- Energy resources: renewable and non-renewable energy sources, use of alternate energy sources. - Land resources: land degradation, soil erosion and desertification. Ecosystems: Definition, concept, structure and functions, types, energy flow -producers, consumers and decomposers, - Ecological succession, food chains, food webs and ecological pyramids. Characteristic features, structure and functions of forest ,grassland ,desert and aquatic ecosystems (ponds, streams, lakes, rivers, oceans, estuaries). -Biodiversity – definition and classification-Biogeographical classification of India -Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values - Biodiversity at global, national and local levels, hot spots of biodiversity-Threats to biodiversity: habital loss, poaching of wildlife, man -wildlife conflicts - Endangered and endemic species of India . Conservation of biodiversity: In-situ and Ex-situ conservation.

Environmental Pollution- Air pollution -. Water pollution - Soil pollution - Marine pollution - Noise pollution - Thermal pollution - Nuclear hazards. Solid Waste Management-Environmental ethics: Issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. dies.- Environment Protection Act. Air (Prevention and Control of Pollution) Act. Water (Prevention and control of Pollution) Act. Wildlife Protection Act. Forest Conservation Act. Issues involved in enforcement of environmental legislation. -Human Population and the Environment: population growth, variation among nations, population explosion, -Environment and human health- Human Rights, Role of Information Technology in Environment and human health.
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Disasters -Natural Disasters- nature, types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents.- Disaster Management- Effect to mitigate natural disaster at national and global levels. International strategy for disaster reduction. -Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community –based organizations and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response; Police and other organizations.

MODULE 5- Agrometeorology and Climate change, rainfed agriculture and watershed management   (20 marks)

Atmospheric weather variables-atmospheric pressure, wind, types of wind, daily and seasonal variation of wind speed, cyclone, anticyclone, land breeze and sea breeze, solar radiation, solar constant, short wave, longwave and thermal radiation, net radiation, albedo; Atmospheric temperature, temperature inversion,

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lapse rate, daily and seasonal variations of temperature, vertical profile of temperature, formation of dew, fog, mist, frost, cloud; Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet, and hail, cloud formation and classification. Agriculture and weather relations - climatic variability, global warming-causes of climate change and its impact on regional and national Agriculture-Climatic change and global warming, Sea level rise, ozone depletion. Weather modifications-Weather forecasting--Climate change-Climate change adaptation-Climate change mitigation

Rainfed agriculture-history of rainfed agriculture and watershed in India; Problems and prospects of rainfed agriculture in India ; Soil and climatic conditions prevalent in rainfed areas; Soil and water conservation techniques, Drought: types, effect of water deficit on physio- morphological characteristics of the plants, Crop adaptation and mitigation to drought; Water harvesting: importance, its techniques, Efficient utilization of water through soil and crop management practices, Management of crops in rainfed areas, Contingent crop planning for aberrant weather conditions, Concept, objective, principles and components of watershed management, factors affecting watershed management

MODULE 6- Agro-forestry -Cropping systems- Farming Systems and sustainable agriculture- organic farming and Field Crop Production (30 marks)

Silviculture-importance and objectives, types of forests-salient features of Indian Forest Policies. Forest regeneration, Natural regeneration - natural regeneration from seed and vegetative parts, coppicing, pollarding, root suckers; Artificial regeneration – objectives, choice between natural and artificial regeneration, essential preliminary considerations- tree stand management. Agroforestry – definition and concepts-Agroforestry systems and practices- different agroforestry systems prevalent in the country and Kerala, shifting cultivation, taungya, alley cropping, wind breaks and shelter belts, plantation crop combinations, home gardens. Multi purpose trees in agroforestry, characterstics- Understorey components and diversification potentials- Component interactions- above ground and below ground interactions. Productive and protective functions-Nitrogen fixation- Soil conservation- Litter dynamics and nutrient cycling – Carbon sequestration and climate change mitigation -carbon neutral farming- Social forestry- concept and importance, practices in Kerala

Farming System- importance, and concept, Types and systems and factors affecting types of farming-Farming system components - Cropping system and pattern, multiple cropping system, Plant Interactions- Efficient cropping systems and their evaluation, allied enterprises and their importance-Cropping systems of Kerala -Rice based, Coconut based systems- - Tools for determining production and efficiencies of cropping systems-; Sustainable agriculture-problems and its impact on agriculture, indicators of sustainability, adaptation and mitigation, conservation agriculture strategies, HEIA, LEIA and LEISA, ecological principles of LEISA and promising techniques for sustainability, Integrated farming system-historical background, objectives and characteristics, components of IFS and its advantages, , Homestead farming systems- Good Agricultural Practices, ITKs and farmer centered techniques and practices

Organic agriculture- - Current status of organic farming in India and Kerala; Tools and practices of organic farming- planned crop rotation, green manures, manuring and composting, multiple cropping, intercropping in relation to maintenance of soil productivity, Biological pest control, biological agents and pheromones, Control of weeds, diseases and insect pests- sanitation, tillage and cultivation, cover cropping, mulching, fire, biorational pesticides, foliar fertilization, buffers and barriers- shelter zones; Impact of organic farming on soil and crop quality- Organic farming

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initiatives in India and Kerala- National Programme for Organic Production (NPOP) – Operational structure of NPOP-Accreditation agencies- Certification Agencies – National Standards for Organic Product (NSOP)-inspection and certification procedures- Marketing and export potential.

Rice (including speciality rice) , wheat, maize, millets, tapioca, potato, yams and aroids, sugarcane, groundnut, sesamum, sunflower, safflower, linseed, important pulses, banana, mango, coconut, cashew, spices and condiments – origin, geographic distribution, economic importance, botany and growth phases, varieties, harvesting, processing, conversion ratios (ratio between harvested and economic produce)-Agroclimatic and agroecological classification of India and Kerala-Production technology of cereals, millets, tuber crops, pulses, oil seeds, fodder crops

MODULE 7- Irrigation and Weed management -Precision farming and nano technology
(20 marks)

Water requirement and irrigation requirement- Soil moisture constants – Evapotranspiration and consumptive use – potential evapotranspiration and reference crop evapotranspiration – crop coefficient – irrigation water quality criteria and its management-Water management of principal crops, critical stages of crops, depth and schedule of irrigation – rice, wheat, banana, coconut, cowpea, sugarcane and vegetables- Methods of irrigation-Agronomic techniques improve water productivity-
Crop water relations, water potential and its components, diffusion and osmosis, absorption of water; Transpiration and stomatal physiology, water use efficiency.

Weeds – harmful effects, classification of weeds, crop weed association – crop associated weeds, crop bound weeds and season bound weeds – critical period of crop weed competition – aquatic weeds and parasitic weeds-Weed control methods-Herbicide formulations- Methods of application-Selectivity of herbicides-Concept of Integrated Weed Management

Precision agriculture: concepts and techniques and issues and concerns for Indian agriculture; Geoinformatics- definition, concepts, tool and techniques; their use in Precision Agriculture. Crop discrimination and Yield monitoring, soil mapping; fertilizer recommendation using geospatial technologies; Spatial data and their management in GIS; Remote sensing concepts and application in agriculture; Image processing and interpretation; Global positioning system (GPS), components and its functions; Introduction to crop Simulation Models and their uses for optimization of Agricultural Inputs; STCR approach for precision agriculture; Nanotechnology, definition, concepts and techniques, brief introduction about nanoscale effects, nano-particles, nano-pesticides, nanofertilizers, nano-sensors, Use of nanotechnology in seed, water, fertilizer, plant protection for scalingup farm productivity.

MODULE 8-Soil and water conservation engineering-farm machinery-protected cultivation-secondary agriculture-Renewable energy resources-green technology
(20 marks)

Causes of soil erosion. Definition and agents of soil erosion, water erosion. Forms of water erosion. Gully classification and control measures. Soil loss estimation by Universal Soil Loss Equation. Soil loss measurement techniques. Principles of erosion control. Engineering measures of soil and water conservation - contouring, contour bund , graded bund and bench terracing Water harvesting and its techniques-Irrigation pumps and their selection.

Tractor types, cost analysis of tractor power and attached implements. Primary and secondary

tillage implements, implements for hill agriculture, implements of intercultural operations, sowing and planting equipments, plant protection equipments and threshing equipments.

Green house technology- Introduction, types of Green Houses; Design criteria of greenhouse for cooling and heating purposes. Green house equipment, materials of construction for traditional and low cost green houses. Irrigation systems used in green houses.

Classification of energy sources, biomass utilization for biofuel production and their application, Familiarization with types of biogas plants and gasifiers, biogas, bio-alcohol, bio-diesel and bio-oil production and their utilization as bio-energy resource, introduction of solar energy, collection and their application, solar energy gadgets: introduction of wind energy and their application.

MODULE 9-Fundamentals of horticulture and production technology of horticultural crops- Post harvest management and value addition of horticulture crops- land scaping and ornamental horticulture   **(15 marks)**

Horticulture - definition, importance, division and classification of horticultural crops- Importance of horticulture in India and Kerala.- Commercial orchards, garden and plantations - selection of site for perennial horticultural crops - climate, soil, socio economic factors-Orchard planting-training and pruning in horticultural crops-fruit set and development- Seedlessness in horticultural crops; significance and induction-Bioregulators- Natural and synthetic regulators - Role of bioregulators in horticultural crops - preparation and methods of application.-Nursery management-layout, planting, aftercare-irrigation, manuring -stage of harvest, harvesting, yield, on farm processing and uses of coconut, arecanut, oil palm, rubber, cashew, tea, coffee and cocoa.

Indian fruit and vegetable processing industry- Importance, problems & prospects- Physiology of maturity, ripening and senescence in fruits and vegetables and their chemical composition, - Post harvest losses - Pre and postharvest factors causing loss and spoilage- Post harvest management techniques - Packaging technology-Government policies, regulations and specifications- Principles and methods of preservation- drying and dehydration - Thermal processing- Preservation by ionizing radiations, chemical methods and fermentation- Recent advances in food preservation techniques- Post harvest technology of coconut, Arecanut, Oil palm, Rubber, Tea, Coffee, Cocoa & cashew, pepper, cardamom, ginger, turmeric, chilies, Tree spices, essential oil yielding crops and cut flowers- Industrial waste utilization.

Landscaping, gardening and commercial Floriculture.–Principles of landscaping. - Lawn making-Annuals and herbaceous perennials - Specialized gardening techniques Roof garden, terrace garden, sunken garden, water garden, rock garden etc. Indoor gardening of plants Bonsai, vertical garden, tray garden, terrarium etc. Introduction to commercial Horticulture -Present status of the cut flower industry in India and abroad – Problems and prospects of commercial floriculture in India and Kerala- classification, varieties grown, identification, environmental requirements, propagation, media and containers, planting, care and management, nutrition, plant protection, harvesting and marketing of flower crops

MODULE 10- Agricultural Marketing, Entrepreneurship Development and Agricultural Extension Management   (15 marks)

Agricultural Marketing – concepts and definitions – scope – Market and Marketing-meaning-definition-elements of a market-Classification of market-Agricultural Marketing-approaches-functional (Exchange function, physical marketing function, facilitating functions)-institutional (agencies, channels)-commodity- Producer's surplus-meaning-types-marketable and marketed surplus importance- factors affecting-Marketing efficiency-meaning-definition-estimation of marketing costs/margins for farm commodities-measures to improve marketing efficiency and tools for risk management-co-operative marketing futures trading-contract farming-International trade-Domestic Vs International trade-theories of international trade-theory of absolute advantage-Globalization and Liberalization-WTO-AOA (market access, domestic support, export subsidies)-Agricultural price policy in India-objectives-role of CACP in agricultural price policy-Administered prices (support price, procurement price, levy price, statutory minimum price, issue price)

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Optional subject- Mathematics

Module 1 Sets, Relations, Functions and Number Theory :- Basic relations between sets, Boolean Operations on sets, Relations, Operations on relations, Equivalence relations and partitions, Functions, Operations on functions, Types of functions, Use of functions to compare size.
The division algorithm, The Euclidean algorithm, Linear Diophantine equations, The Fundamental Theorem of Arithmetic, Linear congruences, Residue classes, Fermat's theorem, Euler's theorem, Wilson's theorem, Euler's phi-function, Mobius function.

(20 Marks)

Module 2 Algebra :- Polynomials, Equality of two polynomials, Roots of an equation, Fundamental Theorem of Algebra, Multiplication of roots, Diminishing and increasing the roots of an equation, Removal of terms of an equation, Reciprocal equations, sum of the integral powers of the roots and symmetric functions of the roots, Descarte's rule of signs.
Groups, subgroups, Cyclic groups, Permutations, Groups of cosets, Normal subgroups and Factor groups, Homomorphism and isomorphism in groups, Rings, Fields and Integral domains, Quotient rings and ideals, Homomorphism of rings.

(20 Marks)

Module 3 Linear Algebra :- Matrices, Types of matrices, Matrix addition, matrix multiplication and their properties, Transpose of a matrix, Determinants and its properties, Inverse of a matrix, Cramer's rule, Rank of a matrix, Elementary transformations, Solution of a system of linear transformations, Characteristic equation, Eigen values and eigen vectors of a matrix, Cayley Hamilton Theorem.
Vector Spaces, Subspaces, Linearly independent and linearly dependent vectors, Basis and dimension of a vector Space, Linear transformations, Representation of linear transformation by matrix, Kernel and image of a linear transformation.

(20 Marks)

Module 4 The real number system, Sequences and Series of Real Numbers:- Countable sets, Uncountable sets and bounded subsets of the set of all real numbers, sequences of real numbers, limit of a sequence, convergent sequences and divergent sequences, Bounded sequences, monotonic sequences, Opertations on convergent sequences, Cauchy sequences.

Convergence and divergence of an infinite series, Series with non-negative terms, Alternating series, Absolute convergence and conditional convergence, Rearrangement of series, Tests for convergence – Comparison test, Cauchy's root test, D'Alembert's Ratio Test, Raabe's Test, Logarithmic Test. **(20 Marks)**

Module 5 Real Valued Functions, Differentiable Functions and Applications of the Derivative :- Bounded functions, Limits of functions, Monotonic functions, Continuous functions, Uniformly Continuous functions, Sequences of functions, Differentiable functions, Rolle's theorem and Mean-value theorem for derivatives.

Increasing and Decreasing functions, Relative maxima and minima, First derivative test, Second derivative test, Absolute maxima and minima, Rectilinear motion - velocity and acceleration. **(20 Marks)**

Module 6 The Riemann Integral and Application of the Definite integral in geometry : - Definition of the Riemann Integral, Existence of Riemann integral, Properties of the Riemann integral, Fundamental theorem of Calculus, Improper Integrals

Area between two curves, Volumes by slicing, Volumes by cylindrical shells, Length of a plane curve, Area of a surface of Revolution, Work and Moments. **(20 Marks)**

Module 7 Analytical Solid Geometry and Vector Algebra :- Direction cosines and Direction ratios of a line, Angle between two lines, The Plane, Angle between two planes, Plane through the intersection of two given planes, Planes bisecting the angle between two planes, projection on a plane, The Straight line- General form and symmetrical form -, Point of intersection of a line and a plane, Angle between a line and a plane, Shortest distance between two lines, Intersection of three planes, The sphere, Equation of a sphere in different forms, Tangent planes, Angle of intersection of two shperes.

