



## SHRI GURU RAM RAI UNIVERSITY

Patel Nagar, Dehradun-248001, Uttarakhand, India

[Estd. by Govt. of Uttarakhand, vide Shri Guru Ram Rai University Act no. 03 of 2017 & recognized by UGC u/s 2(f) of UGC Act 1956]

### 1. Eligibility criteria for Applicants:

An applicant who has passed Post Graduate Degree Examination with at least 55% marks or with an equivalent Grade Point Average (GPA). Relaxation of 5% in the required percentage of marks will be given to applicants belonging to SC/ST/OBC (non-creamy layer)/differently-abled categories.

### 2. Written test:

For RET, there would be two papers i.e. **Paper-I and Paper-II** (Paper-I would be Research Methodology of 50 marks and Paper-II would be Subject specific of 50 marks. Both papers will have 50 questions each with multiple choices). The Entrance Test shall be of two hour duration (i.e. 120 minutes). Applicants have to qualify in aggregate with 50% (45% in case of reserved categories) marks. After qualifying the entrance examination, the applicant has to face a viva voce of 40 marks. Selected applicants list will be displayed on university web site; [www.sgrru.ac.in](http://www.sgrru.ac.in).

### 3. Exemption from RET:

The applicants fulfilling at least one of the following conditions:

- Qualified in NET/SET/GATE/GPAT examination of the apex bodies as CSIR/UGC/ICAR/ICMR/DBT/AICTE.
- M.Phil Degree in a relevant subject obtained from any Recognized University.
- Senior citizen of age of 60 years and above with Master's degree.
- Candidate such as Advocate/Doctor/Artist/Industry Professional/Employee of Government/Semi-Government Organizations with Post Graduate Degree (at least 55% marks) and 10 years of professional experience.

The applicants entitled for exemption from RET shall also submit the application form along with relevant supporting documents within the stipulated period.

## **RET Paper I: Research Methodology**

### **Unit I-Concept & Types of Research**

Meaning and importance of Research – Types of Research – Selection and formulation of Research Problem – Research Design, Classification of Research, Pure and Applied Research, Exploring or Formulative Research, Descriptive Research, Diagnostic Research/Study, Evaluation research/Studies, Action Research, Experimental Research, Analytical Study of Statistical Method, Historical Research.

### **Unit II –Methods Research**

Surveys, Case Study, Field Studies General Survey of various Methods including Survey Method, Interdisciplinary Method, Case Study Method, Sampling Method, Statistical Method, Observation Method, Interview Method, Schedule Method, Questionnaire Method, Documentary Method, Library Method, Historical Method and Scientific Method. Characteristic Features of Scientific Method; Empirical Verifiable, Cumulative, Self - Correcting, Deterministic, Ethical & Ideological neutrality (Value Free), Statistical Generalizability.

### **Unit III - Data Collection and Data Analysis**

Collection, Objectives and Classification of Data, Aims, Methods and Objects of Tabulation of Data, Forms and Processes of Interpretation and Presentation of Data.

Primary, Secondary and Tertiary Data. Construction and adaptation of instruments, administration of questions and tests, Tabulation of data. Data organization in SPSS & Excel, Graphical representation of data

Definition and Aims of Content Analysis, Problems of Content Analysis, Computer and Content Analysis Discussion and Interpretation of results, Testing of Hypothesis: Logical and Statistical Techniques.

### **Unit IV: Report Writing**

Locating Information on a Topic of Interest, Acquiring Copies of Articles of Interest, The Nature of Scientific Variables, Conceptual Versus Operational Definitions of Variables, Levels of Measurement, Various Paradigms, The Basic Format for a Research Report, Identification of the Parts of a Research Report, Citation and Referencing Styles, Essentials of Report Writing, Aids for Writing Good Research Report.

### **References:**

- 1) Bagchi, Kanak Kanti (2007) Research Methodology in Social Sciences: A Practical Guide, Delhi, Abijeet Publications.
- 2) Kothari, C.R (2004) Research Methodology: An Introduction, Delhi, New Age.

## **RET Paper II: Subject Specific**

### **1. Soil Science**

#### **UNIT- I**

Soil fertility and soil productivity; nutrient sources – fertilizers and manures; essential plant nutrients - functions and deficiency symptoms, soil and fertilizer nitrogen – sources, forms, immobilization and mineralization, nitrification, denitrification. Biological nitrogen fixation -types, mechanism, microorganisms and factors affecting; nitrogenous fertilizers and their fate in soils; management of fertilizer nitrogen in lowland and upland conditions for high fertilizer use efficiency.

Soil and fertilizer phosphorus - forms, immobilization, mineralization, reactions in acid and alkali soils; factors affecting phosphorus availability in soils; phosphatic fertilizers - behavior in soils and management under field conditions. Potassium - forms, equilibrium in soils and its agricultural significance; mechanism of potassium fixation; management of potassium fertilizers under field conditions, sulphur - source, forms, fertilizers and their behavior in soils; calcium and magnesium– factors affecting their availability in soils; management of sulphur, calcium and magnesium fertilizers. Micronutrients – critical limits in soils and plants; factors affecting their availability and correction of their deficiencies in plants; role of chelates in nutrient availability.

Common soil test methods for fertilizer recommendations; quantity– intensity relationships; soil test crop response correlations and response functions, fertilizer use efficiency; blanket fertilizer recommendations – usefulness and limitations. Site- specific nutrient management; plant need based nutrient management; integrated nutrient management, soil fertility evaluation - biological methods, soil, plant and tissue tests; soil quality in relation to sustainable agriculture.

#### **UNIT-II**

Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils. Diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids.

Soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions. Ion exchange processes in soil; cation exchange- theories based on law of mass action (Kerr-Vanselow, Gapon equations, hysteresis, Jenny's concept), adsorption isotherms, donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement,; anion and ligand exchange – innersphere and outer-sphere surface complex formation. Fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions, shift of PZC on ligand exchange, AEC, CEC; experimental methods to study ion exchange phenomena.

#### **UNIT-III**

Concept of soil individual; soil classification systems – historical developments and modern systems of soil classification with special emphasis on soil taxonomy; soil classification, soil mineralogy and soil maps – usefulness.

Soil survey and its types; soil survey techniques - conventional and modern; soil series – characterization and procedure for establishing soil series; benchmark soils and soil correlations; soil survey interpretations; soil mapping, thematic soil maps, cartography, mapping units, techniques for generation of soil maps.

#### **UNIT-IV**

Preparation of solutions for standard curves, analytical reagents, qualitative reagents, indicators and standard solutions for acid-base, oxidation reduction and complexometric titration. Soil, water and plant sampling techniques, their processing and handling. Estimation of phosphorus, ammonium and potassium fixation capacities of soils. Principles of visible, ultraviolet and infrared spectrophotometry, atomic absorption, flame-photometry, inductively coupled plasma spectrometry; chromatographic techniques.

Electrochemical titration of clays; estimation of exchangeable cations (Na, Ca, Mg, K); estimation of root cation exchange capacity. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo. Analysis of plant materials by digesting plant materials by wet and dry ashing and of soil by wet digestion method.

## 2. SEED SCIENCE AND TECHNOLOGY

### Unit 1:

Seed Biology, Floral biology, mode of reproduction, sporogenesis, pollination, fertilization, embryogenesis, fruit and seed development and physiological and harvestable maturity. Apomixis, parthenocarpy, polyembryony and somatic embryoids and synthetic seeds. Seed structure of monocot and dicot. Seed maturation and maturation drying in orthodox and recalcitrant seed. Seed chemical composition. Seed dormancy – types, causes, methods to overcome dormancy. Seed germination – phases, types and requirements. Physiological and biochemical changes in germinating seed. Role of hormones in dormancy and germination.

### Unit 2:

Seed Production Genetic purity – concept and factors responsible for deterioration of varieties. Maintenance breeding. Generation system of seed multiplication. Seed production agencies – public and private. Compact area approach / seed village concept in seed production. Seed Replacement Rate, Seed Multiplication Ratio, Seed Renewal Period, Varietal Replacement Rate. Seed production planning. Factors affecting pollination and seed set viz., temperature, humidity, wind velocity, insect pollinators and supplementary pollination. Male sterility, self-incompatibility and their role in hybrid seed production. Techniques of hybrid seed production – emasculation and pollination, detasseling, male sterility, sex expression, self-incompatibility and chemical hybridizing agents. Principles and methods of seed production of varieties and hybrids of cereals – wheat, paddy, sorghum, pearl millet and maize; pulses – chickpea, pigeon pea, green gram, black gram, soybean and cowpea; oilseeds – groundnut, brassica, sesame, sunflower and castor; fibre crops – cotton and jute; vegetable crops – tomato, brinjal, okra, chilli, cabbage, cauliflower, radish, knolkhol, turnip, carrot and cucurbitaceous crops; important forage legumes – lucerne, desmanthus and grasses – cumbunapier and fodder sorghum; plantation crops – coffee, tea, rubber, cocoa, cardamom, coconut and pepper. Disease free clonal propagation of crops – potato, sugarcane, tapioca, fruit crops – mango, citrus, apple, pear, plum. Clonal propagation of annual and perennial flowers like rose, gladiolus, chrysanthemum, marigold, dahlia, phlox and petunia. Clonal standards and degenerations. Micro propagation.

