BIOCHEMISTRY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
BIOCHEM 501*/ ❶ BIF 504	BASIC BIOCHEMISTRY	3+0	I, II
BIOCHEM 502*	INTERMEDIARY METABOLISM	3+0	II
BIOCHEM 503*	ENZYMOLOGY	3+0	I
BIOCHEM 504*/ ❷ MBB 502/ BIF 508	FUNDAMENTALS OF MOLECULAR BIOLOGY	3+0	I
BIOCHEM 505*	TECHNIQUES IN BIOCHEMISTRY	0+3	I, II
BIOCHEM 506/ ❸ BIF 510/ MBB 512	IMMUNOLOGY AND MOLECULAR DIAGNOSTICS	2+1	1I
BIOCHEM 507*	PLANT BIOCHEMISTRY	3+0	II
BIOCHEM 508	ANIMAL BIOCHEMISTRY	3+0	II
BIOCHEM 509	FOOD AND NUTRITIONAL BIOCHEMISTRY	3+1	II
BIOCHEM 591	MASTERôS SEMINAR	1	I, II
BIOCHEM 599	MASTERôS RESEARCH	20	I, II
BIOCHEM 601**	ADVANCED ENZYMOLOGY	3+0	I
BIOCHEM 602**	ADVANCED MOLECULAR BIOLOGY	3+0	II
BIOCHEM 603**	CURRENT TOPICS IN BIOCHEMISTRY	3+0	I
BIOCHEM 604**	ADVANCED TECHNIQUES IN BIOCHEMISTRY	0+3	II
BIOCHEM 605	BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES	3+0	I
BIOCHEM 606/ ❹ MBB 605/ PP 602	ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS	3+0	II
BIOCHEM 691	DOCTORAL SEMINAR I	1	I, II
BIOCHEM 692	DOCTORAL SEMINAR II	1	I, II
BIOCHEM 699	DOCTORAL RESEARCH	45	I, II

*Compulsory for Masterôs programme; ** Compulsory for Doctoral programme

Compulsory Courses to be taken as minor/supporting: MICRO 501, GP 501, MBB 501, STAT 511

Courses open to PG students of other colleges/departments for minor/supporting only: All PG courses (Biochem 501 is compulsory)

To be taught by: ❶ Biochemistry; ❷ Bioinformatics, Biochemistry, Molecular Biology & Biotechnology; ❸ Veterinary Microbiology; ❹ Biochemistry, Molecular Biology & Biotechnology, Plant Physiology

BIOCHEMISTRY

Course Contents

BIOCHEM 501/ BIF 504 BASIC BIOCHEMISTRY 3+0 SEM - I, II

Objective

To provide elementary knowledge/overview of structure, functions and metabolism of biomolecules.

Theory

UNIT-I: Scope and importance of biochemistry in agriculture; acid base concept and buffers; pH; hydrogen bonding, hydrophobic, electrostatic and vander Waals forces; general introduction to physical techniques for determination of structure of biopolymers.

UNIT-II: Classification, structure and function of carbohydrates, lipids, amino acids, proteins, and nucleic acids; biomembranes.

UNIT-III: Fundamentals of thermodynamics; Enzymes: classification, factors affecting enzyme activity, enzyme kinetics; structure and biological functions of vitamins and hormones.

UNIT-IV: Metabolism of carbohydrates, lipids, proteins and nucleic acids; mitochondrial electron transport chain and oxidative phosphorylation; DNA replication, transcription and translation; recombinant DNA technology.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry*. John Wiley.

Metzler DE. 2006. *Biochemistry*. Vols. I, II. Wiley International.

Nelson DL & Cox MM. 2004. *Lehninger Principles of Biochemistry*. 4th Ed. MacMillan.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

BIOCHEM 502 INTERMEDIARY METABOLISM 3+0 SEM - II

Objective

To teach metabolic pathways, their regulation and engineering and methods used in their elucidation.

Theory

UNIT-I: The living cell- a unique chemical system, Introduction to metabolism; methods of studying metabolism, compartmentation of metabolic pathways.

UNIT-II: Catabolic and anabolic pathways of carbohydrates, lipids, their regulation and metabolic disorders.