Scalar product of two vectors and properties of scalar product of two vectors, Vector product of two vectors and properties of vector product of two vectors, Scalar triple product and properties of scalar triple product, Vector triple product. **(20 Marks)**

Module 8 Multiple Integrals and Vector Calculus: :- Double Integrals, Double Integrals over nonrectangular regions, Double Integrals in Polar Coordinates, Surface Area- Parametric Surfaces, Triple Integrals, Triple Integrals in Cylindrical and Spherical Coordinates, Change of variable in Multiple Integrals

Vector Fields, Line Integrals, Independence of Path, Conservative Vector Fields, Green's Theorem, Surface Integrals, Applications of Surface Integrals, Flux, The Divergence Theorem, Stokes' Theorem. **(20 Marks)**

Module 9 Differential Equations and Linear Programming:: - Differential Equations of first order and first degree- Variable Separable, Homogeneous Differential Equations, Linear Differential Equations, Equations reducible to Linear Equations-, Linear Differential Equations of nth Order with constant coefficients, Homogeneous Linear Equations, Exact Differential equations – Conditions of exactness, Integrating factors-, Orthogonal Trajectories

Convex sets and hyperplanes , Slack and surplus variables, Basic feasible soultion of a linear programming problem, The simplex method, Artifical variables, The two phase method for artificial variables, The revised simplex method, Transportation problems.

(20 Marks)

Module 10 Complex Analysis :- Basic properties of Complex numbers, Vectors and Modulii, Complex conjugates, Exponential form, Products and Powers in exponential form, Arguments of Products and Quotients, Roots of Complex Numbers, Functions of a complex variable, Limits and theorems on limits, Continuity, Derivatives, Cauchy-Riemann Equations, Sufficient conditions for Differentiability, Analytic functions and Harmonic functions.

Contour Integrals, Upper Bounds for moduli of Contour Integrals, Simply Connected Domains, Cauchy Integral Formula and its Extensions, Liouville's Theorem and the Fundamental Theorem of Algebra, Maximum Modulus Principle, Taylor Series and Laurent's Series, Isolated Singular Points, Residues, Cauchy's Residue Theorem, The three Types of Isolated Singular points, Residues at Poles. **(20 Marks)**

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Optional subject- Computer Science/Engineering/Applications

Module I   Mathematical Foundations   (15 Marks)

Number systems – Binary, octal, hexadecimal number systems, arithmetic operations, number base conversions, representations of negative numbers.

Counting theory - Permutations and combinations, Binomial theorem, Pigeonhole principle.

Prime numbers – Prime-power factorization, primality testing.

Relations and functions – Binary relation, function – types, equivalence relation and partitions, partial order.

Algebraic structures – Homomorphism, isomorphism, semigroup, monoid, group, cyclic group.

Probability – Discrete and continuous probabilities, Bayes' theorem, Gaussian distribution.

Module II   Computer Hardware & Organization (15 Marks)

Basic concepts – Addressing modes, execution of a complete instruction.

Processor logic design – Design of arithmetic logic unit, design of accumulator. Booth's multiplication algorithm. Instruction and arithmetic pipelines, hazard detection and resolution.

Control unit design – Hardwired control design, microprogrammed control design, horizontal and vertical microinstructions.

I/O devices – Interrupts, direct memory access, standard I/O interfaces, RAID.

Memory - Semiconductor RAMs, semiconductor ROMs, content addressable memory. Cache memory – cache mapping schemes. Flash memory.

Module III   Data Structures & Algorithms   (20 Marks)

Analysis – Asymptotic notation, time complexity, space complexity, methods for analyzing complexity.

Arrays and linked lists – array implementation, sparse matrix, stack, queue, circular queue, priority queue. Dynamic memory allocation, linked lists (single, double, circular).

Trees – Binary trees, tree traversals, binary search tree, basic properties and operations. Self-balancing trees – AVL trees.

Disjoint set operations, union and find algorithm.

Graphs - Representation, bipartite graphs, connected graphs and components, depth first search, breadth first search. Euler graphs, Hamiltonian paths, digraphs, shortest path algorithm (Dijkstra's, Floyd-Warshall), spanning trees, Prim's algorithm, Kruskal's algorithm. Planar graphs, geometric dual. Vertex coloring, chromatic number.

Sorting and searching – Selection sort, insertion sort, quick sort, merge sort, heap sort. Linear search, binary search. Analysis and comparison of various techniques for sorting and searching.

Hashing – Hashing techniques, collision resolution, overflow handling.

Complexity theory – P, NP, NP-complete, NP-hard classes, tractable and intractable problems.

Approximation algorithms, randomized algorithms.

Module IV   Object Oriented Programming   (10 Marks)

Object oriented programming fundamentals – Object modeling using Unified Modeling Language. Classes, objects, methods, constructor/destructor, operator overloading, method overloading, objects as parameters to methods, static members.

Inheritance – Superclass, subclass, protected members, method overriding, abstract class.

Runtime environment – Bytecode, virtual machine like JVM. Dynamic binding, garbage collection, exception handling.

Threads – Multithreading, stopping and resuming threads, thread synchronization.

Module V   Digital Circuits & Microprocessors   (15 Marks)

Boolean algebra – Basic properties and theorems, Simplification of Boolean functions – Karnaugh Map method, logic gates, universal gates.

Combinational logic circuits – Binary adder, subtractor, parallel adder, BCD adder, code convertor, encoder/decoder, multiplexor/demultiplexor, parity generator/checker.

Sequential logic circuits – Flip-flops (SR, JK, T, D, Master-slave), triggering. Asynchronous/synchronous counters, shift registers, ring counter, Johnson counter.

8086 microprocessor – Addressing modes, instruction set, stack structure, interrupt handling, interfacing with memory and peripheral devices.

Module VI   System Software   (10 Marks)

System software – Assembler (one-pass, multi-pass), interpreter, macro preprocessor, linker, loader, text editor, debugger, device driver.

Compiler design – Lexical analysis, tokens, syntax analysis, parse trees. Top-down parsing – recursive descent parser, predictive parser, LL(1) grammar. Bottom-up parsing – shift-reduce parser, operator precedence parser, LR parser.

Syntax-directed translation, intermediate code generation, code optimization, code generation.

Module VII Operating Systems (10 Marks)

Operating systems fundamentals – system calls, microkernel, system boot process.

Process management – process creation and termination, process control block, inter process communication, CPU scheduling criteria and algorithms. Process synchronization – Critical section problem, mutex, semaphore, monitor, producer-consumer problem, readers-writers problem, dining philosophers' problem.

Deadlocks – Necessary conditions, resource allocation graph, deadlock prevention, deadlock avoidance – banker's algorithm, deadlock detection and recovery.

Memory management – address spaces, swapping, paging, segmentation, virtual memory, demand paging, page replacement algorithms, thrashing.

File system – Structure, File-system/directory implementation, allocation methods.

Storage management – magnetic disk structure, disk formatting, disk scheduling.

Module VIII   Database Management Systems   (15 Marks)

Types of data and DBMS, entity-relationship models.

Relational algebra – Select, project operations. Types of join operations. SQL, views, triggers, data definition language, table operations.

Physical organization – Indexing, B-trees, B+ trees, indexing on multiple keys.

Normalization – Functionals dependency, Armstrong's axioms, closures. Normal forms – first, second, third, Boyce-Codd. Lossless join, dependency-preserving decomposition.

Concurrency – Transaction model, concurrent transaction processing and recovery principles, logs, checkpoints, schedules (concurrent, serializable, recoverable, cascade-less), conflict serializability, two-phase locking.

NoSQL databases – Key-value database, document database, graph database.

Module IX   Data Communication   (15 Marks)

Communication model – Simplex, half-duplex, full duplex transmission. Periodic analog signals – time and frequency domain, bandwidth.

Transmission issues – delay distortion, attenuation. Data rate limits – Nyquist bandwidth, Shannon's capacity formula.

Error detection/correction - Parity check, checksum, cyclic redundancy check, forward error correction, Hamming code.

Guided transmission media: twisted pair, Coaxial cable, optical fiber.

Modulation – Pulse Code Modulation, Delta Modulation, Amplitude/Frequency/Phase Shift Keying, Amplitude/Frequency/Phase Modulation.

Wireless transmission, terrestrial microwave, satellite microwave.

Multiplexing – Time division multiplexing, frequency division multiplexing, wavelength division multiplexing, Code division multiple access (CDMA).

Mobile communication - GSM, 4G, 5G.

Module X   Computer Networks   (15 Marks)

Network hardware devices -Hub, switch, router, bridge, repeater.

Data link layer – Design issues, Medium access control, ethernet, wireless LANs - 802.11 standards.

Network layer – IPv4, Ipv6, IP addressing – subnetting, routing – distance vector, link state. Quality of Service. ICMP, ARP, RARP, OSPF, BGP.

Transport layer – Transmission control protocol, user datagram protocol, congestion control.

Application layer – Electronic mail, MIME, SNMP, DNS, streaming protocols.

Internet of Things (IoT), Wide Area Networks, Personal Area Networks – Bluetooth.

Module XI   Theoretical Computer Science   (10 Marks)

Regular languages – Finite state automata, regular expression, closure properties of regular languages, regular grammar.

Context-free grammar – Ambiguity, closure properties, normal forms (Chomsky, Greibach), pushdown automata.

Chomsky classification of grammars, context-sensitive grammar, linear-bounded automaton.

Turing machines – recursive and recursively enumerable languages, universal Turing machine, halting problem.

Module XII Web Technologies   (10 Marks)

HTML - basic text markup, Cascading Style Sheets.

JavaScript, JSON, XML.

World Wide Web - Web browsers, plug-ins, web server, proxy server, Hypertext Transfer Protocol.

Full stack programming – ReactJS, Node.js.

Module XIII   Machine Learning & Artificial Intelligence   (15 Marks)

Supervised leaning – Linear regression, gradient descent algorithm, overfitting, classification, perceptron, naive Bayes, decision tree algorithm.

Neural Network - Multilayer feed forward network, activation functions (Sigmoid, ReLU, Softmax), backpropagation algorithm.

Unsupervised learning – Clustering. Dimensionality reduction – Principal Component Analysis.

Performance measures – Precision, recall, confusion matrix, accuracy, F-measure, receiver operating characteristic curve, area under curve.

Artificial Intelligence – Heuristic functions, minimax algorithm, Alpha-Beta pruning, constraint satisfaction problems. Knowledge representation and inference in first order logic, propositional logic, forward chaining, backward chaining.

Module XIV   Cryptography & CyberSecurity   (15 Marks)

Cipher fundamentals – Substitution ciphers, transposition ciphers, stream cipher, block cipher.

Cryptosystems – Symmetric key cryptography – triple DES, Advanced Encryption Standard. Public key cryptography – RSA, El Gamal, elliptical curve cryptosystems, Diffie-Hellman key exchange.

Key management – Symmetric key distribution, public key distribution, verifying keys, storing keys, updating keys, public key infrastructure, digital certificates.

Authentication – Hash functions, collision resistance, Hash-based Message Authentication Code, Secure Hash Algorithm, Message Digest (MD5).

Network Security fundamentals – IPSec, TLS, HTTPS, S/MIME, Security policy.

Firewalls - Types of firewalls, application layer firewalls, packet filtering firewalls, UTM.

Intrusion detection and prevention. Virtual Private Networks, managing VPNs.

Module XV   Cloud Computing   (10 Marks)

Cloud delivery models - Infrastructure-as-a-Service (IaaS), Platform-as-a-Service(PaaS), Software-as-a-Service (SaaS), XaaS (Anything-as-a-service).

Cloud deployment models- Public cloud, Community cloud, Private cloud, Hybrid cloud.

Virtualization – hardware / OS level virtualization, Hypervisors. Storage/Desktop Virtualization.

Internet Service Providers (ISP), Data center technology.

Amazon Web Services, Google Cloud, Microsoft Azure.

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KERALA FOREST & WILDLIFE DEPARTMENT

Optional subject- Zoology

Module I: Diversity of Animals (Weightage: 10 marks)

Lower Metazoans: Porifera, Cnidaria-Polymorphism, Ctenophora, Platyhelminthes, Nemathelminthes, Annelida, Arthropoda, Mollusca and Echinoderms: Classification with examples. Hemichordates: Position in the animal kingdom, Chordates: Cephalochordates and Urochordates. Vertebrate Phylogeny-Agnatha, Ostracoderms and Gnathostomes Placoderms, Acanthodians, Chondrichthyes and Osteichthyes. Structural and Functional adaptations of fishes. Terrestrial Vertebrates: Tetrapod phylogeny - modern Amphibians, diversity, distribution, status and threats. Reptiles- diversity, Birds and Mammals: diversity. Class Mammalia: Prototheria, Metatheria and Eutheria. Phylogeny of Mammalian orders. Scientific names and common names of organisms under all phylums.

Module II: Wildlife Biology and Conservation (Weightage: 25 marks)

Definition of Wildlife, Values of Wildlife. Need of Wildlife Conservation. Wildlife habitats - Forest Habitat (eg: Shola forest of Western Ghat); Desert Habitat (eg: Thar Desert); Aquatic habitat (eg: Vembanad lake); Wetland habitat (eg: Sunderbans delta); Mangrove habitat (eg: Pichavaram mangrove forest). Mention Biodiversity Hotspots in India. Ecological significance of Keystone species, Edge species and Umbrella species. *In-situ* conservation -National Parks, Biosphere reserves, Wildlife Sanctuaries, Mangrove forests with examples in India and Kerala (Brief description). *Ex-situ* conservation- Zoological Parks with examples in India and Kerala, Captive breeding (Brief description with examples). IUCN Red Data Book Project Tiger, Project Elephant, Project Cheetah, Project Rhino and Project Crocodile. Wildlife conservation organizations, agencies and schemes - WWF, Nagar Van Yojana (NVY), BNHS, Wildlife Conservation Society(WCS), IUCN, ASEAN-WEN. Indian Wildlife (Protection) Act, 1972; Biological Diversity Act of 2002.

Major threats to Wildlife: Habitat loss and fragmentation, Over exploitation, Climate change, Poaching, Pollution. Invasive species. Man-animal conflict and its management. Wildlife monitoring (Brief account) –- Direct count (Block count, Transect methods, Point counts, Visual encounter survey, Waterhole survey), Indirect count (Call count, track and signs, pellet count, pugmark, camera trap, M-stripe). Wildlife Research Institutes- KFRI, KSBB, IIFM, Salim Ali Centre for Ornithology and Natural History (SACON).