### Unit 3:

Seed Processing, Principles of seed processing. Processing sequence for different crops. Layout of seed processing unit. Seed drying – principles and methods. Pre-cleaning, grading, upgrading, seed treatment and packaging. Working principles of seed processing machines viz., cleaner cum grader, specific gravity separator, indented cylinder separator and seed treater. Seed quality maintenance during processing. Seed enhancement techniques – seed coating, pelleting and priming.

### Unit 4:

Seed Quality Control Seed legislation – the Seeds Act 1966, Seed Rules 1968, Seed Control Order, 1983 and Seed Bill 2004. Seed certification – history, concept, organization, phases and Indian

minimum seed certification standards. Field inspection principles and methods. Inspection at harvesting, threshing and processing. Pre- and post-processing quality testing of seed. Seed testing concepts and objectives, its role in seed quality control. Seed sampling, seed moisture testing, purity analysis, germination testing, tolerance limit and seed testing equipments. Quick viability test and seed standards. Seed vigour, its significance and testing methods. Testing for genuineness of varieties – principles and methods based on seed, seedling and plant characters, biochemical techniques – electrophoresis of proteins and isoenzymes and DNA fingerprinting. International Seed Testing Association (ISTA), its role in development of seed testing procedures, rules and seed quality assurance for international seed trade. OECD seed certification guideline – agricultural and vegetable crops.

### **Unit 5:**

Seed Storage Seed storage – principle – purpose and types – short, medium and long term storage. Factors affecting seed storage and role of moisture, temperature and relative humidity. Viability nomographs. Longevity of orthodox and recalcitrant seeds. Seed deterioration causes and methods of control. Physiological, biochemical and molecular changes in seed ageing. Controlled storage. Germplasm storage. Cryo preservation. Seed storage containers, types – safe moisture content. Storage structures. Methods of stacking and their impact on seed quality. Seed storage godown maintenance and sanitation. Management of carry over seed.

### **Unit 6:**

Seed Health Significance of seed health. Procedures for seed health test and rules. Externally and internally seed – borne pathogens, mode of infection, development and spread, methods of detection. Important seed-borne diseases of cereals, oilseeds, pulses, fibre crops, vegetables and their control measures. Quarantine and International procedures of phytosanitary certificates. Important storage pests, their identification, monitoring and detection. Use of pesticides, botanicals, mycotoxins for seed treatments. Carry over infestation, principles of fumigation and safe use of fumigants.

### **Unit 7:**

Seed Industry Development and Marketing National and International seed industry development. Role of OECD and WTO in International seed trade. International Seed Federation (ISF). Market survey, demand forecasting, pricing policies, marketing channels, planning and sales promotion. Economics of seed production. Role of Government, semi Government, cooperative and private sectors in seed trade. Responsibilities of seed companies and dealers in Seed Act. Seed import and export.

### **Unit 8:**

Protection of Plant Varieties Plant Variety Protection (PVP) and its significance. International Union for the Protection of New Varieties of Plants (UPOV) and its role in development of Plant Breeders Rights and Seed Industry Development. UPOV 1978 and 1991 Acts. Plant Breeders Rights and exceptions to it. Breeders exemption and farmers privilege. Plant patent v/s Plant breeders rights.

Impact of PVP on seed supply system. Protection of Plant Varieties and Farmers' Right Act, 2001, its essential features. Criteria for protection of different types of plant varieties. DUS testing principles and application. Breeders, Researchers and farmers rights. Compulsory licensing. Indian Biological Diversity Act, its essential features. Access to Biological resources, benefit sharing.

### **3. Entomology (Agriculture)**

#### **Insect Morphology**

Principles, utility and relevance: insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation, Head-Origin, structure and modification; types of mouthparts and antennae, tentorium and neck sclerites, Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; Wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; Legs: structure and modifications, Abdomen-Segmentation and appendages; Genitalia and their modifications; embryonic and post-embryonic development; Types of metamorphosis. Insect sense organs (mechano-, photo- and chemo- receptors), Structure of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands.

#### **Principles of Integrated Pest Management**

History and origin, definition and evolution of various related terminologies. Concept of IPM. Economic decision levels of insect pest population. Insect dominance, increase in agriculture pest problem, pest outbreak and factors affecting it; Categories of pest, Tools of pest management and their integration- legislative, cultural, physical and mechanical methods, host plant resistance, biological control, semiochemicals, botanicals and chemical control, insecticide resistance management; sampling, survey, surveillance and forecasting. Controversies, criticism and constraints in IPM. Case studies of successful IPM programmes. Pest control appliances and their maintenance.

#### **Insect Taxonomy**

Brief evolutionary history of Insects- introduction to phylogeny of insects and Major Classification of Super class Hexapoda. Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families of orders Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera– Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera, Distinguishing characters, general biology, habits and habitats of Insect orders and economically important families contained in them (Continued). Division Neoptera– Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuropteroid and Coleoptera, Section Panorpid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.

#### **Insect Physiology & Nutrition**



Scope and importance of insect physiology and nutrition, physiology of different systems- digestive, circulatory, respiratory, excretory, nervous, sensory, reproductive, musculature, endocrine and exocrine glands, thermodynamics; physiology of integument, moulting; growth, metamorphosis and diapauses, Insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra- cellular micro-organisms and their role in physiology; artificial diets,

### **Toxicology of Insecticides**

Definition and scope of insecticide toxicology; history of chemical control; pesticide use and pesticide industry in India, classification of insecticides and acaricides based on mode of entry, mode of action and chemical nature. Structure and mode of action of organo- chlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrazoles, insect growth regulators, microbials, botanicals, new promising compounds, etc., principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity, Insecticide metabolism; pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence, Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.

### **Pests of Field Crops**

Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors, Insect pests of cereals and millets and their management. Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs etc.), Insect pests of pulses, tobacco, oilseeds and their management, Insect pests of fibre crops, forages, sugarcane and their management.

### **Biological Control of Crop Pests and Weeds**

History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation, Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa etc., their mode of action. Biological control of weeds using insects, Mass production of quality biocontrol agents- techniques, formulations, economics, field release/application and evaluation, Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.

### **Storage Entomology**

Introduction, history and concepts of storage entomology. Post-harvest losses. Factors responsible for grain losses. Important pests namely insects, mites, rodents, birds and micro-organisms associated with stored grains and agricultural products. Association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage. Sources of infestation. Type of losses in stored grains and their effect on quality including biochemical changes. Ecology of insect pests of stored commodities. Stored grain deterioration process. Type of storage structures. Ideal storage conditions. Management of rodent and bird pests. Preventive and curative measures for the management of insect pests of stored grains. Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored grain pest management.

### **Pests of Horticultural and Plantation Crops**

Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops, Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits, Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, french beans, chow-chow, brinjal, okra, all gourds, gherkin, drumstick, leafy vegetables etc., Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetlevine etc., Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.

### **Insect Ecology**

History and Definition. Basic Concepts. Organisation of the Biological world. Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) - aestivation, hibernation. Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain-web and ecological succession. Interspecific interactions-Basic factors governing the interspecific interactions

## 4. Plant Pathology

### Unit-I

Introduction, definition of different terms, basic concepts. Importance of mycology in agriculture, relation of fungi to human affairs. History of mycology. Concepts of nomenclature and classification, fungal biodiversity, reproduction in fungi. The comparative morphology, ultrastructure, characters of different groups of fungi up to generic level: (a) Myxomycota and (b) Eumycota- i) Mastigomycotina ii) Zygomycotina, iii) Ascomycotina, iv) Basidiomycotina, v) Deuteromycotina. Lichens types and importance, fungal genetics and variability in fungi.

### Unit-II

Methods to prove Koch's postulates with biotroph and necrotroph pathogens., Pure culture techniques. Use of selective media to isolate pathogens. Preservation of plant pathogens and disease specimens. Use of centrifuge, pH meter, micrometer, haemocytometer, camera lucida. Microscopic techniques and staining methods, phase contrast system. chromatography, Use of electron microscope, spectrophotometer, ultracentrifuge and electrophoretic apparatus. Disease diagnostics, serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides, bactericides etc. Field experiments, data collection. Preparation of manuscripts. Importance, definitions and concepts of plant diseases.

### Unit-III

History and growth of plant pathology, biotic and abiotic causes of plant diseases., Growth, reproduction, survival and dispersal of important plant pathogens. Role of environment and host nutrition on disease development, Host parasite interaction, recognition concept and infection. Symptomatology. Disease development- role of enzymes, toxins, growth regulators; defense strategies- oxidative burst; Phenolics, Phytoalexins, PR proteins, Elicitors. Altered plant metabolism as affected by plant pathogens. Genetics of resistance; 'R' genes; mechanism of genetic variation in pathogens. Molecular basis for resistance, marker-assisted selection. Genetic engineering for disease resistance. Disease management strategies.

