

**महाराष्ट्र वन सेवा (मुख्य) परीक्षा**  
**Maharashtra Forest Services (Main) Examination**

-: परीक्षा योजना :-

(१)	लेखी परीक्षा	४०० गुण (एकूण पेपर-२)
(२)	मुलाखत	५० गुण
	एकूण गुण	४५० गुण

विषय	गुण	दर्जा	माध्यम	कालावधी	प्रश्नपत्रिकेचे स्वरूप
वैकल्पिक विषय - १	२००	पदवी	इंग्रजी	३ तास	पारंपारिक / वर्णनात्मक
वैकल्पिक विषय - २	२००	पदवी	इंग्रजी	३ तास	

**List of Optional Subjects / वैकल्पिक विषयाची यादी**

(1)	Agriculture	(8)	Forestry
(2)	Agricultural Engineering	(9)	Geology
(3)	Animal Husbandry and Veterinary Science	(10)	Mathematics
(4)	Botany	(11)	Mechanical Engineering
(5)	Chemical Engineering	(12)	Physics
(6)	Chemistry	(13)	Statistics
(7)	Civil Engineering	(14)	Zoology

**Provided that the candidates will not be allowed to offer the following combination of subjects :**

- Agriculture and Agricultural Engineering.
- Agriculture and Animal Husbandry & Veterinary Science.
- Agriculture and Forestry.
- Chemistry and Chemical Engineering.
- Mathematics and Statistics.
- Of the Engineering subjects viz. Agricultural Engineering, Chemical Engineering, Civil Engineering and Mechanical Engineering—not more than one subject;

## 1. AGRICULTURE ( Subject Code – 1076)

Ecology and its relevance to man, natural resources, their sustainable management and conservation. Physical and social environment as factors of crop distribution and production. Climatic elements as factors of crop growth.

Cropping pattern in different agro-climatic zones of Maharashtra. Concepts of multiple cropping, multistorey, relay and intercropping, and their importance in relation to food production. Package of practices for production of important cereals, pulses, oil seeds, fibres, sugar, commercial and fodder crops grown during Kharif and Rabi seasons. Important features, scope and propagation of various types of forestry plantations such as extension, social forestry, agro-forestry, and natural forests.

Weeds, their characteristics, dissemination and association with various crops; their multiplication; cultural, biological and chemical control of weeds. Modern classification of Indian soils, Mineral and organic constituents of soils. Essential plant nutrients and other beneficial elements in soils and plants. Principles of soil fertility and its evaluation for judicious fertilizer use, integrated nutrient management. Problem soils and their reclamation methods.

Soil conservation planning on watershed basis. Dry land agriculture and its problems. Technology of stabilising agriculture production in rain fed agriculture area.

Water-use efficiency in relation to crop production, criteria for scheduling irrigations. Drip and sprinkler irrigation. Drainage of water-logged soils, quality of irrigation water.

Farm management, scope, important and characteristics, farm planning. Marketing and pricing of agricultural inputs and outputs, price fluctuations and their cost. Types and systems of farming and factors affecting them.

Agricultural extension, its importance and role. Farm mechanization and its role in agricultural production and rural employment. Lab-to-land programmes.

Cell Theory, cell structure, cell organelles and their function, cell division, nucleic acids-structure and function, gene structure and function. Chromosome structure, chromosomal aberrations, linkage and cross-over, and their significance in recombination breeding. Heritability, sterility and incompatibility, classification and their application in crop improvement.

History of plant breeding. Modes of reproduction, selfing and crossing techniques. Pure-line selection, pedigree, mass and recurrent selections, combining ability, its significance in plant breeding. Hybrid vigour and its exploitation, backcross method of breeding, breeding for disease and pest resistance, role of inter-specific and inter-generic hybridization. Role of biotechnology in plant breeding. Improved varieties, hybrids, composites of various crop plants.

Physiology and its significance in agriculture. Absorption and translocation of water, transpiration and water economy. Photosynthesis-modern concepts and factors affecting the process, aerobic and non-aerobic respiration; C3, C4 and CAM mechanisms.

Growth and development; photo-periodism and vernalization. Auxins, hormones, and other plant regulators and their mechanism of action and importance in agriculture. Physiology of seed development and germination; dormancy.

Climatic requirements, cultivation and package of practices of major fruits, vegetable crops and flower plants. Preservation of important fruits and vegetable products.

Diseases and Insect pests of field, vegetables, orchard and plantation crops of India. Principles of control of plant pests and diseases. Biological control of pests and diseases. Integrated pest and disease management. Epidemiology and forecasting. Pesticides, their formulations and modes of action. Compatibility with rhizobial inoculants. Storage pests and diseases of cereals and pulses, and their control.

## 2. AGRICULTURAL ENGINEERING (Subject Code – 1077)

<b>1.</b>	<p><b>Soil and Water Conservation:</b></p> <p>Scope of soil and water conservation. Mechanics and types of erosion, their causes. Rainfall, runoff and sedimentation relationships and their measurement. Soil erosion control measures - biological and engineering including stream bank protection, vegetative barriers, contour bunds, contour trenches, contour ditches, terraces, outlets and grassed waterways. Gully control structures - temporary and permanent - design of permanent soil conservation structures such as chute, drop and drop inlet spillways. Design of farm ponds and percolation ponds. Principles of flood control-flood routing. Watershed Management - investigation, planning and implementation - selection of priority areas and watershed work plan, water harvesting and moisture conservation. Land development - leveling, estimation of earth volumes and costing. Wind Erosion process - design for shelter belts and wind brakes and their management.</p>
<b>2.</b>	<p><b>Aerial Photography and Remote Sensing:</b></p> <p>Basic characteristics of arial photography and types, interpretation keys, equipment for interpretation, imagery interpretation for land use, geology, soil and forestry. Remote sensing - merits and demerits of conventional and remote sensing approaches. Types of satellite image scanners, fundamentals of satellite image interpretation, techniques of visual and digital interpretations for soil, water and land use management. Use of GIS in planning and development of watersheds, forests including forest cover, water resources etc.</p>
<b>3.</b>	<p><b>Irrigation and Drainage:</b></p> <p>Sources of water for irrigation. Planning and design of minor irrigation projects. Techniques of measuring soil moisture - laboratory and in situ, Soil-water plant relationships. Water requirement of crops. Planning conjunctive use of surface and ground water. Measurement of irrigation water, measuring devices - orifices, weirs and flumes. Methods of irrigation - surface, sprinkler and drip, fertigation. Irrigation efficiencies and their estimation. Design and construction of canals, field channels, underground pipelines, head-gates, diversion boxes and structures for road crossing. Occurrence of ground water, hydraulics of wells, types of wells (tube wells and open wells) and their construction. Well development and testing. Pumps-types, selection and installation. Drainage - causes of water logging and salt problem. Methods of drainage, design of surface, sub-surface and vertical drainage systems. Improvement and utilization of poor-quality water. Reclamation of saline and alkali soils. Use of waste water for irrigation - standards of waste water for sustained irrigation, feasibility and economics.</p>
<b>4.</b>	<p><b>Agricultural Structures:</b></p> <p>Site selection, design and construction of farmstead - farm house, cattle shed, dairy barn, poultry shed, machinery and implement shed, storage structures for food grains, feed and forage. Design and construction of fences and farm roads. Structures for plant environment – green houses, poly houses, Common building materials used in construction - timber, brick, stone, tiles, concrete etc., and their properties. Water supply, drainage and sanitation system.</p>

5	<p><b>Farm Power and Machinery:</b></p> <p>Agricultural mechanization and its scope. Sources of farm power - animal and electro-mechanical. Construction and working of internal combustion engines. Fuel, ignition, lubrication, cooling and governing system of IC engines. Different types of tractors and power tillers. Power transmission, power take off (PTO) and control systems. Operation and maintenance of farm machinery for primary and secondary tillage. Traction theory. Sowing transplanting and inter-culture implements and tools. Plant protection equipment – spraying and dusting. Harvesting, threshing and combining equipment. Machinery for earth moving and land development - methods and cost estimation. Ergonomics of man-machine system.</p>
6.	<p><b>Agro-energy:</b></p> <p>Transformer, DC machines, Bio-energy, Biomass-production. Bio-diesel, Bio-hydrogen. Solar (thermal and photovoltaic), wind and bio-gas energy and their utilization in agriculture. Gasification of biomass for running IC engines and for electric power generation. Energy efficient cooking stoves.</p>
7.	<p><b>Agricultural Process Engineering:</b></p> <p>Post harvest technology of crops and its scope. Engineering properties of agricultural produces and by-products. Unit operations - clearing grading, size reduction, concentration, drying/dehydration, evaporation, filtration, freezing and packaging of agricultural produces. Material handling equipment belt and screw conveyors, bucket elevators, their capacity and power requirement. Processing of milk and dairy products - homogenization, cream separation, pasteurization, sterilization, spray and roller drying.</p>
8.	<p><b>Instrumentation and computer applications in Agricultural Engineering:</b></p> <p>Electronic devices and their characteristics-rectifiers, amplifiers, oscillators, multivibrators. Digital circuits - sequential and combinational system. Application of microprocessors in data acquisition and control of agricultural engineering processes, measurement systems for level, flow, strain, force, torque, power, pressure, vacuum and temperature. Computers - introduction, input/output devices, central processing unit, memory devices, operating systems, processors, keyboards and printers. Multimedia and Audio-Visual aids. Introduction to computer languages. Data types in computer, User defined and library function, arithmetic operators. Data structures i.e. Union, structures and linked list.</p>

### 3. ANIMAL HUSBANDRY AND VETERINARY SCIENCE (Subject Code - 1078)

1	<p><b>Animal Nutrition :</b></p> <p><b>1.1</b> Energy sources, energy, metabolism and requirements for maintenance and production of milk, meat, eggs and wool. Evaluation of feeds as sources of energy.</p> <p><b>1.2</b> Trends in protein nutrition: sources of protein metabolism and synthesis, protein quantity and quality in relation to requirements. Energy protein ratios in ration.</p> <p><b>1.3</b> Minerals in animal diet : Sources, functions, requirements and their relationship of the basic minerals nutrients including trace elements.</p> <p><b>1.4</b> Vitamins, Hormones and Growth Stimulating, substances : Sources, functions, requirements and inter-relationship with minerals.</p> <p><b>1.5</b> Advances in Ruminant Nutrition-Dairy Cattle/Buffalo, Sheep Goat: Nutrients and their metabolism with reference to milk production and its composition. Nutrient requirements for calves, heifers, dry and milking cows/buffaloes, nutrient requirements for sheep and goat. Limitations of various feeding systems.</p> <p><b>1.6</b> Advances in Non-Ruminant Nutrition-Poultry-Nutrients and their metabolism with reference to poultry, meat and egg production, Nutrients requirements and feed formulation of broilers and layers at different ages.</p> <p><b>1.7</b> Advances in Non-Ruminant Nutrition-Swine-Nutrients and their metabolism with special reference to growth and quality of meat production, Nutrient requirement and feed formulation for baby-growing and finishing pigs.</p> <p><b>1.8</b> Advances in Applied Animal Nutrition-A critical review and evaluation of feeding experiments, digestibility and balance studies. Feeding standards and measures of food energy. Nutrition requirements for growth, maintenance and production. Balanced rations.</p>
2	<p><b>Animal Physiology :</b></p> <p><b>2.1 Growth and Animal Production:</b> Prenatal and postnatal growth, maturation, growth curves, measures of growth, factors affecting growth, conformation, body composition, meat quality.</p> <p><b>2.2 Milk Production and Reproduction and Digestion:</b> Current status of hormonal control of mammary development, milk secretion and milk ejection. Male and Female reproduction organ, their components and function. Digestive organs and their functions.</p> <p><b>2.3 Environmental Physiology :</b> Physiological relations and their regulation; mechanisms of adaptation, environmental factors and regulatory mechanism involved in animal behaviour, methods of controlling climatic stress.</p> <p><b>2.4 Semen quality:</b> Preservation and Artificial Insemination-Components of semen, composition of spermatozoa, chemical and physical properties of ejaculated semen, factors affecting semen in vivo and in vitro. Factors affecting semen production and quality preservation, composition of diluents, sperm concentration, transport of diluted semen. Deep Freezing techniques in cows, sheep and goats, swine and poultry. Detection of estrus and time of insemination for better conception.</p>