UNIT-III: Bioenergetics; biological oxidation; energy transduction and oxidative phosphorylation; signal transduction; metabolic engineering concepts.

UNIT-IV: General reactions of amino acid metabolism; degradative and biosynthetic pathways of amino acids and nucleic acids, their regulation and metabolic disorders.

Suggested Readings

Berg JM, Tymoczko JL, Stryer L & Clarke ND 2000. *Biochemistry*. 5th Ed. WH Freeman.

Metzler DE. 2006. *Biochemistry*. Vols. I, II. John Wiley.

Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

Zubey GL. 1998. Biochemistry. 4th Ed. WCB London.

BIOCHEM 503 ENZYMOLOGY 3+0 SEM - I

Objective

To impart knowledge about the catalytic role of enzymes, their structure, physico-chemical, kinetic and regulatory properties and mechanism of action.

Theory

UNIT-I: Introduction and historic perspective; enzyme nomenclature and classification, enzyme compartmentalization in cell organelles; measurement of enzyme activity. Cofactors: their structure and role; ribozymes, isozymes, abzymes.

UNIT-II: Enzyme structure; multienzyme complexes; enzyme specificity; active site; mechanisms of enzyme catalysis; isolation and purification of enzymes.

UNIT-III: Enzyme kinetics; enzyme inhibition and activation; allosteric enzymes and their kinetics; regulation of enzyme activity; active site mapping.

UNIT-IV: Applications of enzymes in chemical and food industry; enzyme immobilization; biosensors and clinical applications of enzymes.

Suggested Readings

Bergmeyer HU. 1983. *Methods of Enzymatic Analysis*. Vol. II. Verlag Chemie, Academic Press.

Dixon M, Webb EC, Thorne CJR & Tipton KF. 1979. *Enzyme*s. 3rd Ed. Longman.

Maragoni AG. 2003. *Enzyme Kinetics - A Modern Approach*. John Wiley.

Palmer T. 2001. *Enzymes: Biochemistry, Biotechnology and Clinical Chemistry*. 5th Ed. Horwood Publ.

Price NC & Stevens L. 2003. *Fundamentals of Enzymology*. Oxford Univ. Press.

Wilson K & Walker J. (Eds.). 2000. *Principles and Techniques of Practical Biochemistry*. 5th Ed. Cambridge Univ. Press.

BIOCHEM 504/ FUNDAMENTALS OF MOLECULAR BIOLOGY 3+0 SEM - I

502/ BIF 508 (To be taught jointly by Bioinformatics, Biochemistry, Molecular Biology & Biotechnology)

Objectives

To familiarize the students with the basic cellular processes at molecular level.

Theory

UNIT-I: Historical developments of molecular biology; nucleic acids as genetic material, chemistry, structure and properties of DNA and RNA.

UNIT-II: Genome organization in prokaryotes and eukaryotes; repetitive and non-repetitive DNA, satellite DNA; DNA replication, DNA polymerases; topoisomerases, DNA ligase; reverse transcriptase, nucleases and restriction enzymes; site directed mutagenesis; molecular mechanism of mutation; DNA repair mechanisms.

UNIT-III: Ribosomes structure and function; organization of ribosomal proteins and RNA genes; transcription, RNA editing, RNA processing, etc; genetic code, aminoacyl tRNA synthasesô; inhibitors of replication, transcription and translation.

UNIT-IV: Translation and post translational modifications; regulation of gene expression in prokaryotes and eukaryotes.

Suggested Readings

Lewin B. 2008. *Gene IX*. Peterson Publ.

Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publishers.

Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. W.H. Freeman.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene*. 6th Ed. Pearson Edu. International.

BIOCHEM 505 TECHNIQUES IN BIOCHEMISTRY 0+3 SEM - I, II

Objective

To impart practical knowledge about various techniques used in purification and characterization and estimation of cellular constituents.

UNIT-I: Determination of absorption maxima; extraction and estimation of carbohydrates, amino acids, proteins and nucleic acids.

UNIT-II: Separation of carbohydrates and amino acids by paper chromatography; separation of lipids by thin layer and column chromatography; separation of proteins by ion exchange and gel filtration chromatography.

