16. Animal Genetics and Breeding

Eligibility: Ph.D. in Animal Genetics & Breeding/Animal Breeding & Genetics/Veterinary Biotechnology/Animal Biotechnology.

Syllabus:

Unit-1: Mendalism and its deviations. Gene and genotypic frequencies. Hardy Weinberg equilibrium and its consequences under different allelic systems. Change in gene and genotypic frequencies due to systematic processes (mutation, migration & selection); Concepts of heritability, repeatability, phenotypic, genetic and environmental correlations. Bases and methods of selection. Karyotyping and its application. Chromosomal profiles of various livestock species.

Unit-2: Eukaryotic genome: Gene families, pseudogenes, SnRNPs; Types of RNA including miRNA; Gene conversion; Tandem repeats; Minisatellites and microsatellites; Sequencing of EST. Transposable elements; Transcription and RNA processing; Translation; Regulation of gene expression; Differential expression analysis; Serial analysis of gene expression; Selective gene amplification; The proteasome and longevity of proteins; Gene editing; Gene targeting; Gene knock-out and silencing. Transgenic animals: Application, ethical issues; Gene therapy; Bio-pharming; Cloning; Genome imprinting; Epigenetic modification;Creation of SNP chips and microarray technology; Next-generation sequencing; Genomic selection.

Unit-3: Identification of novel traits and their role in breed improvement programme; Development of mixed model equations; Advancement in biometrical methods including artificial neural network and Bayesian approach; Detection of QTL; Ancestry informative markers for admixture analysis. Formulation of detailed breeding plans under different agro climatic zones/ states of India. Establishment of Bull Mother Farm. Breeding for disease resistance and functional traits; Breeding for climate resilience; Inheritance of animal behaviour traits; Breeding for animal welfare; Different breed improvement programmes in various livestock species and their impact analysis. Advanced techniques in genetic manipulation for multiplication and improvement of livestock species: Use of sexed semen, gene introgression, and cloning, etc.

Unit-4: Multivariate analysis; Discriminant function; D2 analysis; Principal component analysis; Path analysis. Mating designs: Basis, diallel, partial diallel, NCD-1, 2, 3 for reciprocal and maternal effects. Prediction of recombinant inbred lines using genetic parameters; Advances in genotype-environment interaction and selection indices. QTL mapping; Analysis of SNP data for genomic selection; Advances in the estimation of variance component and prediction of breeding value: Threshold, dominance, random regression and survival models.

Unit-5: Fundamental theorem of natural selection; Selection in finite populations; Effect on genetic structure and variance; Design of selection experiments for testing selection theory. Measurement of genetic and environmental trends; Advances in selection indices: Multistage, restricted and retrospective selection indices. Empirical evaluation of selection theory: genetic slippage, limits to the selection, asymmetry of response, selection experiments, the effect of selection on variance. Selection for threshold traits; Selection under single and multiple trait animal models; Direct and correlated response through various selection indices; Relationship between BLUP and selection index; Selection using markers and entire genome; Methods for analysing GS data like RR-BLUP, Bayes-1, 2 and 3, etc.

Unit-6: Overview of bioinformatics; Database concepts; Algorithms; Information resources for protein and genome databases: GenBank, EMBL, SWISSPROT, PROSITE. Nucleotide and protein sequence analysis; Pair-wise and multiple sequence alignments; Phylogeny; Big SNP data analysis methods; Micro-array processing; Clustering; Software for secondary database search and analysis. Genetic characterization; Use of bioinformatics tools for identifying QTL and selection of elite germplasm; GWAS; Development of DNA chips; NGSdata analysis.

Unit-7: Structure of eukaryotic chromosomes; Evolution of karyotype; Various *in- vitro* cell culture techniques; Cell lines and utility; Genotoxicity. Somatic cell genetics; Stem cell genetics; Molecular cytogenetics and gene mapping; Linkage mapping; ISH; FISH; Radiation hybrid mapping; Fibre-FISH; PRINS; Positional cloning; Spectral karyotyping. Image analysis; Chromosome painting; Chromosome walking; Micro-dissection ofchromosomes; Structure and functions of major histocompatibility complex; T Cell receptor; CD4; Interleukins; Toll-like receptors and their functions

Unit- 8: Data preparation and job control commands for statistical analysis of data; Introduction to statistical and standard software packages. Use of software for t-test, Chi-squares test, F-test, ANOVA (CRD, RBD and LSD), correlation and regression (simple, multiple, curvilinear, stepwise) and discriminant analysis. Graphic features of the software packages; Linear programming using appropriate software package; Least-squares analysis;

Data mining techniques such as neural networks, genetic algorithms and fuzzy logic for predictive modelling.

Unit-9: Domestic animal diversity in India: Origin, history and utilization; Present status and flow of AnGR and its contribution to livelihood security; Methodology for phenotypic and genotypic characterization of livestock and poultry breeds through systematic surveys; Management of breed; Physical, biochemical and performance traits and uniqueness of animals of a breed; Social, cultural and economic aspectsof their owners/ commUnitiesrearing the breed. Methods for increasing effective population size of endangered breed/ species: Effective number of alleles, inbreeding effective size, variance effective size,minimum viable population size; Methodology for characterization of AnGR; nuDNA and mtDNA based diversity analysis and relationship among the breeds; Concept of conservation: In-situ and ex-situ (in-vivo and in-vitro); Models of conservation; Prioritization of breeds for conservation; Strategies for conservation of livestock and poultry genetics resources; Gene bank concept; Preservation of ecosystem. Status, opportUnities and challenges in the conservation of AnGR; IPR issues on animal genetic resources/ animal products or by-products; Registration of livestock breeds and protection of livestock owner's rights in India; Breed societies and their role in conservation.

Unit-10: Crossbreeding in cattle in India and abroad; Development of new breeds; Conservation of threatened breeds of cattle and buffaloes; Role of breed associations in dairy improvement; Breeding policy: national and state. Breeding policy: - Sheep and goat improvement programme in India; Conservation of breeds; Culling and replacement; Equivalent Animal Death Rate (EADR).

Poultry Breeding:- Selection criteria and selection indices; Response to selection; Genetic controls; Genotype and environment interaction; Inbreeding and its effects on production traits in egg and meat-type chickens; Development of inbred lines and strains; Strain and line crosses; Introduction to diallel cross; Utilisation of heterosis and reciprocal effect; Recurrent selection, reciprocal recurrent selection and modified RRS; Specialized sire and dam lines; Genetic improvement programs in poultry; Selection strategies for the improvement of layers and broilers; Performance testing of commercial strains; Backyard poultry.

17. Animal Nutrition

Eligibility: Ph.D. in Animal Nutrition/Veterinary Biochemistry/Animal Biochemistry.

Syllabus:

Unit-1: Nutritional Biochemistry, Energy and Protein Nutrition

Classifications and functions of carbohydrates, fats, and proteins, and its digestion and metabolism in ruminants and non-ruminants. Recent concept in energy evaluation measures, Energy partitioning in animal body. Fasting catabolism. Direct and indirect calorimetry. Efficiency of energy and protein utilizationfor various physiological conditions in livestock and poultry. Recent concept in protein quality evaluationmeasures. Developments in ruminant digestive physiology. Advanced concepts in the determination of energy and protein requirements. Recent concepts in protein and energy systems like CNCPS, net energy, metabolizable and available protein.

Unit-2: Advances in Minerals and Vitamins nutrition

General role of minerals, factors affecting mineral requirements. Macro minerals and Micro minerals, their distribution, metabolism, physiological functions, deficiencies, and excess. Mineral interactions. Chelated minerals and concept of nano-minerals. Bio-availability studies in minerals. Bio-markers for mineral status. Mineral interactions. Dietary cation-anion difference (DCAD). Impact of minerals on reproduction, fertility, and immUnity. Soil-plan-animal-human relationship, development of area specific minerals. Toxic minerals and their role in health and production of farm animals. Newly recognized trace minerals. Classification, functions, deficiencies of water soluble and fat-soluble vitamins. Role ofvitamins in energy metabolism. Vitamin-mineral interrelationship. Vitamin toxicosis. Role of vitamins in reproduction, fertility and immUnity. Feed additives and nutraceuticals.

Unit-3: Advances in rumen metabolism: Rumen ecology

Biotechnological applications for lignin degradation. Role of feed additives, chemicals, antibiotics and probiotics and their effect on rumen metabolism. Degradation of anti-nutritional factors in the rumen Manipulation of rumen fermentation; physical, chemical, and biological approaches. Trans-faunation and de-faunation. Genetic manipulation, DNA recombinant technology for improvement in rumen fermentation. Factors influencing the fate

of introduced microbes. Concept of meta-genomics in rumen manipulation, green house gas production from rumen and mitigation strategies.

Unit-4: Recent concepts in Feeding of Non-Ruminants

Latest concepts in nutrition and feeding in different phases of broiler, layer and breeder stocks. In-ovo and early chick nutrition. Nutritional disorders in modern poultry production and their amelioration. Nutritional factors affecting egg quality and hatchability in poultry. Feeding strategies forthe production of designer eggs and meat. Omega fatty acids. Recent trends in amino-acid nutrition. Advances in new generation feed and feed additives. Nutrition and feeding of pigs in various stages of production. Modern concepts of amino-acid nutrition in swine production. Emerging concepts in feeds and feed additives for pigs. Nutritional manipulation for lean meat and designer pork production. Carcass modifiers.Feeding of equines. Feeding of rabbits. Hindgut fermentation and its importance. Nutrient requirements of equines. Special features of equine feeding management. Nutritional management of colic and other health disorders. Nutrient requirements of rabbits for wool and meat production. Nutrition-related disorders in rabbits. Feeding management for dogs and cats of different age groups, viz., pregnancy, lactation, neonatal puppies and kitten, growth, adult maintenance, stress andgeriatrics including feeding behaviour. Water requirements. Deficiencies and excesses of nutrients. Nutritionally responsive disorders: inheriteddisorders of nutrient metabolism, diabetes mellitus, obesity, urinary tract healthand kidney diseases. Parenteral nutrition for hospitalized pets.

Unit-5: Feeding of Ruminant Animals

Nutrient requirements and feeding of calves, heifers, dry pregnant and lactating cows, buffaloes, sheep, and goat. Voluntary feed intake. Determination of digestibility, factors affecting digestibility.Concept of limiting amino acids for high yielders. Strategic feeding of high yielding dairy cows and meat-producing ruminants. Concept of complete feed and total mixed ration. Concept of phase feeding and precision feeding Precision feeding. Phasefeeding. Limiting nutrients and strategic feeding of high yielding ruminants.Feeding during the transition period. Concept of bypass nutrients and their impact on production, re- production, and immune status. Nutritional approaches for increasing the functional properties of milk.

Unit-6: Nutrition of Laboratory, Wild and Zoo Animals

Digestive structure and functions of laboratory animals: rats, mice, and guineapigs. Nutritional requirements of various species of laboratory animals. Feeding oflaboratory animals. Concept of purificd dicts in laboratory animals. Nutrition ofnon-human primates.Natural dietary habits of zoo animals. Feeding schedules of various classes captiveand zoo animals and birds. Feeding orphan and neonates. Role of nutrition in themanagement of health disorders in zoo animals. Fccding of sick and old animals:parenteral nutrition.Feeding habits, and behaviour of wild animals. General aspectsof digestivephysiology of herbivores and carnivores. Nutrition of semi-wild animals like mithunand yak. Nutritive characteristics of forages for wild animals. Adequacy of forageplants for wild and zoo animals.

Unit-7: Advances in Feed Technologyand forages in animal nutrition

Good manufacturer practices (GMP) in feed plants. Planning and designing of feed plants of different capacities. Recent developments in feed processing; particle size reduction, pelleting, extrusions, expanding, conditioning, and micronizing. Automation in feedprocessing. Flow charts for preparation of feeds for various species. Densification of bulk feeds. Silage preparation. Laws and regulation of the feed manufacturing industry. Introduction to labour laws, planning, and production program. Solid state fermentationtechnology. Preparation of complete feeds. Latest concepts in feed microscopy.Forages in ruminant production. Improvement in productivity of fodders and pasture: feed-food crops, silvi-pasture, horti-pasture, shrubs. Use of conserved forages in ruminant feeding. Factors affecting the nutritive value of cultivated and conserved forages.Use of conserved forages in ruminant feeding. Factors affecting the nutritive value of cultivated and conserved forages.Hydroponics as an alternate to green fodder production. Top feeds, fodder trees and their effective utilization.

Unit-8: Toxicants and Anti-Metabolites in Animal Nutrition

Classification of toxicants in animal feeds. Plan origin toxicants, microbial origin toxicants, acquired toxicants (heavy metals, pesticide residue, drug residue) and their effects on animal health and production. Ameliorative measures. De-toxification of plan origin toxicants. Residual effect on animal products and the environment. Antimetabolites in animal feedstuffs. Effects of antimetabolites on animal health and production. Ani- vitamins.Advanced estimation methods for toxicants and anti- metabolites.

Unit-9: Advanced techniques in nutritional research

Principles of animal experimentation – experimental design in nutritional research. Analytical equipment's in animal nutrition research. Estimation of minerals using atomic absorption of Spectro-photometer and ICP. Principles and applications of GC, HPLC, amino acid analyser, SF6, and electron microscopy. Remote sensing and geographic information system (GIS) in animal nutrition research. Analysis of feeds and fodders using NIR.

Unit-10: Nutrigenomics and Advanced Clinical Nutrition

Basic concepts of genetics and molecular biology. Nucleic acid structure and replication, transcription, and translation. Introduction to nutrigenomics and nutrigenetics. Nutritional regulation of gene expression. Introduction to epigenetics and it's influence of early life nutrition and health. Conccpts of proteomics and metabolomics. Microbiome and diseases of nutritional importance. Dietary influences on the microbiome. Metabolic disorders in farm animals. Modern concepts in the metabolic alterations leading to production diseases, viz milk fever, ketosis, downer cow syndrome, retained placenta, sub-acute ruminal acidosis, laminitis, abomasal displacement and mastitis. Optimal nutrition for peri-parturient dairy animals. Nutritional manipulation and feeding of sick and hospitilized animals. Therapeutic nutrition. Feeding managcment of pre and post-operated animals. Role of nutritional management on GI parasites.

18. Animal Physiology

Eligibility: Ph.D. in Veterinary Physiology/Animal Physiology/Veterinary Biotechnology/Animal Biotechnology.

Syllabus:

Unit-1: Physiology of Digestion:

Digestive system of monogastric & polygastric animals.Gastro-intestinal motility, secretary functions, their regulation and GI hormones. Salivary regulation.Digestion and absorption of nutrients in simple & compound stomach. Absorption of water and electrolytes. Development of rumen, rumino-reticular motility, rumen microbiology. Ruminant microbial digestion. Degradation of carbohydrate, fat and protein by rumen microbes, Microbe-microbe interaction. Fate of rumen fermentation products. Protected nutrients and other feed additives for enhancing digestion and absorption. Genetics and biotechnology of rumen microbes. Probiotics.

Unit-2: Cardiovascular and Respiratory Physiology:

Properties of cardiac muscle, Rhythmic excitation of heart, Electrophysiology of heart,Cardiac cycle,Cardiac sounds.Cardiac output &venous return.ECG interpretations.Cardiac murmurs and cardiac arrhythmias. Echocardiography. coronary,systemic and pulmonary circulation. Regional circulation. Pathophysiology of circulation.Hemodynamics. Arterial pressure. Capillary exchanges. Lymphatic circulation. Respiration,Mechanism of ventilation,Transport and exchange of respiratory gases at alveolar and tissue level, Respiratory adjustments at high altitude, Stress and exercise.Pulmonary volumes and capacities.Neural and chemical control of respiration.

Unit-3: Renal Physiology and Body Fluid Dynamics and Electrolytes:

Renal haemodynamics.Glomerular filtration, Tubular reabsorption & secretion.Urine formation-Mechanism of concentration and diluting urine volume. Role of kidney in acid-base balance, Physiology of micturition, Endocrine control of renal function& Renin release. Non-excretory functions of kidney.Body fluids compartments. Exchange of water and electrolytes between body compartments and transport mechanisms. Osmolarity and osmolality of body fluids. Regulation of pH and acid base balance. Cerebrospinal fluid and lymph. Diuresis. Clinicopathological indicators of fluid and electrolyte imbalances. Fluid therapy.