History and introduction to phytopathogenic procarya, viz., bacteria, MLOs, spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria. Evolution, classification and nomenclature of phytopathogenic procarya and list of important diseases caused by them. Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya. General biology of bacteriophages, L form bacteria, plasmids and bdellovibrios. Procaryotic inhibitors and their mode of action against phytopathogenic bacteria. Survival and dissemination of phytopathogenic bacteria. Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, Competition, predation, antibiosis and fungistasis. Suppressive soils, biological control- concepts and potentialities for managing soil borne pathogens.

History of plant viruses, composition and structure of viruses. Symptomatology of important plant viral diseases. Transmission, chemical and physical properties, host virus interaction, virus vector

relationship. Virus nomenclature and classification, genome organization, replication and movement of viruses. Isolation and purification, electron microscopy, protein and nucleic acid based diagnostics. Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, Viroids, prions. Principles of the working of electron-microscope and ultra- microtome. Origin and evolution, mechanism of resistance. genetic engineering, ecology, and listing of important diseases and their management.

#### **UNIT-IV**

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments and botanicals methods of plant disease control. Integrated control measures of plant diseases. Disease resistance and molecular approach for disease management. Foliage, seed and soil application of chemicals, role of stickers, spreaders and other adjuvants, health vis-a-vis environmental hazards, residual effects and safety measures. History of fungicides, bactericides, antibiotics, concepts of pathogen, immobilization, chemical protection and chemotherapy. Nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals.

History and development of chemicals, definition of pesticides and related terms; advantages and disadvantages of chemicals. Classification of chemicals based on chemical nature and mode of action used in plant disease control and their management. Chemicals in plant disease control, viz., fungicides bactericides and botanicals. Formulations and applications of different fungicides; chemotherapy and phytotoxicity of fungicides. Handling, storage and precautions to be taken while using fungicides; compatibility with other agrochemicals, persistence, cost-benefit ratio, factor affecting fungicides. General account off plant protection appliances; environmental pollution, residues and health hazards, fungicidal resistance in plant pathogens and its management.

Concept of biological control, definition, importance, principles of plant disease management with bioagents, history of biological control, merits and demerits of biological control. Types of biological interactions, competitions, mycoparasitism, exploitation for hypovirulence , rhizosphere colonization, competitive saprophytic ability, antibiosis, induced mechanism and its relevance in biological control. Factors governing biological control, role of physical environment, agroecosystem, operational mechanisms and cultural practices in biological control of plant pathogens, biocontrol agents, comparative approaches to biological control of plant pathogens b resident and introduced antagonists, control of soil-borne and foliar diseases. Compatibility of different bio-agents. Commercial production of antagonists, their delivery systems, application and monitoring . biological control in IDM, IDM and organic farming system, bio-pesticides available in market. Quality control system of bio-control agents.

#### **UNIT-V**

History and economic importance of seed pathology in seed industry, plant quarantine and SPS under WTO. Morphology and anatomy of typical monocotyledonous and dicotyledonous. infected seeds. Recent advances in the establishment and subsequent causes of disease development in seed and seedling. Localization and mechanism of seed transmission in relation to seed infection, seed to plant transmission of pathogens. Seed certification and tolerance limits, types of losses caused b seed borne diseases in true and vegetative propagated seeds. Epidemiological factors influencing the transmission of seed borne diseases, forecasting of epidemics through seed borne infection. Production of toxic metabolites affecting seed quality and its impact on human, animal and plant health.

## **5. Agronomy**

### **Unit I**

Crop growth analysis in relation to environment; agro-ecological zones of India. Quantitative agro-biological principles and inverse yield nitrogen law; Mitscherlich yield equation, its interpretation and applicability; Baule unit. Effect of lodging in cereals; physiology of grain yield in cereals; optimization of plant population and planting geometry in relation to different resources, concept of ideal plant type and crop modeling for desired crop yield. Scientific principles of crop production; crop response production functions; concept of soil plant relations; yield and environmental stress. Water and its role in plants; water resources of India, major irrigation projects, extent of area and crops irrigated in India and different states. Soil water movement in soil and plants; transpiration.

### **Unit II**

Soil, plant and meteorological factors determining water needs of crops; scheduling, depth and methods of irrigation; microirrigation system; fertigation; management of water in controlled environments and polyhouses. Water management of the crops and cropping systems; quality of irrigation water and management of saline water for irrigation; water use efficiency. Excess of soil water and plant growth; water management in problem soils; drainage requirement of crops and methods of field drainage, their layout and spacing.

### **Unit III**

Soil fertility and productivity - factors affecting; features of good soil management; problems of supply and availability of nutrients; relation between nutrient supply and crop growth; organic farming - basic concepts and definitions. Criteria of essentiality of nutrients; Essential plant nutrients – their functions, nutrient deficiency symptoms; transformation and dynamics of major plant nutrients. Preparation and use of farmyard manure, compost, green manures, vermicompost, biofertilizers and other organic concentrates their composition, availability and crop responses; recycling of organic wastes and residue management.

### **Unit IV**

Integrated farming systems, organic farming, and resource conservation technology including modern concept of tillage; dry farming; determining the nutrient needs for yield potentiality of crop plants, concept of balance nutrition and integrated nutrient management; precision agriculture.

### **Unit V**

Weed biology and ecology, crop-weed competition including allelopathy; principles and methods of weed control and classification; weed indices. Herbicides introduction and history of their development; classification based on chemical, physiological application and selectivity; mode and

mechanism of action of herbicides. Herbicide structure - activity relationship; factors affecting the efficiency of herbicides; herbicide formulations, herbicide mixtures; herbicide resistance and management; weed control through bio-herbicides, myco-herbicides and allelochemicals; Degradation of herbicides in soil and plants; herbicide resistance in weeds and crops; herbicide rotation.

## **6. Botany**

### **Unit I**

Cryptogams and Phanerogams: A General account, Diagnostic features for classification of flowering plants; ICN, Taxonomic Tools and evidences, Nature, causes and classification of plant pathogen; Dissemination and methods of preservation and control of plant diseases, Host-parasite relationship, plant defense mechanism.

### **Unit II**

Fungal and Bacterial disease of plant crops- rice, wheat, maize, sugarcane, cotton and groundnut; fruit crops- apple, peach, mango, citrus and grapes; vegetable crops- crucifers, tomato, potato and brinjal; other crops- tobacco, turmeric and coriander. Introduction to mushroom groups, taxonomic study of order Agaricales, Ecology of mushrooms, role of mushrooms in forest ecosystems, Mycorrhiza: VAM fungi, ectomycorrhiza and forest ecosystem. Tissue culture of wild mushrooms; Preparation of herbarium: methods of collection, identification and preserving wild mushrooms. Cultivation of edible and medicinal mushrooms: Volvariella, Agaricus, Pleurotus, Lentinus, Ganoderma.

### **Unit III**

Physiology and Biochemistry: Functions of biological molecules, cell and organisms as biochemical entities; Metabolism and biochemical energetic, Palynology: General Introduction and history, Importance of Palynology in plant taxonomy, pollen biotechnology, aerobiology and pollen allergy, forensic palynology, melissopalynology, palaeopalynology and in hydrocarbon exploration.

### **Unit IV**

Plant Breeding: Objectives, activities and achievements. Breeding methods for self, cross pollinated and clonal crops; Breeding for resistance to various stresses and quality; Biotechnology applications in crop improvement, IPR and plant breeders rights (PBR). Green Revolution.

### **Unit V**

Biodiversity: Concept, biodiversity of major groups including microbial biodiversity, distribution, maintenance and loss of biodiversity. Conservation of Biodiversity: Concept, Environmental policies, Biosphere Reserves, National Parks, Sanctuaries, Botanical Gardens, Pollen storage and Seed Banks, Tissue culture and role of biotechnology in conservation of biodiversity; Cryopreservation. CITES, IUCN, Ethnobotany: A General account. Forest types of Uttarakhand and other Himalayan provinces, Forest heritage in Garhwal Himalaya; Classification; forest products (NTFPs, medicinal and aromatic plants, fibre, etc.),

## 7. Chemistry

### Unit I

Structure and bonding in homo- and heteronuclear molecules, including shapes of molecules (VSEPR Theory). Main group elements and their compounds: Allotropy, synthesis, structure and bonding, industrial importance of the compounds. Transition elements and coordination compounds: structure, bonding theories, spectral and magnetic properties, reaction mechanisms. Inner transition elements: spectral and magnetic properties, redox chemistry, analytical applications. Organometallic compounds: synthesis, bonding and structure, and reactivity. Organometallics in homogeneous catalysis. Cages and metal clusters. Bioinorganic chemistry: photosystems, porphyrins, metalloenzymes, oxygen transport, electron-transfer reactions; nitrogen fixation, metal complexes in medicine. Solid state: Crystal structures; Bragg's law and applications; band structure of solids

### Unit II

Basic principles of quantum mechanics: Postulates; operator algebra; exactly-solvable systems: particle-in-a-box, harmonic oscillator and the hydrogen atom, including shapes of atomic orbitals; orbital and spin angular momenta; tunneling. Chemical applications of group theory; symmetry elements; point groups; character tables; selection rules. Chemical thermodynamics: Laws, state and path functions and their applications; thermodynamic description of various types of processes; Maxwell's relations; spontaneity and equilibria; temperature and pressure dependence of thermodynamic quantities; Le Chatelier principle; elementary description of phase transitions; phase equilibria and phase rule; thermodynamics of ideal and non-ideal gases, and solutions. Chemical kinetics: Empirical rate laws and temperature dependence; complex reactions; steady state approximation; determination of reaction mechanisms; collision and transition state theories of rate constants; unimolecular reactions; enzyme kinetics; salt effects; homogeneous catalysis; photochemical reactions.