UNIT-III: Extraction, purification and characterization of enzymes; electrophoretic techniques to separate proteins and nucleic acids.

UNIT-IV: Centrifugation: Cell fractionation; application of GLC, HPLC, FPLC in separation of biomolecules; use of radioisotopes in metabolic studies.

Suggested Readings

Clark JM. 1977. *Experimental Biochemistry*. 2nd Ed. WH Freeman.

Sawhney SK & Singh R. 2000. *Introductory Practical Biochemistry*. 2nd Ed. Narosa.

Willard M, Merritt LL & Dean JA.1981. *Instrumental Methods of Analysis*. 4th Ed. Van Nostrand.

William BL & Wilson K. 1975. *Principles and Techniques of Practical Biochemistry*. Edward Arnold.

Wilson K, Walker J & Walker JM. 2005. *Principles and Techniques of Practical Biochemistry.* Cambridge Univ. Press.

BIOCHEM 506/ BIF 510/ MBB 512 IMMUNOLOGY AND MOLECULAR DIAGNOSTICS 2+1 SEM - II

(To be taught by Veterinary Microbiology)

Objective

To discuss the application of various immunological and molecular diagnostic tools.

Theory

UNIT-I: History and scope of immunology; Components of immune system: organs, tissues and cells; immunoglobulin structure and functions; molecular organization of immunoglobulins and classes of antibodies.

UNIT-II: Antibody diversity; antigens, haptens, antigen-antibody interactions; immunoregulation and tolerance; allergies and other hypersensitive responses; immunodeficiency; vaccines.

UNIT-III: Application of immunology; immunological techniques; principles of ELISA and its applications; monoclonal antibodies and their uses; molecular diagnostics; introduction to the basic principles of molecular technology and techniques used for pathogen detection.

UNIT-IV: Basics and procedures of PCR, PCR based and hybridization based methods of detection; microarrays based detection; multiplexing etc; detection of soil borne and seed born infections; transgene detection in seed, planting material and processed food; molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

- Preparation of buffers and reagents.
- Serological tests such as bacterial slide agglutination, latex agglutination and agar gel immunodiffusion.
- Immunoassays including ELISA, western blotting, and fluorescent antibody test.
- Hybridoma technique for production of monoclonal antibodies.
- Recombinant protein antigen- production and immunization of laboratory animals.
- Extraction of DNA/RNA from pathogenic microorganisms, PCR, genotyping, diagnosis, etc..

Suggested Readings

Bloom BR & Lambert P-H. 2002. *The Vaccine Book.* Academic Press.

Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease.* Humana Press.

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby's Immunology*. WH Freeman.

Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.

Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.

Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology.* Elsevier.

Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.

Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.

Spinger TA, 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

BIOCHEM 507 PLANT BIOCHEMISTRY 3+0 SEM - II

Objective

Detailed information about biochemical and molecular basis of various plant processes and plant growth regulatory substances.

Theory

UNIT-I: Scope and importance of biochemistry in agriculture; plant cell organelles, their separation, structure and functions. Photosynthetic pigments in relation to their functions; photosynthesis: C3, C4 and CAM pathways; photorespiration.

UNIT-II: Sucrose-starch interconversion; biosynthesis of structural carbohydrates, storage proteins and lipids; biochemistry of nitrogen fixation and nitrate assimilation; sulphate reduction and incorporation of sulphur in to amino acids.

UNIT-III: Biochemistry of seed germination and development; biochemistry of fruit ripening; phytohormones and their mode of action; signal transduction.

UNIT-IV: Biochemistry and significance of secondary metabolites: cyanogenic glycosides, glucosinolates, phenolic compounds, terpenoids, alkaloids; plant defense system.

Suggested Readings

Buchanan BB, Gruissem W & Jones RL. 2000. *Biochemistry and Molecular Biology of Plants.* 2nd Ed. John Wiley.

Dey PM & Harborne JB. 1997. *Plant Biochemistry*. Academic Press.

Goodwin TW & Mercer EI. 1983. *Introduction to Plant Biochemistry*. Pergamon Press.

Heldt HS. 1997. *Plant Biochemistry and Molecular Biology*. Oxford Univ. Press.