3	<p><b>Livestock Production and Management :</b></p> <p><b>3.1 Commercial Dairy Farming-</b>Comparison of dairy farming in India with advanced countries. Dairying under fixed farming and as a specialised farming, economic dairy farming. Procurement of goods; opportunities in dairy farming, factors determining the efficiency of dairy animal, Herd recording, budgeting, cost of milk production; pricing policy; Personnel Management. Supply of greens throughout the year, field and fodder requirements of Dairy Farm, Feeding regimes for young stock, heifers and breeding animals, new trends in feeding young and adult stock; Feeding records.</p> <p><b>3.2 Commercial meat, egg and wool production:</b> Development of practical and economic rations for sheep, goats, pigs, rabbits and poultry. Supply of greens, fodder, feeding regimens for young and mature stock. New trends in enhancing production and management. Capital and land requirements and socio-economic concept.</p> <p><b>3.3</b> Feeding and management of animals under drought, flood and other natural calamities.</p>
4	<p><b>Genetics and Animal Breeding :</b></p> <p><b>4.1</b> History of animal genetics. Mitosis and Meiosis : Mendelian inheritance; deviations to Mendelian genetics; Expression of genes; Linkage and crossing over; Sex determination, sex influenced and sex limited characters; Blood groups and polymorphism; Chromosome aberrations; Cytoplasmic inheritance, Gene and its structure; DNA as a genetic material; Genetic code and protein synthesis; Recombinant DNA technology.</p> <p><b>4.2 Population Genetics Applied to Animal Breeding:</b> Quantitative Vs. qualitative traits; Hardy Weinberg Law; Population Vs. individual; Gene and genotypic frequency; Forces changing gene frequency; Random drift and small populations; Theory of path coefficient; methods of estimating inbreeding coefficient, Effective population size; Breeding value, estimation of breeding value, dominance and epistatic deviation; partitioning of variation; Genotype X environment correlation and genotype X environment interaction; Resemblance between relatives.</p> <p><b>4.3 Breeding Systems :</b> Heritability, repeatability, genetic and phenotypic correlations, their methods of estimation and precision of estimates; Aids to selection and their relative merits; Individual, pedigree, family and within family selection; Progeny testing; Methods of selection; Construction of selection indices and their uses; Comparative evaluation of genetic gains through various selection methods; Indirect selection and Correlated response; systems of inbreeding, upgrading, cross-breeding and synthesis of breeds; Crossing of inbred lines for commercial production; Selection for general and specific combining ability.</p>
5	<p><b>Health and Hygiene :</b></p> <p><b>5.1 Histology and Histological Techniques:</b> Cytology structure of cell, organelles &amp; inclusions; cell division-cell types-Tissues and their classification-embryonic and adult tissues-Comparative histology of organs:- vascular, Nervous, digestive, respiratory, musculo-skeletal and urogenital systems-Endocrine glands-Integuments-sense organs.</p> <p><b>5.2 Bovine Anatomy-Regional Anatomy:</b> Paranasal sinuses of OX, surface anatomy of salivary glands. Regional anatomy of infra orbital, maxillary, mandibuloalveolar, mental and cornual nerve block. Regional anatomy of para-vertebral nerves, pudental nerve, median, ulnar &amp; radial nerves, fibular and digital nerves, cranial nerves. Structures involved in epidural anesthesia, superficial lymph nodes, surface anatomy of visceral organs of thoracic, abdominal and pelvic cavities, comparative features of locomotors apparatus and their application in the biomechanics of mammalian body.</p>

	<p><b>5.3 Anatomy of Fowl:</b> Musculo-skeletal system-functional anatomy in relation to respiration and flying, digestion and egg production.</p> <p><b>5.4 Physiology of blood and its circulation, respiration; excretion</b></p> <p><b>5.4.1 Blood constituents:</b> Properties and functions-blood cell formation, Haemoglobin synthesis and chemistry-plasma proteins production, classification and properties; coagulation of blood; Hemorrhagic disorders-anticoagulants-blood groups-Blood volume-Plasma expanders-Buffer systems in blood. Biochemical tests and their significance in disease diagnosis.</p> <p><b>5.4.2. Circulation:</b> Physiology of heart, cardiac cycle-heart sounds, heartbeat, electrocardiograms, Work and efficiency of heart-effect of ions on heart function metabolism of cardiac muscle, nervous and chemical regulation of heart, effect of temperature and stress on heart, blood pressure and hypertension, Osmotic regulation, arterial pulse, vasomotor regulation of circulation, shock. Coronary &amp; pulmonary circulation, Blood-Brain barrier-Cerebrospinal fluid-circulation in birds.</p> <p><b>5.4.3 Respiration:</b> Mechanism of respiration, Transport and exchange of gases-neural control of respiration-chemo receptors-hypoxia-respiration in birds.</p> <p><b>5.4.4 Excretion:</b> Structure and function of kidney-formation of urine methods of studying renal function-renal regulation of acid-base balance; physiological constituents of urine-renal failure-passive venous congestion-Urinary recreation in chicken-Sweat glands and their function. Biochemical tests for urinary dysfunction.</p> <p><b>5.5 Veterinary Hygiene with reference to water, air and habitation:</b> Assessment of pollution of water, air and soil—Importance of climate in animal health—effect of environment on animal function and performance relationship between industrialization and animal agriculture—animal housing requirements for specific categories of domestic animals viz. pregnant cows and sows, milking cows, broiler birds—stress, strain and productivity in relation to animal habitation.</p>
<b>6</b>	<p><b>Animal Diseases :</b></p> <p><b>6.1</b> Pathogenesis, symptoms, post-mortem lesions, diagnosis, and control of infectious diseases of cattle, pigs and poultry, horses, sheep and goat.</p> <p><b>6.2</b> Etiology, symptoms, diagnosis, treatment of production diseases of cattle, pig and poultry.</p> <p><b>6.3</b> Deficiency diseases of domestic animals and birds.</p> <p><b>6.4</b> Diagnosis and treatment of non-specific conditions like impaction, Bloat, Diarrhoea, Indigestion, dehydration, stroke, poisoning.</p> <p><b>6.5</b> Diagnosis and treatment of neurological disorders.</p> <p><b>6.6</b> Principles and methods of immunisation of animals against specific diseases—herd immunity—disease free zones—‘zero’ disease concept—chemoprophylaxis.</p> <p><b>6.7</b> Anaesthesia-local, regional and general-pre-anesthetic medication. Symptoms and surgical interference in fractures and dislocation. Hernia, choking abomasal displacement—Caesarian operations. Rumenotomy—Castrations.</p> <p><b>6.8</b> Disease investigation techniques - Materials for laboratory investigation—Establishment. Animal Health Centres—Disease free zone.</p>



7	<p><b>Veterinary Public Health :</b></p> <p><b>7.1 Zoonoses.</b>—Classification, definition, role of animals and birds in prevalence and transmission of zoonotic diseases—occupational zoonotic diseases.</p> <p><b>7.2 Epidemiology.</b>—Principle, definition of epidemiological terms, application of epidemiological measures in the study of diseases and disease control. Epidemiological features of air, water and food borne infections.</p> <p><b>7.3 Veterinary Jurisprudence.</b>—Rules and Regulations for improvement of animal quality and prevention of animal diseases—State and Central Rules for prevention of animal and animal product borne diseases—S.P. C.A.—Veterolegal cases—Certificates—Materials and Methods of collection of samples for veterolegal investigation.</p>
8	<p><b>Milk Technology :</b> Organization of rural milk procurement, collection and transport of raw milk. Quality, testing and grading raw milk, Quality storage grades of whole milk, Skimmed milk and cream. Processing, packaging, storing, distributing, marketing defects and their control and nutritive properties of the following milks : Pasteurized, standardized, toned, double toned, sterilized, homogenized, reconstituted, recombined and flavoured milks. Preparation of cultured milks, cultures and their management, yoghurt, Dahi, Lassi and Srikhand. Preparation of flavoured and sterilized milks. Legal standards, Sanitation requirement for clean and safe milk and for the milk plant equipment.</p>
9	<p><b>Meat Hygiene:</b> Ante mortem care and management of food animals, stunning, slaughter and dressing operations; abattoir requirements and designs; Meat inspection procedures and judgement of carcass meat cuts-grading of carcass meat cuts-duties and functions of Veterinarians in Wholesome meat production. Hygienic methods of handling production of meat-spoilage of meat and control measures-Post slaughter physicochemical changes in meat and factors that influence them-quality improvement methods-Adulteration of meat and defection-Regulatory provisions in Meat trade and Industry.</p>
10	<p><b>Extension:</b> Basic philosophy, objectives, concept and principles of extension. Different Methods adopted to educate farmers under rural conditions. Generation of technology, its transfer and feedback. Problems of constraints in transfer of technology. Animal husbandry programmes for rural development.</p>

#### 4. BOTANY (Subject Code - 1079)

Sr. No.	Topics
1	<p><b>Cell Biology:</b> Prokaryotic and eukaryotic cells - structural and ultra-structural details. Structure and function of extra cellular matrix or ECM (cell wall) and membranes cell adhesion, membrane transport and vesicular transport. Structure and function of cell organelles (chloroplasts, mitochondria, ER, ribosomes). Nucleus, nucleolus, nuclear pore complex. Chromatin and nucleosome. Cell signalling and cell receptors. Mitosis and meiosis; molecular basis of cell cycle. Numerical and structural variations in chromosomes and their significance. Study of polytene, lamp brush and B-chromosomes-structure, behaviour, and significance.</p>
2	<p><b>Microbiology and Plant Pathology:</b> Viruses, bacteria, and plasmids-structure and reproduction. General account of infection, Phytoimmunology. Applications of microbiology in agriculture, industry, medicine.</p> <p>Important plant diseases caused by viruses, bacteria, mycoplasma, fungi, and nematodes. Mode of infection and dissemination. Molecular basis of infection and disease resistance/defence. Control measures. Fungal toxins.</p>
3	<p><b>Cryptogams:</b> Algae, Fungi, Bryophytes, Pteridophytes - structure and reproduction from evolutionary viewpoint. Economic potential.</p>
4	<p><b>Phanerogams:</b></p> <p><b>Gymnosperms:</b> Concept of Progymnosperms. Classification and distribution of Gymnosperms. Salient features of Cycadales, Coniferales and Gnetales, their structures and reproduction. General account of Cycadofilicales, Bennettitales and Cordaitales.</p> <p><b>Angiosperms:</b> Systematics, anatomy, embryology, palynology, and phylogeny. Comparative account of various systems of Angiosperm Classification. Study of angiospermic families - Brassicaceae (Cruciferae), Leguminosae (Fabaceae), Euphorbiaceae, Malvaceae, Apiaceae (Umbelliferae), Solanaceae, Cucurbitaceae, Asteraceae (Composite), Poaceae (Gramineae), Arecaceae (Palmae).</p> <p>Stomata and their types. Anomalous secondary growth. Anatomy of C<sub>3</sub> and C<sub>4</sub> plant</p> <p>Development of male and female gametophytes, pollination, fertilization. Endosperm its development and function. Patterns of embryo development. Polyembryony, apomixis, Applications of palynology.</p>
5	<p><b>Ecology and Plant Geography:</b> Ecological factors. Concepts and dynamics of community. Plant succession. Concepts of biosphere. Ecosystems and their conservation. Pollution and its control (including phytoremediation). Forest types of India, afforestation, deforestation, and social forestry. Endangered plants, endemism, and Red Data Books. Bio-diversity. Convention of Biological Diversity, Sovereign Rights, and Intellectual Property Rights. Biogeochemical cycles. Global warming.</p>
6	<p><b>Physiology and Biochemistry:</b> Water relations, Mineral nutrition and ion transport, mineral deficiencies. Photosynthesis-photochemical reactions, photophosphorylation and carbon pathways including C<sub>2</sub> pathway (photorespiration), C<sub>3</sub>, C<sub>4</sub> and CAM pathways. Respiration (anaerobic and aerobic, including fermentation electron transport chain and oxidative phosphorylation. Enzymes and coenzymes. Importance of secondary metabolites. Pigments as photoreceptors (plastidial pigments and phytochrome). Photoperiodism and flowering, vernalization, senescence. Growth substances-their chemical nature, role, and applications in agri-horticulture. Stress physiology (heat, water, salinity, metal). Seed physiology. Dormancy, storage, and germination of seed.</p>