Unit-4: Hematology:

Hematopoietic organs.Blood cells and hematological indices, Different types of anaemia,

polycythaemia.Fate of erythrocytes. Plasma volume estimation methods. Colloidal osmotic pressure. Porphyrias. Resistance of the body to infection, tissue macrophage system and inflammatory response. Phagocytic mechanism. Haemoglobin types, Iron binding proteins in blood,Haemoglobin disorders.Hemophilias. ImmUnity, immunoglobulins complement system. Hemostasis and coagulation factors, Role of platelets, Fibrinolysis. Bleeding disorders. Blood groups, transfusion of blood.

Unit-5: Growth and Environmental Physiology of Animal Behaviour, Advances in Ecosystem, Physiology of Stress and Lactation:

Concept and definitions of cellular, prenatal and postnatal growth. Factors affecting growth. Ageing and senescence. Growth anomalies.Minerals and Vitamins-functions and disorders.Weather and climate. Homeothermy, Poikilothermy.Thermoregulation.Animal ethology.Communication in animals. Ecology of farm animals, circadian rhythms .Biometeorology. Climatic adaptation. Various types of stresses. Endurances in animals. Ameliorative measures to combat stress. Mammogenesis. Galactopoiesis. Lactopoiesis. Induced lactation. Composition of milk.

Unit-6: Physiology of Animal Reproduction:

Development of male and female reproductive system. Puberty. Sexual cycles, oogenesis, ovulation and secretions of female reproductive tract. Spermatogenesis.Semen analysis. Secretions of male reproductive tract.Transport of male and female gametes, Fertilization, implantation. Early embryo development and maternal recognition of pregnancy.Hormones of pregnancy.Placentation,parturition and Uterine Involution.Estrus synchronization,Superovulation and Embryo transfer. Sexing and Cryopreservation of semen.IVM, IVF and IVC. Sexing and Cryopreservation of embryos. Transgenic animals. Applications of stem cells in reproduction.

Unit-7: Clinical Physiology:

Relationship of cardiovascular,renal,respiratory systems andliver in healthy domestic animals and compensatory mechanisms during failure/ disorder of one or other systems.Clinical Haematology and enzymology.Metabolism in health and diseases.Common endocrine disorders.Reproductive function alterations during stress.Clinical evaluation of Gastrointestinal tract, Special Senses, Neuromuscular disorders; Assessment of acid base and electrolyte balance.

Unit-8: Myophysiology,Kinesiology and Neuromuscular Physiology:

Muscles & Contractile elements and action potential, mechanism of muscle contraction.Length & tension relationship, Force & velocity relationship. Skeletal muscle energetics.Lever systems of body joints. Kinesiology & application in work physiology.Electromyogram.Neuronal

classification. Properties. Neurotransmission. Functions of brain. Regulatory centres in brain. Reflexes.Special senses.

Unit-9: Endocrinology of Domestic Animals:

Hormone synthesis, Release and transport.mode of hormone action. Animal models to study hormone functions. Hormonal assay. Hypothalamic, hypophyseal, thyroid and adrenal hormones. Gonadal and placental hormones. pineal gland. Endocrine control of carbohydrate and calcium homeostasis. Gut hormones. Prostaglandins. Hormones in fertility and production augmentation.

Unit-10:Instrumentation and Research Techniques in Veterinary Physiology:

Determination of pH, recording of ECG in animals. Physiograph for *in-vitro* live tissue experiments.GC,HPLC and Mass spectrophotometry.Colorimetry. Electrophoresis. Minerals estimation. Organ bath–Applications in experimental physiology.

Unit-11: Physiology of Wild Life:

Identification of sex in wild animals and birds - Hematology-Body temperature measurement– Measurement of stress &senescence. Reproduction management. Understanding sound mechanics and communication methods– Ethology-Government policies for wild life protection.

Unit-12: Avian Physiology:

Digestive & urinary system.Blood, cardiovascular and respiratory system. Reproductive and endocrine system.Nervous system and musculo-skeletalsystem.

Unit-13: Cellular and Molecular Physiology, Advances in Immunophysiology:

Cell membrane& Organelles. DNA replication. Cell signalling. Membrane receptors. Intracellular/nuclear receptors.Second messengers; apoptosis.Cell cycle. Ontogeny and phylogeny of immune system.Immunoglobulins,T-cell and B-cell- development and their functions, Cytokines, MHC and complement system. Immunomodulation. Hypersensitivity, diseases related to immune system, dysfunction, autoimmune disorders, immunodeficiency in livestock species and poultry.

19. Animal Reproduction Gynaecology & Obstetrics

Eligibility: Ph.D. in Animal Reproduction Gynaecology & Obstetrics/Veterinary Gynaecology & Obstetrics.

Syllabus:

Unit-1: General Gynaecology

Puberty and sexual maturity. Endocrine regulation of estrous cyclc in farm animals. Role of pineal gland, endogenous opioids and neuropeptides in reproduction. Folliculogenesis, follicular waves & its manipulation, oogenesis & ovulation. Synchronization of estrus and ovulation in farm animals. Seasonal breeders. Effect of stress, immunological and nutritional factors on fertility. Onset of postpartum ovarian activity and factors affecting it. Transport of gametes in the reproductive tract, fertilization & implantation. Maternal recognition of pregnancy in farm animals. Embryonic and fetal dcvclopmcnt during gestation. Placentation & fetal circulation. Pregnancy diagnosis and its methods in farm animals. Lactation and artificial induction of lactation in cattle & buffaloes.

Unit-2: Female Infertility in Farm Animals

Infertility, its classification & economic impact. Causes of infertility. Importance of body condition score. Negative energy balance, its prevention and amelioration. Out of season breeding. Anoestrus; causes, diagnosis and treatment. Cystic ovarian degeneration; causes, diagnosis and treatment. Anovulation & delayed ovulation; causes, diagnosis and treatment. Luteal insufficiency; causes, diagnosis and treatment. Repeat breeding; its causes, diagnosis and treatment. Early embryonic death; it's causes, diagnosis and therapeutic management. Abortion; Infectious & non-infectious causes of abortion, its diagnosis and prevention. Immunoinfertility and its mechanisms and management. Principles of hormone therapy in reproductive disorders.

Unit-3: Veterinary Obstetrics

Conceptus and its development. The foetal membranes and Placenta. Parturition; its mechanism, stages of parturition. Induction of parturition and termination of abnormal pregnancies. Use of tocolytic drugs. Diseases and accidents during pre, peri and post

parturition. Factors influencing gestation period and birth weight. Transition cow, onset of postpartum ovarian activity. Dystocia & principles of handling of dystocia. Obstetrical procedures; mutations, fetotomy and caesarean section. Management of maternal and fetal dystocia, hydrallantois, hydramnion, fetal mummification, fetal maceration, uterine inertia and uterine torsion. Caesarean section and ovariohysterectomy. Neo-natal physiologyand post-natal adaptations. Assessment of neonatal viability, care of the newborn. Care of the postpartum dam. Involution of uterus, post-partum ovarian dysfunction and theirmanipulation. Congenital anomalies and Teratology.

Unit-4: Andrology and Male Infertility

Puberty and sexual maturity in male. Sexual behavior in males. Examination of bulls for breeding soundness. Spermatogenesis, seminiferous epithelial cycle and spermatogonial wave. Sperm passage in male genitalia, biochemical milieu of male genitalia. Semen and its composition. Mechanism of sperm motility. Tests for assessment of sperm motility, sperm survival and fertilizing capacity of spermatozoa. Mitochondria and their role in sperm metabolism. Sperm plasma membrane and its permeability and binding properties; acrosome and lysosomal enzymes, sperm nucleus and nuclear proteins. Diseases transmitted through semen. Causes of male infertility; hereditary, congenital, infectious, nutritional and hormonal. Pathological and functional disturbances of epididymis, vas deferens and accessory sex glands. Impotentia cocundi and impotentia generandi. Testicular hypoplasia and degeneration; causes and affect on semen and fertility. Coital injuries and vices of male animals. Influence of seminal plasma proteins in modulating fertility. Heat stress and its effect on sperm production. Fructolysis index. Aerobic and anaerobic metabolism of spermatozoa. Markers of fertility in males. Karyotyping to identify sperm defect and DNA mapping for parentage.

Unit-5: Artificial Insemination (AI) and Semenology

Methods of semen collection. Semen evaluation; macroscopic and microscopic examination. Biochemical and microbiological tests of semen. Semen dilution and preservation. Semen additives for enhancement of motility and fertilizing capacity of spermatozoa. Cryopreservation of semen. Effect of cryopreservation on spermatozoa, semen quality and fertility. Factors affecting post-thaw semen quality.

Protocols for AI in different species of animals. Factors affecting success of AI. Biosecurity & biosafety guidelines for frozen semen stations, semen processing laboratories and quarantine stations. Contribution of gonads and accessory sex glands to semen ejaculate. Factors affecting

semen production. Metabolism of sperm. Role of seminal plasma proteins. Species variation in seminal characteristics. Microbial contamination of semen and measures for its prevention. Transmission of venereal diseases through semen and their prevention. Post-thaw evaluation of motility and fertilizing capacity of spermatozoa. Quality control and quality assurance of semen. Antisperm antibodies assay. Flow cytometric assessment of sperm quality.

Unit-6: Basics of Reproductive Biotechnology

Embryo transfer technology; selection of donors and recipients, super-ovulation, synchronization of estrus in donors and recipients. Surgical and non-surgical collection & transfer of embryos. Evaluation and cryopreservation of embryos. Sexing of embryos. Guidelines for export and import of bovine germplasm. Guidelines and standards regarding embryo production. In vivo, in vitro collection of oocytes. *In vitro* culture of granulosa cells, cumulus cells, luteal cells and oviductal cells. *In vitro* maturation, i*n vitro* fertilization and micromanipulation of embryos. Immuno-neutralization and immunomodulation of fertility. Micromanipulation and Intracytoplasmic sperm injection. Stem cell biotechnology. Semen sorting for production of sexed semen. Cloning and biopharming. Transgenic animals & chimeras. Genc cxpression in oocyte and embryo, identification of cellular organelles of gamete. Principle and application of PCR technique in animal reproduction.

Unit-7: Canine and Feline Reproduction

Puberty and sexual maturity. Canine and feline estrous cycle, endocrinology of estrous cycle. Breeding management. Pregnancy & its diagnosis; clinical, ultrasonographic, endocrinological and othcr diagnostic laboratory tests. Parturition and periparturient disordersin dogs and cats. Dystocia; fetal and maternal causes, diagnosis and management. Inductionof parturition and caesarean section. Medical termination of pregnancy. Management of psudopregnancy & pyometra. Infertility and it's management. Postpartum care of dam & lactation. Neonatal care. Population control in dogs; surgical and non surgical methods. Scmen collection techniques and semen evaluation. Freezing of semen and artificial insemination techniques. Male reproductive disordcrs and its management.

Unit- 8: Caprine and Ovine Reproduction

Puberty and sexual maturity. Caprine and ovine estrous cycle. Endocrinology of estrous cycle. Seasonal breeding activity in sheep and goat. Artificial control of oestrus in sheep andgoat. Breeding management. Methods for advancing sheep breeding season, induction of

multiple births in sheep. Artificial insemination. Pregnancy and parturition. Dystocia and its management. Reproductive disorders and its management. Semen collection techniques & semen evaluation. Freezing of semen. Male reproductive disorders and its management.

Unit-9: Equine Reproduction

Puberty and sexual maturity. Estrous cycle, manipulation of estrus in Mare. Broodmare management. Use of ultrasound in breeding management. Infertility and it's management. Pregnancy diagnosis and management pregnant mare. Fetal development. Abortion. Parturition, induced parturition. Management of dystocia. Neonatal management. Common neonatal diseases, orphan foal management. Foal management during the first six months. Semen collection. Semen preservation. Artificial insemination. Embryo transfer. Male reproductive disorders and its management.

Unit-10: Camel Reproduction

Sexual behavior, puberty and sexual maturity, oestrous cycle, signs of oestrus. Seasonal changes & copulation. Semen collection and it's characteristics. Sexual behavior, Pregnancy and foetal development. Pregnancy diagnosis. Parturition. Age of sexual maturity, breeding season. Conception rate, calving interval, reproductive longevity. Early embryonic mortality, reproductive problems in the female. Reproductive problems in the male. Artificial insemination. Nutrition and reproduction. Embryo transfer in camel.

Unit-11: Wild and Zoo Animal Reproduction

Zntroduction to reproduction in wild animals. Pattern of estrous cycle in tiger, deer, monkey and crocodile. Optimal breeding time with emphasis on tiger, deer, monkey and crocodile. Gestational length and pregnancy diagnosis in wild and zoo animals. Parturition in wild and zoo animals. Sexual behavior in wild and zoo animals. Major reproductive disorders in wild and zoo animals. Contraception techniques for deer.

Unit-12: Porcine Reproduction

Oestrus cycle, manipulation of oestrus cycle in sow. Methods for detection of oestrus. Endocrinology of pregnancy. Endocrinology of parturition. Infertility in sow and its management. Pregnancy diagnosis and management of pregnant sow. Fetal development. Abortion and induced parturition. Parturition and its stages. Dystocia. Mastitis-metritis complex. Neonatal management and common neonatal diseases, care of piglets. Breeding

boar selection and management. Semen collection and preservation. Natural service and artificial insemination. Embryo transfer and IVF. Male reproductive disorders and its management.

Unit-13: Imaging Techniques in Animal Reproduction

Basic principles and applications of X-Ray in animal reproduction. Basic principle of ultrasonography, physics of ultrasonography, A-mode, B-mode and M-mode Ultrasonography. Artifacts and principle of Doppler ultrasonography. 4D Ultrasonography. Trans-abdominal & transrectal ultrasonography. Follicular dynamics and luteal characteristics in large and small ruminants, luteal blood flow studies. Use of ultrasonography in pregnancy diagnosis and infertility management. Studies on uterine involution, luteal cyst and follicular cyst, blood flow studies in uterine and foetal arteries ultrasonography. Determination of gestational age in small animals by measuring gestational sac diameter, crown rump length and body diameter. Detection of foetal resorption and mummification. Prediction of parturition time, fetal viability by detecting fetal heart rate, foetal number and sex determination. Testicular and male accessory sex gland ultrasonography. Basic principles and applications of C.T. Scan and MRI in animal reproduction. Application of Laparoscopy in animal reproduction.

20. Aquaculture

Eligibility: PhD in Aquaculture/Coastal Aquaculture /Fish Nutrition & Feed Technology/Fish Nutrition/Fish Nutrition & Biochemistry/Aquatic Animal Health Management//Fish Health Management/Fish Genetics & Breeding/ Aquaculture Engineering.

Syllabus:

Unit-1: Hatchery -Principle & Management

Reproductive biology of commercially important cultivable fin fishes and shellfishes. Principles and practices of induced breeding. Fish endocrinology, Environmental and endocrine control of fish reproduction, broodstock management, evaluation of gonadal development and gametes. Cryopreservation of fish gametes. Breeding and seed production of Indian major and minor carps, exotic carps, magur, stinging catfish, pabda, striped catfish, tilapia, climbing perch, murrels, seabass, milkfish, mullets, pearl spots, scats, grouper, snapper, breams, pompano, cobia, small indigenous fishes, and ornamental fishes. Cold waterfishes mahseer, trout and Salmon. Seed production of commercially important prawns (Macrobrachium rosenbergii), shrimps (Penaeus monodon, P. indicus and P. vannamei), Mud crab (Scylla serrata), spiny lobsters (Panulirus spp), sea cucumbers, edible mussels, edible oysters, pearl oyster and freshwater pearl mussels, clams. Conditioning and transportation of seeds, BMPs in fish hatchery system. Hatchery accreditation and seed certification.