Lea PJ & Leegood RC. 1993. *Plant Biochemistry and Molecular Biology*. 2nd Ed. John Wiley.

BIOCHEM 508 ANIMAL BIOCHEMISTRY 3+0 SEM - II

Objective

To impart knowledge regarding biochemistry of various physiological processes, specialized tissues and hormone action in animal system.

Theory

UNIT-I: Digestion and absorption of food; vitamins. Detoxification; biochemistry of specialized tissues: connective tissue, skin, muscle, nervous tissue and blood and other body fluids.

UNIT-II: Water, electrolyte and acid-base balance; biochemistry of respiration; structure, function and mechanism of major trace elements.

UNIT-III: Hormones of thyroid, hypothalamus, pituitary, pancreas, adrenals; sex hormones; membrane receptors of hormones; signal transduction; biochemistry of reproduction.

UNIT-IV: Immune systems; immunoglobulins; monoclonal antibodies; formation of antibody; antibody diversity; complement system: classical and alternate; major histocompatibility complexes; cell mediated immune response; mechanisms of immunity.

Suggested Readings

Devlin TM. 2006. *Text Book of Biochemistry with Clinical Correlations*. 6th Ed. John Wiley.

Goldsby RA, Kindt TJ, Kuby J & Osborne BA. 2003. *Immunology*. 4th Ed. WH Freeman. & Co.

Harper H. A. 2000. *Physiological Chemistry*. MacMillan.

BIOCHEM 509 FOOD AND NUTRITIONAL BIOCHEMISTRY 3+1 SEM - II

Objective

To impart knowledge regarding the biochemical aspects of various nutrients and their interactions in foods during processing, storage and deterioration.

Theory

UNIT-I: Fundamentals of human nutrition; concept of balanced diet; biochemical composition; energy and food value of various food grains (including cereals, pulses, oilseeds), fruits and vegetables; physico-chemical, functional and nutritional characteristics of carbohydrates, proteins and fats and their interactions (emulsions, gelation, browning etc.).

UNIT-II: Biochemical and nutritional aspects of vitamins, minerals, nutraceuticals, antinutritional factors; biochemistry of post harvest storage.

UNIT-III: Effect of cooking, processing and preservation of different food products on nutrients; biochemical aspects of food spoilage, role of lipase and lipoxygenase, oxidative rancidity and antioxidants.

UNIT-IV: Enzymes in food industry; food additives (coloring agents, preservatives etc.); biogenesis of food flavours and aroma; nutritional quality of plant, dairy, poultry and marine products.

Practical

Estimation of starch, lipid/oil, phenols in plant tissue/sample, Estimation of carotenoids, Estimation of trypsin and chymotrypsin inhibitor activities in seeds, Estimation of vitamin C in fruits; Reducing and non reducing sugar in fruits; estimation of protein contents; estimation of dietary fibre, determination of limiting amino acids; estimation of phytate/oxalate.

Suggested Readings

Alais C & Lindel G. 1995. *Food Biochemistry*. Amazon Springer.
DeMan JM. 1999. *Principles of Food Chemistry*. 3rd Ed. Springer.
Fennema OR. 1996. *Food Chemistry*. 3rd Ed. CRC Press.
Hulme AC. (Ed.). 1970. *Biochemistry of Fruits and Vegetables and their Products*. Vols. I, II. Academic Press.
Ranganna S. (Ed.). 1986. *Handbook of Analysis and Quality for Fruits and Vegetable Products*. Tata McGraw Hill.
Robinson DS. 1987. *Food Biochemistry and Nutritional Value*. Longman.

BIOCHEM 601 ADVANCED ENZYMOLOGY 3+0 SEM - I

Objective

To provide advanced knowledge about the structure, mechanism, kinetics and regulation of enzymes and their use as biosensors.

Theory

UNIT-I: Theory of enzymatic catalysis, specificity, concept of active site and enzyme substrate complex; active site mapping; acid-base and covalent catalysis; factors associated with catalytic efficiency; proximity and orientation; distortion and strain; induced fit hypothesis; mechanism of enzyme reactions.