7	<p><b>Genetics, Molecular Biology and Evolution:</b> Development of genetics, and gene versus allele concepts (Pseudo alleles). Quantitative genetics and multiple factors. Linkage and crossing over-methods of gene mapping including molecular maps (idea of mapping function). Sex chromosomes and sex-linked inheritance, sex determination and molecular basis of sex differentiation. Mutation (biochemical and molecular basis). Cytoplasmic inheritance and cytoplasmic genes (including genetics of male sterility).</p> <p>Structure of nucleic acids and proteins. Multigene families.</p> <p>Organic evolution-evidences, mechanism, and theories. Role of RNA in origin and evolution.</p>
8	<p><b>Plant Breeding, Biotechnology and Biostatistics:</b> Methods of plant breeding introduction, selection, and hybridization (pedigree, backcross, mass selection, bulk method). Male sterility and heterosis breeding. Use of apomixes in plant breeding. Micropropagation and genetic engineering-methods of transfer of genes and transgenic crops; development and use of molecular markers in plant breeding. Standard deviation and coefficient of variation (CV). Tests of significance (Z-test, t-test, and chi-square tests). Correlation</p>
9	<p><b>Morphogenesis:</b> Totipotency, polarity, symmetry, and differentiation. Cell, tissue, organ, and protoplast culture. Somatic hybrids and Cybrids.</p>
10	<p><b>Plant Utility and Exploitation:</b> Origin of cultivated plants, Vavilov's centres of origin. Plants as sources for food, fodder, fibres, spices, beverages, drugs, narcotics, insecticides, timber, gums, resins, and dyes. Latex, cellulose Starch and their products. Perfumery. Importance of Ethnobotany in Indian context. Energy plantation. Botanical Gardens and Herbaria.</p>

## 5. CHEMICAL ENGINEERING (Subject Code - 1080)

Sr. No.	Topic
<b>1</b>	<b>Fluid and Particle Dynamics</b> Viscosity of fluids. Laminar and turbulent flows. Equation of continuity and Navier Stokes equation-Bernoulli's theorem. Flow meters. Fluid drag and pressure drop due to friction, Reynold's Number and friction factor - effect of pipe roughness. Economic pipe diameter. Pumps, water, air/steam jet ejectors, compressors, blowers and fans. Agitation and mixing of liquids. Mixing of solids and pastes. Crushing and Grinding - principles and equipment. Rittinger's and Bond's laws. Filtration and filtration equipment. Fluid-particle mechanics - free and hindered settling. Fluidization and minimum fluidization velocity, concepts of compressible and incompressible flow. Transport of Solids.
<b>2</b>	<b>Mass Transfer</b> Molecular diffusion coefficients, First and second law and diffusion, mass transfer coefficients, film and penetration theories of mass transfer. Distillation, simple distillation, relative volatility, fractional distillation, plate and packed columns for distillation. Calculation of theoretical number of plates. Liquid-liquid equilibria. Extraction - theory and practice. Design of gas-absorption columns. Drying. Humidification, dehumidification. Crystallisation.
<b>3</b>	<b>Heat Transfer</b> Conduction, thermal conductivity, extended surface heat transfer. Convection - free and forced. Heat transfer coefficients - Nusselt Number. LMTD and effectiveness. NTU methods for the design of Double Pipe and Shell & Tube Heat Exchangers. Analogy between heat and momentum transfer. Boiling and condensation heat transfer. Single and multiple-effect evaporators. Radiation - Stefan Boltzman Law, emissivity and absorptivity.
<b>4</b>	<b>Process Equipment Design</b> Factors affecting vessel design criteria - Cost considerations. Design of storage vessels-vertical, horizontal spherical. Design of closures flat and elliptical head. Design of supports. Materials of construction- characteristics and selection.
<b>5</b>	<b>Process Dynamics and Control</b> Measuring instruments for process variables like level, pressure, flow, temperature pH and concentration with indication in visual/pneumatic/analog/digital signal forms. Control variable, manipulative variable and load variables. Linear control theory, Laplace transforms. PID controllers. Block diagram representation transient and frequency response, stability of closed loop system.
<b>6</b>	<b>Material and Energy Balances</b> Material and energy balance calculations in processes with recycle/bypass/purge. Combustion of solid/ liquid/gaseous fuels, stoichiometric relationships and excess air requirements. Adiabatic flame temperature.

7	<p><b>Chemical Engineering Thermodynamics and Reaction Engineering</b></p> <p>Laws of thermodynamics. PVT relationships for pure components and mixtures. Energy functions and inter-relationships - Maxwell's relations. Fugacity, activity and chemical potential. Vapour-liquid equilibria for ideal/non-ideal, single and multi component systems. Criteria for chemical reaction equilibrium, equilibrium constant and equilibrium conversions. Thermodynamic cycles - refrigeration and power.</p> <p>Batch reactors - kinetics of homogeneous reactions and interpretation of kinetic data. Ideal flow reactors - CSTR, plug flow reactors and their performance equations. Temperature effects. Heterogeneous reactions – catalytic and non-catalytic and gas-solid and gas-liquid reactions. Isothermal and non-isothermal reactors.</p>
8	<p><b>Chemical Technology, Safety and Environmental Engineering</b></p> <p>Natural organic products - Wood and wood-based chemicals, pulp and paper, Agro industries - sugar, Edible oils extraction (including tree based seeds), Soaps and detergents. Biomass gasification (including biogas). Coal and coal chemical. Petroleum and Natural gas- Petroleum refining (Atmospheric distillation/cracking/reforming) - Petrochemical industries – Polyethylenes (LDPE/HDPE/LLDPE), Polyvinyl Chloride, Polystyrene. Ammonia manufacture. Cement and lime industries. Paints and varnishes. Glass and ceramics. Fermentation - alcohol and antibiotics.</p> <p>Ecology and Environment. Sources of pollutants in air and water. Green house effect, ozone layer depletion, acid rain. Micrometeorology and dispersion of pollutants in environment. Measurement techniques of pollutant levels and their control strategies. Solid wastes, their hazards and their disposal techniques. Fire and explosion hazards rating - HAZOP and HAZAN. Emergency planning, disaster management. Environmental legislations - water, air environment protection Acts. Forest (Conservation) Act.</p>

## 6. CHEMISTRY (Subject Code - 1081)

Sr. No.	Topics
1	<b>Solid State:</b> Types of solids, Lattice structure and unit cell, Braggs Law, Close packing, Structure of NaCl, ZnS, CaF <sub>2</sub> and rutile, Stoichiometric and nonstoichiometric defects, Impurity defects, semiconductors.
2	<b>Atomic Structure:</b> Quantum theory, Heisenberg's uncertainty principle, Schrodinger wave equation (time independent), particles in one dimension box, hydrogen atom wave function, Shape of s, p, d orbitals, quantum numbers.
3	<b>Chemical bonding:</b> Ionic bond, Factors affecting the stability of the compound, Born-Haber cycle, covalent bond and its characteristics, polarity of bond in the molecule and their dipole moments, Valence bond theory, Molecular orbital theory (LCAO method).
4	<b>Thermodynamics:</b> Thermodynamic system, work, heat and internal energy, First law of thermodynamics, Energy and enthalpy changes in various processes and their temperature dependence, Second law of thermodynamics, entropy as a state function, entropy changes in various process, Free energy function, relation between equilibrium constant and thermodynamic quantities, Nernst heat theorem and third law of thermodynamics, Chemical equilibrium in ideal gas reaction.
5	<b>Electrochemistry:</b> Galvanic cell, concentration cell, electrochemical series, measurement of E.M.F. of cell and its applications, fuel cells, and batteries.  Process at the electrode, double layer at the interface, rate of charge transfer, current density, electro analytical techniques: voltammetry, polarography, amperometry, cyclic voltammetry, ion selective electrode, and their uses.
6	<b>Chemical kinetics:</b> Rate of reaction, differential and integrated rate equations for zero, first and second order reaction, effect of temperature and pressure on the rate of reaction, Study of fast reaction using stop-flow and relaxation method, collision and transition state theory.
7	<b>Coordination chemistry:</b> Introduction to the theory of bonding in transition metal complexes, EAN, valence bond theory, Crystal field theory, and its modification, application of theories in the explanation of magnetism and electronic spectra, Isomerism in coordination compound, IUPAC nomenclature, Stereochemistry of complex with 4 and coordination number, Trans effect and its theory, chelate effect, Stability of complex, synthesis and structure of metal carbonyl, Compounds with metal-metal bond and metal-atom cluster.

8	<p><b>General chemistry of 'f-block' elements:</b></p> <p>Lanthanides and actinides, separation, Oxidation state, lanthanide contraction, Magnetic and spectral properties and uses.</p>
9	<p><b>Surface phenomena and catalysis:</b></p> <p>Adsorption isotherms Langmuir and B.E.T. isotherms: determination of surface area, characteristics, and mechanism of reaction on the heterogeneous catalyst.</p>
10	<p><b>Phase equilibria and solutions:</b></p> <p>Clausius-Clapeyron equation; phase diagram for a pure substance: phase equilibria in binary systems, partially miscible liquids-upper and lower critical solution temperatures; partial molar quantities, their significance and determination; excess thermodynamic functions and their determination.</p>
11	<p><b>Delocalised covalent bonding:</b></p> <p>Aromaticity, anti-aromaticity; annulenes, azulenes, tropolones, kekulene, fulvenes, sydnones.</p>
12	<p><b>(a) Reaction mechanisms:</b></p> <p>General methods (both kinetic and non-kinetic) of study of mechanism or organic reactions illustrated by examples-use of isotopes, cross-over experiment, intermediate trapping, stereochemistry; energy diagrams of simple organic reactions-transition states and intermediates; energy of activation, thermodynamic control and kinetic control of reactions.</p> <p><b>(b) Reactive intermediates:</b></p> <p>Generation, geometry, stability and reactions of carbonium and carbanium ions, carbanions, free radicals, carbenes, benzyne and nitrenes.</p> <p><b>(c) Substitution reactions:</b></p> <p>Substitution reactions: <math>SN_1</math>, <math>SN_2</math>, <math>SN_i</math>, <math>SN_1'</math>, <math>SN_2'</math>, <math>SN_i'</math> and <math>SRN1</math> mechanisms; neighbouring group participation; electrophilic and nucleophilic reactions of an aromatic compound including simple heterocyclic compounds-pyrrole, thiophene, indole.</p> <p><b>(d) Elimination reactions:</b></p> <p><math>E_1</math>, <math>E_2</math> and <math>E_{1cb}</math> mechanisms; orientation in <math>E_2</math> reactions- Saytzeff and Hoffmann; pyrolytic syn elimination-acetate pyrolysis, Chugaev and Cope eliminations.</p> <p><b>(E) Addition reactions:</b></p> <p>Electrophilic addition to <math>C=C</math> and <math>C-C</math>; nucleophilic addition to <math>C=O</math>, <math>C=N</math>, conjugated olefins and carbonyls</p> <p><b>(F) Rearrangements:</b></p> <p>Pinacol-pinacolone, Hoffmann, Beckmann, Baeyer-Villiger, Favorskil, Fries, Claisen, Cope, Stevens and Wagner-Meerwein rearrangements.</p>

<b>13</b>	<p><b>Pericyclic reactions:</b></p> <p>Classification and examples; Woodward-Hoffmann rules, electrocyclic reactions, cycloaddition reactions [2+2 and 4+2] and sigmatropic shifts (1, 3, 3, 3 and 1, 5) FMO approach.</p>
<b>14</b>	<p><b>Chemistry and Mechanism of Reactions :</b></p> <p>Aldol condensation (including directed aldol condensation), Claisen condensation, Dieckmann, Perkin, Knoevenagel, Witting. Clemmensen, Wolff-Kishner, Cannizzaro and von Richter reactions; Stobbe, benzoin and acyloin condensations; Fischer indole synthesis, Skraup synthesis, Bischler Napieralski, Sandmeyer, Reimer-Tiemann and Reformatsky reactions.</p>
<b>15</b>	<p><b>Polymer chemistry:</b></p> <p><b>(a) Physical chemistry of polymers</b></p> <p>Polymer solutions and their thermodynamic properties; number and weight average molecular weights of polymers. Determination of molecular weights by sedimentation, light scattering, osmotic pressure, viscosity, end group analysis methods.</p> <p><b>(b) Preparation and properties of polymers:</b></p> <p>Organic polymers-polyethylene, polystyrene, polyvinyl chloride, Teflon, nylon, terylene, synthetic and natural rubber Inorganic polymers-phosphonitrilic halides, borazines, silicones and silicates.</p>
<b>16</b>	<p><b>Photochemistry:</b></p> <p>Photochemical reactions of simple organic compounds, excited and ground states, singlet and triplet states, Norrish-Type I and Type II reactions.</p>
<b>17</b>	<p><b>Principles of spectroscopy and applications in structure elucidation:</b></p> <p>(a) <b>Nuclear magnetic resonance:</b> Isochronous and anisochronous protons; chemical shift and coupling constants; Application of <math>^1\text{H}</math> NMR to simple organic molecules.</p> <p>(b) Mass spectra Parent peak, base peak, daughter peak, metastable peak, fragmentation of simple organic molecules; <math>\beta</math>-cleavage, McLafferty rearrangement.</p> <p>(c) <b>Electron spin resonance:</b> Inorganic complexes and free radicals.</p>