Unit-2: Aquaculture Systems & Practices

Principles, design, construction and operations, -ponds, cages, pens, rafts, racks, long line and lined ponds. Design and operation of commercially important finfish and shellfish species hatcheries, nurseries and growouts. Principles of closed farming systems, zero water exchange systems- Design of RAS, biofiltration and nitrifiers, Suitable cultivable species for indoor culture systems, polyhouses. RAS, Components, design of mechanical and biological filters for the water reuse system. Flow-through system, Raceways (IPR), IMTA, Partitioned Aquaculture Systems (PAS), Central drainage systems in ponds and tanks, Aquamimicry systems and Pond in pond system. Desert Aquaculture, Biofloc systems, Different carbon sources and bioreactors. Aquaponics: Principles, Components and design of different aquaponics systems, ratio of fish and plants, Resource utilization, Nutrient recycling and zero discharge of nutrients. Physical-chemical properties of soil and water, Water quality standards, Eutrophication, aquatic weed and insect management.

Unit-3: Nutrition & Feed Technology

Nutritional energetics, Energy values of feed, Novel Feed Ingredients, Types of feed and feed formulation methods, Nutritional requirements for different species, nutrition in stress amelioration, Broodstock and Larval nutrition and feeds, Equipment used in feed manufacturing, biorouting of nutrients and nutrient digestibility, bioavailability in feeds, quality control in fish feed manufacturing, Production methods for different micro feeds, live feeds research in India and around the globe. Fish meal replacement-veg proteins, inhibitors and anti-nutritional factors. Nucleotide nutrition, Functional Feed Ingredients-Immunostimulants, enzymes, Phytochemicals, growth promoters etc.

Unit-4: Aquatic Animal Health and Management

OIE and non -OIE listed pathogens of cultivable sp, Bacterial, fungal, viral and nutritional deficiency diseases of fishes in cultivable fishes and control of diseases in various aquaculture systems. Drugs in aquaculture, disease impacts on hatchery production. SPF, SPR and SPT seeds production protocols; Anaesthetics and methods of anaesthetizing fish and shellfish, antimicrobial resistance and impact in aquaculture, parasitic infections and control. Diagnostics- molecular- PCR, RTPCR, Immunology- ELISA and haematology parameters. Emerging fish welfare indicators, Types of vaccines and administrative methods.

Unit-5: Applied Aquaculture Genetics

Quantitative and qualitative genetics; Selection methods and mating designs; Design for selective breeding; Inbreeding and its consequences; Sex control in Aquaculture. Genome markers, Recombinant protein expression in Bacteria, Electroporation Cytogenetics; Cytogenetics and evolution; Karyotyping and chromosome banding; Genetic basis of sex determination; Chromosome manipulation: Ploidy induction, Sex reversal, Gynogenesis and Androgenesis; Chromosomal aberrations; Mutations Natural and Induced, Mutagens.

Unit-6: Applied Aquaculture Biotechnology

Recombinant proteins of commercial importance: enzymes, hormones, bioactive compounds, therapeutic proteins. Probiotics, single cell proteins, Nutraceuticals, Gnotobiotics. Anti-microbial Peptides and their applications. Microalgal bacterial interaction; Metabolics strategy in aquaculture. Surrogate fish production, In vitro gamete production, Sterile fish production, Mono-sex seed production. Lab grown fish meat production, Gene editing/CRISPR technology in aquaculture, Gene-knock out technique, Transgenic technology, Recombinant DNA, Monoclonal antibodies, Cell lines and stem cell culture, DNA markers. Government regulation of Transgenic fish and Biotechnology products.

Unit-7: Used water Treatment Practices

Role of microorganism in wastewater treatment; Microbial load and algal blooms, biological indicators, nutrient composition in waste water. Sludge removal, disposal of wastes and control of pollution to the environment. Bioremediation in wastewater aquaculture; Sludge conversion and management; waste to wealth concept; Environmental biomitigation of fed aquaculture, Effluent treatment systems (ETS).

Unit-8: Aquaculture Engineering and Automation

Selection and operation of aquaculture equipment - aerators, blowers, pumps, filters, feeders, mechanical harvesting system, other equipment. Spatial planning; types of soil and its properties; Site selection, planning and construction of coastal and Brackish water aqua farms. Water budgeting. Automation for water quality management and health management in aquaculture; Use of data acquisition systems in aquaculture. Biological models related to automatic control in aquaculture; Roles of Cloud computing, Internet of Things and Artificial intelligence in aquaculture management practices

Unit-9: Open Water Aquaculture

Global & national status of inland saline soil, Inland saline waters, surface & ground water & underground saline water, Integrated inland saline aquaculture systems, Seaweed farming systems & propagation. Ranching in openwaters, Cages and Pen-Design and Operation, cluster farming, satellite farming, cooperative farming and conservation aquaculture. importance of morpho-edaphic index in reservoir productivity and classification; factors influencing fish production; trophic phases in reservoir; pre-impoundment and post impoundment stages and their significance in establishment of reservoirs fisheries.

Unit-10: Climate change, Economics Policy & Planning

Greenhouse gases, Microplastics in Aquaculture, Carbon footprint and sequestration in aquaculture, climate change impacts and its mitigation, Aquaculture economics- Lifecycle assessment of aquaculture systems, Econometric models applied to aquaculture as tools for sustainable production; Bioeconomic modelling. Aquaculture Insurance, EIA, Ecosystem approach to aquaculture, Exotic sp., Introduction , escapement, contamination of indigenous gene pool; Application of renewable energy in aquaculture, sustainable use of antibiotics. National and International guidelines for sustainable aquaculture, BMP, CRZ implication, eco labelling and traceability, State water bodies protection guidelines. Biosecurity in Aquaculture: International Agreements and Instruments.

21. Fish Health

Eligibility: PhD in Aquatic Animal Health Management/Fish Health/Fish Health Management/Aquaculture/Fish Genetics & Breeding/Fish Biotechnology.

Syllabus:

Unit-1: Principles of Aquatic animal health management

Definition of health and disease in fish. Predisposing factors, biotic and abiotic factors, Stress and general adaptation syndrome. Role of physical, chemical (pH, salinity, toxins, ammonia, nitrogeneous waste, endogeneous chemical metabolites, free radicals, oxidants) soil andwater parameters in fish health. Host-pathogen-environment interaction. Introduction to disease management measures: Management measures for pathogen: therapeutics and sanitizers etc.; Management measures for the environment: bioremediators, biocontrol agents etc.; Management measures for the host: specific pathogen-free (SPF), specific pathogen- resistant (SPR) and specific pathogen-tolerant (SPT); probiotics; immunomodulators; concepts of vaccination.

Unit-2: Host-pathogen interaction

Introduction and concepts of different animal associations; important ecological terms used in bacteriology, virology, parasitology, and pathology; host-parasite relationship; Host-virus interactions; viral adaptation; virus-virus interaction; emerging viruses; the evolution of new viruscs; Macro-environmental and micro-environmental influence on pathogen incidence; Role of parasites as bioindicators; Role of parasites in ecosystem functioning; manipulative parasites; parasites as ecosystem engineers; parasites as biological tags; the evolution of parasites; hyperparasitism; parasitic adaptation; Host-pathogen communication and cell to cell interaction; the interaction between parasites and microbiome. Role of co-infection in disease outcome.

Unit -3: Pathogens and diseases & disorders of fish

Basic understanding of fish pathogens: Bacterial morphology, classification, metabolism, bacterial toxins and virulence factors. Kinetics of microbial population in the aquatic environment, bio-films, microbial interactions, antimicrobial resistance. Evolution and classification of viruses, virus-host relationship, replication of virus, virulence factors. Basics about fungal and oomycete pathogens of fish. Different groups of parasites of fish. Major

diseases and disorders: Aetiology, epidemiology, pathogenicity, virulence, prophylaxis, treatment and control measures of microbial diseases: Major bacterial diseases of finfish and shellfish; Pathogenesis, molecular biology, epidemiology, and control of major viral pathogens of finfish and shellfish (both OIE-listed and non-OIE listed); Basic understanding on major viral diseases of molluscans; Major fungal diseases of finfish and shellfish. Parasiticdiseases: Diseases of importance in aquaculture, clinical signs, etiology, pathology, epidemiology, host-parasite relationship, diagnosis, treatments and control of the disease caused by protozoan and metazoan parasites of fish and shellfish. Environmental and non- infectious diseases of fish: Impact of water and sediment parameters on finfish and shellfish health; Toxins and their role in disease process. Water pollution-microbial changes induced by inorganic and organic pollutants, industrial effluents, domestic sewage and their effects onfish and shellfish health; Mycotoxicosis- important mycotoxins; chemical toxins, and other toxicants and their effects on fish health; Causes, pathogenesis, pathology, diagnosis, and differential diagnosis of various diseases due to nutritional imbalance, vitamin deficiencies and mineral deficiencies and their toxicity; Metabolic disorders; skeletal deformities; chronic diseases/disorders in shrimp such as retarded growth, white faeces syndrome etc.; Diseases ofaquatic wildlife: Major diseases affecting aquatic wildlife such as amphibians: Infectious (viral, parasitic, bacterial) and non-infectious diseases; Effect of anthropogenic factors and contaminants on aquatic wildlife; the zoonotic potential of aquatic wildlife diseases.

Unit-4: Fish Pathology

Introduction to finfish and shellfish anatomy and histology; general pathology of finfish and shellfish. General pathology- degeneration, necrosis, apoptosis, inflammation, classification of inflammation, biology of inflammatory phenomenon, signs and pathology of inflammation, chemical mediators release from inflamed cells and tissues involved and their function. Abnormalities in cell growth aplasia, hypoplasia, atrophy, metaplasia dysplasia. Tumours and neoplasm growth. Clinical and systemic pathology caused by fish pathogens. Inflammation and cellular pathology: Reversible cellular changes and accumulations: fatty changes and pigments; inflammation: causes of inflammation; cellular responses to inflammation; mediators; various patterns of inflammation; the difference between acute and chronic inflammation; tissue repair; Cell death: necrosis, apoptosis, autophagy; necroptosis: their mechanisms and different morphological patterns; Clinical pathology: Normalconstituents of blood; alterations in the haematological parameters and enzymes with reference to different pathological conditions in finfish; haematology of shrimp and

molluscans; clotting mechanisms; other host defence mechanisms; Systemic pathology of finfish: Systemic pathology of finfish integumentary system, respiratory system, vascular system, digestive system, excretory system, nervous system, musculoskeletal and endocrine system due to bacteria, parasites and viruses; Systemic pathology of shellfish: Major pathological changes due to infectious diseases in the integumentary system, lymphoid organ, gill, hepatopancreas, gut and other organs/of crustaceans; major pathological changes due to diseases in molluscans.

Unit-5: Fish defence system and Immunology

Introduction to fish immunology: Phylogeny and ontogeny of the immune system; lymphoid tissues and cellular components of the immune system; T and B cells; mucosal immune system; Finfish immune mechanisms: Molecular players in mucosal immUnity; major histocompatibility complex; pattern recognition receptors and immune pathways; antigen processing and presentation; T-cell activation and differentiation; B-cell activation and differentiation; classical, alternate, lectin pathways of complement; their activation and regulation; mucosal immUnity, ImmUnity against bacteria, virus, different parasite types, fungus. immune evasion, Cytokines and MHC; Shellfish immune mechanisms: Prophenoloxidase system; phagocytosis; encapsulation; antimicrobial peptides; Invertebrate defence mechanisms; quasi-immune response; Immune evasion: Evasion of the immune response by pathogens; Non-specific immune system of finfish: Phagocytosis; mechanism of phagocytosis; complement system: function, components; complement activation; Specific immune system of finfish: Memory function and immunological tolerance; antigens and antigenicity; antigen processing; superantigens; haptens; antibody: structure, types, theories of antibody formation; regulation of immune response; Antibody-mediated and cell-mediated immUnity: Cell- mediated immune responses and their components; antibody-mediated immune responses; polyclonal and monoclonal antibody production and application; the basic concept of aptamers, aptabodies and edible antibodies.

Unit-6: Aquatic Animal Disease Diagnosis

Introduction to fish disease diagnosis: Diagnostic features of important diseases of finfish and shellfish; different roles and levels of diagnosis in aquaculture; the evolution of diagnostic techniques in aquaculture; Safety in microbiology laboratory; bio-safety levels and risk groups; techniques in sterilization; preparation of microbiological media; culture techniques; purification, preservation, and maintenance of bacterial and fungal cultures; Microscopic

techniques: Bright field, darkfield, phase contrast, fluorescence, and electron microscopy; Molecular characterization of pathogens DNA taxonomy and barcoding of parasites; Cell culture-based diagnostic methods: Principles of cell culture; development of primary cell culture; maintenance of cell lines; scaling up of cell culture; characterization and preservation of cell lines; Different cell lines used for fish virus isolation; CPE; Protein-based diagnostic methods: Antibody-based diagnostic methods - immunohistochemistry, ELISA, western blotting, lateral flow assay, etc; Hybridoma technology and monoclonal-antibody-based diagnosis: Nucleic-acid-based diagnostic methods: Nucleic acid amplification methods; types of PCR: reverse transcriptase-PCR, real-time PCR, and other variants of PCR; In situ hybridization; dot blot assay; LAMP, etc; Southern, Northern, Dot/Slot blot hybridization; DNA Microarrays: DNA chips, preparations of DNA arrays; label and applications; other related molecular techniques; Advanced biotechnology tools: eDNA technology; metagenomics; next-generation sequencing; CRISPR technology; digital pathology; RNAi technology; Nanotechnological tools in disease diagnosis.

Unit-7: Fish Pharmacology and Therapeutic Measures for Fish Diseases

Different chemicals and drugs used in aquaculture; categories of aqua-drugs: approved, unapproved and conditionally approved aquaculture drugs, low regulatory priority aquaculture drugs, Anaesthetics and methods of anesthesia of fish and shellfish. Common therapeutants used in aquaculture; their mode of action, dose and dosage, methods of application; Phytotherapy, phage-therapy, nanoparticle-based drugs, antimicrobial peptides, etc. Antibiotics and their mode action, antiviral compounds, virus and gene therapy; use of RNA interference. Common anti-protozoal and anti-metazoal drugs applied in aquaculture; mode of application and their action. Pharmacokinetics and pharmaco- dynamics; residual effect and withdrawal period of various chemotherapeutants. Legislative framework of chemotherapy in aquaculture; drug regulation acts and other legal aspects. **Antimicrobial resistance:** Use and abuse of antibiotics in aquaculture; multidrug resistance; molecular mechanisms; antibiotic resistance and its impact on the environment and human health; Drug toxicity and poisoning; AMR, WHONET, and ATLAS.

Unit-8: Prophylactic Measures

Immunoprophylaxis: Probiotics, prebiotics, immunomodulaters; aquaculture vaccines: history, concept, development of vaccines; routes of administration; adjuvants and ligands; efficacy and limitation of vaccines. Bacterial, parasitic and viral vaccines available in

aquaculture; Vaccine production and delivery: Types of vaccines- killed, live attenuated, synthetic peptide, recombinant, anti-idiotype, DNA and RNAi based vaccines; monovalent and polyvalent vaccines; nanoparticle-based vaccines; vaccine production; quality control; vaccine composition; superantigens; cytokines and therapeutic uses of cytokines; adjuvants and immunostimulants; Safety and regulatory requirements: Environmental concerns of vaccine, and other biological products; vaccination failure and adverse effects.

Unit-9: Epidemiology, Disease Surveillance and Biosecurity

Introduction to epidemiology and concepts: Epidemiological terms; epidemiological concepts and types; Disease surveillance and zonation: Disease surveillance; purpose and objectives of surveillance; approaches to surveillance - principles of active and passive surveillance; sampling principles and applications; Surveillance data management: Principles and data processing, computerized and manual data management; epidemiological software for data analysis; Disease zoning, buffer zones; Developing management practices and biosecurity principles: Health maintenance, better/best management practices (BMP), good aquaculture practices (GAP), hazard analysis and critical control point (HACCP), and biosecurity: principles and practices.