UNIT-II: Effect of different factors affecting enzyme activity; transition state theory; Arrhenius equation, Determination of energy of activation; kinetics of pH and temperature and determination of pKa and qpH of active site amino acids.

UNIT-III: Kinetics of bisubstrate reactions; mechanism determination by radioisotope exchange; kinetics of mixed inhibitions, substrate and product inhibition.

UNIT-IV: Role of enzymes in regulation of metabolism; allosteric enzymes and their kinetics; bifunctional enzymes; enzyme engineering.

Suggested Readings

Dixon M & Web EC. 1979. *Enzymes*. 3rd Ed. Longmans Green.
Seigel IH. 1975. *Enzyme Kinetics.* John Wiley.
Selected reviews and articles from journals.

BIOCHEM 602 ADVANCED MOLECULAR BIOLOGY 3+0 SEM - II

Objective

To impart latest information on the molecular biochemistry of isolation, transfer and expression of genes in plants and biochemical approaches employed in gene therapy.

Theory

UNIT-I: Genome organization; nuclear and organelle genes; concept of genome mapping; molecular evolution; cell development and differentiation.

UNIT-II: Prokaryotic and eukaryotic gene regulation; RNA editing, molecular biology of viruses.

UNIT-III: Methods of gene isolation and transfer in plants and animals, molecular basis of male sterility; application of genetic engineering in different fields.

UNIT-IV: Site directed mutagenesis; gene targeting and gene therapy; bioethics and biosafety guidelines and IPR in recombinant DNA research.

Suggested Readings

Alberts B, Bray D, Lewis J, Raff M, Roberts K & Watson JD. 2006. *Molecular Biology of the Cell*. 6th Ed. Garland Publ.
Lewin B. 2007. *Gene IX*. 9th Ed. Pearson Publ.
Selected articles from journals.

BIOCHEM 603 CURRENT TOPICS IN BIOCHEMISTRY 3+0 SEM - I

Objective

To acquaint the students with the advanced developments in the field of biochemistry and to inculcate the habit of searching and reading the topics of current importance.

Theory

UNIT-I: Advanced topics related to nutrition and metabolism.

UNIT-II: Advanced topics related to enzymology and industrial biochemistry.

UNIT-III: Advanced topics related to molecular biochemistry and immunology.

UNIT-IV: Advanced topics related to metabolic engineering and bioprospecting.

Suggested Readings

Selected articles from journals.

BIOCHEM 604 ADVANCED TECHNIQUES IN BIOCHEMISTRY 0+3 SEM - II

Objective

To impart students a hands on training of techniques of biochemistry and molecular biology.

Practical

UNIT-I: Isolation and purification of protein from microbial/plant/animal source;. electrophoretic separation of protein; determination of molecular weight of protein using PAGE/ gel filtration method.

UNIT-II: Experiments on DNA: isolation, agarose gel electrophoresis and restriction analysis of DNA.

UNIT-III: Isolation of chloroplast and mitochondria by differential centrifugation and their purification by density gradient centrifugation.

UNIT-IV: Isolation and purification of enzymes, isozymic analysis and enzyme immobilization

Suggested Readings

Kolowick NP & Kaplan NP. *Methods in Enzymology*. Academic Press (Series).

Plummer DT. 1998. *An Introduction to Practical Biochemistry*. 3rd Ed. Tata McGraw Hill.

Rickwood D. (Ed.). 1984. *Practical Approaches in Biochemistry*. 2nd Ed. IRL Press, Washington DC.

Wilson K & Goulding KH. 1992. *A Biologist's Guide to Principles and Techniques of Practical Biochemistry*. 3rd Ed. Cambridge Univ. Press.

Wilson K & Walker J. 2000. *Principles and Techniques of Practical Biochemistry.* 5th Ed. Cambridge Univ. Press.

BIOCHEM 605 BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES 3+0 SEM - I

Objective

To impart latest development about biochemistry of biotic and abiotic stresses in plants.

Theory

UNIT-I: Plant-pathogen interaction and disease development; molecular mechanisms of fungal and bacterial infection in plants; changes in metabolism, cell wall composition and vascular transport in diseased plants.