Module III: Wildlife Ecology (Weightage: 25 marks)

Definition and scope of wildlife ecology, Different types of forests. Ecological Principles: Population dynamics: growth, regulation, and interactions; Community ecology: species interactions, trophic levels, and biodiversity. Ecological Principles: Population dynamics: growth, regulation, and interactions; Community ecology: species interactions, trophic levels, and biodiversity. Wildlife Adaptations; Behavioural and physiological adaptations of wildlife species; Adaptations to different habitats and environmental conditions. Population Monitoring Techniques: Sampling methods: Direct count, (Block count, Transect methods, Point count, Visual encounter survey, Waterhole survey), Indirect count (Cell count, Track and signs, Pellet count, Pug mark and Camera count) and remote sensing and GIS applications in wildlife research. Migration and Dispersal: Causes and patterns of migration; Ecological significance of dispersal in wildlife populations. Communication and Social Organization: Types of communication in wildlife; Social structure and organization in wildlife populations. Territoriality and Home Range: Concepts of territoriality and home range, Factors influencing territory size and shape. Human-Wildlife Interactions: Understanding human-wildlife interactions; Impacts of human activities on wildlife behaviour and ecology. Conservation Strategies: Protected areas: types, design, and management; Habitat conservation: restoration, enhancement, and creation (*In-situ* and *Ex-situ* Conservation strategies). Community-Based Conservation: Principles and approaches of community-based conservation –in India and Kerala. Wildlife Laws and Policies: Overview of wildlife laws and policies in India; IWPA 1972 and its ramifications; Role of international conventions and treaties in wildlife conservation (Brief Account only) Gadgil Commission & Kasturirangan Commission. Threatened Species Conservation; Conservation status and threats to endangered species; Conservation efforts for flagship and keystone species; Control of Invasive species in forests with special reference to Kerala Forests. Wildlife Management Techniques: Population control methods: culling, contraception, and translocation; Disease management in wildlife populations. Human-Wildlife Conflict Management: Causes and mitigation strategies for human-wildlife conflicts. Conflict resolution through stakeholder

engagement and conflict-sensitive conservation. Environmental Impact Assessment: Principles and procedures of EIA; Role of wildlife ecology in EIA for development projects. Research Techniques in Wildlife Ecology: Field research methods: trapping, tracking, and observation techniques; Non-invasive studieseDNA, Photogrammetry and AI. Data analysis and interpretation for wildlife ecology research.

Module IV: Biochemistry (Weightage: 10 marks)

Carbohydrates: Structure, classification monosaccharides (trioses, tetroses, pentoses, hexoses, aldoses, ketoses), Disaccharides, polysaccharides, (homo and heteropolysaccharides) and biological importance of carbohydrates. Proteins: Structure, classification of amino acids and protein, structure levels of proteins, Primary, Secondary (α-helix, sheet, random coil, Ramachandran plot), Tertiary and Quaternary structures of proteins., haemoglobin as atypical protein, Denaturation, Renaturation and biological functions of proteins Lipids: classification- simple lipids, (neutral fats and waxes), conjugated lipids (phospholipids, sphingolipids, glycolipids, lecithin, cephalins, cerebrosides, gangliosides), derived lipids (fatty acids, steroids, prostaglandins), biological functions of lipids. : Carbohydrate metabolism – glycogenesis, glycogenolysis, gluconeogenesis, hexose monophosphate shunt, metabolic pathway of glucose- glycolysis, Krebs cycle, Electron transport series, chemiosmotic theory, energetics: hormonal control of carbohydrate metabolism. : Carbohydrate metabolism – glycogenesis, glycogenolysis, gluconeogenesis, hexose monophosphate shunt, metabolic pathway of glucose- glycolysis, Krebs cycle, Electron transport series, chemiosmotic theory, energetics: hormonal control of carbohydrate metabolism. Lipid metabolism: Lipid metabolism – hydrolysis of lipid, beta-oxidation, mention alpha and omega oxidation of fatty acids, hormonal control of lipid metabolism. Nomenclature and classification of enzymes; Cofactors; Specificity of enzyme action. Iso enzymes, Clinical uses of Isoenzymes, co-enzyme, enzyme activation and inhibition. Enzyme kinetics; Chemical nature, mechanism of enzyme action Equation of Michaelis-Menten. Factors affecting rate of enzyme catalyzed reactions; Concept of Km and V max.

Module V: Evolution, Ethology and Chronobiology (Weightage: 15 marks)

Evolution: The First Cell. Evolution of Prokaryotes- origin of eukaryotic cells- evolution of unicellular eukaryotes, genome evolution. Geological Timescale. Major events in evolutionary timescale. Tools and techniques in estimating evolutionary time scale. Mass extinction and its consequences. Fossils- fossilization and its significance, Types of fossilization. Population Genetics. Gene pool, gene frequency, Hardy-Weinberg Law. Rate of

change in gene frequency through natural selection, migration and random genetic drift. Founder effect. Cytogenetic and molecular basis of origin of Man-African origin of modern man- Mitochondrial Eve, Y chromosomal Adam

Ethology: Definition; Importance of studying animal behaviour, Ethology - Origin and history (Brief description); Ethologists: Karl Von Frisch, Ivan Pavlov, Konrad Lorenz, Nikolaas Tinbergen. Types of Behaviour – Stereotyped behaviours (Orientation, Reflexes); Individual behavioural patterns; Instinct vs learned behaviour, Associative learning – classical, operant conditioning. Habituation and imprinting. Social organization of vertebrates (example-Primates). Types of reproductive Behaviour (Brief account), Mate choice, Intra and inter sexual selection (male rivalry and female choice). Sexual conflicts during parental care

Chronobiology: Biological oscillation (concept of average, amplitude, phase and period). Biological rhythm – characteristics; types – short- and long-term rhythms, circadian rhythms, tidal rhythms and lunar rhythms; Circannual. Biological clock. Concept of synchronisation and masking; Zeitgeber, photic and nonphotic zeitgebers. Photoperiod and regulation of seasonal reproduction of vertebrates; mention role of melatonin. Relevance of Biological clock in Chrono-pharmacology; Chronomedicine and Chronotherapy.

Module VI: Animal Physiology (Weightage: 25 marks)

Nutrition: Constituents of normal diet and their daily requirements. Physiological calorie value of food stuffs. Mechanism of Digestion. Mechanism of absorption of monosaccarides, amino acids and lipids and vitamins. The role of hormones and neurotransmitters in the control of gastrointestinal Motility. Energy balance and obesity- causes and consequences. BMR and its significance.

Excretory System: Introduction: Brief description of different types of excretory organs in different animal groups (flame cells, green glands, malpighian tubules). Functional anatomy of mammalian kidney, nephron and juxtaglomerular apparatus- structure, parts and function. Urine formation (glomerular filtration, tubular reabsorption and tubular secretion) Regulation of water balance -Mechanism of concentration of urine – Counter Current system. Renal regulation of acid- base balance & electrolyte balance. Micturition reflex.

Respiratory system: Introduction: Brief description of major respiratory organs (tracheal system, book lungs, gills and ctenidia). Physiological anatomy and histology of respiratory passage and lungs. Mechanism of pulmonary ventilation (inspiration & expiration). Alveolar ventilation. Role of surfactant in alveolar expansion. Pulmonary volumes and capacities – definition & normal values (tidal volume, inspiratory reserve volume, expiratory reserve volume, residual volume, functional residual capacity, inspiratory capacity, vital capacity,

total lung capacity). Exchange of gases- partial pressures involved-lung and tissues. Oxygen dissociation curve – factors affecting binding of oxygen to haemoglobin (PO_2, PCO_2, CO, pH, body temperature, diphosphoglyceric acid level, foetal haemoglobin and also myoglobin). Neural and chemical regulation of respiration: Respiratory centres & factors regulating respiration.

Nervous system: Organisation of human brain. Cerebrum and cerebral lobe. Cerebral cortex and its functional areas. Cortical white matter. Brain stem, Cerebellum, Diencephalon. Functional brain systems - Limbic system and reticular formation. Protection of brain – Meninges, cerebrospinal fluid- formation and function, blood brain barrier and its function. Diseased states of brain - schizophrenia, Alzheimer's disease, Senile dementia & Parkinson's disease. Memory- types of memory- somatosensory, short term, intermediate long term and Long term memory, consolidation of memory. PNS and Autonomic nervous system. Spinal cord – structure. Reflex action, reflex arc.

Special senses: Vision: Structure of eyeball, Fluid systems of the eye, Layers of Retina and photoreceptors (rods & cones). Neuronal cell types and neural circuitry of the retina and visual pathways from retina to visual cortex Image formation. Hearing: Structure of Ear, Mechanism of hearing, Mechanism of balance. Taste: Primary sensations of taste. Taste buds, Physiology of taste, Smell: Olfactory membrane and receptor cells Physiology of olfaction, Tactile response: Mechanoreceptor, Pain receptors, Thermal receptors.

Cardiovascular system: Structural organization of myogenic heart (in human beings). Physiological anatomy of cardiac muscle – specialized tissue. Cardiac cycle. Neural and chemical regulation of heart function. Blood volume and blood pressure. Physiological anatomy of coronary blood flow, Ischemic heart disease. Lymphatic System. Lymph channels of the body. Composition and formation of lymph. Functions of lymph and lymphatic system including.

Muscle physiology: Skeletal, Smooth and Cardiac muscles, physiology of muscle contraction, muscle proteins, molecular mechanism of muscle contraction, muscle twitch, rigor mortis, summation.

Endocrinology: Vertebrate endocrine system. Endocrine glands. Synthesis, physiologic role, control and mechanisms of hormone action. Neuro-endocrine regulation of hormone action. Disorders of hormonal imbalance in Man.

Reproductive physiology: Anatomy and histology of adult testis and ovary. Reproductive cycles of mammals and their hormonal control. Physiology of implantation, pregnancy, parturition, and lactation.

Module VII: Immunology (Weightage: 10marks)

Types of immunity: Innate and Acquired immunity, Active immunity and Passive immunity, Cell-mediated immunity and Humoral immunity. Cells involved in Immunity (B cell and T cells): Types and functions. Interferons and MHCs: Organisation of MHC locus in mice and humans. Lymphoid Organs: Primary and Secondary. Immunoglobulins: Structure, Types and functions. Complement system: Classical, Alternate and Lectin pathways. Active and Passive Immunisation: Types of vaccines (Inactivated vaccines, Attenuated vaccines, DNA vaccines, mRNA vaccines, and Conjugate vaccines). Types of Hypersensitivity: Gell and Coombs classification. Autoimmunity: Rheumatoid arthritis and Lupus erythematosus (Brief account). Immunodeficiency diseases: Types of immunodeficiency diseases (DiGeorge syndrome, Selective IgA deficiency and AIDS). Transplantation Immunity: Types of grafts, Immunological basis of transplantation reactions, and Immunosuppression. Immunological techniques for infectious disease diagnosis: Widal test, ELISA, FISH and GISH. Hematopoiesis and its regulation. Monoclonal Antibodies. Production of Monoclonal Antibodies (Hybridoma technology). Clinical uses of Monoclonal Antibodies.

Module VIII: Developmental Biology (Weightage: 10 marks)

Gametogenesis, fertilization and early development: Production of gametes- Spermatogenesis and Oogenesis, Ultrastructure of gametes, Cell surface molecules in sperm-egg recognition in animals (sea urchin and mammals) Zygote formation-Encounter of sperm and egg, Capacitation, Acrosome reaction, Activation of ovum, Amphimixis, Prevention of Polyspermy, Cleavage and blastula formation; Gastrulation in humans. Morphogenetic movements: Epiboly and Emboly (Invagination, Involution, Infiltration, Ingression, Delamination, Convergence, Divergence). Cell fate and cell lineages. The stem cell concept-Progenitor cells, Adult stem cells, Mesenchymal stem cells, Multipotent adult stem cells, Pluripotent Embryonic stem cells. Significance of organizer and embryonic induction. Assisted Reproductive Techniques: GIFT, ZIFT, TET, ICSI.

Module IX: Genetics (Weightage: 10 marks)

Mendel's experiments: Law of inheritance, Law of segregation and Law of independent assortment. Gene concept, Different types of genes, One gene - one enzyme concept. Interaction of genes, Allelic-incomplete dominance, Lethal genes and Codominance, Epistasis - dominant and recessive, Lethal alleles, Polygenic inheritance (Skin colour in humans), Pleiotropism and Multiple alleles, ABO Blood group system. Cytogenetics; Linkage (Complete and Incomplete linkage), Significance of linkage. Crossing over -

Mechanism and its importance. Chromosome mapping, Pedigree Analysis (Brief account only). Sex-linked, Sex-limited, and Sex-influenced inheritance in animals. Mutation: Spontaneous and induced mutation. Structural chromosomal aberrations (Duplications, Deletions, Inversions and Translocations) and Numerical chromosomal aberrations (Aneuploidy, Euploidy and Polyploidy). Chromosomal anomalies in man: Autosomal (e.g. Down syndrome, Edwards syndrome) and autosomal (e.g. Klinefelters syndrome, Turner's syndrome). Sex determining mechanism - Sex chromosomal mechanism (XX-XY, XX-XO, ZZ-ZW). Genic balance theory, Environmental factors on sex determination, Hormonal control of sex differentiation. Mention Barr bodies, Dosage compensation and Lyon hypothesis, Sex mosaicism, Gynandromorph and Intersex.

Module X: Biotechnology (Weightage: 10 marks)

Genetic engineering and recombinant DNA technology, Steps involved in rDNA technology. Essential tools in recombinant DNA technique: DNA modifying enzymes, Restriction endonucleases, Ligases, Polymerases, and Alkaline phosphatase. Vectors used for cloning and their applications: Plasmidvector, Cosmid vector, Phage vector, BACs, YACs, Expression vectors. Gene transfer techniques: Electroporation, Lipofection, Ultrasonication and Microinjection (Brief account only). Mention gene gun. Screening of Transformants: Antibiotic Selection and Blue/White Screening Methods. cDNA library and genomic library (Brief account only). Techniques in Biotechnology Polymerase Chain Reaction: Basic steps and applications of PCR. Mention RT-PCR and its diagnostic value. Hybridoma technology and monoclonal antibodies. Blotting Techniques: Southern, Northern and Western blotting. Mention DNA fingerprinting. Molecular hybridisation techniques for genome analysis: RFLP, AFLP, RAPD (Brief account only). Human Genome Project. DNA sequencing (Sanger method and Automated sequencing). Recent trends in Gene technology: Gene Targeting (Knock-ins and Knockouts). Targeted Genome Editing (CRISPRs-Cas9). Application of biotechnology in the industry (Eg. Bioprocess and Fermentation Technology), Environment (Eg, Bioremediation) and Medical sectors (Eg. Recombinant insulin production). Food and Agriculture: Application of biotechnology in food (Eg. Single-cell protein) and agriculture sectors (Eg. Genetically modified crops and transgenic animals).