Unit-10: Legislative Framework in Aquatic Animal Health Management

Aquatic animal health safety regulations at national and international levels; Principles of quarantine; Zoning and compartmentalization; Transboundary diseases; Disease reporting; Live fish transportation; Import risk analysis; Health certification: Principle, procedure, the regulatory body for aquaculture health certification; Legislative framework of chemotherapy in aquaculture; drug regulation acts and other legal aspects; One health concept of OIE: World animal health organization and importance for trading; Strategic plan for aquatic animal health: Aquatic animal health information systems; national and regional strategicplan for aquatic animal health; national and international disease reporting; emergency disease preparedness; Safety and regulatory requirements: Environmental concerns of vaccine, and other biological products; biosafety and regulatory requirements for fish diagnostics, diagnostic kits, vaccines, etc.

22. Bioinformatics

Eligibility: Ph.D. in Bioinformatics/Computational Biology/Computer Application/Computer Application and IT/Computer Science/Statistics/Agricultural Statistics /Biotechnology /Agricultural Biotechnology/Molecular Biology and Biotechnology.

Syllabus:

Unit-1: Introduction to Bioinformatics

Overview of available genomic resources on the web; NCBI/ EBI/ EXPASY etc; Nucleic acid sequence databases; GenBank/EMBL/DDBJ; Database search engines: Entrez, SRS. Overview/concepts in sequence analysis; Pairwise sequence alignment algorithms: Needleman and Wunsch, Smith and Waterman; BLAST, FASTA; Scoringmatrices for Nucleic acids and proteins: PAM, BLOSUM, Multiple sequencealignment: PRAS, CLUSTALW. Sequence based gene prediction and annotation.

Unit-2: Computational Biology

Microarrays, RNA-seq, Chip-Seq, EST-clustering, Preprocessing of gene expression data; Data Normalization techniques, Data qualitycontrol: Modelling of errors, Imputation etc; differential expression analysis, Methods of construction of Gene Regulatory Network, Hub gene identification High-throughput screening. Optimization Techniques: concept and applications, Simulated Annealing, GeneticAlgorithms: Ab initio methods for structure prediction; Information theory, entropyand relative entropy. Foundations for Machine learning Techniques, Classification: Decision tree, Bayesian, Rule based classification, ANN,SVM, KNN; Case based reasoning and Applications in Bioinformatics. Clustering: Partition Methods, Heirarchical methods, Density based methods, Grid based clustering, Model based clustering, clustering of high dimensional data, constraints based clustering,Cross Validation Techniques, Markov Model, Bayesian Inference: conceptsand applications, Hidden Markov Model and applications. Dimensional Reduction Techniques, Methods of Feature Selection, Resampling Techniques, Elements of Text Mining and Web Mining, Soft Computing and application in bioinformatics. Concepts of object oriented programming, BioJAVA, BioPerl and R. Files and data manipulation including methods/functions and modules.

Unit-3: Genetics and Genomic Data Analysis

Fundamentals of Population genetics: Hardy –Weinberg law, Effect of systematicforces on changes in gene frequency; Principles of Quantitative genetics: Values,Means and Variances, Detection and Estimation of Linkage, Inbreeding, Selection,Genetic Parameter Estimation,

Variance component estimation, BLUP, G x Einteraction, Path Analysis, Molecular Marker based classification: similarity measures, clustering methods,bootstrapping; QTL mapping: Detection and Estimation of QTL, Single MarkerAnalysis, Interval Mapping and MQM;Design and Analysis of Expression Data; Genome Selection; Genome Prediction,Genetic Markers, Association Mapping; Genome Wide Association Analysis, Population genetics: Hardy-Weinberg law, Estimation of linkage, Inbreeding,Selection, Genetic parameter estimation, Variance component estimation, BLUP,Path analysis, Molecular marker based classification, Estimation of QTL, Singlemarker analysis, MQM. Comparative and functional genomics: DNA chips, qPCR, SAGE, MPSS, Protein interactions, SNPs, HapMaps Analysis of gene expression data, Types and methods of genome sequencc data generation; NGS, Shot gun sequencing method; Problems of genome assembly, Approaches of genome assembly: Comparative Assembly, DE novo Assembly; Read coverages; Sequencing errors, Sequence Quality Matrix, Assembly Evaluation; Challenges in Genome Assembly.Genome editing approaches and their applications;Structural and functional Genome annotation. Genomic selection/prediction.

Unit-4: Bio-molecular Modelling and Simulation

Methods for 3D Structure Prediction: Homology modeling of protein 3D structures– approaches to loop building, energy considerations and evaluation of the accuracyof the model. ab initio approach to 3D structure prediction; Threading approach to3D structure prediction. A Comparison of protein structure prediction methods:CASP, Basic principles of modeling, modeling by energy minimization technique, conceptof rotation about bonds, energy minimization by basic technique for small molecules,Ramachandran plot, torsional space minimization, energy minimization in Cartesianspace, molecular mechanics-basic principle, Basic concepts of Simulation Modelling: Units and derivatives, Force field and energy landscape, Truncation of non-bonded interactions, Introduction to solvation, Periodic boundary condition, Wald summation, implicit solvent model and continuumelectrostatics, Monte Carlo simulation on parallel computers. Replica-exchange simulations, Restraint potentials, Free energy calculations, Membrane simulations, Energy Minimization: Concept of energy minimization - hypersurface, local andglobal energy minima, statement of problem.Derivative minimization methods -first derivative methods: the steepest descents method, linesearch in one dimension, arbitrary step approach, conjugate gradients minimization. Second derivative method– the Newton-Raphson method. Applications of energy minimization.

Unit-5: Biological Data Management

Database Management System (DBMS): Need for DBMS, DBMS Architecture, services,

Data Models: Concepts of Relational Database, Codd's Rules –Normalization, Structured Query Language (SQL): Curation of genomic, genetic, proteomic data, High-throughput screening, array, qPCR data sets; Quality management of data: tools and techniques. Biological datasources, Data granularity, Schema modelling, extraction, transformation and loading of data from various formats, data management, storage and security. Bio-chip information system, visualization and reporting, noSQL database; BIG data Analytics and AI

Unit-6: Genome Wide Association Study

Definition, Allelic spectra of common diseases, Allele frequencies for susceptibility loci, Risks associated with disease-susceptibility variants, Applications of linkage disequilibrium metrics, SNP map, Genome resequencing for full coverage in genome wide association studies, Transmission Disequilibrium Test, common variant hypothesis, rare allele hypothesis, Genome-wide graph theory algorithms, Case-Control design, Trio design, Cohort design, Cross-sectional designs for GWAS Selection of Study Participants, Environmental confounders in GWAS, Confounding by population stratification, Genotyping and Quality Control in GWA Studies, Analysis of association between SNP and traits. Uses of GWAS: gene-gene interaction, detection of candidate haplotypes, association between SNPs and gene expression.

Unit-7: Phylogenetics

Phylogenetic trees and their comparison: Definition and description, various types of trees; Consensus (strict, semi-strict, Adams, majority rule, Nelson); Data partitioning and combination Tree to tree distances, similarity; Phylogenetic analysis algorithms: Maximum Parsimony, Distance based: UPGMA, Transformed Distance, Neighbors-Relation, Neighbor-Joining. Probabilistic models of evolution, Maximum likelihood algorithm; Approaches for tree reconstruction: Character optimization; delayed and accelerated transformation, Reliability of trees, Bootstrap, jackknife, decay, randomization tests; Applications of phylogeny analyses: Comparison of Phylogenetic Trees obtained using DNA seq. vs. protein seq. vs. Full genomes. Need for addition of other properties towards total phylogenetic analysis, Comparative methods for detection of species/ organism relationships, Gene duplication, Horizontal transfer, Domain evolution, Study of co-evolution: Plant-insect interactions. Host-parasite interactions, viral evolution.

23. Computer Application and IT

Eligibility: PhD in Computer Application/Computer Science/Computer Science and Engineering/Computer Engineering/Computer Technology/Information Technology/Information Communication Technology/Bioinformatics.

Syllabus:

Unit-1: Computer Organization and Architecture

Computer Organization and Architecture – Boolean Algebra, Minimization of Boolean Functions, Number System, Basic concepts of floating point number system, Sequential and Combinational Circuits, Flip flops – types, Race Condition and Comparison. Input/Output Unit, Memory Organization, ALU and Control Unit, Instruction and Execution Cycle in CPU, Introduction to Microprocessors, Interrupts, CISC and RISC Architecture.

Unit-2: Programming Languages & Data Structure

Programming Languages (Java, C++, Python), Computer Algorithms, Flow Charts, Encapsulation, Inheritance, Polymorphism, Building Blocks, Control Structures, Arrays, Dynamic Memory Allocation, File management. Internet Programming – Hyper Text Markup Language (HTML) and XML, Building Static and Dynamic Web Pages, Client Side and Server Side Scripting Languages (JSP,.NET,PHP), Mobile Apps, Interaction with Database. Data Structure-Representation of Character, String and their Manipulation, Linear List Structure, Stack, Queue, Heaps, Linked list, Arrays. Tree: Representation of TreeStructures and Different Tree Traversal Algorithms, Graph, Sorting and Searching Algorithms. Python libraries for scientific computing.

Unit-3: Software Engineering

Software Engineering Definition; Requirement Analysis and Specification; Software Development: Phases, Process Models, Project Structure, Project Team Structure, Types of Metrics, Measurement, Software Quality Factors. Planning and Software Project : Requirement analysis, Cost Estimation, Project Scheduling, Quality Assurance Plan and Project Monitoring Plans, Gantt Charts, PERT and CPM, Coding Tools and Techniques, Testing Maintenance, CASE Tools, Object Oriented Analysis and Design, UML Modeling and Diagrams.

Unit-4: Networking & Operating System

Types of Networks, Network topology. Data Communication: Concepts of Data, Signal, Channel, Bandwidth, bit-rate and baud rate. Maximum Data-Rate of Channel; Analog and Digital Communications, Asynchronous and Synchronous transmission. ISO-OSI Reference Model, TCP/IP Reference Model – Data Link Layer Function and Protocols: Framing, Error Control, flow control; sliding window protocol, IP-v4 & IP-v6, Dual Stack. Internet standards and Services, Cryptography, Authentication and firewalls, Adhoc networks. Operating system – Process Management: Inter-Process Communication, Process Scheduling; Memory management: Swapping, Virtual Memory, Paging and Segmentation; Device Management: Deadlocks, Semaphores; File systems – Files, directories, Security and Protection Mechanisms: Basics of Unix/Linux/Windows Server Configuration.

Unit-5: Theoretical Foundation of Computer (Previously Compiler Construction)

Theory of Computation: Models of computation- Finite Automata, Pushdown Automata, Non-determinism and NFA, DPDA and PDAs and Languages accepted by these structures. Grammars, Languages, non-computability and Examples of non-computable problems. Context Free Gramars(CFG), Linear Bounded Automata(LBA), Turing Machine(TA).

Compilers – Regular Expression, Finite automata, Formal languages, Finite State Machines, Lexical Analysis, Semantic Analysis, Parsing Algorithms, Symbol tables, Error Handling, Types of Languages.

Unit-6: Data Base Management System

Definition and Features, Data Models, Relational Database: Logical and Physical Structure, Relational Algebra, Relational Calculus, Database Design, Normalization, Concurrency Control, Security and Integrity, Query Processing and Optimization, Backup and Recovery; Distributed Databases – Concepts, architecture, Design; Structured Query Language (SQL), Concepts and Principles of Data Warehousing, Data Warehousing Design and Schema, GIS Concepts and Principles, Big Data Concepts & Architecture, Data Mining Techniques.

Unit-7: Computer Graphics

Raster Scan and Random Scan Graphics; Continual Refresh and Storages Displays; Display Processors and Character Generators; Colour Display Techniques. Frame Buffer and Bit Operations, Raster graphics, Points, Lines and Curves, Scan Conversion; Line-Drawing

Algorithms; Circle and Ellipse Generation; Polygon Filling; Conic-Section Generation.Anti-Aliasing; Two-dimensional viewing; Basic Transformations; Co-ordinate systems; Windowing and Clipping; Segments; Interactive Picture-Construction Techniques; Interactive Input/Output Devices. Three Dimensional Concepts: 3-D Representations and Transformations; 3-D Viewing; Algorithm for 3-D Volumes, Spline Curves and Surfaces.

Unit-8: Artificial Intelligence and Soft Computing

Introduction to Artificial Intelligence (AI); Games, Theorem Proving, Natural Language Processing, Robotics, Expert System. Knowledge: General Concept of Knowledge, Knowledge Based System, Representation of Knowledge, Knowledge Organization and Manipulation, Acquisition of Knowledge, Ontologies. Symbolic Approach: Syntax and Semantics for Prepositional Logic (PL) and First Order Predicates Logic (FOPL), Properties of Well-Formed Formulas (wffs), Conversion to clausal form, Inference Rules, Resolution Principle, Non deductive inference methods. Search and Control Strategies: Blind Search, Breadth-first search, Depth – First search, Hill Climbing Method, Branch and Bound Search. Machine Learning: Concept of Learning, Supervised and Unsupervised Learning, Neural Networks, Deep Learning, Genetic Algorithms, Fuzzy Logic. Expert Systems: Introduction to Expert System, and its Characteristics, Application and Importance, Rule Based System Architecture; Software Agents.

Unit-9: Data Informatics

Frequency distribution, Measures of Central Tendency, Dispersion, Skewness and Kurtosis. Theory of Probability. Random variable and mathematical expectation. Correlation and Regression. Basic Principles of Design of Experiments. Analysis of Variance. Completely randomized design (CRD), Randomized complete block design (RCBD), Latin Square Design (LSD), Split Plot and Strip Plot Design. Probability Distributions: Binomial, Poisson, Normal Distributions and their Applications. Concept of sampling, Sampling vs. Complete Enumeration, Sampling from a Finite Population, Simple Random Sampling. Generation and Testing of Random Numbers, Simulation of Stochastic Events and processes, Discrete Event Simulation.

Basics of Bioinformatics, Basic Molecular Biology; Genome Analysis; Different Types and Classification of Genome Databases (HTGS, DNA, Protein, EST, STS, SNPs, Unigenes etc.) Role of Bioinformatics in Genomics; Nature of Genomic Data; Overview of Available

Genomic Resources on the Web; NCBI/ EBI/ EXPASY etc; Nucleic Acid Sequence Databases; GenBank/EMBL/ DDBJ; Database Search engines: Entrez, SRS. Overview/Concepts in Sequence Analysis; Pairwise Sequence Alignment Algorithms: Needleman & Wunsch, Smith & Waterman; BLAST, FASTA; Scoring matrices for Nucleic Acids and Proteins: PAM, BLOSUM, Dynamic Programming Algorithm, Multiple Sequence Alignment: PRAS, CLUSTALW. Sequence Based Gene Prediction and its Function Identification, Use of Various Derived Databases in Function Assignment, Use of SSR, SNPs and Various Markers for Identification of Genetic Traits, Gene Expression.

24. Dairy Chemistry

Eligibility: Ph.D. in Dairy Chemistry/Food Safety and Quality Assurance/Chemistry/Biochemistry.