## 7. CIVIL ENGINEERING (Subject Code - 1082)

	<b>PART-A</b> <b>ENGINEERING MECHANICS, STRENGTH OF MATERIALS AND STRUCTURAL ANALYSIS</b>
<b>1.</b>	<p><b>ENGINEERING MECHANICS:</b></p> <p>Units and Dimensions, Norrish-Type and Type II reactions SI Units, Vectors, Concept of Force, Concept of particle and rigid body. Concurrent, Non-Concurrent and parallel forces in a plane, moment of force and Varignon's theorem, free body diagram, conditions of equilibrium, Principle of virtual work, equivalent force system. First and Second Moment of area. Static Friction and Inclined Plane.</p> <p><b><i>Kinematics and Kinetics:</i></b> Kinematics in Cartesian and Polar Coordinates, motion under uniform and nonuniform acceleration, motion under gravity. Kinetics of particle: Momentum and Energy principles, D' Alembert's Principle, Collision of elastic bodies, rotation of rigid bodies.</p>
<b>2.</b>	<p><b>STRENGTH OF MATERIALS:</b></p> <p>Simple Stress and Strain, Elastic constants, axially loaded compression members, Shear force and bending moment, theory of simple bending, Shear Stress distribution across cross sections. Strain Energy in direct stress, bending &amp; shear. Deflection of beams: Mecauly's method, Mohr's Moment area method, Conjugate beam method. Torsion of Shafts, Transmission of power, Elastic stability of columns, Euler's Rankine's and Secant formulae. Principal Stresses and Strains in two dimensions, Mohr's Circle, Thin and Thick cylinder: Stresses due to internal and external pressure-Lame's equations.</p>
<b>3.</b>	<p><b>STRUCTURAL ANALYSIS:</b></p> <p>Castigliano's theorems I and II, unit load method, method of consistent deformation applied to beams and pin jointed trusses. Slope-deflection, moment distribution, Kani's method of analysis and column Analogy method applied to indeterminate beams and rigid frames.</p> <p>Rolling loads and Influences lines: Influences lines for Shear Force and Bending moment at a section of a beam. Criteria for maximum shear force and bending Moment in beams traversed by a system of moving loads. Influences lines for simply supported plane pin jointed trusses.</p> <p><b><i>Arche:</i></b> Three hinged, two hinged and fixed arches, rib shortening and temperature effects, influence lines in arches.</p> <p><b><i>Matrix methods of analysis:</i></b> Force method and displacement method of analysis of indeterminate beams and rigid frames.</p> <p><b><i>Unsymmetrical bending:</i></b> Moment of inertia, product of inertia, position of Neutral Axis and Principle axes, calculation of bending stresses.</p>

	<p style="text-align: center;"><b>PART-B</b></p> <p style="text-align: center;"><b>DESIGN OF STRUCTURES: STEEL AND CONCRETE STRUCTURES</b></p>
1.	<p><b>STRUCTURAL STEEL DESIGN:</b></p> <p><b>Structural Steel:</b> Factors of safety and load factors. Rivetted, bolted and welded joints and connections. Design of tension and compression members, beams of built-up section, rivetted and welded plate girders, gantry girders, stanchions with battens and lacings, slab and gusseted column bases.</p>
2.	<p><b>DESIGN OF CONCRETE STRUCTURES:</b></p> <p><b>Reinforced Concrete:</b> Limit State method of design-Recommendations of I.S. codes design of one way and two-way slabs, staircase slabs, simple and continuous beams of rectangular, T and L sections. Compression members under direct load with or without eccentricity, Isolated and combined footings. Cantilever and Counter fort type retaining walls. Concept of mix design.</p> <p><b>Water tanks:</b> Design requirements for Rectangular and circular tanks resting on ground.</p> <p><b>Prestressed concrete:</b> Methods and systems of prestressing, anchorages, Analysis and design of sections for flexure based on working stress, loss of prestress.</p>
	<p style="text-align: center;"><b>PART-C</b></p> <p style="text-align: center;"><b>FLUID MECHANICS, OPEN CHANNEL FLOW AND HYDRAULIC MACHINES</b></p>
1.	<p><b>FLUID MECHANICS:</b></p> <p>Fluid properties and their role in fluid motion, fluid statics including forces acting on plane and curve surfaces.</p> <p><b>Kinematics and Dynamics of Fluid flow:</b> Velocity and accelerations, stream lines, equation of continuity, irrotational and rotational flow, velocity potential and stream functions, flownet, methods of drawing flownet, sources and sinks, flow separation, free and forced vortices.</p> <p>Control volume equation, continuity, momentum, energy and moment of momentum equations from control volume equation, Navier-Stokes equation, Euler's equation of motion, application to fluid flow problems, pipe flow, plane, curved, stationary and moving vanes, sluice gates, weirs, orifice meters and Venturi meters.</p> <p><b>Laminar Flow:</b> Laminar flow between parallel, stationary and moving plates, flow through tube.</p> <p><b>Boundary layer:</b> Laminar and turbulent boundary layer on a flat plate, laminar sub layer, smooth and rough boundaries, drag and lift.</p> <p><b>Turbulent flow through pipes:</b> Characteristics of turbulent flow, velocity distribution and variation of pipe friction factor, hydraulic grade line and total energy line, siphons, expansion and contractions in pipes, pipe networks, water hammer in pipes and surge tanks.</p> <p><b>Open channel flow:</b> Uniform and non-uniform flows, momentum and energy correction factors, specific energy and specific force, critical depth, resistance equations and variation of roughness coefficient, rapidly varied flow, flow in contractions, flow at sudden drop, hydraulic jump and its applications surges and waves, gradually varied flow, classification of surface profiles, control section, step method of integration of varied flow equation, moving surges and hydraulic bore.</p>

2.	<p><b>HYDRAULIC MACHINES AND HYDROPOWER:</b></p> <p>Centrifugal pumps-Types, characteristics, Net Positive Suction Height (NPSH), specific speed. Pumps in parallel.</p> <p>Reciprocating pumps, Air vessels, Hydraulic ram, efficiency parameters, Rotary and positive displacement pumps, diaphragm and jet pumps.</p> <p>Hydraulic turbines, types classification, Choice of turbines, performance parameters, controls, characteristics, specific speed.</p> <p>Principles of hydropower development. Type, layouts and Component works. Surge tanks, types and choice.</p>
	<p style="text-align: center;"><b>PART-D</b></p> <p style="text-align: center;"><b>GEO-TECHNICAL ENGINEERING</b></p>
1.	<p>Types of soil, phase relationships, consistency limits particles size distribution, classifications of soil, structure and clay mineralogy.</p> <p>Capillary water and structural water, effective stress and pore water pressure, Darcy's Law, factors affecting permeability, determination of permeability, permeability of stratified soil deposits.</p> <p>Seepage pressure, quick sand condition, compressibility and consolidation, Terzaghi's theory of one-dimensional consolidation, consolidation test.</p> <p>Compaction of soil, field control of compaction. Total stress and effective stress parameters, pore pressure coefficients.</p> <p>Shear strength of soils, Mohr Coulomb failure theory, Shear tests.</p> <p>Earth pressure at rest, active and passive pressures, Rankine's theory, Coulomb's wedge theory, earth pressure on retaining wall, sheetpile walls, Braced excavation.</p> <p>Bearing capacity, Terzaghi and other important theories, net and gross bearing pressure, applicability of different bearing capacity theories, evaluation of bearing capacity from field tests, allowable bearing capacity, Settlement analysis, allowable settlement, Immediate and consolidation settlement.</p> <p>Stability of slope, Conventional methods of slices, stability number.</p> <p>Proportioning of footing, isolated and combined footings, rafts, buoyancy rafts, Pile foundation, types of piles, pile capacity, static and dynamic analysis, design of pile groups, pile load test, settlement of piles, lateral capacity. Foundation for Bridges. Ground improvement techniques-preloading, sand drains, stone column, grouting, soil stabilisation.</p>
	<p style="text-align: center;"><b>PART-E</b></p> <p style="text-align: center;"><b>CONSTRUCTION TECHNOLOGY, EQUIPMENT, PLANNING AND MANAGEMENT</b></p>
1.	<p><b>CONSTRUCTION TECHNOLOGY:</b></p> <p><i><b>Engineering Materials:</b></i> Physical properties of construction materials: Stones, Bricks and Tiles; Lime, timber, Cement and Surkhi Mortars; Lime Concrete and Cement Concrete, use of ferrocement, fibre-reinforced and polymer concrete, high strength concrete and light weight concrete. Plastics, rubber and damp-proofing materials, termite proofing, Materials, for Low-cost housing.</p>

	<p><b>Construction:</b> Building components and their functions; Brick masonry: Bonds, jointing. Stone masonry. Design of Brick masonry walls as per I.S. codes, plastering, pointing. Types of Floors &amp; Roofs. Ventilators, Repairs in buildings, Principle of buildings, provisions of National Building Code. Building estimates and specifications; Cost of works; valuation.</p>
2.	<p><b>CONSTRUCTION EQUIPMENT:</b></p> <p>Standard and special types of concreting and earth-work equipment, Preventive maintenance and repair, factors affecting the selection of equipment, economical life, time and motion study, capital and maintenance cost.</p>
3.	<p><b>CONSTRUCTION PLANNING AND MANAGEMENT:</b></p> <p>Construction activity, schedules, job layout, bar charts, organization of contracting firms, project control and supervision. Cost reduction measures.</p> <p><b>New-work analysis:</b> CPM and PERT analysis, contraction of network for cost optimization, updating, Cost analysis and resource allocation. Elements of Engineering Economics, methods of appraisal, present worth, annual cost, benefit-cost, incremental analysis. Choosing between alternatives including levels of investments. Project profitability.</p>
	<p style="text-align: center;"><b>PART-F</b></p> <p style="text-align: center;"><b>SURVEY AND TRANSPORTATION ENGINEERING</b></p>
1.	<p><b>SURVEY:</b></p> <p>Leveling traverse survey, corrections, and adjustments, contouring, topographical map. Surveying instruments for above purposes. Tacheometry. Circular and transition curves.</p>
2.	<p><b>TRANSPORTATION ENGINEERING:</b></p> <p><b>Railways:</b> Permanent way, sleepers, rail fastenings, ballast, points and crossings, design of turn outs, stations and yards, turntables, signals, and interlocking, level crossing. Construction and maintenance of permanent ways: creep of rail and ruling gradient.</p> <p><b>Highway Engineering:</b> Principles of highway planning, Highway alignments. Geometrical design: Cross section, camber, super-elevation, horizontal and vertical curves. Classification of roads: low-cost roads, flexible pavements, rigid pavements. Design of pavements and their construction. Drainage of roads: Surface and sub-surface drainage.</p> <p><b>Traffic Engineering:</b> Forecasting techniques origin and destination survey, highway capacity. Channelised and unchannelised intersections, rotary design elements, markings, sign, signals, street lighting; Traffic surveys.</p>
	<p style="text-align: center;"><b>PART-G</b></p> <p style="text-align: center;"><b>HYDROLOGY, WATER RESOURCES AND ENGINEERING</b></p>
1.	<p><b>HYDROLOGY</b></p> <p>Hydrological cycle, precipitation, evaporation, transpiration, depression storage, infiltration, overland flow, hydrograph, flood frequency analysis, flood estimation, flood routing through a reservoir, channel flow routing-Muskingam method.</p> <p><b>Ground water flow:</b> Specific yield, storage coefficient, aquifers, aquitards, radial flow into a well under confined and unconfined conditions, tube wells, pumping and recuperation tests, ground water potential.</p>