Module XI: Ecology and Disaster Management (Weightage: 25 marks)

Concept of an ecosystem. Interrelationships between the living world and the environment. Structure of an ecosystem: Brief account on abiotic and biotic factors. Primary production and energy flow in an ecosystem. Pond as a typical ecosystem (Trophic relationships, producers, consumers and decomposers). Population Ecology: Characteristics of a population. Ecotypes. A brief account ofmetapopulation. Exponential and logistic growth, equation and patterns, r and K strategies. Population regulation– density-dependent and independent factors. Community Ecology: Community characteristics: stratification, species diversity, species abundance, species dominance community periodicity. Brief accounts on a niche, trophic level and guild. Ecological succession: Types and different stages. Eg. Succession in an aquatic ecosystem. Environmental Pollution: Types of pollution (Air, water, and soil). Sources of pollution, eutrophication, effects of pollution on the ecosystem, pollution indicators. Control and management (bioremediation, sewage treatment, green chemistry). Air pollution mapping software (eg. AirNow, IQAir, AirVisual). Sustainable development, ecosystem approach. Environment ImpactAssessment, pollution sensors, green audit.

Disaster management: Disaster: Definition. Classification of disasters- human-induced andnatural. Natural Hazards (Cyclone, Tsunami, Heat Wave, Landslide, Urban Floods, Floods and Earthquakes). Man-made hazards (Chemical,nuclear and biological). Cause and impact of disasters Disaster management: Prevention, mitigation strategies, preparedness. Policies and agencies: National Disaster Management Plan, 2019, Kerala State Disaster Management Plan, 2016. Kerala State DisasterManagement Authority (KSDMA) and National Disaster ManagementAuthority (NDMA). Need of Disaster management strategies: A case study on Kerala flood 2018. Role of Information Technology in Disasters

Module XII: Cell Biology (Weightage: 15 marks)

Cell: Characteristics of a prokaryotic cell and a eukaryotic cell. Fluid mosaic model of the plasma membrane. Cytoskeleton: Microtubules, Microfilaments and intermediatefilaments Endomembrane Systems: Brief account of structure and functions of endoplasmic reticulum, Golgi apparatus, Lysosome,and Vacuoles. Ribosomes: Basic structure and function. Mention types (Prokaryotic ribosomes, Archaeal ribosomes, Eukaryotic ribosomes). Ribosome locations (Free ribosomes and Membranebound ribosomes).Mitochondria: Structure (Outer and inner membranes),Functions. Mention mitochondrial diseases. Nucleus: Structure of interphase nucleus, Chromatin (Euchromatin and Heterochromatin), Nucleolus, Structure of ametaphase chromosome. Brief accounts of giant chromosomes (Polytene chromosomes, Lamp brush chromosomes). Cellular Processes (Cell Growth and Division): Cell cycle -Stages (G1, S, G2 and M phases), Mitosis and meiosis. Cell cycle regulation. Cellular Transport Mechanisms: Passive and active transport,Endocytosis, Exocytosis, and Vesicle trafficking. Cell Signalling: Concept of cell communication. Brief accounts on cell signalling pathways and receptor-ligand interactions. Extracellular (Glucagon), Intracellular (Cyclic AMP), and Intercellular (Calcium) messengers. Types of Signalling Molecules: Hormones, Neurotransmitters, Growth factors, Cytokines, and Extracellular matrix components.. Modes of Cellular Signalling: Mention Endocrine signalling, Paracrine signalling, Autocrine signalling and Synaptic signalling. Signal Transduction Pathways: Signalling molecules (ligands), cell surface receptors, intracellular signalling molecules (e.g., kinases, second messengers), and target proteins (e.g.,transcription factors). Examples of common signalling pathways - MAPK (mitogen-activated protein kinase) pathway, the PI3K/Akt pathway, and the cAMP (cyclic adenosine monophosphate) pathway.

Module XIII: Molecular Biology (Weightage: 10 marks)

Nucleic Acids: Nucleic Acids: Molecular composition, Nucleic acid sequences, Types (DNA, RNA, Mention Artificial nucleic acids). DNA: Typical structure; Alternative forms of DNA (A DNA, B DNA, Z DNA); Brief account of biological functions. RNA: Structure of tRNA (Cloverleaf model), Types of RNA(Messenger RNA, Ribosomal RNA, Signal recognition particle RNA, Transfer RNA, Transfer-Messenger RNA). Biological functions of RNA. Central Dogma of Molecular Biology: Definition, Central dogma reverse (Teminism), One gene-one enzyme hypothesis, One gene-one polypeptide hypothesis. DNA Replication: DNA replication in Prokaryotes and Eukaryotes (Proof for Semi-conservative model, Messelson and Stahl experiment). Transcription: Brief account of transcription in Prokaryotes and Eukaryotes. Mention reverse transcription and post-transcriptional modifications. Genetic Code: Concept of genetic code. Mention codons. Characteristics of genetic code (Reading frame and start and stopcodons). ble hypothesis.Translation: Steps and basic mechanism of translation in prokaryotes and eukaryotes. Gene Regulation: Operon, Inducible and repressible Operon system, lac operon, trp operon.

NOTE: - It may be noted that apart from the topics detailed above, questions from other topics prescribed for the educational qualification of the post may also appear in the question paper. There is no undertaking that all the topics above may be covered in the question paper.

Distribution of Weightage of marks

Module I: Diversity of Animals (Weightage: 10 marks)

Module II: Wildlife Biology and Conservation (Weightage: 25 marks)

Module III: Wildlife Ecology (Weightage: 25 marks)

Module IV: Biochemistry (Weightage: 10 marks)

Module V: Evolution, Ethology and Chronobiology (Weightage: 15 marks)

Module VI: Animal Physiology (Weightage: 25 marks)

Module VII: Immunology (Weightage: 10 marks)

Module VIII: Developmental Biology (Weightage: 10 marks)

Module IX: Genetics (Weightage: 10 marks)

Module X: Biotechnology (Weightage: 10 marks)

Module XI: Ecology and Disaster Management (Weightage: 25 marks)

Module XII: Cell Biology (Weightage: 15 marks)

Module XIII: Molecular Biology (Weightage: 10 marks)

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Optional subject- Physics

1. MECHANICS (12 marks)

Dynamics of Rigid Bodies: Rotation of rigid bodies, Angular velocity, Angular acceleration, angular momentum, Moment of Inertia, Parallel an perpendicular axes theorem, Calculation of Moment of inertia of uniform rod, ring, disc, annular ring, solid cylinder, hollow cylinder and solid sphere, Kinetic energy of rotating and rolling bodies, Torque, Law of conservation of angular momentum

Conservation of Energy: Energy Conservation law- Work – power- Kinetic Energy – Work Energy theorem- Conservative Forces - potential energy4

2. CLASSICAL AND RELATIVISTIC MECHANICS (12 Marks)

Particle dynamics: Motion of a charged particle in electromagnetic field – mechanics of a system of particles, Law of conservation of linear momentum –law of conservation of angular momentum – law of conservation of energy. Motion in central force field: Equivalent one body problem – general features of motion– Kepler's laws of planetary motion and their deduction.

Collisions: Conservation laws- Conservation of momentum- laboratory and centre of mass systems- kinetic energies in the lab and CM systems-Cross-section of elastic scattering

3. QUANTUM MECHANICS (12Marks)

Wave Mechanics: Wave nature of particles- uncertainty principle -Properties of wave function- Normalization and orthogonality condition -wave packets, relation between Particle velocity, group velocity and phase velocity

Quantum mechanics: Fundamentals, Eigen values and Eigen functions-, Hermitian operator, Postulates of Quantum Mechanics, - Time dependent Schrodinger equation,- Time independent Schrodinger equation

4. PROPERTIES OF MATTER (12 Marks)

Elasticity: Elastic moduli, bending moment-cantilever-centrally loaded beams and uniformly loaded beams- I section girders, torsion of a cylinder-expression for torsional couple, work done in twisting a wire.

Surface Tension: Surface tension, angle of contact, shapes of drops - excess pressure inside liquid drop and bubble, Surface tension and temperature.

Fluid Dynamics: Streamline and turbulent flow, equation of continuity, Bernoulli's theorem, venturimeter, viscosity, Newton's law of viscosity- Stoke's formula, terminal velocity

5. HEAT AND THERMODYNAMICS (14 Marks)

Transfer of heat: Thermal conductivity -, radial flow of heat, thermal conductivity of rubber, Weidman- Franz law. Radiation of heat, Stefan's law, solar constant, determination of solar temperature

Thermodynamics: Zeroth Law & First law of Thermodynamics, Thermodynamic Processes-Expression for work done in isothermal and adiabatic processes. specific heat capacity and latent heat. Reversible and irreversible processes. Second law of thermodynamics-Carnot engine- Principle of refrigerator- working and efficiency

6. ELECTROMAGNETISM AND CURRENT ELECTRICITY (12 Marks)

Electromagnetism: Electromagnetic Induction, Faraday's law, Lenz's law, The wave equation of electromagnetic waves in vacuum, Energy and momentum in electromagnetic waves.

Current Electricity: Ohm's law, Transient currents, Charging and discharging of a capacitor through LCR circuit, Time Constant

Alternating current (AC): AC through series LCR (acceptor circuit) and parallel LCR circuit (rejecter circuit)- Q- factor, Power in AC-power factor

7. SOLID STATE PHYSICS (16 Marks)

Crystal Structure: Solids- Amorphous and Crystalline Materials. – Unit Cell -Types of Lattices-Miller Indices-Reciprocal Lattice-Diffraction of X- rays by Crystals. Bragg's Law. X-ray diffraction techniques-Inter atomic forces.

Semiconductors: P and N type Semiconductors- Conductivity of Semiconductors- mobility-Hall Effect- Hall coefficient

Magnetic Properties of Matter: Dia, Para, Ferri and Ferromagnetic Materials. Curie's law, Weiss's Theory of Ferromagnetism and Ferromagnetic Domains. B-H Curve. Hysteresis and Energy Loss

Superconductivity: Critical Temperature-Critical magnetic field-Meissner effect- Type I and type II Superconductors.BCS theory- (Qualitative)

8. ELECTRONICS (16 Marks)

Diodes and circuits; PN junction- forward and reverse bias-r m s value and peak inverse voltage- diode characteristics-ac and dc resistances- half wave and full wave rectifiers- dc value of current, ripple factor and efficiency- filters (shunt capacitor, LC and RC)- Zener diode- voltage regulator

Transistors: Bipolar Junction Transistor (BJT) - operation- CB,CE and CC characteristics- alpha , beta and gamma – relation between transistor currents- -selection of operating point-ac and dc load lines-Q point -BJT amplifiers- input and output impedances- graphical analysis of CE amplifier(frequency response, band width and gain in dB)- RC phase shift oscillator.

Modulation: Need for modulation, Fundamentals of modulation – Amplitude modulation and frequency modulation

9. DIGITAL ELECTRONICS (14 Marks)

Number systems :-Decimal number system-binary number system- conversion of binary number to decimal and decimal number to binary- binary addition and subtraction-2's complement-binary subtraction using 2's complement-conversion of decimal fraction to binary fraction-BCD -hexadecimal number system-conversion of hexadecimal number to decimal, decimal to hexadecimal, binary to hexadecimal and hexadecimal to binary -ASCII

Boolean algebra and logic gates: - Logic gates AND, OR, NOT, NAND,NOR And Ex-OR gate- realization of other logic functions using NAND / NOR gates- -Boolean laws- Demorgan's theorem-Simplification of Boolean equations using Boolean laws. Karnaugh maps

10.COMPUTRE SCIENCE (8 Marks)

Basics of computers:-Hardware- input and output units- memory unit- ALU-control unit–- Software – operating systems, memory, - RAM, ROM, PROM, EPROM, EEPROM– flash memory-speed size and cost-Basic concepts of cache memory and virtual memories. Secondary storage-magnetic hard disks-optical disks. Microprocessors and microcontrollers, Intel 8085 (basic concepts)- interrupts (definition only) -assembly language - simple programs- addition, subtraction

11.INSTRUMENTATION (16 Marks)
Measurements: Basic concepts- Instruments for measuring basic parameters-ammeter- voltmeters-multimeter- digital voltmeter
Oscilloscopes- Cathode ray tubes- CRT circuits- vertical deflection system- horizontal deflection system-multiple trace- oscilloscope probes and transducer- storage oscilloscopes.

Transducers : Basic principles- classification of transducers- Passive and Active transducers- strain gauges- temperature measurements- thermistors-photosensitive devices.

Error Analysis: Significant figures- Basic ideas of error measurement, uncertainties of measurement, importance of estimating errors, dominant errors, random errors, systematic errors, rejection of spurious measurements.   Estimating and reporting of errors, absolute and relative errors, standard deviation, Variance in measurements, error bars and graphical representation

12.   NUCLEAR AND PARTICLE PHYSICS (16 Marks)

Nuclei: Constituents of nucleus and their Intrinsic properties- size- mass- binding energy- average binding energy and its variation with mass number- main features of binding energy versus mass number curve- nuclear stability- parity- magnetic moment - Nuclear forces

Radio activity: Alpha decay-basics of α-decay processes, theory of α-emission, Gamow's theory, Geiger Nuttal law, b decay, energy kinematics for b decay, positron emission , electron capture, neutrino hypothesis, Gamma decay: Gamma ray emission & kinematics, internal conversion.

Nuclear fission and fusion: Nuclear fission-energy released in fission-Bohr Wheeler's theory-chain reaction -multiplication factor-critical size-atom bomb-nuclear reactors- breeder reactors-uses of nuclear reactors. Nuclear fusion-sources of stellar energy- hydrogen bomb- -Tokamak- inertial confinement-nuclear power in India

13.   OPTICS (12 Marks)

Laser: Einstein coefficients, population inversion - cavity threshold condition,–Ruby laser - He-NE laser, Dye laser, semiconductor laser, (working principle only) Application of lasers- characteristics of laser beams

Fibre Optics: optical fibre, numerical aperture, step index fibre, graded index fibre, single mode fibre, multimode fibre, Fibre optic   sensor (qualitative), fibre optic communication (qualitative), Advantages of   fibre optic communication system.

Holography: Principle, recording of holograms, reconstruction of images (qualitative), application of holography, different types of holograms, transmission and reflection types.
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14.SPACE AND ATMOSPHERIC PHYSICS (10 Marks)

The active Sun: Sun-mass, radius, etc. Solar structure, Astronomical Unit, Sunspots, Flare, CME, Solar storms, Solar activity, Solar wind**.**

The earth's Atmosphere: Layers, temperature profile, Temperature distribution in the troposphere, Temperature of stratosphere, temperature of mesosphere and thermosphere, Temperature variability, The pressure profile, Scale height, Density variation- Ionosphere: Effect on scale height, Ionospheric electric fields

15.PHOTONICS (8 Marks)

Semiconductor photon sources and detectors : -light emitting diodes (LEDs)- LED characteristics- responsivity- spectral distribution- materials- response time-device structures (Basics). photo electron emission- p-n photo diodes-PIN photo diodes-hetero structure photo diode- Schotky barrier photodiodes – avalanche photo diodes

16.NANO SCIENCE AND TECHNOLOGY (10 Marks)

Nanophysics: - nanometre- Nanostructures: Zero, One Two and Three dimensional nanostructures Top down vs bottom up techniques, Lithographic process, Non Lithographic techniques: Sol-Gel Technique

Applications of nanotechnology: Expected benefits from nanotechnologies, Energy and Energy Efficiency, new energy producers, Medicine, security, Other Applications

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Optional subject- MECHANICAL ENGINEERING

Engineering Mechanics (10 Marks)

Free-body diagrams and equilibrium; friction and its applications including rolling friction, belt-pulley, brakes, clutches, screw jack, wedge, vehicles, etc.; trusses and frames; virtual work; kinematics and dynamics of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations; Lagrange's equation.