Syllabus:

Unit-1: Physico-Chemical Aspects of Milk Constituents

Physico-chemical properties of milk and milk constituents and factors affecting them; Specific compositional differences among milk from various species; Variation in milk composition due to breed, feed, season, stage of lactation and mastitis; Acid-base equilibria, Oxidation-reduction potential, Density, Viscosity, Interfacial tension, Freezing point, Electrical Conductivity, Thermal Conductivity, Refractive index; Buffer capacity and buffer index; Colloidal and surface phenomena in milk; Adsorption at solid-liquid and liquid-liquid interphases; Gibb's equations; Interfacial tension, surface tension, surface active agents,general aspects of foaming, churning and whipping of cream; Emulsion and emulsion stability; Coalescence and dispersion; Nano emulsions and Nano micelles: Definition, criticalmicelle concentration, formation and stability; Colloidal stability of casein micelles in milk, zeta potential, size distribution of casein micelles and fat globules; Gels and their formation, structure and stability; Acid and rennet gels; Role of enzymes as biological catalyst; factors affecting the rate of enzyme reaction and thermal inactivation

Unit-2: Milk Carbohydrates, Minerals & Vitamins

Lactose: Occurrence, isomers, molecular structure; Physical and chemical properties of lactose: crystalline habits, lactose glass, specific rotation, equilibrium, solubility, density, sweetness and hydrolysis, pyrolysis; oxidation, reduction, degradation with strong bases, derivatives dehydration and fragmentation, browning reaction; Biosynthesis of lactose; Lactose intolerance; Oligosaccharides in milk: health significance. Major and minor minerals; Factors affecting variation in salt composition of milk; Distribution and importance of trace elements in milk; Physical equilibrium amongst milk salts; Effect of various treatments on salt equilibrium; Partitioning of salts and factors affecting them; Salt balance and its importance in the processing of milk; Protein-mineral interactions; Water soluble vitamins: Molecular structure, levels in milk and milk products; Factors affecting their levels; Biological significance; Relationship of ascorbic acid with redox potential (Eh) of milk and milk products.

Unit-3: Chemistry of Milk Lipids

Classification of milk lipids; Gross composition of milk lipids from different species: human, bovine, buffalo, sheep, goat, and camel; Milk fat globule membrane: Origin, composition, structure and physical chemistry; Fatty acid profile of milk lipids; factors affecting the profile of fatty acids. Biosynthesis of fatty acids, neutral lipids, phospholipids, sphingolipids and cholesterol. Unsaponifiable matter: Composition, chemistry, levels and physiological functions of sterols; Fat-soluble vitamins and carotenoids in milk; Properties of milk lipids: hydrolysis by alkali, water and enzymes; Hydrogenation, halogenation, transesterification, inter-esterification and fractionation; Milk fat crystallization and its polymorphism; Deterioration of milk fat; Autoxidation: Definition, theories, induction period, secondary products, factors affecting autoxidation, prevention and measurement. Thermal oxidation; Chemical and biological properties of heated and oxidized fats; Antioxidants: Definition, types, reaction mechanism and estimation. Lipolytic enzymes in milk of different species including human; Assay for lipase activity. Dietary and biological significance of milk lipids.

Unit-4: Chemistry of Milk Proteins

Milk proteins of different species and their variability; Distribution and fractionation of different nitrogen fractions of milk proteins; Nomenclature of milk proteins; Genetic polymorphism. Major milk proteins: caseins, methods of isolation, fractionation of casein and heterogeneity, physico-chemical properties; Casein micelle models; Whey proteins: Classes, distribution, methods of isolation and their physico-chemical properties; Minor milk proteins: Proteose-peptone, immunoglobulins, lactoferrin, and fat globule membrane proteins; Biosynthesis of milk proteins, milk fat globule membrane (MFGM) proteins; Amino acid composition, primary structure and structural properties of casein and whey proteins; Their structure-functional relationship; Physical, chemical and enzymatic modification of milk proteins and their functional characteristics; Bioactive mechanism and biological role of specific and non-specific antimicrobial proteins in milk; Milk protein derived bioactive peptides: properties, significance and application; Bitter peptides in cheese; Growth factors in milk; Nutritive and therapeutic aspects of milk proteins and peptides; Milk protein allergy: mechanism and method of their reduction in dairy products; Milk enzymes: lipases, proteases, phosphatases, catalase, peroxidase, xanthine oxidase, lysozyme, lactoperoxidase and galactosyltransferase, properties and significance.

Unit-5: Chemistry of Dairy Processing

Heat induced changes and interactions between protein, lipids, carbohydrates and minerals during processing of milk; Inactivation of indigenous milk enzymes during processing;

Physical changes in fat globules in un-homogenized and homogenized milk; Cold agglutination: mechanisms and role; Specific and non-specific enzymatic coagulation ofmilk; Heat-induced changes in milk constituents during preparation and storage of concentrated and dried milks; Age gelation: Mechanism and control; Effect of process variables on heat stability of evaporated milk; Biochemical changes during ripening of different varieties of cheese; Lactic acid fermentation in cheese and other fermented dairy products; Chemical defects in cheese; Storage stability of cream, butter and ghee; Physico- chemical properties of ghee; Role of different ingredients during processing and storage of ice cream/ frozen desserts; Concept of antifreeze protein/ice structuring protein in ice cream; HPP-induced changes in milk constituents; Chemistry involved in encapsulation of bioactive compounds, factors affecting their stability during processing; Fortification of milk with vitamins, minerals and nutraceuticals; Stability of high intensity sweeteners during processing of milk and milk products; Milk fat replacers.

Unit-6: Chemistry of Food Constituents

Forms of water in foods; Water-solute interactions, food stability in relation to water activity; Solute mobility; Property of ice crystals; Role of ice in the stability of food at sub-freezing temperatures; Carbohydrates: Starch- Types, functional properties, modification of starches for industrial applications, physico-chemical changes taking place during malting and processing; Oligosaccharides: Structure, properties, applications; Hydrocolloids: classes, properties and food applications; Interactions among hydrocolloids and proteins; Proteins: Classification, physico-chemical properties of food proteins from various sources; Structure- function relationship and their modifications; Denaturation of food proteins; Application of enzymes in food Industry; Immobilized enzymes; Browning reactions in foods; Lipids: Physico-chemical properties, their modifications; Composition of various types of edible oils/fats with special reference to their quality; Auto-oxidation of food lipids; Phytochemicals and role; Food Additives: Sweeteners, anticaking agents, antioxidants, humectants, preservatives, neutralizers, emulsifiers, texture modifiers, flavours, colours etc.

Unit-7: Chemical Quality Assurance and Management Tools

Concept of quality assurance and quality control in relation to dairy industry; Quality management systems - good manufacturing practices (GMP); HACCP certification; ISO 9001, ISO 22000, FSSC, Total quality management (TQM); Lean and Six sigma, Five–S, Kaizen, Kanban and other quality tools; Good laboratory practices (GLP); Laboratory accreditation; Role of international organizations: ISO, IDF, CAC, AOAC, WTO; Role of national organizations: BIS, FSSAI, Agmark, QCI, EIC, APEDA; Sampling of milk and milk

products; Food labeling guidelines; Detergents, sanitizers and disinfectants; Calibration of milk testing glassware; Preparation of standard reagents; Detection of adulterants in milk and milk products; Instrumentation in analysis of milk and milk products. Occurrence of pesticide residues, antibiotic residues, heavy metals etc. in dairy products and their testing methods; Laboratory auditing; Food traceability systems; Food recall and withdrawal.

Unit-8: Analytical Techniques in Dairy Chemistry

Principles and types (Paper and Column Chromatography, TLC, GLC, HPLC, gel- permeation, ion-exchange, affinity). HPLC: Theory, instrumentation and application in analysis of dairy foods. Electrophoresis: Isoelectric focusing and 2-D polyacrylamide gel electrophoresis; Capillary zone electrophoresis, Enzyme linked immune-sorbent assay, blotting techniques; Separation of bio-molecules using membranes; Centrifugation: principle, types and applications. Spectrophotometry: UV, visible, IR, fluorescence and flame photometry; Potentiometry: ion-selective electrodes; Dynamic light scattering/ particle size analyzer: Principles and applications; Atomic spectroscopy: AAS (Atomic Absorption Spectroscopy, Atomic Emission Spectroscopy, ICPS (Inductively coupled plasma spectroscopy); Differential scanning calorimetry; NMR (Nuclear Magnetic Resonance), FTIR (Fourier Transform Infrared); ELISA and lateral flow assay; X-ray crystallography; Mass spectroscopy; Protein sequencing; Circular dichroism spectroscopy.

25. Dairy Microbiology

Eligibility: Ph.D. in Dairy Microbiology/Food Safety & Quality Assurance/Microbiology.

Syllabus:

Unit-1: Microbial and Morphology

Principles of classification and taxonomy of bacteria and archaea: major taxonomy methods, phylogenetic tree, ultra structure of prokaryotic and eukaryotic cells, chemotaxis, bacterial motility; Endospore formation in bacillus, physiological microbial development, changes and genetic aspects of sporulation; Biotechnological application of endospores; Microbial diversity, bacterial classification, bacterial commUnities and diversity in natural eco-systems with special reference to lactic acid bacteria; Extremophiles: habitats and microorganisms, biochemistry and physiology of adaptation, biotechnology of extremophiles; Fungi: recent classification, importance of yeasts and molds in dairy foods; Virology: classification and nomenclature, characteristics of viruses, viral reproduction, viroid and prions.

Unit-2: Microbial Growth Characteristics

Bacterial growth: types, factors affecting growth, growth measurement, stress responses and their regulation; Mathematics and kinetics of bacterial growth, unrestricted versus nutrient-limitcd growth; Counting viable but non-culturable microbes, growth in natural environments and limitations; pH homeostasis, its significance in foods; Gut stress and heat shock response, nutritional stress and starvation stress response, starvation protecting proteins.

Unit-3: Microbial Metabolisms

Bacterial metabolism, metabolic pathways: alternate pathway of carbohydrate metabolism; Alternate pathways of glucose utilization; Gluconeogenesis; Regulation, glycogen synthesis; Tricarboxylic acid cycle, glyoxylate cycle; Utilization of sugars other than glucose, cellulose degradation; Metabolism of starch and glycogen; Energy generation and transport of metabolites; Substrate level and oxidative phosphorylation; Measurement of proton motive force (PMF); Electron transport systems; Anaerobic respiration; Conversion of PMF to energy; Types of ATPase pumps, generating ATP in alkalophiles; Energetics of chemolithotrophs; Metabolite transport; Sugar, amino acids, ion transports; New insight into respiration and fermentation mechanism in lactic acid bacteria; Specific transport systems.

Unit-4: Processing and Preservation of Dairy Foods

Basic principles of processing and preservation techniques: Bactofugation, thermal

processing, pulsed electric field,treatment, membrane filtration; Prevention of post-contamination; Identification of sources of contamination in heat-treated milks; Heat-induced damage and repair in bacterial cells; Bacteriological grading of raw and heat-treated milk; Microbiological spoilage of thermally processed milks; Naturally occurring preservative systems in milk; Preservation of milk and milk products by physical and chemical agents; Food grade b iopreservatives (GRAS); Enhancing antimicrobial potentials of lactic acid bacteria (LAB) by recombinant DNA technology and genetic engineering; Aflatoxins in milk, mode of action on microbes and biological consequences, advances in their detection.

Unit-5: Microbiology of Processed Dairy Products

Factors influencing the microbiological quality of traditional dairy products, fat-r i c h products, frozen d a i r y products, concentrated and dried milks and other processed dairy products; Microbial defects in processed dairy products; Microbiological safety in relation to potential pathogens, microbial toxins and their public health significance.

Unit-6: Starter Culture Technology

LAB as starters: Types of starter cultures and their classification; Conventional and molecular techniques for their identification; Concepts of starter growth, metabolism of lactose and citrate; Production of taste and aroma compounds by starters in fermented milks; Changes caused in milk by growth of starters; Modern trends in propagation, production and preservation of starter cultures; Judging of starter quality and activity; Starter defects; Starter failure; Role of starters in the preparationof fermented milk products; Therapeutic properties of fermented foods; Microbial defects in these products, safety and their prevention and control; Genetics and molecular biology of acid, flavour and therapeutic properties of LAB.

Unit-7: Microbiology of Fermented Milks & Cheeses

Microbiology of hard, semi-hard and soft varieties of cheese; Role of starter culture and non-starter lactic acid bacteria during preparation and ripening of cheese; Rennet and rennet substitutes; Nutritive and therapeutic properties of cheese; Microbiological changes during cheese ripening; Enzyme modified cheese, GMO cheese, functional cheeses; Accelerated ripening of cheese; Microbial defects in cheese, their prevention and control; Microbiological safety.

Unit-8: Industrial Microbial Fermentation

Fermentation: types and modes; Batch chemostat, turbidostat and fed batch culture systems; Upstream and downstream processing; Growth kinetics; Biomass production; Applications of biosensors in fermentation.

Unit-9: Microbial Quality Assurance & Microbial Food Safety

Microbiological aspects of quality control and quality assurance during manufacture of dairy products; Good Manufacturing Practices (GMP), Sanitary Standard Operating Procedures (SSOP); Total Quality Management (TQM) in dairy industry; Application of HACCP in dairy industry; ISO 9000-2000, ISO 9004-2000, ISO 9001-2000, HARPC, SAFE, FSMS, FSSC, PRP, OPRP Biosafety levels, sampling methods as per ICMSF, microbiological standards by CODEX, FSSAI, ICMSF; Risk assessment approaches; Conventional and current methods for detection of food pathogens; Application of immunological, PCR, Real time PCR, DNA probs , microarrays (biochips), biosensors; Conventional and rapid methods for detection of hygiene indicators: SPC, coliforms, *E. coli*, yeasts and molds, spore counts, dye reduction tests, d–count, petrifilm, ISO methods for detection of food pathogens, VIDAS, SPR, RT-PCR; Biosensors for rapid detection of hygienic indicators, pathogenic bacteria, antibiotics, pesticides, heavy metals, aflatoxin M1 residues; Antimicrobial resistance in dairy animals and public health concern: Global and national perspective of AMR in dairy sector.

Unit-10: Microbial Genetics

Nucleic Acids: Structure of DNA – A, B and Z and triplex DNA, function of DNA, RNA, DNA replication models; Protein-Nucleic acid i nteractions and helix-turn-helix (HTH) motif; Genetic Code DNA replication, gene expression, protein synthesis, PCR, real time PCR; Mutations: Spontaneous and Induced, types of mutations; Mutagenic agents (physical and chemical); Molecular basis of mutagenesis; DNA damage and repair: Molecular mechanisms, photoreactivation, excision repair, mismatch repair, post replication repair and SOS repair; Site directed mutagenesis; Directed evolution; Targeted genome editing and CRISPR/Cas9. Prokaryotic Transcription; Promoters- Constitutive and Inducible; Operators; regulatory elements; Initiation; Attenuation; Termination - Rho-dependent and independent; Transcriptional regulation-Positive and negative; Operon models, -Lac, Gal and Trp; Translation: Translation machinery and process, initiation, elongation, termination; Protein Synthesis, peptide bond formation and translocation; Regulation of prokaryotic translation.

Unit-11: Microbial Genetic Engineering

Plasmid: Structure and replication, types; Moveable genetic elements: Transposons, IS and Tn elements; Molecular mechanism of transposition; Recombination in bacteria: homologous and non-homologous, 'illegitimate' recombination and site-specific recombination; Transformation and competence factors; Transduction and conjugation; Structure of F plasmids, Hfr; Recombination methods as a tool for gene mapping; Genetic Engineering; rDNA;Restriction Enzymes: Types, mode of action and application as a tool for gene manipulation; Vectors: Cloning and expression vectors; Construction of genomic and cDNA library; Construction of full length cDNA; Microarray, gene silencing, gene knock out; Intracellular signalling in microorganisms: cell-cell communication (quorum sensing); Signal transduction mechanism or pathways; Pyrosequencing, Illumina, Ion torrent, Nanopore sequencing technologies for whole genome and metagenome sequencing.

Unit-12: Functional Dairy Products and Probiotics

Probiotics: Characteristics f or selection; Stability during storage and gastrointestinal trnsit; Probiotic mode of action and disease control; Prebiotics, synbiotic and postbiotics; Scientific assessment of probiotics/functional foods: Regulations and future prospects; Functional dairy and plant based fermented food products; Microbial production of bioactive compounds.

26. Dairy Technology

Eligibility: Ph.D. in Dairy Technology/Dairy Engineering/Food Science and Technology/Food Technology/Livestock Products Technology.

Syllabus:

Unit-1: Milk and Milk Products

Current status of dairy industry in India; Manufacture, packaging, storage, defects, sensory evaluation and quality analyses of liquid milk products, traditional Indian dairy products, cheeses, fermented milks, fat rich dairy products, ice cream and frozen desserts, by-products of the dairy processing operations, condensed and dried milk products.