2.	<p><b>WATER RESOURCES ENGINEERING:</b> Ground and surface water resource, single and multipurpose projects, storage capacity of reservoirs, reservoir losses, reservoir sedimentation, economics of water resources projects.</p> <p><b>Irrigation Engineering:</b> Water requirements of crops: consumptive use, quality of water for irrigation, duty and delta, irrigation methods and their efficiencies. Canals: Distribution systems for canal irrigation, canal capacity, canal losses, alignment of main and distributory canals, most efficient section, lined canals, their design, regime theory, critical shear stress, bed load, local and suspended load transport, cost analysis of lined and unlined canals, drainage behind lining.</p> <p><b>Water logging:</b> causes and control, drainage system design, salinity.</p> <p><b>Canal structures:</b> Design of cross regulators, head regulators, canal falls, aqueducts, metering flumes and canal outlets.</p> <p><b>Diversion head work:</b> Principles and design of weirs of permeable and impermeable foundation, Khosla's theory, energy dissipation, stilling basin, sediment excluders.</p> <p><b>Storage works:</b> Types of dams, design, principles of rigid gravity and earth dams, stability analysis, foundation treatment, joints and galleries, control of seepage.</p> <p><b>Spillways:</b> Spillway types, crest gates, energy dissipation.</p> <p><b>River training:</b> Objectives of river training, methods of river training.</p>
	<p style="text-align: center;"><b>PART-H</b> <b>ENVIRONMENTAL ENGINEERING</b></p>
	<p><b>Water Supply:</b> Estimation of surface and subsurface water resources, predicting demand for water, impurities of water and their significance, physical, chemical and bacteriological analysis, waterborne diseases, standards for potable water.</p> <p><b>Intake of water:</b> pumping and gravity schemes. Water treatment: principles of coagulation, flocculation and sedimentation; slow-, rapid-, pressure-, filters; chlorination, softening, removal of taste, odour and salinity.</p> <p><b>Water storage and distribution:</b> storage and balancing reservoirs: types, location and capacity. Distribution system: layout, hydraulics of pipe lines, pipe fittings, valves including check and pressure reducing valves, meters, analysis of distribution systems, leak detection, maintenance of distribution systems, pumping stations and their operations.</p> <p><b>Sewage systems:</b> Domestic and industrial wastes, storm sewage-separate and combined systems, flow through sewers, design of sewers, sewer appurtenances, manholes, inlets, junctions, siphon.</p> <p><b>Sewage characterization:</b> BOD, COD, solids, dissolved oxygen, nitrogen and TOC. Standards of disposal in normal water course and on land.</p> <p><b>Sewage treatment:</b> Working principles, units, chambers, sedimentation tanks, trickling filters, oxidation ponds, activated sludge process, septic tank, disposal of sludge, recycling of waste water. Introduction of solid waste management.</p> <p><b>Environmental pollution:</b> Sustainable development. Radioactive wastes and disposal. Environmental impact assessment for thermal power plants, mines, river valley projects. Air pollution. Pollution control acts.</p>

## 8. FORESTRY (Subject Code - 1083)

Sr. No.	Topic
1.	<p><b>Silviculture – General:</b></p> <p><b>General Silvicultural:</b>– Definition, objectives and scope of silviculture. History of Indian Forestry, Divisions and interrelationships with other branches. Classification of origin of forests - High forests, coppice forests, virgin forest, pure and mixed forests, even and uneven aged stands. Forest types of India- classification. Introduction to Site factors - climatic, edaphic, physiographic, biotic. Trees and their distinguishing features, growth patterns and development. Root growth fine root/functional root production. Ecological and physiological factors influencing vegetation, natural and artificial regeneration of forests; methods of propagation, Nursery Management : Types of Nursery, Site Selection, Layout, , nursery beds, Containers, irrigation and water management, grading and hardening of seedlings.</p>
2.	<p><b>Silvicultural Systems :</b></p> <p>Classification of Silvicultural system and its modifications, Clear felling, shelter wood systems, Selection system, coppice systems and conversion systems. Management of silviculture systems of temperate, subtropical, humid tropical, dry tropical and coastal tropical forests with special reference to plantation silviculture, choice of species, establishment and management of standards, enrichment methods, technical constraints, intensive mechanized methods, aerial seeding thinning.</p>
3.	<p><b>Silviculture - Mangrove and Cold desert:</b></p> <p><b>Mangrove:</b> habitat and characteristics, mangrove, plantation-establishment and rehabilitation of degraded mangrove formations; silvicultural systems for mangrove; protection of habitats against natural disasters.</p> <p><b>Cold desert:-</b> Characteristics, identification and management of species.</p>
4.	<p><b>Silviculture of Trees:</b></p> <p>Origin, distribution, general description, phenology, silvicultural characters, regeneration methods, silvicultural systems of management, stand management practices pest and diseases and economic importance of tree species of India. Silviculture of some of the economically important species in India such as <i>Acacia catechu</i>, <i>Acacia nilotica</i>, <i>Acacia auriculiformis</i>, <i>Albizia lebbek</i>, <i>Albizia procera</i>, <i>Ailanthus excels</i>, <i>Adina cardiafolia</i>, <i>Anthocephalus Cadamba</i>, <i>Anogeissus latifolia</i>, <i>Azadirachta indica</i>, <i>Bamboo spp</i>, <i>Butea monosperma</i>, <i>Cassia siamea</i>, <i>Casuarina equisetifolia</i>, <i>Cedrus deodara</i>, <i>Chukrasia tabularis</i>, <i>Dalbergia species</i>, <i>Diospyrous melanoxylon</i>, <i>Dipterocarpus spp.</i>, <i>Eucalyptus spp</i>, <i>Gmelina Arborea</i>, <i>Hardwickia binata</i>, <i>Lagerstroemia Lanceolata</i>, <i>Pinus roxburghi</i>, <i>Shorea robusta</i>, <i>Populus spp</i>, <i>Pterocarpus marsupium</i>, <i>Prosopis juliflora</i>, <i>Santalum album</i>, <i>Semecarpus anacardium</i>, <i>Shorea robusta</i>, <i>Salmalia malabaricum</i>, <i>Tectona grandis</i>, <i>Terminalia species</i>, <i>Ponamia pinnata</i>, <i>Melia dubia</i>, <i>Madhuca indica</i>.</p>
5.	<p><b>Agroforestry, Social Forestry and Joint Forest Management:</b></p> <p><b>Agroforestry and Social Forestry:</b> Agroforestry, Farm forestry, – definition, scope concepts, and objectives. Classification of agroforestry systems. Social, ecological, and economic reasons for agroforestry. History of agroforestry. Components of Agroforestry, Microclimate amelioration and introduction to carbon sequestration under agroforestry systems. Tree-crop interaction in agroforestry– Definition, kind of interaction, Aboveground and below ground interactions. Tree Architecture, structure and growth of</p>

	<p>trees, crown and root architecture, Crop sequencing and its management, selection of suitable crops combinations Agro forestry systems under different agro-ecological zones; selection of species and role of multipurpose trees and NTFPs, techniques, food, fodder and fuel security. Design and Diagnosis under Agroforestry systems.</p> <p>Social, Community Forestry, Urban Forestry: objectives, scope and necessity; peoples participation.</p> <p><b>Joint Forest Management :</b> Principles, objectives, methodology, scope, benefits and role of NGOs. Details of steps involved such as formation of Village Forest Committees, Joint Forest Participatory Management.</p>
6.	<p><b>Forest Soils and Soil Fertility:</b></p> <p><b>Forests Soils:</b> Classification, factors affecting soil formation; physical, chemical and biological properties.</p> <p>Forest soils characteristics, classification- distinguishing features- factors affecting soil formation; physical, chemical and biological properties. Forest soil formation and vegetation development.</p> <p><b>Soil Fertility:</b> Properties of soils under different forest ecosystems. Forest soil - biology-distribution of various microorganisms in soil ecosystem and their interaction effects.</p> <p>Essential nutrient elements-occurrence, availability and their functions. Nutrient deficiencies-visual symptoms. Site productivity and nutrient cycling in forest soils. N, P and K, macro and micronutrient fertilizers and their uses in forest nursery.</p> <p>Nitrogen fixation-Rhizobium-tree legume symbiosis, Frankia X non-legume symbiosis, asymbiotic and associative N<sub>2</sub> fixation. Nitrification and denitrification in forest ecosystems. Microbial transformation of phosphorous, sulphur, and micronutrients. Mycorrhizae: types, biology and importance with specific relevance to tree crops and mobilization of phosphorus and micro-nutrients. Rhizosphere and phyllosphere concept. Fertility management of forest soils. Integrated nutrient management in plantation forestry.</p>
7.	<p><b>Environment and Climate change:</b></p> <p><b>Environment:</b> components and importance, principles of conservation, impact of deforestation; forest fires and various human activities like mining, construction and developmental projects, population growth on environment.</p> <p><b>Pollution:</b> types, global warming, green house effects, ozone layer depletion, acid rain, impact and control measures, environmental monitoring; concept of sustainable development. Role of trees and forests in environmental conservation; control and prevention of air, water and noise pollution. Environmental policy and legislation in India. Environmental Impact Assessment. Economics assessment of watershed development vis-a-vis ecological and environmental protection.</p> <p><b>Climate change:</b> Understanding climate change and its Consequences. Global warming and its effects on Forest. Forest and climate change: Vulnerability and adaptability - Evidence of forest disturbance due to climate change –Climate change influence on agro-forestry- Climate resilient forestry. Role of afforestation and forest regeneration in absorption of CO<sub>2</sub>. Economic worth of carbon storage in forest. Green India mission-Indian Network for Climate Change Assessment State Action Plans on Climate Change.</p>

8.	<p><b>Tree Improvement and Seed Technology:</b></p> <p>General concept of tree improvement, methods and techniques, Reproduction in forest trees. Anthesis and pollination – their importance in tree breeding variation and its use, provenance, seed source, exotics; quantitative aspects of forest tree improvement, seed production area and seed orchards, progeny tests, use of tree improvement in natural forest and stand improvement, genetic testing programming, selection and breeding for resistance to diseases, insects, and adverse environment; the genetic base, forest genetic resources and gene conservation in situ and ex-situ. Vegetative propagation and clonal forestry. DUS testing.</p>
9.	<p><b>Forest Management and Management Systems:</b></p> <p>Objective and principles; techniques; stand structure and dynamics, Increment: Mean annual Increment, Current Annual Increment, and their relationship. Sustained yield relation; Increasing and progressive yields rotation, normal forest, growing stock; regulation of yield; management of forest plantations, commercial forests, forest cover monitoring. Approaches viz., (i) site-specific planning, (ii) strategic planning, (iii) Approval, sanction and expenditure, (iv) Monitoring (v) Reporting and governance. Sustainable forest management-concept, objectives, criteria and indicators.</p>
10.	<p><b>Forest Working Plan:</b></p> <p>Forest planning, evaluation and monitoring tools and approaches for integrated planning; multipurpose development of forest resources and forest industries development; working plans and working schemes, their role in nature conservation, bio-diversity and other dimensions; preparation and control. Divisional Working Plans, Annual Plan of Operations. Working plan-preparations-objectives and uses-forest maps and their uses.</p>
11.	<p><b>Forest Mensuration and Remote Sensing:</b></p> <p><b>Forest Mensuration</b> - Definition and objectives - Scales of measurement- Units of measurements - Precision, bias and accuracy- Methods of measuring - diameter, girth, height and volume of trees; form-factor; Volume table : preparation of volume tables-graphical method-regression method volume estimation of stand, Determination of growth of trees - current annual increment; mean annual increment. Stump analysis- Stem analysis. Sampling methods and sample plots. Yield calculation; yield and stand tables,</p> <p><b>Remote sensing</b> – Classification, Aerial and space remote sensing; Aerial photographs – types, classification, scale and season and time of aerial photography. Photo interpretation - Satellite remote sensing - platforms and sensors; Satellite systems. Indian Remote Sensing Programme; Application of satellite based remote sensing techniques in forestry - vegetation mapping using satellite imagery, Forest cover monitoring and damage assessment;</p> <p>Geographic Information Systems for management and modeling. Application of GIS in forestry – using imageries and integration with GIS data. Maps-its projection-Toposheet and Map reading. Global Positioning System (GPS) applications in resource inventory.</p>
12.	<p><b>Surveying and Forest Engineering:</b></p> <p><b>Forest surveying</b> - Scope and types of surveying, chain surveying, types and instruments used; different methods of surveying, maps and map reading, Basic principles of forest engineering. Building materials and construction. Plane table surveying; plane table and its accessories, methods of plane table surveying. Leveling: terms used types of level. Theodolite and its uses. Contour surveying, Roads and Bridges; General principles, objects, types, simple design and construction of timber bridges.</p>