Engineering Materials (15 Marks)

Basic concepts on structure of solids, Crystalline materials, Defects in crystalline materials, Alloys and binary phase diagrams, structure and properties of common engineering materials. Heat treatment of steels. Plastics, Ceramics and composite Materials, common applications of various materials.

Mechanics of Materials (15 Marks)

Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; concept of shear centre; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.

Theory of Machines (20 Marks)

Types of Kinematics Pair, Mobility, Inversions, Kinematic Analysis, Velocity and Acceleration Analysis of Planar Mechanisms, CAMs with uniform acceleration and retardation, cycloidal motion, oscillating followers; Vibrations –Free and forced vibration of undamped and damped SDOF systems, Transmissibility Ratio, Vibration Isolation, Critical Speed of Shafts. Gears – Geometry of tooth profiles, Law of gearing, Involute profile,

Interference, Helical, Spiral and Worm Gears, Gear Trains- Simple, compound and Epicyclic; Dynamic Analysis – Slider – crank mechanisms, turning moment computations, balancing of Revolving & Reciprocating masses, Gyroscopes –Effect of Gyroscopic couple on automobiles, ships and aircrafts, Governors.

Machine Design (15 Marks)

Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.

Thermodynamics (10 Marks)

Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; availability and irreversibility; thermodynamic relations.

IC Engines and Power Plants (15 Marks)

Air-standard Otto, Diesel and dual cycles. Spark Ignition and compression ignition engines, four stroke engine and two stroke engines, mechanical, thermal and volumetric efficiency, Heat balance. Combustion process in S.I. and C.I. engines, pre-ignition detonation in S.I. engine Diesel knock in C.I. engine. Choice of engine fuels, Octane and Cetane ratings.

Power Plant Engineering: Rankine and Brayton cycles with regeneration and reheat, gas turbines. Fuels and their properties, Flue gas analysis, Boilers, steam turbines and other power plant components like condensers, air ejectors, electrostatic precipitators and cooling towers – their theory and design, types and applications.

Fluid Mechanics and Turbomachinery (20 Marks)

Fluid properties; fluid statics, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings; basics of compressible fluid flow.

Turbomachinery: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines.

Heat-Transfer, Refrigeration and Air Conditioning (20 Marks)

Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system,

Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan- Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis

Refrigeration and air-conditioning: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes, cooling loading calculations.

Casting, Forming and Joining Processes (10 Marks)

Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.

Machining and Machine Tool Operations (15 Marks)

Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, jigs and fixtures; abrasive machining processes; NC/CNC machines and CNC programming.

Metrology and Inspection (10 Marks)

Limits, fits and tolerances; linear and angular measurements; comparators; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly; concepts of coordinate-measuring machine (CMM).

Manufacturing Management (25 Marks)

Production Planning and Control, Forecasting-Moving average, exponential smoothing, Operations scheduling; assembly line balancing. Product development. Breakeven analysis, Capacity planning. PERT and CPM.

Control Operations: Inventory control-ABC analysis. EOQ model. Materials requirement planning. Job design, Job standards, work measurement, Quality Management-Quality control.

Operations Research: Linear Programming-Graphical and Simplex methods. Transportation and assignment models. Simple queuing models.

Value Engineering: Value analysis, for cost/value. Total quality management and forecasting techniques. Project management.

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Optional subject- Environmental Science

Module 1   **10 Marks**

Fundamentals of Environmental Science - Definition, Scope and Importance of Environmental Science; Multidisciplinary nature of environmental Science.The atmosphere or the air: Layers of Atmosphere, Composition of air; importance of atmosphere, meteorological conditions and air circulation. The hydrosphere or water: Importance of water, distribution of water at global, national and state level. Hydrological cycle. Lithosphere or the rock and the soil: Elementary composition of rocks in the earth crust. Types of rocks; Process of soil formation: Physical weathering, Chemical and biological weathering of rocks; Role of soil in shaping the biosphere.

Module 2   **10 Marks**

Environmental Factors: Climatic Factors - Light, Temperature of Air (atmospheric temperature), Rainfall (precipitation), Humidity of air, atmosphere (gases and wind), fire. Topographic Factors: height of mountains, direction of mountains and valleys, steepness of slope and exposure of slope. Edaphic factors: Soil - soil formation, soil profile, soil erosion, soil conservation. Biotic factors: Intraspecific interactions; Interspecific interactions: Neutralism, Commensalism, Mutualism, Proto co-operation, Parasitism, Predation.

Module 3   **20 Marks**

Ecosystem Definition; Components of ecosystem; Abiotic components: Light, Temperature, Pressure, Water, Wind, Soil; Biotic components; Energy flow in an ecosystem: Primary production, Secondary production; Food chain: Grazing food chain, Detritus food chain; Ecological pyramids: Pyramid of number, Pyramid of biomass, Pyramid of energy; Food web; Ecological indicators. Biogeochemical cycles: a)

Gaseous cycles: Oxygen cycle, Carbon cycle and Nitrogen cycle. b) Sedimentary cycles: Phosphorus cycle, Sulphur cycle.

Module 4   10 Marks

Population Ecology and Community Ecology: Population characteristics- Population growth and its dynamics; natality, mortality, growth patterns; Age distribution, Malthus theory; Community structure, Species diversity, Ecological dominance, Ecotone, Edge effect, Ecological equivalence, Succession and Climax; Ecological adaptations. Types of biodiversity; genetic, Species and ecosystem biodiversity; Cultural values, importance of biodiversity; hot spots of biodiversity; India as a megadiversity centre; threats to biodiversity: rare, endangered, threatened and endemic species ; biogeographical distribution of species; biodiversity
conservation – *in-situ , ex-situ* and agrobiodiversity conservation, national parks and sanctuaries; wildlife conservation ; Red data book ; medicine ; sustainability , Intellectual Property Right (IPR). National Biodiversity Act

Module 5   20 Marks

Sun-Earth System: planetary motion and seasons; Solar radiation, effect of atmosphere - scattering, absorption and reflection, greenhouse effect; Structure of atmosphere and atmospheric circulation; General circulation of the atmosphere and Indian monsoons; General circulation of Oceans. Thermodynamics, Atmospheric stability: Composition of dry air and atmospheric water vapor content; Potential temperature, virtual temperature, isothermal and adiabatic processes; Stable, unstable and neutral equilibriums, Inversions; Atmospheric boundary layer - depth, structure, diurnal variations and their significance in pollutant dispersion. Clouds and precipitation.Weather and climate - Climatic zones, continental & maritime climates; Climate change and variability, Natural and anthropogenic causes of climate change, El Nino and ENSO events. Earth's geological history and development and evolution of the earth systems; Gaia Hypothesis; Introductions to various systems - Atmosphere,Hydrosphere, Lithosphere, Biosphere and their linkages. Properties and Structure of the Earth: crust, mantle, core, earth's magnetic field; Recycling of the lithosphere - the rock cycle, weathering and erosion, sedimentation, metamorphism; Rock types; Concept of plate tectonics and continental drift; Geological time-scales. Global water balance: hydrological cycle, relationship of surface, groundwater and stream-flow, Stream hydrograph; Groundwater - aquifers; Groundwater exploitation and management.

Module 6   20 Marks

Energy basics: Laws of thermodynamics; Forms and types of energy; Energy resources classification -; conventional and non- conventional; secondary energy sources; sun as source of energy, nature of its radiation,thermal dynamics of earth system, solar constant, distribution of solar radiation across various atmospheric levels, ecologically

important radiations, energy flow in Ecosystems. Non-renewable energy resources: Coal, oil, natural gas, heavy radioactive elements; India's non- renewable energy reserves and usage pattern; world's energy reserves and consumption; Non-renewable energy usage and limitations, role of fossil fuels in modern economy, Environmental impacts of fossil fuels exploitation and utilization. Renewable energy resources: Biomass, wind, hydroelectric, ocean, geothermal; Secondary energy resources - electricity, hydrogen; Alternate energy resources; Renewable energy usage, limitations and scope; modern techniques for energy resource recovery using microbes, solar collectors, photovoltaics, solar ponds, nuclear-fission and fusion, Magneto-Hydrodynamic Power (MHD) and biomass gasification. Nuclear energy generation and environmental safety. Energy production and impacts on environment: degradation of air, water and land; Important multipurpose power projects and environmental issues in India; Energy use pattern in different parts of the world and its impact on the environment; energy utilization in urban and rural contexts; Sustainable energy management, problems and solutions; Energy crisis and challenges of energy transformation; Energy conservation measures for sustainable development.

Module 7   20 Marks

Environmental pollution: Pollution - physical, chemical and biological; radio nuclides, Electromagnetic radiations, Electro-smog, noise and light pollution; sources . History of evolution of the earth's atmosphere. Air pollution: Particulate matter - Respirable and irrespirable, inorganic and organic species in PM; gaseous pollutants; Green-house gases, Ozone layer , Photochemical smog , Acid rain; Meteorological factors affecting air pollutants; Effects of pollutants on life forms; Ambient air quality standards. Pollution monitoring methods and pollution abatement. Water pollution: pollution of water resources, types and sources. Pollution monitoring methods and pollution abatement: Water, soil and biological sample analysis . Wastewater and its treatment. Soil-weathering and pedogenesis, classification of types of soil (Reference to India and Kerala),soil quality parameters and assessment. Soil pollution. Solid wastes: definition, types, source, categories, generation rates; Waste management approaches ; Hazardous wastes; Biomedical wastes; Nuclear wastes; Environmental impacts of wastes; recycling of wastes and waste minimization techniques; solid waste processing technologies, biological and chemical techniques for energy and other resource recovery; Waste biomass resources, utilization of organic manure; waste and earthworms, vermicomposting .

Module 8   20 Marks

Major classes of environmental pollutants - routes of entry into ecosystems - surface waters, land, atmosphere; long-range movement and global transport of pollutants; Fate of pollutants in ecosystems - biotransformation, bioaccumulation and biomagnification. Toxicity testing . Biochemical effects of environmental contaminants. Environmental health and safety- Diseases through pollution. Management to control diseases;

Occupational health, health and safety considerations; Environmental health and human society, Health problems in different types of industries. Environmental health and occupational hygiene; Occupational health & safety management system, OHSAS – 18000.

Module 9   20 Marks

Environmental Microbiology: - characteristics, classification, identification and morphology of microorganisms. Physiological status of microorganisms in the environment. Microbes in air, water and soil. Microorganisms in extreme environments, genetically engineered microorganisms. The aquatic microorganisms. Nature of marine and fresh water environments, Water and disease transmission, Microbial analysis of water quality. Soil microorganisms, Microbial diversity in soil, biogeochemical role of soil microorganisms. Soil microorganisms associated with plants. Soil microorganism's interactions with the atmosphere, the role and importance of microbial ecosystems, biogeochemical transformation. Environment Biotechnology–Role of biotechnology in Environmental Protection, biotechnology in industrial pollution control – Agro – biotechnology – Bio- pesticides and Bio-fertilizers; Ecological Engineering-Aquatic macrophyte based wastewater treatment systems (AMATS)-constructed/artificial wetlands, Nutrient film techniques (NFT), Municipal solid waste management, Role of composting and vermicomposting; Biodegradable plastics – Biopolymers-PHBs and PHAs, Phyto – reactors-Plants used to produce genetically engineered products. Biotechnological Methods in Pollution Control – Air pollution control: Bio scrubbers, biofilters and membrane bioreactors. Bio-desulphurization of coal. Green belts. Bioremediation: Soil/ land contaminated with oil spills, and synthetic organic compounds (xenobiotics) such as PCBs, PAHs. Bioremediation technology, bioremediation of marine oil spills. Phytoremediation. Biosensors. -Concept, principle, and development of biosensors. Biosensor's for environmental monitoring-BOD, ammonia, and nitrite.

Module 10   10 Marks

Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions, Heat and cold waves, Climatic change: global warming, Sea level rise, ozone depletion. Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, industrial waste water pollution, road accidents, rail accidents, air accidents, sea accidents. Disaster Management- Effect to migrate natural disaster at national and global levels. International strategy for disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, community – based organizations and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response; Police and other organizations.

Module 11   **20 Marks**

Basics of Environment Impact Assessment (EIA) and Risk Assessment (RA): EIA practice in India, EIA Notifications 1994, 1997 2009; Other related notifications. Types of EIA: Rapid EIA, comprehensive EIA, strategic EIA, data collection, ecological impacts, environmental impacts (Air, water, land and noise), socioeconomic and cultural impacts, health impacts, prediction of impacts; methodologies, cost benefit analysis, Environmental Management Plan (EMP). Environmental Impact Statements (EIS); Reviewing EIA/EIS

Module 12   **20 Marks**

Environmental ethics: concepts, ethical theories.   Major Indian environment / conservation related acts: Introduction to Water (Prevention and Control of Pollution) Act - 1974, Water (Prevention and Control of Pollution) Cess Act -1974, Wildlife (Protection) Act -1972, Forest (Conservation) Act -1980, Air (Prevention and Control of Pollution) Act -1981. The Environment (Protection) Act -1986, The Public Liability Insurance Act – 1991. Laws on water and air pollution control: Powers of Central and State Pollution Control Boards, Prevention and control of Water Pollution. Air Pollution Control Areas, pollution control strategies, Prohibition of Emission of Air Pollutants. Environment (Protection) Act - 1986, Hazardous Wastes (Management and Handing) Rules - 1989, The Natural Environment Tribunal Act - 1995, Legal Measures to Control Noise Pollution, Solid waste management and handling rules-2000; Biomedical wastes (Management and Handling) Rules - 1999; Coastal Regulation Zone Notification – 1991, Biodiversity Act - 2002. International environmental treaties and conventions: Montreal Protocol, Earth Summit, Agenda 21, Convention on Biological Diversity (CBD) , Kyoto Protocol, Paris convention, Copenhagen Summit - 2009, Millennium Development Goals, Basel convention. International Organisations: United Nations Environment Programme (UNEP), International Union for Conservation of Nature and Natural Resources (IUCN), International Panel on Climate Change (IPCC), International Panel on Oceans (IPO)

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Optional subject- Chemistry

Module 1: Fundamentals of Chemistry (20 Marks)

Atomic Structure

Discovery of electron, proton, neutron

Rutherford and Bohr models of atom

Quantum mechanical model of atom

Quantum numbers and electronic configuration

Aufbau principle, Pauli exclusion principle, Hund's rule

Mole Concept

Avogadro's number, molar mass

Empirical and molecular formulas

Stoichiometry and calculations involving chemical reactions

Chemical Bonding

Ionic, covalent, and metallic bonds

VSEPR theory and molecular shapes

Hybridization and molecular orbital theory

Bond energy, bond length, and bond order

Module 2: Physical Chemistry (40 Marks)

Thermodynamics

First law of thermodynamics, internal energy, enthalpy

Second law of thermodynamics, entropy, Gibbs free energy

Third law of thermodynamics

Applications to chemical reactions (Hess's law, standard enthalpies)

Chemical Equilibrium

Dynamic nature of equilibrium, equilibrium constant

Le Chatelier's principle and its applications

Calculations involving equilibrium constants (Kc, Kp)

Solutions

Concentration terms (molarity, molality, normality, mole fraction)

Raoult's law and ideal solutions

Colligative properties (boiling point elevation, freezing point depression, osmotic pressure)

Electrochemistry

Electrolytes and non-electrolytes, conductance in electrolytic solutions

Electrochemical cells, standard electrode potentials

Nernst equation, electrochemical series

Applications of electrochemistry (batteries, fuel cells, corrosion)

Chemical Kinetics

Rate of a reaction, factors affecting reaction rates

Rate laws, order of reaction, molecularity

Arrhenius equation, activation energy

Mechanisms of complex reactions

Surface Chemistry

Adsorption and absorption, types of adsorption

Freundlich and Langmuir adsorption isotherms

Colloids and emulsions, properties and applications

Module 3: Inorganic Chemistry (40 Marks)

Coordination Chemistry

Nomenclature and isomerism in coordination compounds

Werner's theory, Valence Bond Theory (VBT), Crystal Field Theory (CFT)

Stability of coordination compounds, applications in bioinorganic chemistry

Solid State

Classification of solids (crystalline and amorphous)

Crystal lattices and unit cells, Bravais lattices

Packing efficiency, voids, and density calculations

Bragg's law and X-ray diffraction

Nuclear Chemistry

Radioactivity, types of radioactive decay

Half-life, nuclear reactions, and stability of nuclei

Applications of radioisotopes (medical, industrial, archaeological)

Inorganic Qualitative Analysis Principles

Solubility product, common ion effect

Qualitative analysis of cations and anions

Spot tests and group separation techniques

Chemical Bonding in Inorganic Compounds

Bonding in ionic and covalent compounds

Shapes of molecules and ions (VSEPR theory)

Hybridization and shapes of molecules (sp, sp2, sp3, etc.)