### Unit III

Principles of stereochemistry: Configurational and conformational isomerism in acyclic and cyclic compounds; stereogenicity, stereoselectivity, enantioselectivity, diastereoselectivity and asymmetric induction. Organic reaction mechanisms involving addition, elimination and substitution reactions with electrophilic, nucleophilic or radical species. Determination of reaction pathways. Common named reactions and rearrangements – applications in organic synthesis. Pericyclic reactions – electrocycloaddition, cycloaddition, sigmatropic rearrangements and other related concerted reactions. Principles and applications of photochemical reactions in organic chemistry.

### Unit IV

Synthesis and reactivity of common heterocyclic compounds containing one or two heteroatoms (O, N, S), Chemistry of natural products: Carbohydrates, proteins and peptides, fatty acids, nucleic acids, terpenes, steroids and alkaloids. Polymer chemistry: Molar masses; kinetics of polymerization

### Unit V



Characterisation of inorganic compounds by IR, Raman, NMR, EPR, Mössbauer, UV-vis, NQR, MS, electron spectroscopy and microscopic techniques. Nuclear chemistry: nuclear reactions, fission and fusion, radio-analytical techniques and activation analysis. Structure determination of organic compounds by IR, UV-VIS,  $^1\text{H}$  &  $^{13}\text{C}$  NMR and Mass spectroscopic techniques.

## 8. Mathematics

### UNIT – I

**Linear Algebra:** Vector spaces, subspaces, linear dependence, basis, dimension, algebra of linear transformations. Algebra of matrices, rank and determinant of matrices, linear equations. Eigenvalues and eigenvectors, Cayley-Hamilton theorem. Matrix representation of linear transformations. Change of basis, canonical forms, diagonal forms, triangular forms, Jordan forms. Inner product spaces, orthonormal basis. Quadratic forms, reduction and classification of quadratic forms.

### UNIT – II

**Complex Analysis:** Algebra of complex numbers, the complex plane, polynomials, power series, Transcendental functions such as exponential, trigonometric and hyperbolic functions. Analytic functions, Cauchy-Riemann equations. Contour integral, Cauchy's theorem, Cauchy's integral formula, Liouville's theorem, Taylor series, Laurent series, and calculus of residues.

**Algebra:** Permutations, combinations, Euler's  $\phi$ -function, primitive roots. Groups, subgroups, normal subgroups, quotient groups, homomorphism, cyclic groups, permutation groups, Cayley's theorem, class equations, Sylow theorems. Rings, ideals, prime and maximal ideals, quotient rings, unique factorization domain, principal ideal domain, Euclidean domain. Polynomial rings and irreducibility criteria. Fields, finite fields, field extensions, Galois Theory.

### UNIT – III

#### **Ordinary Differential Equations (ODEs):**

Existence and uniqueness of solutions of initial value problems for first order ordinary differential equations, singular solutions of first order ODEs, system of first order ODEs. General theory of homogenous and non-homogeneous linear ODEs, variation of parameters, Sturm-Liouville boundary value problem, Green's function.

#### **Partial Differential Equations (PDEs):**

Lagrange and Charpit methods for solving first order PDEs, Cauchy problem for first order PDEs. Classification of second order PDEs, General solution of higher order PDEs with constant Coefficients. Method of separation of variables for Laplace, Heat and Wave equations.

### UNIT – IV

**Numerical Analysis:** Numerical solutions of algebraic equations, Method of iteration and Newton-Raphson method, Rate of convergence, Solution of systems of linear algebraic equations using Gauss elimination and Gauss-Seidel methods, Finite differences, Lagrange, Hermite and spline interpolation, Numerical differentiation and integration, Numerical solutions of ODEs using Picard, Euler, modified Euler and Runge-Kutta methods.

### UNIT – V

Descriptive statistics, exploratory data analysis. Sample space, discrete probability, independent events, Bayes theorem. Random variables and distribution functions (univariate and multivariate); expectation and moments. Independent random variables, marginal and conditional distributions. Characteristic functions. Standard discrete and continuous univariate distributions. Linear programming problem, simplex methods, duality. Elementary queuing and inventory models. Steady-state solutions of Markovian queuing models: M/M/1, M/M/1 with limited waiting space, M/M/C, M/M/C with limited waiting space, M/G/1.

## **9. Biotechnology**

### **Unit I**

Plasma membrane: Structure, organisation, lipid bilayer, proteins & glycoconjugates, liposomes. Function- Ionic transport, types of transport (symport antiport, active & passive,), channel proteins. Intracellular compartmentalization Structure, organization and functions of Nucleus, Mitochondria, lysosome, Golgi body, Chloroplast, Peroxisome, Endoplasmic reticulum (Rough and smooth) Cell motility and shape: Structure and functions, Microfilament, Microtubules and Intermediate filament

### **Unit II**

Mechanism of DNA replication in prokaryotes and eukaryotes, Mechanism of transcription in prokaryotes and eukaryotes, Reverse transcription, Post transcriptional processing of RNA: (capping, polyadenylation, splicing, RNA editing), Mechanism of translation in prokaryotes and eukaryotes.

### **Unit III**

DNA sequencing: chemical and enzymatic methods, PCR. Site directed mutagenesis, Ribonuclease protection assay, Gel retardation assay, DNA foot printing, DNA finger printing, DNA profiling, Genomic analysis: Exon-intron trapping, S-1 mapping, RFLP, RAPD, AFLP. Gene therapy: Principles, strategies and ethics of gene therapy, Sequence alignment and applications: Local and Global alignment, Scoring Matrices; Homology and related concepts; Dot matrix; general gap, gap penalty.

### **Unit IV**

Spectroscopic methods: principle and applications of UV-visible, IR, NMR, ESR Measurement of radioactivity: GM Counter, gamma counter, liquid scintillation counter. Tracer techniques of Autoradiography, Radioimmunoassay, Chromatography - General principle, types and application, Electrophoresis - General principle and application, Centrifugation: Basic principles. Common centrifuges used in laboratory, Microscopy.

### **Unit V**

Carbohydrate – Classification, structure and functions, TCA cycle, Glycolysis, Amino acids & Proteins structures, Introduction to Monoclonal Antibodies and Hybridoma technology, Antigen-Antibody Interactions: Precipitation Reaction, Agglutination Reactions, RIA, ELISA, Western Blotting, Immuno precipitation, Immuno-fluorescence.

## 10. Microbiology

### Unit I

Landmark achievements in 20th century: Refutation of a biogenesis: discovery of penicillin: discovery of vaccination: proposal of one gene one enzyme hypothesis: discovery of double helix structure of DNA: discovery of recombinant DNA technology. Major contribution of scientists– Leeuwen hoeck, Edward Jenner, Alexander Flemming, Joshep Lister, Robert Koch, Louis Pasteur, Hargobind Khorana.

### Unit II

Whittaker's five– kingdom concept of living organism-(General characteristics of those five groups), characteristics and importance of yeast, moulds (Penicillium Aspergillus), protozoa, Giardia, Plasmodium, plant diseases (brown spot of rice, stem rot of jute, black stem rust of wheat, apple scab, grey blight of tea, bacterial blight of rice, citrus canker).

### Unit III

Principles and applications, dark field, bright field, resolving power, numerical aperture, chromatic aberration, phase contrast microscopy, fluorescent microscopy, inverted microscopy, stereo microscopy, electron microscopy, TEM and SEM. Stains and staining- Principles of staining, simple staining, negative staining, differential staining, Gram and acid fast staining, flagella staining, capsule and endospore staining.

### Unit IV

Introduction to biomolecules- Outline structure, function and examples of carbohydrate, lipid, protein (primary, secondary, tertiary and quaternary). Amino acids, DNA, RNA Control of microbes- Sterilisation, disinfection, antiseptic, tyndallisation, pasteurization: Physical- dry heat, moist heat, UV light, ionizing radiation, filtration, HEPA filter, Chemical-phenol and phenolic compounds, (halogen aliphatic alcohol, formaldehyde, ethylene oxide, heavy metals) anionic and cationic detergent Cell structure and sub cellular organelles of bacterian– Slime layer, capsule, cell wall, flagella, pili, fimbriae, nucleoid, plasmid and episome (F, R, Ti as example) ribosome,

Virology-General classification of virus, (structure, nucleic acid, cultivation of bacteriophage, coliphage), animal virus (chick embryo, tissue culture, plant virus, TMV using carborandum). Importance of viruses, life cycle of viruses, lytic cycle (T4) and lysogenic (lambda).