Unit-2: Advanced Dairy & Food Processing

UHT processed milk products: properties and prospects, equipment, heat stability and deposit formation, effect on milk quality; Principles and equipment for bactofugation and bacto- therm processes; Partial/High Pressure Homogenization and its application in dairy industry; Microfluidization of milk; Concentration processes and their impact on quality of finished products; Advances in drying of milk and milk products; Freeze drying: physico-chemical changes and industrial developments; Hurdle technology and its application in development of shelf-stable products; Use of carbonation in extending the shelf life of dairy products; Advances in bakery processing: Application of dairy ingredients in bakery and confectionary products; Technological aspects and issues in fermented foods and beverages; Extrusion processing of food and dairy products; Advances in cleaning and sanitization of dairy equipment: Bio-films; Bio-detergents; Innovations in sanitizers: chemical, biological, radiation; Assessing the effectiveness of cleaning and sanitization of dairy equipment.

Unit-3: Alternate Processes For Dairy and Food Industry

Non-thermal processing technologies for food: Irradiation, High frequency heating, Infra-red (IR) heating, Ohmic heating, Ultrasonic treatment, High hydrostatic pressure processing, Pulsed electric field processing; Their principles, effect on food constituents and salient applications in food sector/industry; Enzymes in dairy and food processing; Newer concepts in food processing including organic foods; Processing of organic raw material; Genetically modified foods; Space foods; Nutrigenomics, metabolomics and other Omics concepts in dairy and food processing.

Unit-4: Rheology And Structure of Dairy and Food Products

Rheological classification and characterization of dairy foods: Shear-rate and timedependence of the flow-curve; Factors affecting flow behaviour; Viscosity of food dispersions: dilute and semi-dilute systems, concentration effects; Dynamic measurement of viscoelasticity; Instrumental measurements: Empirical and fundamental methods; Viscometers: Types and working; Rheometer: principles and operational features; LargeDeformations and failure in foods: Texture Profile Analysis; Microstructure of dairy products; Tribology and its applications. Food emulsions; Emulsifiers and their functions in foods; Dairy based foams and their applications, Structure of dairy based emulsions, foams and gels; Blends of stabilizers and emulsifiers.

Unit-5: Biotechnology for Dairy Applications

Development and impact of biotechnology on dairy and food industry; Principles of recombinant DNA technique; Preparation and applications of microbial rennet, recombinant chymosin; Exogenous free and microencapsulated enzymes, immobilized enzymes; Production, bio-functional properties and applications of protein hydrolysates; Enzymatic hydrolysis of lactose for preparation of whey and UF-permeate beverages; Bio-preservatives: characteristics and their applications in dairy and food industry.

Unit-6: Membrane Processing for Dairy Applications

Membrane techniques; Classification and characteristics of filtration processes; Types of commercially available membranes; Membrane hardware, design of membrane plants, modelling of ultrafiltration (UF) processes; Membrane fouling-problems and mitigation strategies; Cleaning and sanitization of different types of membranes; Applications of ultrafiltration (UF), reverse osmosis, nano-filtration and microfiltration in the dairy industry; Application of membrane processing techniques for the manufacture of lactose, low lactose milk powder, dairy whiteners, WPC, WPI, MPC, MPI, native micellar casein powder, etc.; Properties and utilization of WPC, WPI, Milk Protein Concentrate (MPC) and Milk Protein Isolate (MPI); Application of membrane processing on quality of traditional dairy products, fermented milks and cheese.

Unit-7: Dairy and Food Packaging

Trends in packaging industry; Testing of packaging materials; Adhesives; Graphics; Coding (Barcode and Quick Response code) and labeling used in food packaging; Protective packaging of foods; Effect of light, oxygen and moisture on packaged food; Packaging of dairy and food products; Modified atmosphere packaging; Shrink and stretch packaging; Self-heating and self-cooling cans; Retort pouch technology; Microwavable, biodegradable,

and edible packages; Principles and applications of Active, Smart, Intelligent and Antimicrobial packaging; Industrial packaging: Unitizing, palletizing, containerizing, distribution systems for packaged foods; Safety aspects of packaging materials; Sources of toxic materials and migration of toxins into food materials; Interaction of food flavours with packaging.

Unit-8: Functional Foods, Nutraceuticals, Novel Dairy Ingredients

Milk nutraceuticals and functional foods: Trends, market, classes, mechanisms of action and applications; Milk fortification; Developments in Infant formula and complementary foods; Geriatric Foods, Sports foods; Dairy foods for metabolic disorders; Reduced calorie foods, Low sodium and low lactose foods: Herbs and phytochemicals for fusion health foods; Bioactive ingredients from milk; Probiotic, prebiotic and synbiotic foods.

Unit-9: Advances in Technology of Lipids, Proteins andCarbohydrates

Current industrial trends in fats and oils, proteins and carbohydrates: their sources from animal, plant and microbial origin; Structural aspects and physico-chemical properties in relation to food processing; Processing techniques; Properties and applications; Significance in nutrition, therapeutics and health; Functional properties and applications of fats, oils, carbohydrates and proteins in processed foods; Effects of processing on structure and properties; Physical, chemical and enzymatic modifications of fats, starch and proteins; Inter-molecular interactions during food processing operations.

Unit-10: Process Control for Product Monitoring

Product-Process Monitoring in dairy and food industries; Quality-prediction model based on quality kinetics and process state equations, simulation modelling; Process/Product Optimization: optimization procedures; Process Control: objectives, control loop, loop elements and their functions, modes thereof; Techniques and equipment; Real-time instrumentation: sensors, biosensors, time-temperature indicators (TTI), E-Nose and E-Tongue, Advanced analytical techniques Gas Chromatography-Olfactometry; GC-MS, LC-MS, NMR, FTIR; Principles and applications of Differential Thermal Analysis, Differential Scanning Calorimetry, X-ray crystallography, circular dichroismspectroscopy, dynamic light scattering, laser diffraction, image analysis, Nuclear Magnetic Resonance; Principles and applications emerging spectroscopic techniques for evaluation of foods: Automated milk analyzers; Colour Characterization: Principles and applications of colour and appearance through instrumentation.

Unit-11: R&D Management in Dairy and Food Industry

Global scenario of R&D efforts in dairy processing; Determinants of Consumer Preferences; Competitive positioning and value chain configuration in global market; Structure and design of R&D organization, Analysis of organization behavior: Transactional analysis; Personnel management: Typology analysis, individual and the organization, team building, human behaviour at work, motivation; Skill requirements of an R&D manager; New product development: strategies, models and life cycle analysis; Food innovation dynamics; Criterion for selection of R&D projects; Technology development process; Techniques for monitoring R&D functions; Intellectual property rights: Indian Patenting Act, International patenting laws; Technology commercialization; Quality management systems.

27. Economic Botany & Plant Genetic Resources

Eligibility: Ph.D. in Plant Genetic Resources / Genetics and Plant Breeding/ Plant Breeding & Genetics/ Seed Science & Technology / Genetics / Plant Breeding/ Economic Botany/ Agricultural Botany/ Botany.

Syllabus:

Unit-1: Plant Taxonomy and Biosystematics

Taxonomy of cultivated plants: use of taxonomic literature, concept and methods of herbarium and field study, criteria used for classification, identification of plants of economically important families. Classical and modern evidencesinplanttaxonomy, molecularsystematics; global taxonomic initiatives: barcoding, taxonomic databases. Crop Systematics: systems of classification; concepts of species and taxa; Classical and modern species concepts; Differentiation and evolution of species; Domesticated species, wild-cultivated continuum.

Unit-2: Economic Botany and Crop Diversification

Introduction to economic botany; Origin, history, domestication, botany, classification, reproductive systems, genetic resources management and cultivationof various crop plants; Structure, development and chemical constituents of plant parts; Economic uses and commercial importance of potential crops, biofortified crops; revival of lesser-known crops; processing and use of crop residues. Social and religious significance of plants in environmental amelioration. Case studies of economic gains due to use of lesser-known crops/ genes in history of agriculture.

Unit-3: Economic Botany of Field Crops

Origin, history, domestication, botany, genetic resource management and cultivation of Cereals, millets, pseudo cereals, major and minor pulses, oilseeds, fiber crops, sugar yielders, fodders and green manure crops.

Unit-4: Economic Botany of Horticultural Crops

Origin, history, domestication, botany, genetic resource management and cultivation ofimportantplants in horticulture including vegetablecrops, fruits and nuts,floricultural plants, medicinal and aromatic plantsspices and condiments, beverages, fumitory and masticatory plants, rubber yielding plants, cellulose and starch yielding plants, insecticidal and herbicidal plants; Important taxa in agro-forestry and multipurpose trees/shrubs, flavoring agents, dye-, tannin-, gum- and resin- yielding plants, narcotics; non-traditional economic plants.

Unit-5: Biodiversity and Plant Genetic Resources

Biodiversity an overview: genetic, species and ecosystem diversity, species richness and endemism; centers of crop plant origin, Indian gene center; plant domestication and evolution of crop plants, crop wild relatives, concept of gene pool; Agrobiodiversity: Origin and history of agriculture, impact of climate change; Managing plant genetic resources: basic science issues and institutional aspects of managing agrobiodiversity; Traditional Knowledge Digital Library (TKDL), Farmers' seed systems; Valuing Plant Genetic Resources and ecosystem services; commUnity biodiversity management. Basic elements of plant ecology, commUnity ecology; ecosystems, conservation ecology, biogeography and evolution; Biodiversity functioning and conservation, habitat fragmentation; Biodiversity resources and their harvesting; pollution and over-exploitation. Concepts in Conservation Genetics: Genetic versus demographic and environmental factors; genetically viable populations, reproductive fitness; Legal issues related to endangered species and their protection.

Unit-6: Germplasm Augmentation

Principles and methods of exploration and collecting, phyto-geographical regions/ecological zones and associated diversity; Geo-Spatial analysis for mapping eco-geographic distribution of diversity, remote sensing,useofdrones; population, gene pool and gene pool sampling inself-and cross-pollinated and vegetatively propagated species; sampling strategies and surveys; Ethnobotanical aspects of PGR; collecting crop wild relatives; Post-exploration handling of germplasm.Genetic principles, indicators and analyses of diversity; identification of gaps in collection; genetic erosion; eco-geographic surveys; legal aspects and the FAO code of conduct; Traditional knowledge systems, taxonomic databases and documentation systems. Plant introduction: History, principles, objectives and importance of plant introduction, pre-requisite and conventions for exchange of PGR, national and international legislations and policies.

Unit-7: Germplasm Conservation

Principles and methods of in-situ and ex-situ conservation; concept of base, active and working collections; Importance of seed gene banks; richness index, status of global seed gene banks.Seed genebanking: seed structure, function, storage behavior, desiccation anddormancy;theories of ageing, principle and testing proceduresof viability and vigor;Genebank standards, International Seed Testing Association (ISTA), Association of Official Seed Analysts (AOSA)guidelines; monitoring viability; strategies for revival and rescue of rare genetic material. Principles and practices of germplasm regeneration and maintenance. In vitroand cryo genebanking: In vitro techniques in PGR management, virus elimination, somaclonal variation; Concept of active and base in vitrogenebank. Principles andtechniquesof cryopreservation; Management of in vitroand cryo genebank and monitoring genetic stability.

Unit-8: Insitu and On-farm Conservation

Complementary strategies for conservation, scientific basis of in situ on farm conservation; In situ conservation of wild species in nature reserves, In situ conservation of crop diversity on-farm. Designation, management and monitoring of genc management zones (GMZs)/ gene sanctuaries; National action plan for agrobiodiversity; Delhi Declaration on Agrobiodiversity. Social, cultural and economic context of on farm conservation; natural vs farmer-managed; farmers'variety choice; genetic structure of land races; CommUnity seed gene banks, value of local crop diversity to farmers and markets; Seed systems: formal vs. informal. Institutional frameworks for the implementation of on farm conservation, identification of target crops, site selection, commUnity sensitization; I ncreasing crop genetic diversity's competitiveness for farmers.

Unit-9: Biotechnology and Genomics in PGR Management

Principles and techniquesof plant tissue culture, in vitro techniques in collecting and exchange of germplasm; genetic stability. Genomics: molecular markers and their applications in analysis of genetic diversity; DNA Fingerprinting and cultivar identification; concepts of DNA barcoding and species delineation; DNA sequencing, genotyping by sequencing (GBS), genome wide association study (GWAS), genomicselectioningermplasm collections; statistical analysis of genomic data.

Unit-10: Plant Biosecurity and Plant Quarantine

Concepts and components of biosecurity, Quarantine, Invasive Alien Species, bio warfare, emergence/ resurgence of insects, pests and disease; national regulatory mechanism andinternational agreements, phytosanitary measures, pest risk analysis, early warning and fore castingsystem; strategies for combating risks and costs associated with agro-terrorism event; integratedapproach for biosecurity. Principles, objectives, techniques and relevance of plant quarantine, regulations and plant quarantine setup in India; economic significance of seed-borne pests; post-entry quarantine, domestic quarantine, salvaging techniques, seed certification,international linkages in plant quarantine; Concepts of biosafety, risk analysis and monitoringstrategies; consequences of genetically modified crops on the environment; Genome Editing;Treatiesand multilateral agreements governing trans boundary movement GMOs, Indian regulatory system for biosafety.

Unit-11: Germplasm Characterization, Maintenance and Regeneration

Cropdescriptors and germplasm characterization procedures; Measuring diversity using agro-morphological data, biochemical data and DNA marker data; statistical procedures to measure population genetic variation; Principles and methods for formulating core and mini core collections and the irvalidation. Principles and practices of germplasm regeneration and maintenance; concept

of genetic integrity, genetic shift, genetic drift and optimum environment; post-harvest handling of germplasm; maintenance of wild relatives of crop plants. Statistical techniques in management of germplasm; Plant genetic resources informatics: national and international conventions influencing access to PGR information; Indian and Global PGR databases and portals.

Unit-12: Germplasm Evaluation and Genetic Enhancement for PGR Utilization

Principles and practices of germplasm evaluation for specific traits; biotic and abiotic stress tolerance, quality, nutritional traits; high throughput phenotyping systems; Advanced methodology of germplasm evaluation and predictive methods for identification of useful germplasm,Experimental designs, analyses of evaluation data; reference collections; germplasm registration; application of genomics in identification of desirable traits, QTLs, genes and alleles. Genetic enhancement: Concepts of gene pools; pre-breeding; handling and maintenance of crop wild relatives; In congruity and its management, testing and improving the adaptability of wide cross derivatives.

Unit-13: PGR Policy and Regulatory Mechanisms

Concep to fintellectual property and IPRs, conflict between commUnity rights and private rights; Plant breeder's right sand farmer'srights; UPOV and PPV & FRA; registration of plant varieties and essentially derived varieties. International instruments concerning agro-biodiversity, Agenda21, Conventionon Biological Diversity (CBD), Global Plan of Action (GPA), Nagoya protocol; National legislations related to biodiversity conservation, National Biodiversity Authority (NBA); FAO and global system of PGR, the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA); digital sequence information vs. tangible genetic resources. Agreement on Agriculture (AOA); agreement on application of sanitary and phytosanitary measures (SPSAgreement), international plant protection convention, agreement on technical barriers to trade (TBT).

Unit-14: Principles of Genetics and Plant Breeding for PGR Management

Principles of genetics for managing plant genetic resources; Genetic structure of populations: Hardy-Weinberg principle; Quantitative genetics; mapping quantitative trait loci; Linkage disequilibrium and association analysis. Molecular population genetics, the neutral theory of molecular evolution; Evolutionof multigene families, phylogeography, analysis of molecular variance (AMOVA). Principles of plant breedingfor managing plant genetic resources; Concept of plant ideotype; Participatory plant breeding; Molecular breeding, mapping populations, markers assisted selection; Marker assisted pre-breeding programs.