Module 4: Organic Chemistry (50 Marks)

Basic Principles and Concepts

Hybridization, resonance, inductive effect, hyperconjugation

Acid-base concepts in organic chemistry

Nomenclature of organic compounds (IUPAC system)

Stereochemistry

Optical isomerism, chirality, enantiomers, diastereomers

Geometric isomerism, E/Z notation

Conformational analysis of alkanes and cycloalkanes

Alcohols, Phenols, Aldehydes, and Ketones

Structure, nomenclature, physical properties

Methods of preparation and reactions (oxidation, reduction, nucleophilic addition)

Special reactions (Aldol condensation, Cannizzaro reaction, Reimer-Tiemann reaction)

Carboxylic Acids and Amines

Structure, nomenclature, physical properties

Methods of preparation and reactions (acid-base properties, substitution, decarboxylation)

Amines: Basicity, preparation, and reactions (Hofmann rearrangement, Gabriel synthesis)

Benzene and its Derivatives

Structure and stability of benzene, aromaticity

Electrophilic aromatic substitution (nitration, sulfonation, halogenation, Friedel-Crafts reactions)

Diazonium Salts

Preparation and reactions (Sandmeyer reaction, Gattermann reaction)

Applications in organic synthesis

Module 5: Biochemistry (20 Marks)

Carbohydrates

    Classification (monosaccharides, disaccharides, polysaccharides)

    Structure and properties, reactions of glucose and fructose

    Glycosidic linkage and polysaccharides (starch, cellulose, glycogen)

Amino Acids and Proteins

    Structure, classification, and properties of amino acids

    Peptide bond formation, primary, secondary, tertiary, and quaternary structure of proteins

    Enzyme catalysis and mechanism of enzyme action

Nucleic Acids

    Structure and function of DNA and RNA

    Replication, transcription, and translation

    Mutations and genetic code

Biochemical Techniques

    Chromatography (paper, thin-layer, column)

    Electrophoresis (gel electrophoresis, SDS-PAGE)

Module 6: Applied Chemistry (20 Marks)

Photochemistry

    Laws of photochemistry (Grotthuss-Draper law, Stark-Einstein law)

    Quantum yield, photochemical reactions (photosynthesis, vision)

    Jablonski diagram, fluorescence, and phosphorescence

Catalysis

    Types of catalysis (homogeneous, heterogeneous, enzyme catalysis)

    Mechanism of catalytic action, characteristics of catalysts

    Industrial applications of catalysis (Haber process, Contact process)

Gaseous State

    Gas laws (Boyle's law, Charles's law, Avogadro's law)

    Ideal gas equation, kinetic molecular theory of gases

    Real gases and deviations from ideal behavior, Van der Waals equation

Module 7: Advanced Topics in Chemistry (10 Marks)

Green Chemistry

    Principles of green chemistry

    Green synthesis and sustainable processes

Nanochemistry

Synthesis and properties of nanomaterials

Applications of nanotechnology in chemistry

Environmental Chemistry

Chemical principles in environmental science

Pollution (air, water, soil), greenhouse gases, and climate change

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Optional subject- Electrical Engineering

Module-1 (20 Marks)

Introduction to Semiconductor devices: Evolution of electronics – Vacuum tubes to nano electronics. Resistors, Capacitors and Inductors (constructional features not required): types, specifications. Standard values, color coding. **PN Junction diode:** Principle of operation, V-I characteristics, principle of avalanche breakdown, Zener diode, Photo Diode, Light Emitting Diodes (LED), **Bipolar Junction Transistors:** PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration. **MOSFET- Structure**, Enhancement and Depletion types, principle of operation and characteristics. **Rectifiers and power supplies:** Block diagram description of a dc power supply, Working of a full wave bridge rectifier, capacitor filter (no analysis), working of simple zener voltage regulator. **Regulated power supplies:** Review of simple zener voltage regulator, series voltage regulator, 3 pin regulators-78XX and 79XX, DC to DC conversion, Circuit/block diagram and working of SMPS. **Power Electronic Devices :** Silicon Controlled Rectifier (SCR), TRIAC working, characteristics. **Instrumentation :** Introduction to measuring instruments Generalized Configurations and Functional elements of Instrumentation systems, Need for Measurement Systems, Classification of Types of Measuring instruments. Static and Dynamic characteristics of measuring instruments. Sensors and Transducers: - Need, Classification and selection criteria. **Transducer Principles of operation**, construction, theory, advantages and disadvantages, applications of Resistive Transducers: Potentiometers, strain gauges, (metallic and semi-conductor type), Resistance Thermometer, Thermistors. Inductive Transducers: LVDT (Linear variable differential transformer). Capacitive Transducers, capacitive microphone, Active Transducers: Thermocouple, Piezo-electric transducer, Hall Effect transducer, Flow meter **Electronic Measuring Instruments** : Digital storage oscilloscope, Working principle and applications of waveform analyser, digital frequency meter, harmonic distortion meter, harmonic analyser, spectrum analyser and logic state analyser IEEE - 488 General Purpose Interface Bus (GPIB) Instruments with application. EMI, Grounding and Shielding.

Module-2 (20 Marks)

Number Systems and Codes: Binary and hexadecimal number systems; Methods of base conversions; Binary and hexadecimal arithmetic; Representation of signed numbers; Fixed and floating point numbers; Binary coded decimal codes; Gray codes; Excess 3 code. Alphanumeric codes: ASCII. Basics of verilog -- basic language elements: identifiers, data objects, scalar data types, operators. **Boolean Postulates and Fundamental Gates** : Boolean postulates and laws – Logic Functions and Gates De-

Morgan's Theorems, Principle of Duality, Minimization of Boolean expressions, Sum of Products (SOP), Product of Sums (POS), Canonical forms, Karnaugh map Minimization. Modeling in verilog, Implementation of gates with simple verilog codes. **Combinatorial and Arithmetic Circuits** : Combinatorial Logic Systems - Comparators, Multiplexers, Demultiplexers, Encoder, Decoder. Half and Full Adders, Subtractors, Serial and Parallel Adders, BCD Adder. Modeling and simulation of combinatorial circuits with verilog codes at the gate level. **Sequential Logic Circuits:** Building blocks like S-R, JK and Master-Slave JK FF, Edge triggered FF, Conversion of Flipflops, Excitation table and characteristic equation. Implementation with verilog codes. Ripple and Synchronous counters and implementation in verilog, Shift registers-SIPO, SISO, PISO, PIPO. Shift Registers with parallel Load/Shift, Ring counter and Johnsons counter. Asynchronous and Synchronous counter design, Mod N counter. Modeling and simulation of flipflops and counters in verilog. **Logic families and its characteristics:** TTL, ECL, CMOS - Electrical characteristics of logic gates – logic levels and noise margins, fan-out, propagation delay, transition time, power consumption and power-delay product. TTL inverter - circuit description and operation; CMOS inverter - circuit description and operation; Structure and operations of TTL and CMOS gates; NAND in TTL and CMOS, NAND and NOR in CMOS.

Module-3 (20 Marks)

Mesh and Node Analysis : Mesh and node analysis of network containing independent and dependent sources. Supermesh and Supernode analysis. Steady-state AC analysis using Mesh and Node analysis. **Network Theorems** : Thevenin's theorem, Norton's theorem, Superposition theorem, Reciprocity theorem, Maximum power transfer theorem. (applied to both dc and ac circuits having dependent source). **Application of Laplace Transforms :** Review of Laplace Transforms and Inverse Laplace Transforms, Initial value theorem & Final value theorem, Transformation of basic signals and circuits into s-domain. Transient analysis of RL, RC, and RLC networks with impulse, step and sinusoidal inputs (with and without initial conditions). Analysis of networks with transformed impedance and dependent sources **Network functions** : Network functions for the single port and two port network. Properties of driving point and transfer functions. Significance of Poles and Zeros of network functions, Time domain response from pole zero plot. Impulse Function & Response. Network functions in the sinusoidal steady state, Magnitude and Phase response. **Two port network Parameters** : Impedance, Admittance, Transmission and Hybrid parameters of two port network. Interrelationship among parameter sets. Series and parallel connections of two port networks. Reciprocal and Symmetrical two port network. Characteristic impedance, Image impedance and propagation constant (derivation not required).

Module-4 (20 Marks)

Elements of communication systems, Examples of analog communication systems, Frequency bands, Need for modulation. Noise in communication system, Definitions of Thermal noise (white noise), Various types of noise -- Shot noise, Partition noise, Flicker noise, Burst noise, (No analysis required) Signal to noise ratio, Noise factor, Noise temperature, Narrow band noise. **Amplitude modulation** (AM), Double-side band suppressed carrier (DSB-SC) modulation Single sideband modulation (SSB) – spectrum, power, efficiency of all the three variants. (Study of only tone modulation in DSB-SC, AM, and SSB.)

Amplitude-modulator implementations – switching modulator, balanced modulator. AM demodulators -- Coherent demodulator. Envelope detector. **Frequency modulation** – modulation index, frequency deviation, average power, spectrum of tone modulated FM. Heuristics for bandwidth of FM. Narrow band FM and wide-band FM. FM generation: Varactor diode modulator, Armstrongs method. FM demodulation – slope detection, PLL demodulator. Module V Superheterodyne reciever, Principle of Carrier synchronization using PLL, NTSC Television broadcasting. **Elements of digital communication system**: Sources, channels and receivers. Classification of communication channels. Discrete sources. Source coding techniques. Waveform coding methods. Sampling theorem. Sampling and reconstruction. Pulse code modulation. Sampling, quantization and encoding. Different quantizers. A-law and mu-law quantization. Practical 15 level mu and A law encoding. **Nonlinear Source Coding:** Differential PCM, adaptive PCM, Delta modulator and adaptive delta modulator. Issues in delta modulation. Slope overload. **Signaling Codes in Telephony** : Signalling codes in digital telephony. T1 signalling system. AMI and Manchester codes. Binary Nzero substitution, B3ZS code, B6ZS code. **Digital Modulation Schemes** : Digital modulation schemes. Baseband BPSK system and the signal constellation. BPSK transmitter and receiver. Base band QPSK system and Signal constellations. Plots of BER Vs SNR (Analysis not required). QPSK transmitter and receiver. Quadrature amplitude modulation. **Channel Coding and Receivers** : Transmission through AWGN Channel. Capacity of an AWGN channel. Receivers. Correlation and matched filter receiver. Channel coding schemes. Repetition code. Block codes Cyclic codes.

Module-5 (20 Marks)

Introduction to Continuous Time Signals : Definition of signal. Basic continous-time signals. Frequency and angular frequency of continoustime signals . Basic operation on signals. Classification of continous-time signals:Periodic and Nonperiodic signals.Even and Odd signals, Energy and power signals. Noise and Vibration signals. **Discrete Time Signals** : Basic discrete-time signals. Frequency and angular frequency of discrete-time signals.Classification of discrete-time signals:Periodic and Non-periodic signals.Even and Odd signals, Energy and power signals. **Systems** : System definition. Continuous-time and discrete-time systems. Properties – Linearity, Time invariance, Causality, Invertibility,Stability. Representation of systems using impulse response. **Linear time invariant systems** : LTI system definition. Response of a continous-time LTI system and the Convolutional Integral. Properties. Response of a discrete-time LTI system and the Convolutional Sum. Properties. Correlation of discrete-time signals **Frequency analysis of signals :** Concept of frequency in continous-time and discrete-time signals. Fourier transform of continuous time and discrete-time signals. Parsevals theorem. Interpretation of Spectra. The sampling theorem. **Signal Processing Fundamentals** : Discrete-time and digital signals. Basic elements of digital processing system- ADC, DAC and Nyquist rate. Frequency aliasing due to sampling. Need for anti-aliasing filters. Discrete Time Fourier Transforms – Properties. Computation of spectrum. **Discrete Fourier Transform** – Properties and Application Discrete Fourier transform - DFT as a linear transformation, Properties - circular convolution, Relationship of the DFT to other transforms, IDFT, Properties of DFT and examples. Filtering of long data sequences - FFT-Radix-2 DIT and DIF algorithms. Computational complexity of DFT and FFT -application. **Digital Filters** Digital FIR Filter: Transfer function - Difference equation, Linear phase FIR filter, Concept of windowing, Direct form and cascade realization of FIR and IIR filters. Digital IIR Filters - Transfer function, Difference equation. Direct and parallel

Structures. Design of analogue Butterworth filters, Analog frequency transformations, Impulse invariance method. Bilinear transformation, Analog prototype to digital transformations. Finite word length effects in digital filters and DSP Hardware Fixed point arithmetic, Floating point arithmetic, Truncation and Rounding, Quantization error in ADC, Overflow error, Product round off error, Scaling , Limit cycle oscillation. General and special purpose hardware for DSP: Computer architectures for DSP – Harvard, pipelining, MAC, special instruction, replication, on chip cache. General purpose digital signal processors (TMS 320 family) - Implementation of digital filtering on dsp processor. Special purpose DSP hardware

Module-6 (20 Marks)

Wave shaping circuits: First order RC differentiating and integrating circuits, First order RC low pass and high pass filters. Diode Clipping circuits - Positive, negative and biased clipper. Diode Clamping circuits - Positive, negative and biased clamper. Transistor biasing: Need, operating point, concept of DC load line, fixed bias, self bias, voltage divider bias, bias stabilization. **BJT Amplifiers:** RC coupled amplifier (CE configuration) – need of various components and design, Concept of AC load lines, voltage gain and frequency response. Small signal analysis of CE configuration using small signal hybrid-pi model for mid frequency and low frequency. (gain, input and output impedance). High frequency equivalent circuits of BJT, Miller effect, Analysis of high frequency response of CE amplifier. **MOSFET amplifiers:** MOSFET circuits at DC, MOSFET as an amplifier, Biasing of discrete MOSFET amplifier, small signal equivalent circuit. Small signal voltage and current gain, input and output impedance of CS configuration. CS stage with current source load, CS stage with diode-connected load. Multistage amplifiers - effect of cascading on gain and bandwidth. Cascode amplifier. **Feedback amplifiers:** Effect of positive and negative feedback on gain, frequency response and distortion. The four basic feedback topologies, Analysis of discrete BJT circuits in voltage-series and voltage-shunt feedback topologies - voltage gain, input and output impedance. **Oscillators:** Classification, criterion for oscillation, Wien bridge oscillator, Hartley and Crystal oscillator. (working principle and design equations of the circuits; analysis of Wien bridge oscillator only required). **Power amplifiers:** Classification, Transformer coupled class A power amplifier, push pull class B and class AB power amplifiers, complementary-symmetry class B and Class AB power amplifiers, efficiency and distortion (no analysis required) Regulated power supplies: Shunt voltage regulator, series voltage regulator, Short circuit protection and fold back protection, Output current boosting.