## Unit V

Air microbiology- Microorganisms in the air, sampling techniques, air borne pathogens.

Microbiology of water-Microbiology of fresh water and wastewater (sewage), BOD, COD (definitions), general outline of water treatment process: septic tank, sedimentation Activated sludge and trickling filter process. Important water borne diseases– cholera, typhoid, (name of pathogen, preventive measures). Outlines of method for detection of microorganisms in drinking water (presumptive, confirmatory and completed tests). Distinction between fecal and non-fecal coliforms, IMVIC tests.

## 11. Zoology

Animal Diversity: General characters and Classification of Non Chordate Phyla, General character and Classification of chordates.

Cell Biology: Theories in Origin of cell and cell as a unit of life, Structure of Prokaryotic and eukaryotic Cell, Cellular Organelles and their functions : Plasma membrane and its various models, ionic transport, type of transport, cell cycle and its regulation Molecular basis of signal transduction. Cancer and its types, Apoptosis and necrosis, oncogenes and tumour suppressor gene Viral and cellular oncogene.

Molecular Biology :DNA replication. Genetic code. Transcription and translation in prokaryotes and eukaryotes.RNA Synthesis and processing. Mutations & DNA repair systems. Theories in support of DNA as a genetic material, The central Dogma of Molecular Biology. DNA: Structure and conformation, supercoiling,packing of DNA into chromosomes. Structural polymorphism of DNA & RNA. Threedimensional structure of t-RNA. Cell communication and cell signaling

Genetics : Mendelian laws (Law of dominance, Law of Independent assortment,)Exception of Mendelian laws, lethal allele, multiple alleles gene interaction (modification of dihybrid ratios) Sex linked inheritance, linkage and crossing over, Fine Structure of gene , Giant Chromosome (Polytene and lampbrush chromosome) , Pedigree analysis in man , genetic disorders, cytoplasmic inheritance and extrachromosomal inheritance, Operon hypothesis, Hardy-Weinberg law and its application, Mutation and its types.

Evolution and Systematics: Concepts of organic evolution and evolutionary theories. Origin of life (including aspects of prebiotic environment and molecular evolution). Micro and macroevolution. Synthetic theory of evolution, Natural selection. History of animal taxonomy. Species concepts (Typological, Nominalistic, Biological and Evolutionary). Linnean hierarchy. Zoological Nomenclature: ICZN; Taxon, Rank and Categories. Preparation of Keys, Techniques of museum preparation. The evolutionary time scale; Eras, periods and epoch; Major events in the evolutionary time scale; Origins of unicellular and multi cellular organisms; Stages in primate evolution including Homo.

Biostatistics and Tools and Techniques :Calculation of mean, median, mode, range, variance, standard deviation. Concepts of coefficient of variation, skewness & kurtosis. Simple correlation. Elementary idea of random variables. Students-t, chi-square and F- test of significance. Introduction to some distributions of random variables: Binomial, Poisson, normal. Microscopy, principle & applications - Light microscope and phase contrast microscope ,Fluorescence microscope, Electron microscope , General Principle and applications of, Colorimeter , Spectrophotometer, Flame photometer Separation techniques- Chromatography, principle type and applications. Electrophoresis, Centrifugation , Ultra centrifuge.

Animal Physiology: Physiology of digestion & absorption: Mechanism of Digestion and absorption of proteins, fats and carbohydrates. Physiology of respiration: Exchange of respiratory gases at the pulmonary surface. Transport of respiratory gases by blood. Oxyhaemoglobin dissociation curve. Neural and chemical control of respiration. Physiology of cardiovascular system: Characteristics of vertebrate cardiac muscle. Initiation, conduction and regulation of heart beat. ECG and myocardial infarction. Blood pressure and its regulation. Blood groups. Coagulation of blood. Physiology of excretion: Formation of urine: Functional anatomy of the kidney. Glomerular filtration and its control. Counter current mechanism. Functions of aldosterone, antidiuretic hormone and renin-angiotensin system in renal physiology. Nervous system: Functional differentiation of brain, Neuron - the basic functional unit. Ionic basis of resting and action potentials of neurons, Mechanism of synaptic transmission. Reflexes and types of reflexes. Mechanism of thermoregulation in poikilotherms, homeotherms and heterotherms.

Developmental Biology :Potency, commitment, Specification, Cell Fate and Cell lineages, Stem Cells, Programmed cell death, Aging and Senescence. Development and differentiation of sperm and oocytes, capacitation, vitellogenesis. Mechanism of fertilization acrosomal reaction, cortical reaction and fertilization membrane. Blocks to polyspermy, Parthenogenesis. Cellular differentiation (transcriptional regulation of gene expression, differential RNA processing and translation). axes and pattern formation in Drosophila, amphibia and chick; organogenesis –eye lens induction, limb development and regeneration in vertebrates; differentiation of neurons, post embryonic development-larval formation, metamorphosis; environmental regulation of normal development; sex determination.

Ecology :Definition, Scope, Importance, Application. Limiting Factors: Liebig's law of the minimum, Shelford's law of tolerance. Combined concept of limiting factor, Factor interaction. Homeostasis. Biogeochemical cycle (nitrogen, phosphorus, carbon & water cycle). Ecosystem. Concept; Energy flow; Food chains & Ecological pyramids. Habitat Ecology: Concept of habitats & ecological niche. Population: Concept & attributes: Biotic potential, Density, Natality, Mortality; Intrinsic rate of natural increase, survivorship curves. Population growth forms; Carrying capacity; Population regulation (Density dependent and independent). Community: Concept & characteristics: Density, Dominance, Diversity & Stratification. Succession of communities; Key stone species.

Immunology :Overview of The Immune System. Cells and Organs of The Immune System. Antigens, Haptens & Epitopes Immunoglobulins: Structure and Function. Major Histocompatibility Complex. Cytokines, Cell mediated cytotoxicity: Mechanism of T cell & NK cell mediated lysis. Hypersensitivity and Autoimmunity. Introduction to Transplantation. Vaccines: Active and Passive Immunization Introduction to Monoclonal Antibodies and Hybridoma technology. Antigen-Antibody Interactions: Precipitation Reaction, Agglutination Reactions, RIA, ELISA, Western Blotting, Immuno precipitation, Immuno-fluorescence.

## 12. GEOLOGY

### UNIT-1

- **MINERALOGY**

Detail study of important silicates & Non Silicate Minerals with reference to general and structure formulae, classification, atomic structures, chemistry including substitution of element and mode of occurrence. Identification of minerals under polarizing microscope, Physical & Chemical properties of mineral. Properties of uniaxial and biaxial crystal.

- **PETROLOGY**

1. Igneous Petrology: Forms of Igneous rocks- Extrusive and Intrusive forms, Structures of lava, Textures- Factors controlling textures & types 2.Sedimentary Petrology: Sedimentation- Weathering, Transportation, Deposition- Lithification and diagenesis. Depositional Environments, Classification & Structures of Sedimentary rocks. 3.Metamorphic Petrology: Agents & Kinds of Metamorphism, Fabric (Structures/textures) of Metamorphic Rocks.

### UNIT-2

- **PHYSICAL GEOLOGY & STRUCTURAL GEOLOGY**

Basic concepts and Application of geomorphology , Elementary idea of cosmogony, Interior of earth, geochronology, theories of isostasy, Geomorphic processes and land forms– fluvial, glacial, Aeolian, coastal and karst. Theory of stress and strain, kinematic analysis, Mohr's Circles, strain and stress ellipsoids, Geometry and Classification of fold & Mechanics of folding, Geometry and Causes and dynamics of faulting, joints, foliations, unconformities.

- **GEOTECTONICS**

Evidence of continental drift, Concept of Plate Tectonics and Sea floor spreading, Major tectonic features of the oceanic and continental crust, Seismic belts of the earth, Palaeomagnetism, Polar Wandering and reversal of earth's magnetic field, geodynamics of Indian plate.

- **HYDROGEOLOGY**

Origin & Distribution of Groundwater, hydrological cycle, Classification of rocks with respect to water bearing characteristics, Geological structures favoring groundwater occurrence, Aquifer and its Classification, Hydrological properties of rock. Darcy's law, water table, flow nets, springs. Methods of groundwater exploration.

### UNIT-3

- **PALEONTOLOGY & STRATIGRAPHY**

Stratigraphy: Principles - Law of uniformitarianism, Law of Order of Superposition: Nature of Geological Record, Stratigraphic classification and Nomenclature Unit, Correlation of Strata, Standard Stratigraphic scale. Palaeontology- Types of fossils – modes of fossil preservation. Tracks and Trails. Morphology and Geological distribution of Foraminifera, Brachiopods, Lamellibranchs, Gastropods, Cephalopods, Echinoids & Trilobites.