28. Electronics and Instrumentation

Eligibility : PhD degree in Electronics Engineering/Electronics and Telecommunication Engineering/Electrical and Electronics Engineering/Electronics and Instrumentation Engineering/Instrumentation Engineering.

Syllabus:

Unit-1: Transducers and Applications

Introduction to Measurement Systems: General concepts and terminology, measurement systems, sensor classification, static characteristics of measurement systems-accuracy, linearity, resolution, precision and sensitivity etc. estimation of errors. Dynamic characteristics of measurement systems. Zero-order first-order and second-order measurement systems and response. Measuring Devices: Displacement: Resistive Potentiometer, Resistive strain gauges inductive displacement transducer, Capacitive Displacement Transducers, Piezo Electric Transducers, Ultrasonic Methods. Temperature: Thermal expansion methods, Thermo electric, radiation methods-thermal and photon detectors based thermometers. Pressure: Methods of pressure measurement: Dead weight gauges and manometers, elastic transducers, high pressure measurement. Flow: Anemometers, velocity sensors obstruction meters, averaging Pitot tubes, Rota meters, Electromagnetic, Vortex shedding, Ultrasonic Flow meters. Velocity and Acceleration: Seismic displacement, velocity and acceleration pickups (Accelerometers). Gyroscopic angular displacement and velocity sensors. Force and Torque: Methods of force measurement and characteristics, Bonded strain gauge, Variable Reluctance, Piezo Electric Transducer, Torque measuring on rotating shafts. Humidity, Density and Radiation Measurement: Capacitive Impedance and Piezoelectric Hygrometers. Differential Pressure, U-tube and ultrasonic Densitometers and pH measurement: Ion Selective Type. Radiation Fundamentals - Radiation Detectors - Radiation Thermometers and Optical Pyrometers. Digital Sensors: Position encodes, variable frequency sensors-quartz digital thermometer, SAW sensors, digital flow meters, sensors based on semiconductor junctions: thermometers based on semiconductor junctions, magneto diodes and magneto transistors, photodiodes and phototransistors, charge-coupled sensors.

Unit-2: Signal Conditioning Circuits

Bridges: The Wheat Stone Bridge – Single Variable Element, Two Single Variable Element & Four Single Variable Element, Excitation, Readout – bridge amplifier, instrumentation

Amplifier, minimize common mode voltage, Isolator, Chopper Amplifier Interference: Local Problems, Subsystems Problems – grounding mechanisms, Outside & Local Interface – guard circuit, Analog Filtering – Design of 1st order & 2nd order filters, Operational Amplifiers, Instrumentation Amplifiers, Isolation Amplifiers, Systcm Solutions Offsetting & Linearizing: Offsetting – use of bridge in offsetting, 4 – to – 20 mA Current Transmission – typical 4 – 20 mA Transmission, isolated 4 – 20 mA Transmission, basic 0 to 10V to 4 to 20mA Translation circuit, Non Linearity & Linearizing – Digital Linearizing & Analog Linearizing Thermoswitches & Thermocouples Interfacing: Thermo switches, Ambient Referenced Thermocouples, Isolated Thermocouple Measurement, Thermocouple to Frequency, Thermocouple to 4 – to – 20 m A Temperature Transmitter, Isolated Multiplexing of Thermocouples RTD's Interfacing: Single Op – Amp Interface, using a Signal Conditioner, Bridge configuration using 3 – wire RTD, Linearizing RTD Circuits, Current Transmitters for RTD Outputs, RTD Based Precision controllcr Thermistor Interfacing: Simple Interface Circuits, High – Resolution Differential Thermometer, Current Transmitters, Thermistor to Frequency Conversion Semiconductor Temperature Transducers Interfacing: T – to – F Conversion using Diodes, Absolute Temperature – to – current Conversion, Temperature Control Circuits, Multiplexed Applications, Isolation, 4 – to – 20 m A Current Transmission Pressure Transducer Interfacing: Strain Gauge Based Transducers, Potentiometer to Frequency Transducer, Interfacing High level Semiconductor Transducers, Isolated Pressure Transmitter, Pressure Control System. Force Transducer Interfacing: Spring Driven Rheostat, Strain – gauge & Signal Conditioner, High Resolution Load Cell Platform Interface, Strain Gauge to Frequency Conversion, Isolators & Transmitters Flow Meter Interfacing: Differential Pressure Flow meters, Frequency output Flowmeters, Anemometers, Hinged Vane Flowmeter, Thermal Flow Meter, Transmission & Readout Level Transducers Interfacing: Float & Potentiometer, Optical Sensing & Thermal Sensing Miscellaneous Applications: 4 – to – 20 m A Transmission, Topics on Filtering, Programmable – Gain Isolator, High – Performance Floating Data Amplifier, Isolated All – Electronic Multiplexing, Pulsed – Mode Bridge Excitation

Unit-3: Process Control Instrumentation

Introduction: Incentives for process control, Design aspects of process control system, Process degree of freedom. Mathematical model of first order processes: level, pressure and thermal processes – Second order process: Interacting and non-interacting processes, – Time and frequency response analysis. Basic Single Loop Control Actions: Characteristics and

dynamics of Discrete Control Modes: ON-OFF, Multi Speed, Floating Controllers. Characteristics and dynamics of feedback control modes: Proportional, Integral and Derivative control modes – P+I, P+D and P+I+D control modes. P-I-D Controller Tuning and Stability Analysis: Tuning of Controllers: Evaluation criteria – IAE, ISE, ITAE, Tunings – Process reaction curve method – Ziegler Nichols method – Damped oscillation method. Design of Lead, Lag compensators, stability analysis MIMO Systems –Multi-loop Control: MIMO Systems: Dynamics of Distillation column and Heat exchangers processes, Multi loop Controllers: Feed-forward control – ratio control-cascade control – adaptive – split-range control – multivariable control – examples from distillation column and boiler systems. Modern control practices in: Power plants, pharmaceuticals and petrochemicals industries. Final Control Element: I/P converter – pneumatic and electric actuators – valve positioner – control valves –characteristics of control valves – inherent and installed characteristics – control valve sizing – cavitation and flashing – selection criteria.

Unit-4: Data Acquisition Systems

Data Loggers and Data Acquisition Systems: Data acquisition systems-configurations components, analog multiplexcs and sample and hold circuits-specifications and design considerations. DACs: specifications – characteristics, types of DACs (serial, parallel, direct and indirect). Hybrid and monolithic DACs. ADCs: specifications – characteristics, types of ADCs (serial, parallel, direct and indirect). Hybrid and monolithic ADCs. sigma – delta ADCs', Hybrid DAS – Schematic diagram – configurations – specifications. Error Budget of DACs and ADCs: Error sources, error reduction and noise reduction techniques in DAS.Error budget analysis of DAS. Case study of a DAC and an ADC. Data AcquisitionHardware and Software: Specifications of Hardware-IO analog signal range, gain for analog input and resolution in ADC converter, resolute\ion in DAC and counter chips, sampling frequency and maximum update rates, triggering capacity. Digital lines and ports, data acquisition VIs. Distributed AND Stand Alone Data Loggers: Introduction, methods of operation-programming and logging data using PCMCIA cards, standard alone operation- direct and remote connection to the host PC, standalone logger/controller hardware interface-RS232C, RS485 standard, communication bottlenecks and system performance, usingEthernet to connect data loggers. IEEE 488 Standard: Introduction, characteristics, physical connection configurations, device types, bus structure, GPIB hand shake, device communication, IEEE 488.2, standard commands for programmable instruments. Display

Systems: LCD Flat panel displays, Digital storage CROs, Plasma displays, Projection systems. Analyzers – Spectrum Analyzers – guidelines, various triggering techniques, different types of spectrum analyzers, Recorders. Display devices and Display systems, LogicAnalyzers – State and time referenced data capture. Scalar and Vector Nctwork analyzers.

Unit-5: Virtual Instrumentation

Virtual Instrumentation: Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming. VI Programming Techniques: VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web. VI Chassis Requirements: Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. VISA and IVI. Application of Virtual Instrumentation: Instrument Control, Signal Measurement and generation: Data Acquisition. Advanced LabVIEW Data Concepts: Advanced file I/O, Configuring INI files, Calling code from other languages, Fitting Square Pegs into round holes: Advanced. Connectivity in Lab VIEW: Lab VIEW web server, E-mailing data from Lab VIEW, Remote Panels, Self-describing data, shared variables, talking to other programs and objects, talking to other computers, database, report generation. Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control.

Unit-6: Analytical Instrumentation

Electrochemical Instruments: Basic concepts of Analytical instrumentation, Electro chemical instruments- pH meter, Conductivity meter, Dissolved oxygen analyzers using Polarographic principle – sodium analyzer- silica analyzers– Polarographic Instruments. Absorption Spectrophotometers: UV, VIS spectrophotometers – single beam and double beaminstruments – instrumentation associated with the above spectrophotometers – sources and detectors. IR SPM– sources and detectors for IR spectrophotometers, FTIR, Raman Spectroscopy, Interpretation & Analysis. Emission Spectrophotometers: Flame emission and atomic absorption spectrophotometer – Atomic emission spectrophotometer – sources for Flame Photometers and online calorific value measurements. Gas and LiquidChromatographs: Basic principle of gas chromatography, liquid chromatography, HPLC

different types of columns, detectors, recorders and associated equipment, Salient features of liquid chromatography, Detectors used, applications of high pressure liquid chromatography, Interpretation and- Analysis. Principle of Nuclear Magnetic Resonance: Instrumentation associated with NMR spectrophotometer – Introduction to mass spectrophotometers, Principle and brief discussion on electron spin resonance (ESR). Gas Analyzers: Flue gas analysis using thermal conductivity principle, Katharometer – oxygen analyzers using paramagnetic principle, Zirconium oxide cells, Pollution Monitoring Instruments. Industrial analyzer circuits; CO monitors – Nox analyzer – Sox Analyzer - H2S analyzer systemNuclear Radiation Detectors: GM counter, Scintillation counter, Ionization chamber – Solid state detector, Gamma Spectrometry, Industrial application of radiation measurement. Thermal Analyzers: Differential Scanning Calorimetry (DSC), Derivative Thermo Gravimetric Analyzers (DTGA).

Unit-7: Real Time and Embedded Systems

Introduction: Embedded systems overview, design challenge, processor technology, IC technology, Design Technology, Trade-offs. Single purpose processors RT-levelcombinational logic, sequential logic (RT-level), custom single purpose processor design (RT-level), optimizing custom single purpose processors. General Purpose Processors and Communication Interface: Basic architecture, operation, Pipelining, Programmer's view, development environment, Application Specific Instruction-Set Processors (ASIPs) – Micro Controllers and Digital Signal Processors. Need for communication interfaces, RS232 /UART, RS422 / RS485, USB, Infrared, IEEE 1394 Firewire, Ethernet, IEEE 802.11, Blue tooth. Introduction to RTOS and Basic Design: Architecture of the Kernel, Tasks and Task scheduler, Interrupt service routines, Semaphores, Mutex, Mailboxes, Message Queues, Event Registers, Pipes, Signals Principles, Semaphores and Queues, Hard real time scheduling considerations, Saving memory and power an example RTOS like µC – OS (Open Source) Embedded S/W Development tools. Real Time Operating Systems: Timers, Memory Management, Priority inversion problem, Embedded operating systems Embedded Linux, Real-time operating systems, RT Linux, Handheld operating systems, Windows CE. Design Technology: Introduction, Automation, Synthesis, Parallel evolution of compilation and synthesis, Logic Synthesis, RT synthesis, Behavioral Synthesis, Systems Synthesis and Hardware/ Software Co-Design, Verification, Hardware/Software co-simulation, Reuse of intellectual property codes.

Unit-8: Digital Image Processing

Introduction: Fundamentals steps of Image processing, Components of an Image processing system, Image sampling and quantization, relationship between the pixels. Gray level transformation, Smoothing and sharpening spatial filters, Smoothing and sharpening frequency domain filters, Homo morphic filtering. Image Transforms: 2-Dimensional Orthogonal and Unitary Transforms-1-Dimensional DFT-2-Dimensional DFT- Cosine Transform- The Sine Transform- The Hadamard Transform- The Haar Transform- The Slant Transform –The KL Transform- The Singular Value Decomposition Transform.

Image Enhancement: Basic Gray Level Transformations-Image Negatives, Log transformations, Power-law Transformations, Piecewise-Linear Transformation Functions-Histogram Processing-Histogram equalization, Histogram matching, local Enhancement, Use of Histogram Statistics for Image Enhancement-Enhancement using Arithmetic/Logic Operations-Image Subtraction, Image Averaging. Image Segmentation: Edge linking and boundary detection, Thresholding- Global and Adaptive, Region based segmentation, Segmentation by morphological watersheds, color segmentation. Colour Image Processing: Colour Fundamentals- Colour Models- Pseudocolour Image Processing- Basics of Full- Colour Image Processing – Colour Transformations- Smoothing and Sharpening – Colour Segmentation – Noise in Colour Images – Colour Image Compression Morphological Operations: Dilation and erosion, Opening and closing, Hit or Miss transforms, Morphological algorithms, Extensions to gray scales images and its applications. Image compression: Compression models, Error free coding, lossy coding, compression standards, color image compression, Introduction to fractals.

Image Representation and Description: Representation-Chain codes, Polygonal Approximations, Signatures, Boundary Segments, Skeletons- Boundary Descriptors- simple descriptors, shape numbers, Fourier Descriptors, statistical moments -Regional Descriptors-simple descriptors, topological descriptors, texture, moments of two- dimensional functions. Image Degradation/Restoration: Unconstrained and Constrained Restoration- Restoration in the presence of Noise Only-Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Estimating the degradation Function-Estimation by Image Observation, Estimation by Experimentation, Estimation by Modeling- Inverse Filtering- Minimum Mean Square Error (Wiener) Filtering- Constrained Least Squares Filtering – Geometric Mean Filter - Geometric Transformations-Spatial transformations, Gray-level Interpolation.

Unit-9: PLC, SCADA Programming and their Applications

Programmable Logic Controller (PLC) Basics: Definition, Overview of PLC systems, input/output modules, Power supplies and Isolators. Basic PLC programming: Programming On-Off inputs/ outputs. Creating Ladder diagrams, Basic PLC functions, PLC Basic Functions, register basics. PLC Intermediate and Advanced Functions: Arithmetic functions, Number comparison functions, Skip and MCR functions, data move systems. Utilizing digital bits, sequencer functions, Matrix functions. PLC Advanced Functions: Analog PLC operation, Networking of PLC, Applications of PLC: Controlling of Robot using PLC, PID control of continuous processes etc. HART and Field Bus: Introduction –Evolution of signal standard – HART Communication Protocol – Communication Modes – HART (Highway Addressable Remote Transducers) modes-Control system interface HART commands – HART Field Controller – Field Bus Architecture Basic requirement of field bus standard fieldbus topology, CAN bus. SCADA: Basic building blocks of computer control system – SCADA – MTU and RTU, Case studies On SCADA.

Unit-10: Roboti Design and Control

Robot Fundamentals: Definitions, History of robots, present and future trends in robotics, Robot classifications, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Issues in design and controlling robots Repeatability, Control resolution,spatial resolution, Precision, Accuracy, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Applications of robots. Drives used in robots- Hydraulic, Pneumatic and Electric drives, Comparison of drive systems and their relative merits and demerits. Manipulator Kinematics: Matrix Algebra, Inverse of matrices, rotational groups, matrix representations of coordinate transformation, transformation about reference frame and moving frame Forward & Inverse Kinematics examples of 2R, 3R & 3P manipulators, Specifying position and orientation of rigid bodies Euler's angle and fixed rotation for specifying position and orientation Homogeneous coordinate transformation and examples D-H representation of kinematics linkages Forward kinematics of 6R manipulators using D-H representations Inverse kinematics of 6R manipulators using D-H representations, Inverse Kinematics geometric and algebraic methods.