UNIT-II: Plant defence response; antimicrobial molecules; genes for resistance; hypersensitive response and cell death; systemic and acquired resistance.

UNIT-III: Plant viruses: host-virus interactions, disease induction, virus movement, and host range determination; viroids, pathogen-derived resistance.

UNIT-IV: Biochemical basis of abiotic stresses namely osmotic (drought, salinity), temperature, heavy metals, air and water pollutants; synthesis and functions of proline and glycine betaine in stress tolerance interaction between biotic and abiotic stresses; stress adaptation.

UNIT-V: Reactive oxygen species and biotic and abiotic stress; antioxidants enzymes defense system; role of calcium, nitric oxide and salicylic acid in plant development; molecular strategies for imparting tolerance against biotic and abiotic stresses.

Suggested Readings

Basra AS. 1997. *Stress Induced Gene Expression in Plants*. Harwood Academic Publ.

Chessin M, DeBorde D & Zipf A. 1995. *Antiviral Proteins in Higher Plants.* CRC Press.

Crute IR, Burdon JJ & Holub EB. (Eds.). 1997. *Gene-for-Gene Relationship in Host-Parasite Interactions.* CABI.

BIOCHEM606/ MBB 605/ PP 602 ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS 3+0 SEM - II

(Pre-requisite MBB 501)

(To be offered jointly by Biochemistry, Molecular Biology & Biotechnology, Plant Physiology)

Objective

To discuss recent advances and applications of functional genomics and proteomics in agriculture, medicine and industry.

Theory

UNIT-I: Genome sequencing and functional genomics; Human, animal, plant, bacterial and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters; etc.

UNIT-II: Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation and domestication etc.

UNIT-II: Proteomics: protein annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/ management, etc.

UNIT-IV: Metabolic pathway engineering, Discussion on selected papers on functional genomics, metabolomics, proteomics, integrative genomics etc.

Suggested Readings

Specific journals and published references.

BIOCHEMISTRY

List of Journals

- Annual Review of Biochemistry
- Annual Review of Genetics
- Annual Review of Plant Physiology and Plant Molecular Biology
- Biochemical and Biophysical Research Communication
- Biochemical Journal
- Biochim. Biophysic Acta
- Cell
- Current Science
- Federation of European Biochemical Society
- Indian Journal of Experimental Biology
- Journal of Biological Chemistry
- Journal of Immunology
- Journal of Molecular Modeling
- Journal of Plant Biochemistry and Biotechnology
- Nature
- Physiologia Plantarum
- Plant Physiology
- Plant Science
- Planta
- Proceedings of National Academy of Sciences, USA
- Protein Science
- RNA
- Science
- Scientific American
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Plant Sciences

e-Resources

- www.unixl.com/dir/molecular_sciences/biochemistry/biochemistry_jobs/
- www.unixl.com/dir/medical_sciences/
- http://www.ncbi.nlm.nih.gov/
- http://us.expasy.org
- http://us.expasy.org/spdbv/
- http://www.brenda.uni-koeln.de/
- http://www.worthington-biochem.com
- http://www.cefotaxime.net
- http://home.123india.com/nbsc/
- http://www.biochemist.org
- http://www.gwu.edu/~mpb

Suggested Broad Topics for Master's and Doctoral Research

- Immobilization of industrially important enzymes
- Manipulation of metabolic pathways for reserve biosynthesis and utilization
- Biochemistry and molecular biology of biotic and abiotic stresses in plants
- Biochemistry of fruits and vegetables during ripening and post ripening
- Manipulation of metabolic pathways at molecular level to increase shelf life of fruits and to increase contents of alkaloids, flavones and isoflavones, PUFA etc.
- Use of molecular markers for identification and improvement of crop plants
- Enzyme engineering and functional genomics/proteomics
- Biochemical and molecular evaluation of varieties for quality improvement
- Use of biomolecules as biosensors

Å Study of metabolome and elucidation of metabolic pathway of secondary metabolites