13.	<p><b>Forest Ecology:</b></p> <p><b>Forest ecology</b> - Biotic and abiotic components, forest eco-systems; forest community concepts; vegetation concepts, Community ecology- species interactions, ecological succession, terminology, basic concepts, theories of succession, food webs, ecological pyramids and energy flow, ecological succession and climax, primary productivity, nutrient cycling and water relations; physiology in stress environments (drought, water logging salinity and alkalinity). Forest types in India, identification of species, composition and associations; dendrology, taxonomic classification, principles and establishment of herbaria and arboreta. Conservation of forest ecosystems. Clonal parks, Vegetation Parks.</p>
14.	<p><b>Forest Resources and Utilization:</b></p> <p>Environmentally sound forest harvesting practices; Logging: Definition and scope of logging, logging plan and execution. Implements used in logging operation, traditional and improved tools. Extraction techniques and principles, transportation system, storage and sale; Non-Timber Forest Products (NTFPs) definition and scope; gums, resins, oleoresins, fibres, oil seeds nuts, rubber, canes, bamboos, medicinal plants, charcoal, lac and shellac, Katha and Bidi leaves, collection; processing and disposal. Need and importance of wood seasoning and preservation; general principles of seasoning, air and kiln seasoning, solar dehumidification, steam heated and electrical kilns. Composite wood; adhesives-manufacture, properties, uses, plywood manufacture-properties, uses, fibre boards-manufacture properties, uses; particle boards manufacture; properties uses. Present status of composite wood industry in India. Pulp-paper and rayon; present position of supply of raw material to industry, wood substitution, utilization of plantation wood; problems and possibilities. Wood processing and Modification.</p> <p>Anatomical structure of wood, defects and abnormalities of wood, timber identification - general principles.</p>
15.	<p><b>Forest Protection, Range Management and Wildlife Biology:</b></p> <p><b>Forest Protection:</b> Classification of forest pests: types of damages and symptoms; factors for outbreak of pests. Injuries to forest - abiotic and biotic, destructive agencies, insect-pests and disease, effects of air pollution on forests and forest die back. Susceptibility of forests to damage, nature of damage, cause, prevention, protective measures and benefits due to chemical and biological control. General forest protection against fire, equipment and methods, controlled use of fire, economic and environmental costs; timber salvage operations after natural disasters.</p> <p><b>Range Management:</b> Grazing Management: types, Rotational and controlled grazing, different methods of control against grazing and browsing animals; Range Protection, effect of wild animals on forest regeneration, human impacts; encroachment, poaching, live fencing, theft, shifting cultivation and control.</p> <p><b>Wildlife Biology</b> :Classification of Indian Mammals, Basic requirements of wildlife, Wildlife Ecology, Biotic factors, Biological basis of wildlife, Productivity; Effect of light and temperature on animals; Wildlife Habitat: Niche, Territory, Home Range, Territoriality, Edge, Cruising Radius, Carrying Capacity; Animal behaviour and adaptation; Habitat Improvement: Food, Water, Shelter improvement.</p>
16.	<p><b>Forest Economics:</b></p> <p><b>Forest Economics</b>- Meaning, definition- Basic concepts. Fundamental principles, cost-benefit analyses; estimation of demand and supply; analysis of trends in the national and international market and changes in production and consumption patterns; assessment and projection of market structures; role of private sector and co-operatives; role of corporate financing. Socio-economic analyses of forest productivity and attitudes; valuation of forest</p>

	goods and service. Pricing of timber and non timber products. Marketing- definition – Marketing Process – Need for marketing – Role of marketing — Marketing functions – Classification of markets – Marketing of various channels. Timber Depots; types, lay out and management.
17	<p><b>Forest Tribology, Anthropology and Ethnobotany:</b></p> <p><b>Tribology</b> - Tribal scene in India; tribes, concept of races, principles of social grouping, stages of tribal economy, education, cultural tradition, customs, ethos and participation in forestry programmes. Tribes in India and Maharashtra. Relation between tribes and forests-forest as their immediate environment. Forest management and tribal welfare- management conflicts and way forward. Role of forest department in tribal welfare. Role of Non wood Forest products in the economy of tribal's and Tribal cooperative societies.</p> <p><b>Anthrapology:</b> Meaning, scope and development of Anthropology. Relationships with other disciplines. Main branches of Anthropology, their scope and relevance.</p> <p><b>Ethnobotany:</b> Definition and scope of ethnobotany. Terms employed in relation to ethnobotany and its relationship with man and domestic animals. Ethnic – people and their contribution in therapeutic and ethnobotanical knowledge especially with respect to medicinal and allied aspects. Important plants and their folk uses for medicines, food, dyes, tans, etc. Indian Systems of Medicine; Ayurveda and Unani - Introduction, nomenclature, habitat, distribution and botanical features of medicinal and aromatic plants. Factors affecting action and toxicity of drug plants and their chemical constituents.</p>
18.	<p><b>Soil Conservation and Watershed management:</b></p> <p><b>Soil conservation</b> - definition, causes for erosion; types - wind and water erosion; conservation and management of eroded soils/areas, wind breaks, shelter belts; sand dunes; reclamation of saline and alkaline soils, water logged and other waste lands. Role of forests in conserving soils. Maintenance and build up of soil organic matter, provision of loppings for green leaf manuring; forest leaf litter and composting; Role of microorganisms in ameliorating soils; N and C cycles, VAM. Forest floor – stratification – types of humus. Mineral transformations-carbon cycle with reference to organic matter decomposition and humus formation, Microbial degradation of cellulose &amp; lignin. Bio-fertilizers – their importance.</p> <p><b>Watershed Management</b> - concepts of watershed; role of mini-forests and forest trees in overall resource management, forest hydrology, watershed development in respect of torrent control, river channel stabilization, avalanche and landslide controls, rehabilitation of degraded areas; hilly and mountain areas; watershed management and environmental functions of forests; water-harvesting and conservation; ground water recharge and watershed management; role of integrating forest trees, horticultural crops, field crops, grass and fodders. Soil and water Conservation: contour trenches, check dams, spurs, farm ponds, earth dams.</p>
19.	<p><b>Biodiversity conservation:</b></p> <p><b>Biodiversity:</b> Introduction, definition, genetic, species &amp; ecosystem diversity and biogeographical classification of India, Value of biodiversity. Biodiversity at global, National and local levels, India as a mega-diversity nation. Hot-spots of biodiversity, Threats to biodiversity: Endangered and endemic species of India, Conservation of biodiversity.</p>

20.	<p><b>Forest Policy and Legislation:</b></p> <p><b>Legislation-</b> History of forest development; Indian Forest Policy of 1894, 1952 and 1990. National Forest Policy, 1988 of People's involvement, Joint Forest Management, Involvement of women; Forestry Policies and issues related to land use, timber and non-timber products, sustainable forest management; industrialization policies; institutional and structural changes. Decentralization and Forestry Public Administration. Forest laws, necessity; general principles, Indian Forest Act 1927; Forest Conservation Act, 1980; Wildlife Protection Act 1972 and their amendments; Application of Indian Penal Code to Forestry. National Agroforestry Policy 2014—National and International organizations in Agroforestry. Tree felling Act, Maharashtra Forest Act and Rules. Biological Diversity bill 2002 Forest Right Act, 2006.</p> <p><b>Forest Certification:</b> Definition of forest certification. Chain of custody, Schemes of Certification. Responsible sourcing of wood. Principal stages in the process of certification.</p>
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## 9. GEOLOGY (Subject Code - 1084)

Sr. No.	Topic
<b>1</b>	<b>Geomorphology and Remote sensing</b>
	<p>a. Basic concepts of geomorphology. Weathering and mass wasting. Landforms, slopes. Geomorphic cycles and their interpretation, Morphology and its relation to structures and lithology. Geomorphology of Indian sub-continent.</p> <p>b. Aerial photographs and their interpretation merits and limitations. The Electromagnetic Spectrum. Orbiting satellites and sensor systems. Indian Remote Sensing Satellites. Satellites data products. Applications of remote sensing in geology. The Geographic Information System and its applications. Global Positioning System.</p>
<b>2</b>	<b>Structural Geology and Engineering geology</b>
	<p>a. Principles of geologic mapping and map reading, projection diagrams, stress and strain ellipsoid and stress-strain relationships of elastic, plastic, and viscous materials. Strain markers in deformed rocks. Behaviour of minerals and rocks under deformation conditions. Folds and faults classification and mechanics. Structural analysis of folds, foliations, lineations, joints and faults, unconformities. Superposed deformation. Time – relationship between crystallization and deformation. Introduction to petro-fabrics.</p> <p>b. Engineering properties of rocks. Geological investigations for dams, tunnels and bridges. Rock as construction material. Alkali-aggregate reaction. Earthquake-resistant structures.</p>
<b>3</b>	<b>Igneous Petrology and Metamorphic petrology</b>
	<p>a. Generation and crystallisation of magma. Crystallisation of albite-anorthite, diopside-anorthite and diopside-wollastonite- silica systems. Magmatic differentiation and assimilation. Petrogenetic significance of the textures and structures of igneous rocks. Petrography and petrogenesis of granite, syenite, diorite, basic and ultrabasic groups, charnockite, anorthosite and alkaline rocks. Carbonatites.</p> <p>b. Types and agents of metamorphism. Metamorphic grades and zones. Phase rule. Facies of regional and contact metamorphism. ACF and AKF diagrams. Textures and structures of metamorphic rocks. Metamorphism of arenaceous, argillaceous and basic rocks. Minerals assemblages, Retrograde metamorphism. Metasomatism and granitisation, migmatites.</p>

<b>4</b>	<b>Paleontology, Stratigraphy</b>
	<p>a. Species, Megafossils and Microfossils. Modes of preservation of fossils. Morphology, geological history and evolutionary trend in Cephalopoda, Trilobita, Brachiopoda, Echi-noidea. Evolutionary trend in Hominidae, Equidae and Probo-scidae. Siwalik fauna, Gondwana flora and its importance.</p> <p>b. Classification of stratigraphic sequences: lithostratigraphic, biostratigraphic, chronostratigraphic and magnetostratigraphic and their interrelationships. Distribution and classification of Precambrian rocks of India. Study of stratigraphic distribution and lithology of Phanerozoic rocks of India with reference to fauna, flora and economic importance. Major boundary problems -Cambrian/ Precambrian, Permian/ Triassic, Cretaceous/ Tertiary and Pliocene/Pleistocene. Study of climatic conditions, paleogeography and igneous activity in the Indian subcontinent in the geological past. Tectonic framework of India</p>
<b>5</b>	<b>General geology and Geochemistry</b>
	<p>a. The Solar System, origin and interior of the earth. Radioactivity and age of earth; Island arcs, deep sea trenches and mid-ocean ridges. Continental drift-evidences and mechanics, plate tectonics. Isostasy.</p> <p>b. Cosmic abundance of elements, Composition of the planets and meteorites, Structure and composition of earth and distribution of elements, Trace elements, Elements of crystal chemistry - types of chemical bonds, coordination number, Isomorphism and polymorphism, Elementary thermodynamics.</p>
<b>6</b>	<b>Mineralogy and Economic Geology</b>
	<p>a. Classification of crystals into systems and classes of symmetry. Use of projection diagrams to represent crystal symmetry. Crystal defects. Elements of X-ray crystallography. Petrological microscope and accessories. Optical properties of common rock forming minerals. Pleochroism and, extinction angle, double refraction, birefringence, twinning. Physical and chemical characters of rock forming silicate mineral groups. Structural classification of silicates. Common minerals of igneous and metamorphic rocks.</p> <p>b. Ore, ore minerals and gangue, tenor of ore, classification of ore deposits. Process of formation of minerals deposits. Controls of ore localisation. Ore textures and structures, Metallogenic epochs and provinces, Geology of the important Indian deposits of aluminium, chromium, copper, gold, iron, lead, zinc, manganese, titanium, uranium and thorium and industrial minerals. Deposits of coal and petroleum in India. National Mineral Policy. Conservation and utilization of mineral resources. Methods of prospecting-geological, geophysical, geo-chemical and geo-botanical, Techniques of sampling. Estimation of reserves of ore, Methods of exploration and mining metallic ores, industrial minerals and marine mineral resources.</p>

<b>7</b>	<b>Sedimentology and Sedimentary petrology</b>
	Sedimentary rocks: Processes of formation, diagenesis and lithification. Clastic and non-clastic rocks-their classification, petrography and depositional environment, Sedimentary facies and provenance. Sedimentary structures and their significance. Heavy minerals and their significance. Sedimentary basins of India.
<b>8</b>	<b>Hydrology and Environmental geology</b>
	<p>a. Hydrologic cycle and genetic classification of water. Movement of subsurface water, Springs. Porosity, permeability, hydraulic conductivity, transmissivity and storage coefficient, classification of aquifers. Water-bearing characteristics of rocks. Ground-water chemistry. Salt water intrusion. Types of wells. Drainage basin morphometry. Exploration for groundwater. Groundwater recharge.</p> <p>b. Natural hazards-floods, landslides, coastal erosion, Environmental impact of urbanization, open cast mining, industrial and radioactive waste disposal, use of fertilizers, dumping of mine waste and fly-ash. Volcanoes-causes and products, volcanic belts. Earthquakes-causes, effects, earthquake belts, seismicity of India, intensity and magnitude, seismographs. Pollution of ground and surface water, marine pollution, environment protection-legislative measures in India.</p>