### UNIT-4

- **MINERAL EXPLORATION & MINING GEOLOGY**

Prospecting for economic minerals, sampling assaying and evaluation of mineral deposits, geological and geo-botanical techniques of prospecting, Gravity method, Brief outline of well-



logging techniques and their methods, Drilling and type of drilling methods, Planning, exploration and exploratory mining of surface and underground mineral deposits, Cycles of surface and underground mining operations. Concept of ore & ore deposits. Indian distribution and characters of metallic ore and non metallic minerals. Metallogenic epochs and provinces of Indian subcontinent, Para genesis, zoning, mineral deposits of Indian oceans National mineral policy and mineral conservation

## **UNIT-5**

- **REMOTE SENSING**

Aerial remote sensing and photogrammetric, remote sensing applications GPS- Components, segments, GPS satellites, Types of GPS, types of antennas, Data input from Automated Surveying and Global Positioning System. GIS- spatial distribution of geological data.

## 13. Physics

### I. Mathematical Physics

Inverse and Trace of Matrix, Unitary Matrices, Orthogonality, Eigen values-Eigen vectors and Diagonalisation of matrices, Function of complex variable, Analytic functions, Cauchy's integral theorem and Cauchy's integral formula, theorem of residues, Contour integration.

### II. Classical Mechanics

Newton's laws. Dynamical systems, Central force motions. Two body Collisions - scattering in laboratory and Centre of mass frames. Rigid body dynamics- moment of inertia tensor. Non-inertial frames and pseudoforces. Lagrangian and Hamiltonian formalism and equations of motion.

### III. Quantum Mechanics

Wave-particle duality. Schrödinger equation (time-dependent and time-independent). Eigenvalue problems (particle in a box). Wavefunction in coordinate and momentum representations. Commutators and Heisenberg uncertainty principle. Motion in a central potential: orbital angular momentum, angular momentum algebra, spin, addition of angular momenta; Hydrogen atom. Stern-Gerlach experiment. Time-independent perturbation theory and applications.

### IV. Atomic & Molecular Physics

Atomic models, Basic nuclear properties: size, shape and charge distribution, spin and parity, Quantum states of an electron in an atom. Electron spin. Spectrum of helium and alkali atom. hyperfine structure and isotopic shift, LS & JJ couplings. Zeeman, Paschen-Bach & Stark effects. Electron spin resonance. Nuclear magnetic resonance, chemical shift. Frank-Condon principle.

### V. Condensed Matter Physics

Bravais lattices. Reciprocal lattice, structure factor, Bonding of solids. Free electron theory and electronic specific heat. Drude model of electrical and thermal conductivity. Hall effect and thermoelectric power. band theory of solids: metals, insulators and semiconductors. Superconductivity: type-I and type-II superconductors. Defects and dislocations.

## **14. Education**

### **Unit-I**

Philosophical & Sociological Bases of education

### **Unit-II**

Advanced Educational Psychology

### **Unit-III**

Research methodology and Statistics in Education

### **Unit-IV**

Comparative Education and Curriculum Development

## **15. Management**

### **UNIT I -Management**

Definition and scope, Management functions and process, Management Roles and Skills, Historical background of management, Managing Internal (Organizational Culture) and External Environment, Social responsibility and Managerial Ethics, Managerial Decision making- Process, Types of problems and decisions, Decision making conditions & styles.

Planning-meaning, process, purpose, establishing goals, developing plans issues in planning, Strategic management –process, formulating and implementing strategies, types of strategies. Organizing- definition, Organizational Structure and design options and decisions, Staffing, Managing change and innovation. Leading- Foundations of behavior, understanding groups and teams, Motivating employees- motivation theories, current issues, Leadership- Theories, issues, styles. Controlling – Definition,importance, process, types, contingency factors, contemporary issues, Effective control system, Operations and value chain management.

### **UNIT II - Finance**

Accounting Process leading to preparation of Trial Balance and Financial Statements – Analysis of Financial Statements – Fund Flow Statements – Cash Flow Statements – Cost Accounting – Methods and Techniques of Costing. Cost of Capital – Weighted Average and Marginal Concept – Application in Capital Budgeting decisions – Capital Expenditure decisions – Working Capital Management – Working Capital requirements – Financing Working Capital requirements. Indian Financial System – Financial Markets – Financial Institutions – Financial Instruments – Financial Services.

### **UNIT III-Human Resource Management**

HRM- Definition, importance, process, Human resources planning, HR demand supply forecast. Job analysis and job design. Recruitment, Selection, Placement, Orientation of employees. Employee Training- Meaning, scope, importance, process, methods. Skill training, Management

development. Employee performance management- meaning, process, importance, Performance appraisal methods.

#### **UNIT IV- Marketing**

Nature and scope of sales management; Sales Force Management; Designing Sales Territories and sales quotas; Need and scope of distribution management; marketing channels strategy, levels of channels, Retailing wholesaling, designing channel systems, Channel management; Logistics and supply chain management; Consumer Behaviour: Consumer Motivation , Personality, Perception, Attitude, Learning and its impact on Consumer Behaviour; Socio-Cultural settings and Consumer Behaviour - Quantitative Models in Marketing , Branding & Brand Management; Developing and measuring Brand Equity; Use of Internet and Social Media in marketing; Role of service sector in the economy & its contribution to GDP; Distinctions between Services and Goods & its marketing.

#### **Unit V: Biostatics and Research Methodology**

Types of research, Types of research designs, Qualitative and quantitative research, applied research, Sampling methods, and Preparation of research proposal. Basic statistics- Overview of Statistics, Classifying Data to convey meaning, Measures of Central Tendency – Mean, Median & Mode, Measures of Variation – Range, Average Deviation, Standard Deviation, Software in statistical analysis, Probability, Types of errors in statistics, Tests of significance, and Sample Size.

## **16. Commerce**

### **Unit I Accounting:**

Basic accounting standard and principles, Journal & Ledger entries, Trial Balance Final A/c (Trading, Profit and Loss Account & Balance Sheet), Partnership Accounts, Company Accounts, Financial Statement Analysis, Ratio Analysis, Cash Flow Analysis,

### **Unit II**

#### **Cost & Management Accounting:**

Concept Of Different Costs, Elements of Costs, Break-Even-Point Analysis, Marginal Costing, Standard Costing, Budgetary Control

#### **Unit III: Financial Management:**

Basic Concept of Financial Management, Time Value of Money, Capital Structure, Capital Budgeting, Cost of Capital, Working Capital Management, Dividend Decisions.

#### **Unit IV: Economics, Banking and International Business:**

Business Economics Nature and uses of Business Economics, Demand Analysis and Elasticity of Demand, Curve Analysis Law. Utility Analysis and Indifference of Returns and Law of variable proportion Cost, Revenue, Price determination in different market situation: Perfect competition, Monopolistic competition, Monopoly, Price discrimination and Oligopoly, Pricing Strategies.

Business Environment and Policy Framework in India, International Business, Balance of Payment, International Banking, Foreign Exchanges And Foreign Trade Policy.

Banking Structure, Types of Banks & Their Functions, Role Of RBI, SEBI, NABARD & Rural Banking, E- Banking, Financial Institutions, Financial Regulators, Banking Sector Reforms

#### **Unit V: General Management:**

Planning, Decision Making, Organization, Motivation, Leadership, Organization Structure, Organizational Culture, Marketing, Marketing Mix, HR Planning, Recruitment, Selection, Job Description, Job Analysis, Job Specification, Training & Development, Performance Appraisal

#### **Unit VI: Taxation and Law:**

Basic Concepts, Residential Status, Incidence of Tax for Different Tax Payers, Exempted Incomes, Heads of Income, Deductions and Rebates, Indian Contract Act, 1872, Sale of Goods Act, 1930, RTI Act, Negotiable Instruments Act, 1881, Goods and Services Tax (GST), The Companies Act, 2013

## **17. Economics**

### **Unit-I**

Theory of Consumer Behavior: Basic concepts; Marshall's Approach; Ordinal Utility Theory: Optimizations, derivation of demand function, income-leisure, substitution and income effects; Theory of revealed preference, Consumer Surplus and Elasticity of Demand. Public Revenue: Sources of Revenue, Taxation – characteristics of a good taxation system. Agrarian Reforms: Land Reforms, New agricultural policy; Production structure of Indian Agriculture;

### **Unit- 2**

Keynesian Theory of Income Determination: Concepts and Functions; Two sector, Three sector and four sector Models of Income Determination; Investment Multiplier; Balanced Budget Multiplier. Theories of Consumption: Keynesian Theory; Consumption Puzzle; Absolute Income Hypothesis, Relative Income Hypothesis. Planning commission v/s NITI Aayog. Concepts and uses of sampling. Conceptualization of Trade: Classical, Neo Classical and New Theories of trade, Planning for Rural Development:

### **Unit- 3**

Banking – Theories of Banking; Commercial and Central Banking Systems – Functions, Credit Creation and Credit Control; Banking and Non-Banking Financial Intermediaries in India; RBI – Functions, Monetary Policy – Methods and Recent Changes in India; International Monetary policy transmission mechanism. Regional and Multinational agreements. Structure and Working of International Monetary Fund and World Bank. LPG policy in India. Managing Agriculture: role of agri-business, linking farmers with new markets, diversifying agriculture.