BIOINFORMATICS

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
BIF 501[@]/ ❶ FSC 604/ MBB 555/ ABT 608	INTRODUCTION TO BIOINFORMATICS	2+1	I
BIF 502[@]	ADVANCED BIOINFORMATICS	2+1	I
BIF 503[@]	TECHNIQUES IN BIOINFORMATICS	0+2	II
BIF 504**/ ❷ BIOCHEM 501	BASIC BIOCHEMISTRY	3+0	I, II
BIF 505**/ ❸ STAT 532	STATISTICS FOR BIOLOGICAL SCIENCES	2+1	I
BIF 506	CONCEPTS IN COMPUTING	2+2	I
BIF 507*	PROGRAMMING LANGUAGES FOR BIOINFORMATICS	2+2	I
BIF 508**/ ❹ MBB 502/ BIOCHEM 504	FUNDAMENTALS OF MOLECULAR BIOLOGY	3+0	I
BIF 509**/ ❸ STAT533	MATHEMATICS FOR BIOLOGICAL SCIENCES	2+0	I
BIF 510/ ❺ MBB 512/ BIOCHEM 506	IMMUNOLOGY AND MOLECULAR DIAGNOSTICS	2+1	II
BIF 511	INTRODUCTION TO DATABASE SYSTEMS	2+1	II
BIF 512*	COMPUTATIONAL AND SYSTEM BIOLOGY	2+2	II
BIF 513*	BIOMOLECULAR SEQUENCE ANALYSIS	1+1	I
BIF 514	DYNAMIC WEB-DESIGN	1+2	I
BIF 515*	BIOLOGICAL DATABANKS AND DATA MINING	1+2	II
BIF 516*	MOLECULAR MODELLING AND DRUG DESIGN	2+2	I
BIF 517**/ ❻ MBB508	GENOMICS AND PROTEOMICS	2+1	I
BIF 518	PHARMACOGENOMICS AND IPR	2+1	II
BIF 591	MASTERõS SEMINAR	1	I, II
BIF 599	MASTERõS RESEARCH	20	

* Compulsory for Masterõs programme; ** May be taken as Minor/Supporting course

[@] Courses open to all PG students of other departments/colleges only

Minor Subject for BIF students ï Molecular Biology & Biotechnology or Biochemistry with BIF 504/BIOCHEM 501 and BIF 517/ MBB 508

Supporting Subject for BIF students ï STAT 532 and STAT 533

To be taught by: ❶ Molecular Biology, Biotechnology & Bioinformatics; ❷ Biochemistry; ❸ Statistics; ❹ Bioinformatics, Biochemistry, Molecular Biology & Biotechnology; ❺ Veterinary Microbiology; ❻ Bioinformatics, Molecular Biology & Biotechnology

BIOINFORMATICS

Course Structure

BIF 501/ MBB 555/ ABT 608 FSC 604 **INTRODUCTION TO BIOINFORMATICS** (To be taught jointly by Bioinformatics and Molecular Biology & Biotechnology) **2+1** **SEM - I**

Objective

To impart an introductory knowledge about the subject of Bioinformatics to the students studying any discipline of science.

Theory

UNIT-I: Introduction, biological databases ï primary, secondary and structural, Protein and Gene Information Resources ï PIR, SWISSPROT, PDB, GenBank, DDBJ. Specialized genomic resources.

UNIT-II: DNA sequence analysis, cDNA libraries and EST, EST analysis, pair wise alignment techniques, database searching, multiple sequence alignment.

UNIT-III: Secondary database searching, building search protocol, computer aided drug design ï basic principles, docking, QSAR.

UNIT-IV: Analysis packages ï commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

- Usage of NCBI resources
- Retrieval of sequence/structure from databases
- Visualization of structures
- Docking of ligand receptors
- BLAST exercises.

Suggested Readings

Attwood TK & Parry-Smith DJ. 2003. *Introduction to Bioinformatics*. Pearson Edu.

Rastogi SC, Mendiratta N & Rastogi P. 2004. *Bioinformatics: Concepts, Skills and Applications*. CBS.

BIF 502 **ADVANCED BIOINFORMATICS** **2+1** **SEM - I**

Objective

To understand the usage of advanced techniques in Bioinformatics.

Theory

UNIT-I: Biological databases, database hierarchies, sequence and structure databases. Pair wise sequence alignment and database similarity searching: global and local alignments, matrices, gap penalties and statistical significance.