Module-7 (20 Marks)

Computer Arithmetic and Processor Basics : Algorithms for binary multiplication and division. Fixed and floating-point number representation. Functional units of a computer, Von Neuman and Harvard computer architectures, CISC and RISC architectures. Processor Architecture – General internal architecture, Address bus, Data bus, control bus. Register set – status register, accumulator, program counter, stack pointer, general purpose registers. Processor operation – instruction cycle, instruction fetch, instruction decode, instruction execute, timing response, instruction sequencing and execution (basic concepts, datapath. **8051 Architecture Microcontrollers and Embedded Processors :** Architecture

– Block diagram of 8051, Pin configuration, Registers, Internal Memory, Timers, Port Structures, Interrupts. Assembly Language Programming - Addressing Modes, Instruction set (Detailed study of 8051 instruction set is required). **Programming and Interfacing of 8051**: Simple programming examples in assembly language. Interfacing with 8051 using Assembly language programming: LED, Seven segment LED display. Programming in C - Declaring variables, Simple examples – delay generation, port programming, code conversion. Interfacing of – LCD display, Keyboard, Stepper Motor, DAC and ADC -- with 8051 and its programming. **Advanced Concepts** : 8051 Timers/Counters - Modes and Applications. Serial Data Transfer – SFRs of serial port, working, Programming the 8051 to transfer data serially. Introduction to ARM - ARM family, ARM 7 register architecture. ARM programmer's model. System software - Assembler, Interpreter, Compiler, Linker, Loader, Debugger. **The Memory System** : Types of memory - RAM, ROM. Memory Characteristics and Hierarchy. Cache memory – The basics of Caches, Mapping techniques, Improving Cache performance. Virtual memory – Overlay, Memory management, Address translation. Input/Output Organization – Introduction, Synchronous vs. asynchronous I/O, Programmed I/O, Interrupt driven I/O, Direct Memory Access.

Module-8 (20 Marks)

Operational amplifiers(Op Amps): The 741 Op Amp, Block diagram, Ideal op-amp parameters, typical parameter values for 741, Equivalent circuit, Open loop configurations, Voltage transfer curve, Frequency response curve. Differential Amplifiers: Differential amplifier configurations using BJT, DC Analysis- transfer characteristics; AC analysis- differential and common mode gains, CMRR, input and output resistance, Voltage gain. Constant current bias, constant current source; Concept of current mirror-the two transistor current mirror, Wilson and Widlar current mirrors. **Op-amp with negative feedback:** General concept of Voltage Series, Voltage Shunt, current series and current shunt negative feedback, Op Amp circuits with voltage series and voltage shunt feedback, Virtual ground Concept; analysis of practical inverting and non-inverting amplifiers for closed loop gain, Input Resistance and Output Resistance. Op-amp applications: Summer, Voltage Follower-loading effects, Differential and Instrumentation Amplifiers, Voltage to current and Current to voltage converters, Integrator, Differentiator, Precision rectifiers, Comparators, Schmitt Triggers, Log and antilog amplifiers. **Op-amp Oscillators and Multivibrators:** Phase Shift and Wien-bridge Oscillators, Triangular and Sawtooth waveform generators, Astable and monostable multivibrators. Active filters: Comparison with passive filters, First and second order low pass, High pass, Band pass and band reject active filters, state variable filters. **Timer and VCO**: Timer IC 555- Functional diagram, Astable and monostable operations;. Basic concepts of Voltage Controlled Oscillator and application of VCO IC LM566, Phase Locked Loop – Operation, Closed loop analysis, Lock and capture range, Basic building blocks, PLL IC 565, Applications of PLL. **Voltage Regulators:** Fixed and Adjustable voltage regulators, IC 723 – Low voltage and high voltage configurations, Current boosting, Current limiting, Short circuit and Fold-back protection. Data Converters: Digital to Analog converters, Specifications, Weighted resistor type and R-2R Ladder type. Analog to Digital Converters: Specifications, Flash type and Successive approximation type.

Module-9 (20 Marks)

Control Systems Introduction: Basic Components of a Control System, Open-Loop Control Systems and Closed-Loop Control Systems, Examples of control system Feedback and its effects: Types of Feedback Control Systems, Linear versus Nonlinear Control Systems, Time-Invariant versus Time-Varying Systems. Mathematical modelling of control systems: Electrical Systems and Mechanical systems. Transfer Function from Block Diagrams and Signal Flow Graphs: impulse response and its relation with transfer function of linear systems. Block diagram representation and reduction methods, Signal flow graph and Mason's gain formula. **Time Domain Analysis of Control Systems:** Introduction- Standard Test signals, Time response specifications. Time response of first and second order systems to unit step input and ramp inputs, time domain specifications. Steady state error and static error coefficients. **Frequency domain analysis:** Frequency domain specifications, correlation between time and frequency responses. **Stability of linear control systems:** Concept of BIBO stability, absolute stability, Routh Hurwitz Criterion, Effect of P, PI & PID controllers. Root Locus Techniques: Introduction, properties and its construction, Application to system stability studies. Illustration of the effect of addition of a zero and a pole. Nyquist stability criterion: Fundamentals and analysis Relative stability: gain margin and phase margin. Stability analysis with Bode plot. Design of Compensators: Need of compensators, design of lag and lead compensators using Bode plots. **State Variable Analysis of Linear Dynamic Systems:** State variables, state equations, state variable representation of electrical and mechanical systems, dynamic equations, merits for higher order differential equations and solution. Transfer function from State Variable Representation, Solutions of the state equations, state transition matrix Concept of controllability and observability and techniques to test them - Kalman's Test.

Module-10 (20 Marks)

Optical Communication System – Block Diagram – Advantages Of Optical Fiber Communication Systems – Principles Of Light Transmission In A Fiber Using Ray Theory – Single Mode Fibers, Multimode Fibers – Step Index Fibers, Graded Index Fibers (Basic Concepts Only) – Attenuation In Optical Fibers – Absorption Losses, Scattering Losses, Bending Losses, Core And Cladding Losses. Optical transmitters: LED and semiconductor LASER, characteristics, transmitter design. Optical receivers: Common photo detectors. Receiver design. **Basic Radar System**– Applications – Radar Range Equation (Qualitative Treatment Only) – Factors Influencing Maximum Range – Basic Pulsed Radar System – Block Diagram – Display Methods- A - Scope, PPI Display - Instrument Landing System – Ground Controlled Approach System. **Cellular Communication**, Hand off, Frequency Reuse, Principles of Multicarrier communication, Multiple Access techniques, CDMA Systems: General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, GSM standard and service aspects – GSM architecture, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards,4G, 5G Module 4 (Satellite Communication) Basic concept of satellite communication, Keppler's law, Satellite orbits, Geosynchronous satellites, Active and Passive satellite, Block diagram for Satellite uplink, Transponder and earth station receiver. **Data Communication and Networks :** Study of OSI and TCP/IP protocol suit: The Model, Functions of

each layer, TCP/IP Protocol Suites. Wireless Ad Hoc Networks: Issues and Challenges, Wireless Sensor Networks: Architecture, Data dissemination, Data gathering, MAC Protocols, Location discovery, Quality of a sensor network 6LoWPAN, **Microwaves and Antenna-** Basic antenna parameters: gain, directivity, beam width and effective aperture calculations, effective height, wave polarization, radiation resistance, radiation efficiency, antenna field zones. Duality and Principles of reciprocity, Helmholtz theorem (derivation required), Field, directivity and radiation resistance of a short dipole and half wave dipole (far field derivation). **Broad band antenna:** Principle of Log periodic antenna array and design, Helical antenna: types and design. Designof Microstrip RectangularPatchantennas and feeding methods. Principles of Horn, Parabolic dish antenna (expression for E, H and Gain without derivation), Mobile phone antenna – Inverted F antenna, Arrays of point sources, field of two isotropic point sources, principle of pattern multiplication, linear arrays of 'n' isotropic point sources. Array factor, Grating lobes. Design of Broadside, End fire and Dolph Chebyshevarrays. Concept of Phase array, **Microwaves :** Introduction, advantages, Cavity Resonators- Derivation of resonance frequency of Rectangular cavity. Single cavity klystron- Reflex Klystron Oscillators: Derivation of Power output, efficiency and admittance. Magnetron oscillators: Cylindrical magnetron, Cyclotron angular frequency, Power output and efficiency. Travelling Wave Tube: Slow wave structures, Helix TWT, Amplification process, Derivation of convection current, axial electric field, wave modes and gain.

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KERALA PUBLIC SERVICE COMMISSION

**SYLLABUS FOR THE POST OF
RANGE FOREST OFFICER IN
KERALA FOREST & WILDLIFE DEPARTMENT**

Optional subject- CIVIL ENGINEERING

	TOPIC	MARKS
1	**Construction Materials and Management:**	**15 marks**
	Physical and Chemical properties, classification, standard tests, uses and manufacture/quarrying of materials e.g. building stones, silicate based materials, cement, asbestos products, timber and wood based products, bituminous materials; Construction Materials: Structural Steel – Composition, material properties and behaviour; Concrete - Constituents, Advantages and uses of concrete, cement aggregates, importance of water quality, water cement ratio, workability, mix design, storage, batching, mixing, placement, compaction, finishing and curing of concrete, quality control of concrete, mix design, short term and long-term properties. Construction Management: Types of construction projects; Project planning and network analysis - PERT and CPM;	
2	**Estimating, Costing and Valuation:**	**15 marks**
	Estimation: methods and unit of measurement, Buildings, roofs, RCC and steel works, structures, sanitary and water supply works, Road, irrigation works. *Analysis of rates*: Items of work – earthwork, Brick work (Modular & Traditional bricks), RCC work, Shuttering, Timber work, Painting, Flooring, Plastering. Boundary wall, Brick building, Water Tank, Septic tank, Bar bending schedule, Centre line method, Midsection formula, Trapezoidal formula, Simpson's rule.	

	Valuation: Value and cost, scrap value, salvage value, assessed value, sinking fund, depreciation and obsolescence, methods of valuation	
3	**Geotechnical Engineering**:	**30 marks**
	Soil Mechanics : Three-phase system and phase relationships, index properties; Definitions-void ratio, porosity, degree of saturation, water content, specific gravity of soil grains, unit weights, density index and interrelationship of different parameters, Grain size distribution curves and their uses. Atterberg's limits, ISI soil classification and plasticity chart. Permeability of soil: coefficient of permeability, determination of coefficient of permeability, Unconfined and confined aquifers, effective stress, quick sand, consolidation of soils: Principles of consolidation, degree of consolidation, normally consolidated soil, e-log p curve, computation of ultimate settlement. Shear strength of soils, direct shear test, Vane shear test, Triaxial test. Soil compaction, Laboratory compaction test, Maximum dry density and optimum moisture content, earth pressure theories, active and passive earth pressures, Bearing capacity of soils, plate load test, standard penetration test. *Foundation Engineering:* Sub-surface investigations - Drilling bore holes, sampling, plate load test, standard penetration and cone penetration tests; Earth pressure theories - Rankine and Coulomb; Stability of slopes – Finite and infinite slopes, Stress distribution in soils – Boussinesq's theory; Pressure bulbs, Shallow foundations – Terzaghi's and Meyerhoff's bearing capacity theories, effect of water table; Combined footing and raft foundation; Settlement analysis in sands and clays;	
4	**Structural Engineering**	**30 marks**
	Solid Mechanics: Bending moment and shear force in statically determinate beams; Simple stress and strain relationships; Simple bending theory, flexural and shear stresses, shear centre; Uniform torsion, Transformation of stress; buckling of column, combined and direct bending stresses. *Structural Analysis*: Statically determinate and indeterminate	

	structures by force/ energy methods; Method of superposition; Analysis of trusses, arches, beams, cables and frames; Displacement methods: Slope deflection and moment distribution methods; Influence lines; Stiffness and flexibility methods of structural analysis. *RCC Structures*: Working stress and Limit state design concepts; RCC beams-flexural strength, shear strength, bond strength, design of singly reinforced and double reinforced beams, cantilever beams. T-beams, lintels. One way and two way slabs, Columns with axial and eccentric loading, isolated footings, staircases, retaining wall, water tanks. *Steel Structures:* Working stress and Limit state design concepts; Design of tension and compression members, beams and beam-columns, column bases; Connections – Bolted and welded, simple and eccentric, beam-column connections, trusses; Concept of plastic analysis - beams and frames.	
5	**Surveying** :	20 marks
	Common methods and instruments for distance and angle measurement for CE work—their use in plane table, traverse survey, levelling work, triangulation, contouring and topographical map.	
6	**Water Resources Engineering**	30 marks
	Fluid Mechanics: Properties of fluids, fluid statics; Continuity, momentum and energy equations and their applications; Potential flow, Laminar and turbulent flow; Flow in pipes, pipe networks; Concept of boundary layer and its growth; Concept of lift and drag. Hydraulics: Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow, hydraulic jump, uniform flow, gradually varied flow and water surface profiles. Hydrology: Hydrologic cycle, precipitation, evaporation, evapo-transpiration, watershed, infiltration, unit hydrographs, hydrograph analysis, reservoir capacity, flood estimation and routing, surface run-off models, ground water hydrology - steady state well hydraulics and aquifers; Application of Darcy's Law. Irrigation: Types of irrigation systems and methods; Crop water requirements - Duty, delta, evapo-transpiration; Gravity Dams and Spillways; Lined and unlined canals, Design of weirs on permeable foundation; cross drainage structures.	
7	**Transportation Engineering**:	30 Marks
	Highway Engineering – cross sectional elements, geometric design,	

	types of pavements, pavement materials – aggregates and bitumen, different tests, Design of flexible and rigid pavements – Water Bound Macadam (WBM) and Wet Mix Macadam (WMM), Gravel Road, Bituminous construction, Rigid pavement joint, pavement maintenance, Highway drainage, Railway Engineering- Components of permanent way – sleepers, ballast, fixtures and fastening, track geometry, points and crossings, track junction, stations and yards. Traffic Engineering – Different traffic survey, speed-flow-density and their interrelationships, intersections and interchanges, traffic signals, traffic operation, traffic signs and markings, road safety	
8	**Environmental Engineering**:	**30 Marks**
	Water and Waste Water Quality and Treatment: Basics of water quality standards – Physical, chemical and biological parameters; Water quality index; Unit processes and operations; Water requirement; Water distribution system; Drinking water treatment. Sewerage system design, quantity of domestic wastewater, primary and secondary treatment. Effluent discharge standards; Sludge disposal; Reuse of treated sewage for different applications. Air Pollution: Types of pollutants, their sources and impacts, air pollution control, air quality standards, Air quality Index and limits. Municipal Solid Wastes: Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal).	