Robotics Dynamics: Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton –Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation,

computational consideration. Trajectory Planning: Introduction, general considerations in path description and generation, joint space schemes, Cartesian space schemes, path generation in runtime, planning path using dynamic model point to point and continuous trajectory, 4-3-4 & trapezoidal velocity strategy for robots. Robot Sensors: Internal and external sensors, position-potentiometric, optical sensors, encoders - absolute,incremental,touch and slip sensors velocity and acceleration sensors, proximity sensors, force& torque sensors, laser range finder, camera. Micro-controllers, DSP, centralized controllers, real time operating systems. Robot Controllers: Essential Components-Drive for Hydraulic and Pneumatic actuators, H-bridge drives for Dc Motor Overload over current and stall detection methods, example of a micro-controller/ microprocessor based- robot Controller. Micro-robotics and MEMS (Microelectro mechanical systems), fabrication technology for Micro-robotics, stability issue in legged robots, under-actuated manipulators. Robot Vision: Introduction, Image acquisition, Illumination Techniques, Image conversion, Cameras, sensors, Camera and system interface, Frame buffers and Grabbers, Image processing, low level & high level machine vision systems.

Unit-11: Speech Processing

Introduction to speech processing - its necessity. Digital models for speech signals: process of speech production, acoustic theory of speech production, and models of speech production, auditory knowledge. Digital representation of speech waveform: sampling speech signals, quantization, delta modulation, differential PCM, code conversion, other new methods of coding. Fundamentals of speech analysis: background of speech processing tools, spectrographic analysis, short time analysis, time frequency analysis, homomorphic analysis. Linear predictive coding of speech: basic principles, solutions of LPC equations, prediction error, application of LPC parameters. Fundamentals of speech recognition: current state of speech recognition systems, techniques and problems for noisy speech recognition, statistical and speech model based methods. Speech enhancement: spectral subtraction, noise masking, and comb filtering, statistical modeling.

29. Environmental Science

Eligibility: Ph.D. in Environmental Sciences/Agricultural Physics/Agro-forestry/Agricultural Meteorology/Soil science/Soil Science and Agricultural Chemistry/Agricultural Chemistry and Soil Science/Agricultural Chemicals/Agricultural Microbiology/Microbiology.

Syllabus:

Unit-1:
Definition and scope of environment science and its interrelationship with other sciences and agriculture; Origin and evolution of the earth and its environs-atmosphere: hydrosphere, Lithosphere and biosphere; Biogeochemical cycles; Components of environment - biotic, abiotic and social; Weather and climate; History and evolution of human settlement; Effect of various developmental activities on environment. Origin of solar system, Basic concept and scope of environmental geosciences, Geological time scale, Geological resources, types of rocks

Unit-2:
Basic ecological concepts - habitat ecology, systems ecology, synecology, autecology; Ecosystem concept; Structure and functions of biotic and abiotic components; Energy in ecosystems and environment; Energy exchange and productivity-food chains and food webs-ecological pyramids, nutrient cycles and recycle pathways; Population - characteristics and measurement; CommUnities - habitats, niches, population dynamics, species and individual in the ecosystem; Recent trends in ecology; Types characteristic features, structure and function of forest, grassland, plantation, desert; Aquatic and agro-ecosystem; Ecological succession - types and causes, Ecosystem models, Concept of radioecology

Unit-3:
Biodiversity concepts, levels and types, changes in tune and space, evolution, centres of origin of crops, species concept; Significance of biodiversity; Plant genetic resources, exploration and collection; Crop domestication, plant introductions; Migration and utilization; IUCN clauses and concept of threatened and endangered species; Biogeography; Principles of conservation of biological diversity in-situ and ex-situ. Causes of loss of biodiversity: introduction of exotics and invasive plants; Methods of conservation, role of national parks, wildlife sanctuaries, biosphere reserves; National and global conservation measures, institutions and conventions; Indian Biodiversity Act 2002; Biodiversity and economics with special reference to India; Biodiversity in relation to global environmental

changes; Biodiversity hot spots in India and world; Biodiversity and life security. Climate change effects on biodiversity, Wildlife protection programmes

Unit-4:

Composition of air; Air pollution: sources and classification of major air pollutants; Smoke, smog, photochemical smog and SPM; Methods of air pollution monitoring; Effects of air pollutants on crops, vegetation, animals and human health; mitigation measures for combating air pollution; AQI, APTI; Factors affecting plant response to air pollution; Acid rain, physiological and biochemical effects of SO2, HF, PAN and O3 on vegetation, toxicity symptoms on vegetation, defence mechanism against air pollutants in plants, sensitive and tolerant plant species to air pollutants. National and international laws and policies on air pollution; Permissible limits of air pollutants in the residential, commercial and industrial areas (NAAQS); Noise pollution-concept and effects., Air pollution controlling strategies and devices, vehicular air pollution control devices, Indoor air pollution

Unit-5:

Soil and water pollution: sources and types of soil and water pollutants; Effects of pollutants on soil health and productivity; Radioactive pollutants, their life time and disposal; Point and non-point sources of water pollution, major types of water pollutants, their impacts on environment and agro-ecosystems; Pollution in fresh water bodies, ponds, lakes, rivers and wells. Effects of soil and water pollutants on crop plants, animals, microorganism and human health; National and International laws and maximum permissible limits of soil and water pollutants; Biomagnification and its impact on loss of biodiversity; Physical, chemical and biological properties of wastes; Effluent treatment processes for major industries viz. distilleries; paper and pulp, sugar, sewage and other agro-industrial wastes; Resource, product recovery, recycling and value addition to wastes; Biodegradation and bioconversion of organic wastes, composting, landfills; Vermicomposting, biogas. animal feed. mushroom cultivation etc.; Plastic pollution and its management, Use of sludge, flyash, effluents and other agro industrial wastes in agriculture; Microbial, chemical and phytoremediation processes; Microbiological and public health aspects of waste disposal; Heavy metal contamination of environments, source and sinks of heavy metals, Basic concept of environmental toxicology, Dose-response relationships, Food adulteration, Laws and policies regarding food adulterations and food safety, Nuclear pollution and management, Radioactivity

Unit-6:

Climate change: Global warming and greenhouse effect, sources and sinks of greenhouse gases, major GHGs, analytical techniques of monitoring greenhouse gases in atmosphere; Global climate change - its history and future predictions. Impact of climate change on agriculture, forestry, water resources, sea level rise, livestock, fisheries, coastal ecosystemand dynamics and pests and discases and overall ecological processes; Climate change and food security; Contribution of agriculture and forestry to climate change; International conventions on climate change; Stratospheric ozone layer depletion-effect of UV radiation onplants and human health; Adaptation and mitigation strategies of climate change, global dimming agrobiological effects of CO2 fertilization on crops; Carbon sequestration and clean development mechanism, Introduction to climate change models, system & simulation modeling, Fundamentals of dynamic simulation, Basics of air and water pollutant dispersion modeling

Unit-7:

Energy consumption pattern in urban and rural India; Types of renewable sources of energy; Solar energy: concepts of heat and mass transfer; design of solar thermal system and their applications in heating. cooling. distillation. drying. dehydration etc., design of solar photovoltaic systems, power generation for rural electrification-water pumping, solar ponds; Wind energy for mechanical and electrical power generation, types of wind mills; Geothermal and tidal energy; Biogas from animal and agricultural wastes, types of biogas plants, utilization of biogas for heating, cooking lighting and power generation; Characteristics of biogas slurry and its utilization; Energy from biogas; Liquid fuels from petrocrops, energy plantation crops; Concepts of producer gas; characterization of materials for producer gas, types of gasifiers; Animals draft power and its utilization in rural sector; Briquetting of agro-wastes for fuel; Potential of renewable energy sources in India, Integratedrural energy programme; Causes of failure of biogas plants in rural India, Basic concept of environmental engineering, Concept of material and energy balance, Method of describing motion, velocity, acceleration, overland flow and pollutant transport

Unit-8:

Natural resources of India: land, soil, water and forest and their conservation and management including wildlife; Effects of deforestation on soil erosion; State of Indian

forest, Land degradation; Environment and rural economy; Wasteland: their extent, characteristics and reclamation; Soil and water conservation, rain water harvesting and watershed management; Desertification and biological invasion; Rain water harvesting; Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources; Disaster management: floods, droughts, earthquakes; Tsunami, cyclones and landslides; Nuclear hazards; Environmental impact assessment for physical, chemical, biological and socio-economic factors; Legislative implications of EIA, environmental impacts assessment and environmental auditing; Major global environmental issues; Human population and environment: population growth, variation among nations. Population explosion - Family welfare programme; World food resources; World food problems; Environment and human health; Environmental ethics: issues and possible solutions; Environmental policies and laws in India; Public environmental awareness; Human rights; Role of information technology in environmental and human health; Industrial pollutants; Seaweeds and their utilization in agar, alginic acid, carrageenan, agarose and agaropectin production; Impact of green revolution on the environments.

Unit-9:

Frequency distribution, mean, median, mode and standard deviation; Normal, binomial and poisson distribution; Correlations - partial and multiple; Regression coefficients and multiple regression. Tests of significance Probability, F and Chi-square (X2) tests; Experimental designs - basic principles, completely randomized, randomized block, Latin square and split plot designs.

30. Farm Machinery & Power

Eligibility: Ph D in Farm Machinery and Power Engineering/Farm Machinery and Power/Renewable Energy Engineering/Renewable Energy/Mechanical Engineering.

Syllabus:

Unit-1: Farm Mechanization and Equipment

Construction, operation and design requirements of tillage and seed bed preparation implements like mould board plough, disc and chisel type implements, land levelers, ridgers, rotary and oscillating implements. Machinery for crop planting, transplanting, row crop cultivation, weeding, fertilizer application, spraying and dusting, their principles of working and design requirements. Operating principles and design features of machinery for harvesting and threshing of field crops, root crops. Function and principle of operation of special purpose machinery *viz.* laser leveler, precision planters, forage harvester, baler and crop residue management equipment. Benefits of mechanization, constraints and strategies for mechanization of small and medium farms.

Unit-2: Engines and Tractor systems

Internal combustion engines, its thermodynamics, operating cycle and principles of operation. CI engines for tractors, their performance characteristics, design features, principles of ignition, combustion and valve timing. Systems of CI engine, their operation *viz.* cranking, valve actuation, fuel supply, governing, lubrication, air intake, exhaust, turbo charging, cooling, electrical and exhaust emission control. Tractor power transmission system to drive wheel and PTO. Requirements and design features of steering, braking, hitch, hydraulic implement control and wheel geometry, adjustment for agricultural tractors and power tillers. Basic tire design. Traction theory and theoretical determination of soil thrust and rolling resistance. Soil and tire parameters influencing traction and traction aids. Traction prediction models and traction characteristics of tires. Mechanics of farm tractor chassis, longitudinal and lateral stability and weight transfer. Recent trends in tractor design.

Unit-3: Farm Machinery Design

Design of power transmission elements in farm machinery. Application of computer aided drafting and tools for kinematic and structural design and verification. Fluid power, components of system and their characteristics, design of simple hydraulic circuits for use in farm machinery. Analysis of forces on implements like mould board plough, chisel plough, disc plough, disc harrows, cultivators and their hitch system. Principles in design of planting,

transplanting, fertilizer application and inter cultivation machinery. Sprayer, concepts behind spray application of chemicals, droplet size, pressure, application rate spay pattern and nozzle spacing on a boom. Design of functional components of crop sprayer. Design of harvesting, threshing and cleaning systems of combine harvesters.

Unit-4: Farm Machinery Testing, Evaluation and Management

Testing and standardization of tractors and Farm Machinery in India. Objectives of certification and standardization. Testing of tractor and power tiller engines, test equipment and procedure. Test procedure to measure performance of seed drills, planters, fertilizer applicators, weeding tools, crop sprayers and dusters. Procedure to measure capacity, efficiencies and losses in threshers, combine harvesters, potato digger shaker, chaff cutters and balers. Concepts of field performance *viz.* machine, power and operator. Analysis of cost of tillage, sowing, crop spraying and harvesting operations and their use for purchase and replacement decisions. Selecting optimum size of machinery and power source. Custom hiring, opportUnities and challenges. Comparison of economics of custom hiring centres viz ownership and cooperative system. Systems approach to farm machinery selection and scheduling. Network analysis, transportation, CPM and PERT applied to farm machinery management.

Unit-5: Ergonomics and Safety

Ergonomics and its application in the agricultural work system. Principles of anthropometry in workspace and equipment design. Principles of design of manual handling tasks and its application in agricultural equipment design. Human postures, postural stress and its role in design of farm machinery. Work physiology, work capacity, stress fatigue and recovery and its application in studying manual agricultural operations. Human energy expenditure, calibration of subjects, physiological workload and its assessment. Effect of noise, vibration, illumination, dust and chemical hazards on operator, and techniques of reducing them. ISO standards related to measurement and limits for ergonomic considerations. Tractor as a man- machine system- operator's seating, access and exit. Safety considerations and operator's protective gadgets in farm operations. Standards for safety of tractors and agricultural machinery.

Unit-6: Machinery for Precision Agriculture and Automation

Precision agriculture, mapping in farming for decision making, understanding and identifying variability. Geographical Positioning System (GPS), its function and usage. Geographic Information system (GIS), its function and use for decision making. Yield monitors and variable rate applicator for precision agriculture. Precision weed control and chemical application. Robots, their classification and features. Technologies of robot, actuators,

motors, power supplies and end effectors. Application of robots in agriculture for harvesting and picking, weed control, autonomous mowing, pruning, seeding, spraying and thinning. Application of drones in agriculture and use of drones for crop spraying.

Unit-7: Instrumentation and Measurement Techniques

Static and dynamic characteristics of instruments. Measurement of translational and rotary displacement. Strain gauges, their principle of working and application. Measurement of force, torque and shaft power, pressure, sound, flow, temperature and relative humidity using transducers. Signal conditioning, principles of amplification, filtering, AD/DA conversion. Data communication and acquisition using microprocessor based systems.

Unit-8: Renewable Energy Systems

Basic concepts in solar energy, the solar constant, Sun-Earth angles, solar radiation on flat and inclined surface. Solar flat plate collectors, their construction, working principles, performance analysis, efficiency factor and characteristic curves. Factors influencing performance of flat plate collectors. Solar air heaters, their classification and performance analysis. Solar photovoltaic conversion, basic parameters of a solar cell, effect of temperatureon efficiency, PV module materials and array. Application of solar PV modules for water lifting. Wind power, rotor design procedure, Betz limit, ideal horizontal axis wind turbine, wake rotation, momentum theory and blade element theory, blade shape for ideal rotorwithout wake rotation. Wind mills for water lifting. Electrical energy generation by wind turbine, power transformers, electrical machines and ancillary electrical equipment.

Unit-9: Thermo and Biochemical Conversion of Biomass

Direct use of biomass *viz.* carbonization, size reduction, baling, pelletization, briquetting technologies. Biomass gasification, principles, stoichiometric considerations. Gasifier, itsparts and accessories, performance evaluation, operation and maintenance. Configurations of gasifier and their characteristics. Biogas technology, factors influencing anaerobic digestion, engineering design of biogas Units for biogas production from solid and liquid wastes. Biogas plants, their performance evaluation, maintenance, failure of biogas plants and rectification. Bioconversion of biomass to alcohol, types of bio mass and their pre-treatment, production process. Design of fermenter for alcohol production and process parameters. Production of biodiesel, biodiesel transesterification system and its performance. Calarimeters and calorific value measurement.

Unit-10: Statistical Methods

Probability and probability distributions. Principle of least squares. Linear and non-linear regression. Multiple regression. Correlation analysis. Selection of variables. Validation of

models. Sampling techniques. Determination of sample size. Sampling distribution of mean and proportion. Design of experiments. Hypothesis testing. Concept of p-value. Student's t-test. Large sample tests. Confidence intervals. ANOVA and testing of hypothesis in regression analysis. Analysis of variance for one way and two way classification (with equal cell frequency). Transformation of data. Advantages and disadvantages of nonparametric statistical tests. Scales of measurements. Run-test. Sign test. Median test. Wilcoxon-Mann Whitney test. Chi-square test. Kruskal-Walli's one way and Friedman's two way ANOVA by ranks. Kendall's Coefficient of concordance.