### **Unit- 4**

Perfect competition, monopoly, oligopoly, monopolistic competition and non-price competition. The labour market, Equilibrium in the economy. Economic growth and the economic cycle. Unemployment, Inflation, Exchange rates. International trade, balance of payments and protectionism, Protectionism and globalization. Human Development Index and Physical Quality of Life Index. Industrial Economics, Banking and Non-Banking Institutions. Introduction to Credit Rating - CRISIL and ICRA. Population and Population Policy in India.

## 18. Pharmaceutical Sciences

### UNIT 1- PHARMACEUTICAL CHEMISTRY-

Introduction to pharmaceutical chemistry: definition, scope, and importance, Basics of organic chemistry: structure and reactivity of organic molecules, functional groups, isomerism, and stereochemistry, Medicinal chemistry: design and development of drugs, drug targets, drug-receptor interactions, drug metabolism, and pharmacokinetics, Biochemistry: biomolecules, enzymes, metabolic pathways, and their role in drug action and metabolism. Prodrugs and drug latentiation-Carrierlinked prodrugs, Bio precursors, Protein Binding and Bioisosterism. Basic principles of analytical chemistry: qualitative and quantitative analysis, gravimetric and volumetric analysis, and acid-base titrations, Instrumental methods of analysis: spectrophotometry, chromatography, electrochemistry, and mass spectrometry, Quality control.

**UNIT 2- PHARMACOLOGY-** Introduction to pharmacology: definition, scope, and importance, Mechanism of drug action: drug-receptor interactions, signal transduction pathways, and molecular targets, Classification of drugs: based on their pharmacological activity, chemical structure, and therapeutic uses.

Pharmacokinetics: absorption, distribution, metabolism, and excretion of drugs. Preclinical evaluation: Pharmacological evaluation of acute, sub-acute, and chronic toxicity studies. Guidelines of regulatory agenciesCPCSEA, WHO, FDA, etc.

**UNIT 3- PHARMACEUTICS-** Pharmaceutical dosage forms: types, formulations, and factors affecting drug absorption and bioavailability, Drug delivery systems: routes of administration, sustained-release systems, and targeted drug delivery, pharmaceutical technology: physical and chemical properties of drugs, stability, and formulation development, Biopharmaceutics: Biopharmaceutical classification, dissolution tests, Bioavailability. types of drug delivery systems, Applications of microspheres, Compartment Modeling. Dose adjustment in renal and hepatic failure.

**UNIT 4- PHARMACOGNOSY-** Introduction to pharmacognosy: sources, classification, quality control, and adulteration of crude drugs and their detection. Extraction techniques: successive and exhaustive extraction and other methods of extraction. Separation of phytoconstituents by the latest CCCET and SCFE techniques, including preparative HPLC and flash column chromatography. Phytochemistry: chemical constituents of medicinal plants, their isolation, and biological activities. Quality control and Standardization of herbal drugs: Significance and determination of Extractive values, Ash values, Heavy metals, Pesticidal residue and microbial load in herbal preparations.

**UNIT 5- PHARMACY PRACTICE-** Definition and scope of clinical pharmacy, Concepts in Pharmaceutical Care, Activities of a clinical pharmacist (Drug therapy review, ward round participation, Detection & management of adverse drug reactions, Medication history interview, pharmacist interventions, patient medication counselling), critical evaluation of biomedical literature, Definition, aims & scope of pharmacovigilance, Hospital and its organization, Drug distribution systems, Rational drug use, Drug utilization evaluation, Pharmacoeconomic evaluation, Basic clinical pharmacokinetics, Clinical research study designs.

Introduction to Clinical trials, Various phases of clinical trial, Introduction to Pharmacoepidemiology, Pharmacoepidemiologic Methods, Pharmacoeconomics, Community pharmacy and its management.

## 19. (A). Pharmaceutical Chemistry (M.Sc. based)

### Unit I

Structure, formation, reaction, stereochemistry and stability of Carbocation, Carbanions, free radicals, carbene, and nitrene. Mechanism involving free radical, nucleophile & electrophile mediated reactions.  $S_N1$ ,  $S_N2$  and mixed  $S_N1$  and  $S_N2$  mechanism and its stereo chemical aspects. Factor influencing nucleophilic substitution reactions, Reactivity effects of substrate structure, attacking nucleophilic group, leaving group and reaction medium, ambient nucleophile. Mechanisms involving Aromatic electrophilic reaction, Aromatic nucleophilic reactions, free radical reactions and elimination mechanism. Mechanism and stereo chemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemo selectivity, orientation and reactivity. Addition to cyclo propane ring. Geometrical isomerism & stereochemistry of olefins. Stereoisomerism of rings, stability of rings, ease of ring formation, Actual shape of six membered rings & its relation to properties & reactivity. Optical rotation, its significance, instrumentation. Optical rotatory dispersion-terminology, plain curve, rotatory dispersion & circular dichroism and octane rule.

### Unit II

Chromatography: principles, instrumentation and application of following separation techniques Paper chromatography, Thin layer chromatography, Column chromatography, HPLC, GC, HPTLC, Electrophoresis, Ion exchange and Gel filtration chromatography. UV-Visible spectroscopy: Theory, absorption law, Colorimetric Methods, Chromophore and auxochrome concept, Solvent effect, Instrumentation and applications, Woodward's Fieser, Fieser Kuhn and Nelson rule, Spectral correlation with structures. Atomic spectrophotometry: Atomic emission & Atomic absorption spectrophotometry: principle, instrumentation, interferences and applications. Infrared spectroscopy, Interpretation of IR, spectra of simple compounds. NMR, Spectrometry: Principle, ionization techniques, instrumentation, fragmentation pattern & applications. GC-MS and LC-MS: Principle, Instrumentation and Applications.

### Unit III

Carbohydrate : Introduction, classification, mutarotation, constituent of glucose, ring structure of glucose, configuration of monosaccharides, structure elucidation of disaccharides- sucrose, maltose, lactose, polysaccharides- starch. Glycosides arbutin, amygdaline.

Alkaloids : General introduction, distribution in plants, classification, isolation & purification. General methods of structure determination. Structural elucidation of atropine, quinine, Nicotin, Terpenoids : General introduction, classification, isolation & purification, isoprene, structure elucidation of citral, menthol, camphor, Structures of abietic acid and  $\beta$ -carotene. Plant Pigments: Occurrence, nomenclature and general methods of structure determination. Isolation and synthesis of cyanidin, and quercetin. Porphyrins: General Introduction of haemoglobin and chlorophyll. Chemistry of chlorophyll (without synthesis). Structure and synthesis of haem.



Heterocyclic compounds: General chemical behaviour of aromatic heterocycles, classification (structural type), Heteroaromatic reactivity and tautomerism in aromatic heterocycles Strain –bond angle and torsional strains and their consequences in small ring heterocycles. Conformation of six-membered heterocycles with reference to molecular geometry, barrier to ring inversion, pyramidal inversion and 1,3-diaxial interactions. Stereo-electronic effects, aromatic and related effects. Attractive interactions - hydrogen bonding and intermolecular nucleophilic, electrophilic interactions., Small Ring Heterocycles: Three-membered and four-membered heterocycles-synthesis and reactions of aziridines, oxiranes, thiiranes, azetidines, oxetanes and thietanes, Benzo-Fused Five-Membered Heterocycles: Synthesis and reactions including medicinal applications of benzopyrroles, benzofurans and benzothiophenes, Six-Membered Heterocycles with One, Two or More Heteroatoms: Synthesis and reactions of pyrylium salts and pyrones and their comparison with pyridinium & thiopyrylium salts and pyridines Synthesis and reactions of quinolizinium and benzopyrylium salts, coumarins and chromones Synthesis and reactions of diazines, triazines, tetrazines and thiazines

#### **Unit-IV**

Concept of isosterism and bioisosterism and their applications in drug design, Antimetabolite approach to drug design, Analog drug design, Prodrugs and drug latention – Carrier-linked prodrugs – Bioprecursors – Role of functional groups in prodrug design, General pathways of drug metabolism

Specific and non-specific drug action , Drug receptors, Basic concept and classification of receptors, Forces involved in drug receptors- interactions , Receptor agonism and antagonism , Stereochemical aspects of drug action – Stereoselectivity of optical isomers – Role of planarity in drug action – Stereoselectivity of conformational isomers,

#### **Unit-V**

Green chemistry: History, need, and goals. Green chemistry and Sustainability. Dimensions of sustainability, Limitations/Obstacles in pursuit of the goals of Green Chemistry. Opportunities for the next generation of materials designers to create a safer future. Hazard assessment and mitigation in chemical industry , Future trends in Green Chemistry: Oxidation-reduction reagents and catalysts, Statistical data analysis: Accuracy and precision, significant figures and computations, mean and standard deviation, distribution of random errors, reliability of results, confidence interval, comparison of results, comparison of means of two samples, paired t-test, number of replicate determinations and its use, correlation and regression, linear regression, analysis of variance, rejection of data.