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KERALA PUBLIC SERVICE COMMISSION

SYLLABUS FOR THE POST OF
RANGE FOREST OFFICER IN
KERALA FOREST & WILDLIFE DEPARTMENT

Optional subject- Forestry

Module 1   **15 marks**

Definition of forest and forestry. Classification of forest and forestry, branches of forestry and their relationships. Definition, objectives and scope of Silviculture. Status of forests in India and their role. History of forestry development in India. Trees and their distinguishing features. Growth and development. Forest reproduction. Site factors. Classification of climatic factors. Role played by light, temperature, rainfall, snow,   wind, humidity and evapo-transpiration in relation to forest vegetation. Bioclimatic and micro climate effects. Edaphic factors - influence of biological agencies, parent rock, topography on the   soil formation. Soil profile – physical and chemical properties. Physiographic factors - influence of altitude, latitude, aspect and slope on vegetation. Biotic factors - influence of plants, insects, wild animals, man and domestic animals on vegetation.. Influence of forests on environment. Tending and cultural operations. Thinning-kinds of thinning - improvement felling- salvage cuttings- pruning- pollarding, lopping. Forest types of India and their distribution. Plant- forest succession, competition and tolerance.

Module 2   **20 marks**

Regeneration of forests – objectives, ecology of regeneration- Natural and Artificial regeneration. Advance growth, coppice, root sucker. Regeneration survey. Artificial regeneration. Factors governing the choice of regeneration techniques. Choice of species. Preparation of planting material - field planting-site preparation- planting density spacing -marking- boundary demarcation, fencing, alignment and staking-kinds of pit making-patterns of planting, Plant protection and sanitation measures, - forest nutrition- fertilization in trees. Silvicultural system -definition, scope and classification. Even aged and uneven aged forests and their crown classes. Detailed study of the silvicultural systems: Clear felling systems including clear strip, alternate strip and progressive strip systems. Shelterwood system -Uniform system, Group system, Shelterwood strip system, Wedge system, Strip and group system, Irregular shelterwood system, Indian irregular shelterwood system. Seed tree method. Selection system and its modifications. Accessory systems. Coppice system -Simple coppice system, Coppice of the two rotation system, Shelterwood coppice system, Coppice with standard system, Coppice-

with-reserve system, Coppice selection system, Pollard system. Conversion and its implications. Choice of silvicultural system. Dauerwald concept. Culm selection system in Bamboo, Silvicultural systems followed in other countries. Plantation silviculture - Choice of species- Plantation establishment- Plantation maintenance-. Nutrition in plantations- nutrient deficiencies, symptoms of deficiency- use of fertilizers- - Major pest and disease in plantations. Dynamics of stand growth- stand density management in plantations- spacing-planting density regulation- Thinning regimes- improvement fellings- CCF-MCA- Site quality evaluation- stand basal area site index concept in plantation forestry- plantation productivity assessment- growing stock assessment Clonal plantations. LULUCF and REDD concepts, AR-CDM concepts.

Module 3   10 marks

Propagation through seeds; seed germination, seed dormancy. Seed biology. Production of quality seeds; Candidate tree, plus tree and elite seed tree. Seed production areas; establishment and management of SPA. Seed orchards; types of seed orchard, establishment and management of seed orchards. Seed collection; planning and organization, seed collection methods, factors affecting choice of seed collection methods, seed maturity tests, precaution for handling of recalcitrant seeds. Seed processing. Seed storage. Seed testing. Classes of tree seeds, certification procedure of tree seeds. Vegetative propagation techniques: cuttings, factors affecting rooting of cuttings budding, layering and grafting. Propagation through specialized organs like bulb, rhizome, corm, runners and suckers. Micro-propagation. Establishments of nursery: types of nursery, site selection, planning and layout of nursery area. Nursey growing containers and media.

Module 4   15 marks

Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems, and economic importance of the following tree species of India. Broadleaved species: *Tectona grandis, Shorea robusta, Dalbergia latifolia, Dalbergia sissoo, Anogeissus spp, Terminalia spp., Santalum album, Swietenia macrophylla, Albizia spp, Santalum album, Pterocarpus marsupium, Gmelina arborea, Pterocarpus santalinus, Azadirachta indica, Hopea parviflora, Lagerstroemia microcarpa, Bamboos, reeds and rattan, Quercus spp.* Conifers*: Abies pindrow, Picea smithiana, Cedrus deodara, Pinus roxburghii, Pinus wallichiana*. Fast growing MPTs*:,Tropical pines, Eucalyptus spp, Casuarina equisetifolia, Leucaena leucocephala, Ailanthus triphysa, Grevillea robusta, Pongamia pinnata, Melia dubia, Acacia spp, Populus spp*

Module 5   **15 marks**

Agroforestry definition and scope. History of agroforestry. Classification of agroforestry system - structural, functional, socioeconomic, and ecological basis. Traditional agroforestry systems: shifting cultivation, taungya, homegardens. Land capability classification and land use . Plantation agriculture and plantation forestry. Choice of species for agroforestry. Provisional and regulatory services of agroforestry- Food and nutritional security- Tree crop interactions in Agroforestry-Positive and Negative interactions. Industrial agroforestry concept and importance. Agroforestry systems in different agro climatic zones, components, production and management techniques. Alley cropping, High-density short rotation plantation systems, silvicultural woodlots/energy plantations. Different types of Pastoral siviculture and silvopastoral systems Silvoagriculture systems- Agrosilviulture, Pastoral silviculture , Silvopastoral and Agrosilvopastoral systems and their mangement; agrihortisilviculture, silvihorticulture, hortipastoral , aquaforestry, shelterbelts and windbreaks ; live fences; fodder trees and protein banks. Canopy management. Diagnosis and design methods and approaches. Biophysical and ecological functions of agroforestry: Nutrient cycling and role of agroforestry in soil and water conservation. Carbon sequestration-Climate change mitigation and phytoremediation. Adverse effects of trees on soils - competition, allelopathy – causes and mechanisms. Soil fertility considerations in Agroforestry – nutrient needs of trees and crops, activities of soil fauna and microorganisms affecting plant growth. People's participation, rural entrepreneurship through Agroforestry and industrial linkages. Financial and socio-economic analysis of Agroforestry systems. Evaluation of tangible and intangible benefits.

Module 6   **20 marks**

Forest Protection – classification of injurious agencies. Forest Fire - causes and Management. Injury to forest due to man, lopping – fuel wood collection – Encroachment- - method of control. Forest weeds and weed management, management of woody climbers, parasites and epiphytes. Forest Pathology- tree disease classification, Principles of tree disease management, - Causes and symptoms- losses due to forest tree diseases, root diseases (wilt, root- and butt rot), stem diseases (heart rots, stem blisters, rusts, stem wilt, cankers, pink diseases, gummosis, water blister) and foliar diseases (rust, powdery mildew, leaf spot, leaf and twig blight, abnormal leaf fall, needle blight etc.) of Etiology, symptoms, mode of spread, epidemiology and management, including chemical, biological, cultural and silvicultural practices. Nursery diseases and their management. Disease due to physiological causes. Abiotic diseases. Forest Entomology in India. Methods and principles of pest control: Mechanical, physical, silvicultural, legal, biological and chemical. Principles and techniques of Integrated Pest Management in forests. Classification of forest pests: types of damages and symptoms; factors for outbreak of pests. Nature of damage and management: Insect pests of forest seeds, forest nursery and

standing trees of timber yielding species of natural forest and Plantation forest species. Insect pests of freshly felled trees, finished timbers and their management.

Module 7   15 marks

Forest Mensuration- Definition, objectives and scope of forest mensuration. Scales and Units of measurement, error and accuracy. Measurement of individual tree parameters. Bark measurements. Crown measurement . Height measurement –principles, instruments.Trees stem form- classification of form factors and form quotient. Volume tables- classification and preparation. Tree biomass- estimation methods. Age determination of tree- objective and methods. Tree growth measurement –stump analysis, stem analysis and increment boring. Measurement of tree crops –crop diameter, crop height, crop age and crop volume. Stand growth, site quality, site index, stand structure, yield tables, preparation and stand table. Forest inventory – definition objectives, kinds of enumeration. Sampling- definition, advantages, kinds of sampling, random sampling, Non random sampling. Point sampling- horizontal and vertical point sampling.

Module 8   15 marks

Forest Management - Scope, Objective and Principles. Organization of state forests.. Sustained yield-definition, Principles and limitations increasing and progressive yields. Sustainable Forest Management-Criteria and Indicators- Rotation-definitions-various types of Rotations-length of rotations choice of type and kind of rotation. Normal forest-definitions basic factors of normality. Growing stock, Estimation of growing stock. Yield regulation- concept, basis and yield regulation models- Estimation of growth and yield prediction in forest stands- Stand structure - Stand density - Working plan-Working Plan Code 2014- preparations objectives and uses-forest maps and their uses. Joint forest management - Modern tools in forest management. Concept and Importance of Ecotourism.

Module 9   15 marks

Tree improvement. Reproduction in forest trees. Anthesis and pollination – their importance in tree breeding. Incompatibility and sterility. Quantitative inheritance- Genetic, environmental and interaction components of variation - heritability and genetic advance. Genetic basis of tree breeding. Natural variability in trees – types and importance.- forces that change variability. Exotic forestry. Provenance testing. Selection- seed production areas–seed orchards. Progeny trial and improvement of seed orchards. Combining ability and genetic gain – Hybridization in trees – back cross breeding, heterosis breeding. Mutation breeding; Ploidy breeding. Breeding

procedures for development of hybrids, / varieties of various crops. DUS testing, Concepts of Geographical indications. Artificial hybrids in trees crossing in trees-problems and perspectives. Breeding for resistance to insect pests' diseases, air pollution and for wood properties. Vegetative propagation and Clonal forestry. Conservation of forest tree germplasm.

Module 10   20 marks

Wood as raw material - merits and demerits of wood as raw material. Kinds of woods. Physical properties of wood–density and specific gravity; wood and water relationship-moisture content, shrinkage, swelling, movement, fibre saturation point, equilibrium moisture content; electrical, thermal and acoustic properties of wood. Mechanical properties of wood- tension, compression, static bending, impact bending, shear, indentation, torsion, cleavage and nail and screw pulling test. Suitability of wood for various end uses based on mechanical and physical properties. Wood seasoning – Introduction, principles, objectives and importance of wood seasoning; classification of timber based on seasoning behaviour; seasoning methods – air seasoning, kiln seasoning, type of kilns and drying schedules, special seasoning methods; seasoning defects and their control. Wood preservation– principles, processes, need, types of wood preservatives. classification of timbers based on durability, general idea about fire retardants and their usage. Non-pressure methods – steeping, dipping, soaking open tank process, Boucherie process. Pressure methods – full cell process, empty cell process (Lowry and Rueping). Wood machining: Sawing milling– sawing techniques; Saw mill machineries-cross-cutting machines, head saws re-saws. Wood working- wood working machineries**.** Dimensional stabilization of wood by surface coating method, bulking method, impregnation of resins and polymers. Wood finishing. Pulping-mechanical, chemical, semichemical and semi-mechanical- manufacture of rayon and other cellulose derived products. Manufacture, properties and uses of Composite wood-plywood, fiberboard, particleboard and hard board. Improved wood-types . Destructive distillation of wood. Saccharification of wood. Production of wood molasses, alcohol and yeast. Structural uses of Timber. Decorative uses of wood. Wood carving and handicrafts. Nano technology in wood.. Other forest based industries – veneer, sawn wood, furniture, bamboo, sports goods, pencil making, match box and splint making.

Module 11   10 marks

Collection and management and importance of Non-Timber Forest Products (NTFP). Fodder (grasses and tree leaves), canes and bamboos. Essential Oils and Non-essential oils. Important fixed oil yielding trees. Gums and resins - Resins and Oleoresins, Tans, Dyes , Beedi leaves , Fibers and flosses, Katha and Cutch, Drugs, spices, wild edible plants . Animal products – honey and wax, silk, lac, fish, Wild edible animal products. Mineral products and other miscellaneous products.

Module 12   **15 marks**

History of Wildlife in India; Values of Wildlife, Basic requirements of wildlife –Food chain, Food web, Ecological pyramids; Wildlife Ecology: Biotic factors, Biological basis of wildlife, Productivity; Effect of light and temperature on animals; Zoogeographical regions and biomes of the world; Wildlife Habitat, Animal behavior and adaptation; Wildlife census; Habitat Improvement; Captive wildlife: Zoos and safari parks, Captive breeding for conservation, Central zoo authority of India. Principles and practices of wildlife management; Forest and wildlife management in India. Population Management. Species conservation projects. Wildlife Management plan for Protected Areas; *In-situ* and *Ex-situ* management/ conservation. Man-animal conflict and its management; Red data book and IUCN; Wildlife Ecotourism: sustainable tourism and people's participation; Agencies in wildlife conservation: IUCN, CITES, WWF, IBWL; Community participation in wildlife management; Case studies; Wildlife policies and legislation.

Module 13   **15 marks**

Forest Policy: definition, necessity and scope. Legal and institutional approaches to forest resource management. Legal rights- types of legal rights, law of evidence, admission, confession, punishments. Constitutional provisions related to forest conservation. Indian National Forest Policies-NFP-1894, NFP, 1952 and NFP, 1988, Forest Law: legal definition. Indian Evidence Act, 1872 as applied to forestry matters. Indian Forest Act. Detailed study of IFA 1927. Forest (Conservation) Act, 1980 and its amendments. The Biological Diversity Act, 2002 and amendmends. The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006. Indian Penal Code and Criminal Procedure Code related to forests. National Green Tribunal.

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