## 10. MATHEMATICS (Subject Code - 1085)

Sr.No.	Topics
1.	<p><b>Calculus and Analytic Geometry:</b></p> <p>Functions of several variables: continuity, differentiability, partial derivatives, maxima and minima, Lagrange's method of multipliers, Jacobian. Riemann's definition of definite integrals, indefinite integrals, infinite and improper integrals, beta and gamma functions. Double and triple integrals (examples only).</p> <p>Cartesian and polar coordinates in two and three dimensions, second degree equations in two and three dimensions, reduction to canonical forms, straight lines, shortest distance between two skew lines.</p>
2.	<p><b>Algebra and Real Analysis:</b></p> <p>Groups, subgroups, normal subgroups, homomorphism of groups quotient groups basic isomorphism theorems, Sylow's group, permutation groups, Cayley theorem.</p> <p>Real number system, ordered sets, bounds, ordered field, real number system as an ordered field with least upper bound property, Cauchy sequence, completeness, Continuity and uniform continuity of functions, properties of continuous functions on compact sets. Riemann integral, improper integrals, absolute and conditional convergence of series of real and complex terms, rearrangement of series.</p>
3.	<p><b>Complex Analysis and Numerical Analysis:</b></p> <p>Analytic function, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's integral formula, power series, Taylor's series, Laurent's Series, Singularities, Cauchy's residue theorem, contour integration. Conformal mapping, bilinear transformations.</p> <p>Numerical methods: Solution of algebraic and transcendental equations of one variable by bisection, Regula-Falsi and Newton-Raphson methods, Newton's (Forward and backward) and Lagrange's method of interpolation.</p>
4.	<p><b>Dynamics and Vector Analysis:</b></p> <p>Degree of freedom and constraints, rectilinear motion, simple harmonic motion, motion in a plane, projectiles, constrained motion, work and energy, conservation of energy, motion under impulsive forces, Kepler's laws, orbits under central forces, motion of varying mass, motion under resistance.</p> <p>Scalar and vector fields, triple, products, differentiation of vector function of a scalar variable, gradient, divergence and curl in Cartesian, cylindrical and spherical coordinates and their physical interpretations.</p>
5.	<p><b>Linear Algebra and Ordinary Differential Equations:</b></p> <p>Matrices, Cayley-Hamilton theorem, Eigen values and Eigenvectors, Matrix of linear transformation, row and column reduction, Echelon form, equivalence, congruence and similarity, reduction to canonical form, rank, orthogonal, symmetrical, skew symmetrical, unitary, Hermitian, skew-Hermitian forms and their Eigen values.</p> <p>Formulation of differential equations, order and degree, equations of first order and first degree, integrating factor, equations of first order but not of first degree, Clariaut's equation, singular solution. Higher order linear equations, with constant coefficients, complementary function and particular integral, general solution.</p>

6.	<p><b>Partial differential equations and Mechanics:</b></p> <p>Curves and surfaces in three dimensions, formulation of partial differential equations, solutions of equations of type <math>\frac{dx}{P} = \frac{dy}{Q} = \frac{dz}{R}</math>, Orthogonal trajectories, Charpit's method of solutions, linear partial differential equations of the second order with constant coefficients.</p> <p>Generalized coordinates, constraints, holonomic and non-holonomic, systems. D'Alembert's principle and Lagrange's equations, Hamilton equations, motion of rigid bodies in two dimensions.</p>
7.	<p><b>Numerical integration and Numerical solution of ordinary differential equations:</b></p> <p>Simpson's one-third rule, trapezoidal rule, Gaussian quadrature formula.</p> <p>Euler and Runge Kutta methods (second order and fourth order)</p>
8.	<p><b>Computer Programming and Linear Programming:</b></p> <p>Storage of numbers in Computers, bits, bytes and words, binary system. Arithmetic and logical operations on numbers. Bitwise operations. AND, OR, XOR, NOT, and shift/rotate operators. Octal and Hexadecimal Systems. Conversions with decimal Systems.</p> <p>Linear programming problems, basic solution, basic feasible solution and optimal solution of transportation and assignment problems.</p>



## 11. MECHANICAL ENGINEERING (Subject Code - 1086)

Sr. No.	Topic
1.	<b>Mechanical Design:</b> Stress and strains in two dimension, Principal stresses and strains, thermal stresses, bending and shear stresses in beams, deflection of beams, Static and dynamic failure theories, Kinematic and dynamic analysis of planar mechanisms, Mechanical Vibration: Single and two degree of freedom systems, Gear trains, Flywheels, Governors. Balancing of rotary and translator masses. Design of mechanical elements – shafts, bearing, gear, pressure vessels.
2.	<b>Engineering Materials and smart materials:</b> <b>Engineering materials:</b> 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. <b>Smart Materials:</b> Piezoelectric Polymers, Magnetostrictive materials, Electro-active Materials, Ionic Polymer Matrix Composite (IPMC), Shape Memory Effect, Shape Memory Alloys, Shape Memory Polymers, Electro-rheological Fluids, Magneto Rheological Fluids.
3.	<b>Manufacturing Science:</b> Conventional machining processes, NC, CNC. Metal forming – Rolling, forging, extrusion. Casting and welding processes, Non-conventional processes, EDM, ECM, plasma machining, laser beam and ultrasonics. Tools, dies and mould design. Mechanical measurement and instrumentation.
4.	<b>Smart Manufacturing:</b> <b>Mechatronics</b> – Sensors, actuators, control systems, microprocessors and microcontrollers, programmable logic controllers, SCADA. <b>Flexible Manufacturing Systems:</b> Types of FMS, FMS components, Computer Integrated Manufacturing, AGVs, ASRS, Automatic parts identification systems and data capture. <b>Additive Manufacturing Systems:</b> Photo polymerization, material jetting, binder jetting, material extrusion, Powder bed sintering techniques, sheet lamination, 3 D printing and Industry 4.0
5.	<b>Production management:</b> Strategic planning: Plant Location and Facility Layout, Breakeven analysis, Project management- PERT and CPM, Forecasting-Moving average, exponential smoothing, Operations scheduling; Assembly line balancing, Product development, Capacity planning. Control Operations: Inventory control-ABC analysis, EOQ model, MRP, ERP. Theory of Constraints, Supply Chain Management, Operations Research: Linear programming-Graphical and Simplex methods, Transportation and assignment models, Single server queuing model. Value Engineering: Value analysis for cost/value. Total quality management and Coordinate Measuring machine quality control, Reliability engineering.

<b>6.</b>	<b>Numerical methods and computer programming:</b> C programming for Solution of Transcendental / Polynomial Equations and System of Linear Equation, Interpolation and Polynomial Approximation, Numerical Integration and Differentiation.
<b>7</b>	<b>Thermodynamics :</b> Basic concepts. Open and closed systems, Applications of Thermodynamic Laws, Gas equations, steady flow energy equation, Availability, Irreversibility and TdS relations. Selection of site for steam, hydro, nuclear and stand-by power plants, selection base and peak load power plants Modern High pressure, High duty boilers, Draft and dust removal equipment, Fuel and cooling water systems, heat balance, station and plant heat rates, operation and maintenance of various power plants, preventive maintenance, economics of power generation.
<b>8</b>	<b>I.C. Engines, Fuels and Combustion:</b> Spark Ignition (SI) and Compression ignition (CI) 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. GDI and CRDI engine, Choice of engine fuels, Octane and Cetane ratings. Alternate fuels Carburation and Fuel injection, Engine emissions and control. Solid, liquid and gaseous fuels, stoichiometric air requirements and excess air factor, fuel gas analysis, higher and lower calorific values and their measurements. Recent developments - electrical vehicles.
<b>9</b>	<b>Heat Transfer, Refrigeration and Air conditioning:</b> One and two dimensional heat conduction. Heat transfer from extended surfaces, Heat exchangers. Fundamentals for diffusive and connective mass transfer, Radiation laws, heat exchange between black and non black surfaces, Network Analysis. Heat pump refrigeration cycles and systems, Condensers, evaporators and expansion devices and controls. Properties and choice of refrigerant, Refrigeration Systems and components, psychometrics, comfort indices, cooling loading calculations, solar refrigeration. ODP and CWP : impact on refrigeration industry, Norms of HAVC&R.
<b>10</b>	<b>Turbo-machines and fluid flow:</b> Continuity, momentum and Energy Equations. Adiabatic and Isentropic flow, Fanno lines, Rayleigh lines. Theory and design of axial flow turbines and compressors, Flow through turbo-machine blade, cascades, centrifugal compressor. <b>Computational fluid dynamics:</b> Solution approaches - Finite difference method, Finite Volume Technique, Navier-Stokes Equations, Turbulence modelling.

## 12. PHYSICS (Subject Code - 1087)

Sr. No.	Topics
<b>1</b>	<p><b>Classical Mechanics:</b></p> <p>Centre of mass and laboratory coordinates conservation of linear and angular momentum. Inertial and non-inertial frames, rotating frames, centrifugal and Coriolis forces, Foucault pendulum. Constraints, degrees of freedom, generalized coordinates and moments. Lagrange's equation and applications to linear harmonic oscillator, simple pendulum and central force problems. Cyclic coordinates. Eulerian angles, inertia tensor, principal moments of inertia. Euler's equation of motion of a rigid body, force-free motion of a rigid body. Simple harmonic motion, damped oscillation, forced oscillation and resonance. Beats. Stationary waves in a string. Pulses and wave packets.</p>
<b>2</b>	<p><b>Optics:</b></p> <p>Phase and group velocities. Laws of reflection and refraction from Fermat's principle. thin lens formula, nodal planes, system of two thin lenses, chromatic and spherical aberrations. Interference of light - Young's experiment, Newton's rings, Michelson interferometer. Multiple beam interference and Fabry-Perot interferometer. Holography and simple applications. Fraunhofer diffraction-single slit, double slit, diffraction grating, resolving power. Fresnel diffraction. Diffraction by a circular aperture and the Airy pattern. Production and detection of linearly and circularly polarised light. Double refraction. Optical activity. Principles of fibre optics attenuation; material dispersion, single mode fibres. Properties of Laser.</p>
<b>3</b>	<p><b>Electricity and Magnetism:</b></p> <p>Laplace and Poisson equations in electrostatics and their applications. Energy of a system of charges. Potential and field due to a dipole, force and torque on a dipole in an external field. Dielectrics and polarisation. Solutions to boundary-value problems. Magnetic shell, uniformly magnetized sphere. Ferromagnetic materials, hysteresis, energy loss. Kirchhoff's laws and their applications. Biot-Savart law, Ampere's law, Faraday's law, Lenz's law. Self-and mutual-inductances. Mean and r.m.s. values in AC circuits. LR CR and LCR circuits-series and parallel resonance. Quality factor. Principle of transformer. Displacement current and Maxwell's equations. Wave equations in vacuum. Vector and scalar potentials.</p>
<b>4</b>	<p><b>Thermal and Statistical Physics:</b></p> <p>Laws of thermodynamics, reversible and irreversible processes, entropy. Isothermal, adiabatic, isobaric, isochoric processes and entropy change. Otto and Diesel engines, Gibbs' phase rule and chemical potential. Van der Waals equation of state of a real gas, critical constants. Maxwell-Boltzman distribution of molecular velocities, transport phenomena, equipartition and virial theorems. Maxwell relations and applications. Blackbody radiation and Planck radiation law, Stefan-Boltzmann law, Wien displacement law and Rayleigh-Jeans law.</p>

<b>5</b>	<b>Quantum Mechanics:</b> Wave-particle duality. Schrodinger equation and expectation values. Uncertainty principle. Solutions of the one-dimensional Schrodinger equation for free particle (Gaussian wave-packet), particle in a box. Reflection and transmission by a potential step and by a rectangular barrier. Particle in a three dimensional box, density of states.
<b>6</b>	<b>Atomic Physics and Molecular Physics:</b> The hydrogen atom. The angular momentum, the spin half problem and properties of Pauli spin matrices. Stern-Gerlach experiment, electron spin, fine structure of hydrogen atom. LS coupling, J-J coupling. Spectroscopic notation of atomic states. Normal Zeeman effect. Franck Condon principle and applications. Elementary theory of rotational, vibrational and electronic spectra of diatomic molecules. Raman effect and molecular structure. Elementary theory and applications of NMR.
<b>7</b>	<b>Nuclear and Particle Physics:</b> Basic nuclear properties - size, binding energy, angular momentum, parity, magnetic moment. Semi-empirical mass formula and applications. Salient features of nuclear forces. Shell model of the nucleus - success and limitations. Violation of parity in beta decay. Gamma decay and internal conversion. Qvalue of nuclear reactions. Nuclear fission and fusion. Classification of elementary particles and their interactions. Conservation laws. Quark structure of hadrons. Field quanta of electroweak and strong interactions. Elementary ideas about Unification of Forces. Physics of neutrinos.
<b>8</b>	<b>Solid State Electronics :</b> Crystal structure. Band theory of solids-conductors, insulators and semiconductors. Intrinsic and extrinsic semiconductors, p-n-p and n-p-n transistors. Amplifiers and oscillators. Op-amps. Digital electronics-Boolean identities, De Morgan's laws, Logic gates and truth tables, Simple logic circuits.
<b>9</b>	<b>Biological Physics:</b> Biological fluids, Physico-chemical properties, viscosity, surface tension, pH, osmosis, osmotic pressure, diffusion. Thermodynamics approach to Bio-Physics, Laws of thermodynamics and living organisms, comparison of living and non-living systems as a thermodynamics system. Applications of diffusion to biology, Nerve impulses, Simplified mechanism of the action potential, The Hodgkin-Huxley equation.