## **20. Social Works**

### **Unit 1**

Personality: Concept, Stages of Development with special reference to Indian Concept of life span, Types, Determinants.

Heredity and Environment theories of Personality: Sigmund Freud, Carl Jung, Alfred Alder, All port.

### **Unit 2**

Concept of Normalcy and Abnormalcy.

Defence Mechanism

Etiology of Abnormal Behaviour.

Symptoms of Abnormal Behaviour.

Types of Abnormal Behaviour: Psychosis and Psychoneurosis.

Management of Mental disorder.

### **Unit 3**

Motives & Principles of Social Work.

Social Work as a Profession.

Philosophy and Basic Values of Social Work.

Social Work Education, Training and Knowledge.

### **Unit 4**

Social Welfare and Development Programmes: Child Development, Youth Development, Women's Empowerment, Welfare of the Aged, Handicapped, Welfare of Backward Classes with special reference to Scheduled Castes/Scheduled Tribes, Labour Welfare.

Social Welfare Agencies: Government and Non-Government Organizations. Historical Development of Social Case Work. Social Group Work: Meaning, Objectives, Principles, Processes, Skill and Role of Group Worker. Community Organization: Meaning, Objectives, Steps, Assumption, Principles, Models and Strategies.

### **Unit 5**

Methods of Data Collection: Questionnaire Schedule Interview, Observation and Case Study.

Eradication of Major Social evils – Dowry, Child Marriage, Child Prostitution, Child Labour, Domestic Violence.

### **Unit 6**

Latest policy and those awareness, Recent trends in Counselling, Concept of HRM and HRD, its objectives, Scope and Principles. People's Participation in Rural Development, History of Medical and Psychiatric Social Work.

## **21 . Cancer Research**

### **Unit I: Fundamentals of cancer**

Introduction to cancer and cancer management, classification of cancers and tumors, Cancer epidemiology.

### **Unit II: Etiology of cancer**

Etiology of cancer, Tobacco and cancer pathogenesis, Virus mediated oncogenesis (RNA and DNA viruses), inflammation and cancer, Chemical & physical carcinogens, carcinogenesis mechanism, types of carcinogenesis.

### **Unit III: Molecular Biology of Cancer**

Cellular Oncogenes, tumor suppressor genes, onco-signaling, cell cycle regulation, Apoptosis, Necrosis, autophagy, senescence, telomeres Gene Regulation. Genomic Instability, Angiogenesis and its implication in tumor progression, evolution and pathogenesis of metastasis, Models for metastasis, cancer stem cells

### **Unit V: Tumor Immunology and Immunotherapy**

Anti-tumor immune response of regulatory T cells, NK cells, immune surveillance theory, tumor associated antigens, evasion of immune surveillance by cancer cells, Principles of immunotherapy, CART cells.

### **Unit VI: Experimental Techniques in Cancer Research**

Cancer cell culture techniques, Cell Proliferation assays, Cancer stem cell assays & Radiolabelling Techniques Gene silencing/ over expression Animal models for cancer

## 22. Yogic science

### UNIT-I: Various Systems of Yoga

1. Gyanyoga, Bhaktiyoga.
2. Kramayoga, Rajyoga.
3. Hathyoga, Mantrayoga.

### UNIT-II: Introduction Of Yogis And Their Sadhna /Accustom System

1. Practice Based Tatv Mimansa and Achara Mimansa of Nyas and vaisheshik.
2. Practice Based Tatv Mimansa and Achara Mimansa of Samkhya and Yoga.
3. Practice Based Tatv Mimansa and Achara Mimansa of Mimansa and Vedanta.

Ancient - Maharishi Patanjali, Adi Shankracharya, Gorakshanath

Mordan - Swami Vivekanand, Shri Aravind, Maharishi Raman and Swami Dayanand Saraswa

### UNIT-III: Introduction of Yogic Text

1. Patanjali Yoga Sutra, Hathpradipeeka and Gherand Sanhita.
2. Shiv Samhita and Yoga Vashisht.
3. Sidhsiddhant Paddhati and Hath Ratnawali.

### UNIT-IV: Nature of Yoga In Fundamental Upnishad

1. Mandukya Upnishad - Four Stages of Conciousness & Relation with Omkar.
2. Etreya Upnishad - Soul, Universe & Brahm.
3. Taitreeya Upnishad - Short Summary of Panchkosh, Acharyopdes (Dikshant), Siksha Valli, Anand Valli and Bhrigu Valli.

### UNIT-V: Anatomy & Physiology

1. Digestive System - structure and function.
2. Physiology of Digestion and effect of yogic practices on the digestive system.
3. Respiratory system structure and function and effects of yogic practices on Respiratory system. Muscle classification, histology and properties of each type distribution. Mechanism of muscle contraction (brief), neuromuscular transmission (brief). Ligaments, tendons, skeletal-bones-types, structural and function, spinal column. Joints type, structure and function. Effect of yoga on Musculo-Skeletal System.

## **23. Hospital Administration**

### **Unit I: Introduction to Management**

The evolution of Management, Definition and importance of Management, Different schools of Management thought- classical school, Management Sciences School, Behavioral School, Human Relation School, Operational approach, system approach and contingency approach to Management. Hospital Planning, Organizing, Staffing, directing and controlling.

### **Unit II: Health Systems in India**

Health planning in India including various committees and National Health Policy and Health Goals set from time to time. Organised sector with reference to Centre, State, District and Block level structures and local bodies and Panchayati Raj Organisation and functions of community health centres and Primary Health Centres (PHCs). Health Manpower, Primary Health care and concept, Alternative systems of medicine, like Ayurveda, Homeopathy, etc.

### **Unit III: Outpatient & In Patient Services**

Radiotherapy, Nuclear medicine, surgical units, and OT Medical units, G & Obs. units & LR. Pediatric, neonatal units, Critical care units, Physical medicine & Rehabilitation. Skin, Eye, ENT, Neurology, Dental, Gastroenterology, Endoscopy, Pulmonology, Cardiology, Cath lab, Nephrology & Dialysis, Urology, Orthopedics, Transplant units, Burn Unit.

### **Unit IV: Medical Record**

Definition and types of medical record, Importance of medical record, Flow chart of function, Statutory requirements of maintenance, coding, indexing and filing, Computerization of record, Report and returns by the record department, Statistical information and ICD.

### **Unit V: Biostatics and Research Methodology**

Types of research, Types of research designs, Qualitative and quantitative research, applied research, Sampling methods, and Preparation of research proposal. Basic statistics- Measures of central tendencies, dispersion, Uses of graphs and tables, Software in statistical analysis, Probability, Types of errors in statistics, Tests of significance, and Sample Size.

## **24. Geography**

### **Unit I**

#### **Geographical Thought:**

Contribution of Greeks and Romans Geographers Arab World, Models and paradigms, system theory, phenomenological approach, Determinism and possibilism, Areal differentiation and spatial organisation. Fundamental concepts and methods in contemporary geomorphology; Endogenetic and Exogenetic forces, Denudation and weathering, Geosynclines, continental drift and plate tectonics, Concept of geomorphic cycle, Landforms associated with fluvial, glacial, arid, coastal and karst cycles.

### **Unit II**

#### **Climatology:**

Composition and structure of the atmosphere, Heat budget of the earth, Distribution of temperature, Atmospheric pressure and general circulation of winds, Monsoon and jet stream, Tropical and temperate cyclones, Classification of world climates, Koppen's and Thornthwaite's schemes. Ocean deposits, Coral reefs, Temperature and salinity of the oceans, Density of sea water, Tides and ocean currents.

### **Unit III**

#### **Bio-Geography:**

World distribution of plants and animals, Forms and functions of ecosystem, Conservation and management of ecosystems, Problems of pollution. Patterns of world distribution, Growth and density of population, Patterns and processes of migration, Demographic transition. its situation, types, size, spacing and internal morphology of rural and urban settlements, City- region, Primate city, Rank- size rule, Settlement hierarchy, Christaller's Central Place theory, August Losch's theory of market centres.

### **Unit IV**

#### **Population:**

Theories of population growth; Optimum population; Population projection; population pressure and population explosion; problem of declining and zero growth; population resources regions. Theory of Agriculture localization; Agriculture regionalization; Crop-relation, agricultural efficiency; agricultural productivity; Mix farming, multiple farming, crop-combination.

### **Unit V**

#### **Cartography : Types of maps**

Techniques for the study of spatial patterns of distribution, Choropleth, Isopleth and Pie diagrams, Mapping of location – specific data. Remote sensing and Computer application in mapping, Digital mapping, Geographic Information System (GIS).