### 13. STATISTICS (Subject Code - 1088)

Sr. No.	Topic
1.	<b>Probability:</b> Random variables, Theorems of probability, Conditional probability, independent events, Bayes' theorem, and its application, standard discrete and continuous probability distributions, their inter-relations, and limiting cases, moments, distribution functions, Markov's inequality, Chebyshev's inequality, Cauchy Schwarz inequality, Laws of large numbers, Central Limit theorems and its applications, simple properties of finite Markov chains.
2.	<b>Statistical Inference:</b> Properties of estimators, methods of estimation, properties of maximum likelihood, and other estimators; MVUE, Rao-Blackwell, and Lehmann-scheffe theorems, Cramer-Rao Inequality, and confidence intervals. Simple and composite hypothesis, Type I and Type II errors, size and power of a test, Most Powerful and Uniformly Most Powerful tests, Neyman - Person lemma, Likelihood Ratio test and its properties and applications. SPRT, OC and ASN functions. Test of goodness of fit. Parametric and Non-parametric Test.
3.	<b>Linear Inference and Multivariate Analysis:</b> Linear statistical models, least square method and analysis of variance, Gauss – Markov theorem, Multiple and partial regression, Simple and multiple linear regression, Regression diagnostics and sensitivity analysis, Bivariate and multivariate normal distribution, Marginal and conditional distribution, MLE of mean vector and covariance matrix, Wishart distribution, Mahalanobis $D^2$ , and Hotelling $T^2$ and its application, Canonical Correlation, Principal component analysis.
4.	<b>Sampling Theory and Design of Experiment:</b> Simple and Stratified random sampling, Systematic and cluster sampling, two-stage and PPS sampling. Ratio and regression methods of estimation. Horvitz - Thompson estimators.  Principal of design of experiments, CRD, RBD, LSD, and their analysis, $2^2$ and $2^3$ factorial designs. Confounding, Balanced incomplete Block design.
5.	<b>Industrial Statistics:</b> Quality Control; Process Control, and Product Control, and charts, Acceptance Sampling plan, single and double sampling plans, OC, ASN, AOQ, and ATI curves, LTPD, and AOQL.  Concept of reliability, Reliability of series system, parallel system, and k out of n system, Life distributions, reliability function, hazard rate, Notions of aging - IFR, DFR, IFRA. Problems in life testing.
6.	<b>Optimization techniques:</b> Linear programming problem, graphical method simplex method, two - phase method, Duality theory, transportation and assignment problem, two person game, zero sum games. Replacement analysis, Deterministic Inventory Models. Markov chains, TPM, Classification of states, Poisson process, elements of queueing theory, M/M/1, M/M/K and G/M/1 queues.

7.	<p><b>Quantitative Economics and Official Statistics:</b></p> <p>Components of Time Series, Tests for stationery of series, ARIMA models and determination of orders of autoregressive and moving average components, forecasting.</p> <p>Commonly used index numbers - Laspeyre's, Paashe's and Fisher's ideal index numbers, consumer price index number, index numbers of agricultural and industrial production, tests for index numbers like proportionality test, time-reversal test, factor-reversal test.</p> <p>General linear model, ordinary least squares, and generalized least squares methods of estimation, Multicollinearity, Autocorrelation, and Heteroscedasticity.</p> <p>Present official statistical system in India relating to population, agriculture, industrial production, trade and prices, methods of collection of official statistics, their reliability and limitation and the principal publications containing such statistics, various official agencies responsible for data collection and their main functions.</p>
8.	<p><b>Demography and Psychometry:</b></p> <p>Sources of demographic data, census, registration, ad-hoc surveys, and Hospital records. Complete life table and its main features, Uses of life table, Makehams and Gompertz curves. Measurement of Fertility: CBR, GFR, ASBR, TFR, GRR, NRR. Measurement of Mortality: CDR, STDR, ASDR, IMR.</p> <p>Methods of standardization of scales and tests, Z - score, standard score, T-scores, percentile scores, intelligence quotient and its measurement and uses, the validity of test scores its determination, use of factor analysis and path analysis in psychometry.</p>

## 14. ZOOLOGY (Subject Code - 1089)

Sr.No.	Topic
1	<p><b>Non-chordata and Chordata :</b></p> <ol style="list-style-type: none"> <li>a. Classification of Animal kingdom upto classes; Acoelomata, pseudocoelomate and Coelomata.</li> <li>b. Porifera: General characteristics, types of cell, Skeleton, canal system and reproduction.</li> <li>c. Coelenterate: Polymorphism (polyps, and medusa), nematocyst (defensive structures) and its role in defense; coral reefs, alternation of generation life history of Obelia.</li> <li>d. Platyhelminthes: Parasitic adaptation; general features and life history of Fasciola hepatica and Taenia solium.</li> <li>e. Nematodes: General features, life history of Ascaris and parasitic adaptation in Nematodes.</li> <li>f. Annelida: General features – Segmentation and reproduction in life history of earthworm (Pheretima)</li> <li>g. Arthropoda: General characteristics, compound eye in house fly, Vision in spider, Respiration in arthropods (prawn, cockroach and scorpion), modification of mouth parts in insects (cockroach, mosquito, and honey bee ); metamorphosis in insects and its hormonal regulation; social organization in insects (termites and honey bees).</li> <li>h. Mollusca : General characteristics, Feeding, locomotion, shell diversity, Life history of Sepia, torsion and detorsion in gastropods.</li> <li>i. Echinodermata : Water vascular system Feeding, locomotion, larval forms;</li> <li>j. Pisces : Types of Scales, migration, lateral line system.</li> <li>k. Amphibia : General characteristics of three order of class amphibian; parental care.</li> <li>l. Reptilia : Classification and characteristics of each class with examples, skull types; status of crocodiles.</li> <li>m. Aves: characteristic features of respiratory, circulatory, excretory, reproductive, Skelton system of birds wrt flight adaptation, migration in birds.</li> <li>n. Mammalia: General features of egg laying mammals, pouched-mammals, aquatic mammals and primates, dentition; histological structures of endocrine glands (pituitary, thyroid, parathyroid, adrenal, pancreas, gonads)</li> <li>o. Comparative functional anatomy of various systems of vertebrates, digestive system, respiratory system, circulatory system including heart and aortic arches; urinogenital system.</li> </ol>
2	<p><b>Ecology :</b></p> <ol style="list-style-type: none"> <li>a. Biosphere: Biogeochemical cycles, green-houses effect, ozone layer and its impact on atmosphere.</li> <li>b. Population, characteristics, population dynamics, population stabilization.</li> <li>c. Conservation of natural resources - wildlife (Project Tiger). National parks and sanctuaries.</li> <li>d. Environmental biodegradation; pollution and its impact on biosphere and its prevention.</li> </ol>

3	<b>Ethology :</b> <ol style="list-style-type: none"> <li>Behaviour : Sign stimuli, learning, instinct, habituation, conditioning, imprinting.</li> <li>Role of hormones in drive; role of pheromones in alarm spreading; predator detection, predator tactics, social behavior in insects.</li> <li>Biological rhythms; Biological clock.</li> </ol>
4	<b>Economic Zoology :</b> <ol style="list-style-type: none"> <li>Apiculture, sericulture, pearl culture, prawn culture, poultry.</li> <li>Major infectious and communicable diseases (malaria, cholera AIDS and COVID-19) their vectors, pathogens and prevention.</li> <li>Cattle and livestock diseases, their pathogens (helminthes) and vectors (ticks, mites)</li> <li>Pests of sugar cane (<i>Pyrilla perpusiella</i>), and rice (<i>Sitophilus oryzae</i>).</li> </ol>
5	<b>Biostatistics :</b> Designing of experiments; null hypothesis; correlation, distribution and measure of central tendency, chi square, student t-test.
6	<b>Instrumental methods:</b> <ol style="list-style-type: none"> <li>Spectro photometry, flame photometry, PCR, RT-PCR.</li> <li>Electron microscopy (TEM, SEM).</li> </ol>
7	<b>Cell Biology :</b> <ol style="list-style-type: none"> <li>Structure and function of cell and its organelles: Fluid mosaic model of plasma membrane; transport across plasma membrane, nucleus, mitochondria, Golgi bodies, endoplasmic reticulum, ribosome's and Lysosomes, cell division (mitosis and meiosis)</li> <li>Watson-Crick model of DNA, replication of DNA, protein synthesis, transcription in eukaryotes.</li> </ol>
8	<b>Genetics:</b> <ol style="list-style-type: none"> <li>Genetic code.</li> <li>Sex determination in <i>Drosophila</i>, and human.</li> <li>Mendel's laws of inheritance, recombination, linkage, multiple alleles, genetics of blood groups.</li> <li>Mutations and mutagenesis : radiation and chemical.</li> <li>Cloning technology, plasmids and cosmids as vectors.</li> <li>Gene Expressions and regulation : lac operon.</li> <li>Pedigree analysis, congenital diseases in human (sickle cell anemia, thalassaemia).</li> <li>Human genome mapping; DNA finger-printing.</li> </ol>
9	<b>Evolution:</b> <ol style="list-style-type: none"> <li>Origin of life</li> <li>Natural selection, role of mutation in evolution, mimicry, variation, isolation, speciation.</li> <li>Fossils and fossilization; evolution of horse and human.</li> <li>Hardy-Weinberg Law, causes of change in gene frequency.</li> <li>Zoological nomenclature; international code. Cladistics.</li> </ol>



<b>10</b>	<b>Biochemistry</b> <ol style="list-style-type: none"> <li>Structure and role of carbohydrates, fats, lipids, proteins, amino acids, nucleic acids;</li> <li>Glycolysis and Krebs cycle, oxidative phosphorylation;</li> <li>Hormone classification (steroid and peptide hormones), biosynthesis and function of pituitary, thyroid, parathyroid, adrenal and pancreas, and their functions in growth and metabolism.</li> <li>Enzymes: Classification of enzymes and mechanisms of action; vitamins and coenzymes.</li> </ol>
<b>11</b>	<b>Physiology</b> (with special reference to mammals) <ol style="list-style-type: none"> <li>Constituents of blood; blood groups and Rh factor in human.</li> <li>Oxygen and carbon dioxide transport; structure and function of hemoglobin.</li> <li>Role of salivary glands, liver, pancreas and intestinal glands in digestion.</li> <li>Excretory products; structure of nephron, reabsorption and secretion at PCT Loop of Henle, DCT and Collecting ducts, renin angiotensin system in regulation of urine formation;</li> <li>Types of muscles, Mechanism of contraction of skeletal muscles, sliding theory.</li> <li>Neuron, conduction of nerve impulse (saltatory conduction and continuous conduction), transmission at synapse.</li> <li>Physiology of reproduction, role of hormones (estrogen, testosterone, androgen)</li> </ol>
<b>12</b>	<b>Developmental Biology</b> <ol style="list-style-type: none"> <li>Differentiation from gamete to neurula stage; morphogenesis and morphogen; fate maps of gastrulae in frog and chick; organogenesis of eye and heart, placentation in mammals.</li> <li>Aging, Neoteny, Teratogenesis; Neoplasia</li> <li>Invasiveness of placenta; in vitro fertilization; embryo transfer, cloning.</li> </ol>

सचिव

दिनांक — २४/०१/२०२३

महाराष्ट्र लोकसेवा आयोग