UNIT-II: Multiple sequence alignment and phylogenetic analysis, Microarray technology: applications, analysis of data, clustering analysis. Pharmacogenomics: introduction, applications, Genome for medicine, current and future perspectives.

UNIT-III: System modeling and metabolomics ï concepts and principles. Nutrigenomics: system biology in nutrition and health arena.

UNIT-IV: Genome annotation, EST clustering, protein modeling and design.

Practical

- Development of small database
- Phylogenetic analysis
- Microarray data analysis (sample data from open sources)
- Other practical exercises based on above topics

Suggested Readings

Baxevanis AD & Ouellette BFF. 2001. *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*. Wiley Interscience.

Mount DW Cold. 2001. *Bioinformatics: Sequence and Genome Analysis*. Spring Harbor.

Stekel D. 2003. *Microarray Bioinformatics*. Cambridge University Press.

Tomita M & Nishioka T. 2005. *Metabolomics: The Frontier of Systems biology*. Springer Verlag.
Wong SHY. 2006. *Pharmacogenomics and Proteomics: Enabling the Practice of Personalized Medicine*. American Association for Clinical Chemistry.

BIF 503 TECHNIQUES IN BIOINFORMATICS 0+2 SEM - II

Objective

To explore the usage of various Open source software for Bioinformatics applications

Practical

UNIT-I: Gene Information Resources: GenBank, EMBL, Protein Information Resources: Swiss-Prot, BLOCKS, Gene Prediction Tools: GENSCAN, GRAIL.
UNIT-II: Structural Databases: PDB, CSD, RELIBASE, REBASE, File Format Converter Tools: BABEL, ReadSeq, NCBI Resources.
UNIT-III: Visualization tools ï RasMol, QMol, SwissPDB, Pymol, Modeling Tools: MODELLER, SwissPDB, Geno3D, Docking Tools: Chimera, Dock, AutoDock, GRAMM, Hex, Argus Lab.
UNIT-IV: Proteomics Tools: EXPASY, CDART, 3D-Structure Optimization Tools, Sequence Analysis Tools: BLAST, FASTA, EMBOSS, TCOFFEE, Phylogenetic Analysis Tools: Phylip, NTSYS, CLUSTALW/CLUSTALX, BIOEDIT.

Suggested Readings

Software Manuals and Help files.

BIF 504/ BIOCHEM 501 BASIC BIOCHEMISTRY 3+0 SEM - I, II

(To be taught by Biochemistry)

Objective

To provide elementary knowledge/overview of structure, functions and metabolism of biomolecules.

Theory

UNIT-I: Scope and importance of biochemistry in agriculture; acid base concept and buffers; pH; hydrogen bonding; hydrophobic, electrostatic and van der Waals forces; General introduction to physical techniques for determination of structure of biopolymers.
UNIT-II: Classification, structure and function of carbohydrates, lipids, amino acids, proteins, and nucleic acids; Biomembranes.
UNIT-III: Fundamentals of thermodynamics; Enzymes: classification, factors affecting enzyme activity, enzyme kinetics, Structure and biological functions of vitamins and hormones.
UNIT-IV: Metabolism of carbohydrates, lipids, proteins and nucleic acids. Mitochondrial Electron transport chain and oxidative phosphorylation; DNA replication, transcription and translation; recombinant DNA technology.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outlines of Biochemistry*. John Wiley.
Metzler DE. 2006. *Biochemistry*. Vols. I, II. Wiley International.
Nelson DL & Cox MM. 2004. *Lehninger Principles of Biochemistry*. 4th Ed. MacMillan.
Voet D, Voet JG & Pratt CW. 2007. *Fundamentals of Biochemistry*. John Wiley.

BIF 505/ STAT 532 STATISTICS FOR BIOLOGICAL SCIENCES 2+1 SEM - I

(To be taught by Statistics)

Objective

To understand the basic principles of statistics and mathematics and their applications in relation to Biological system.

Theory

UNIT-I: Introduction to Statistical Bioinformatics, Principles of sampling from a population; Random sampling.
UNIT-II: Frequency distributions: Graphical representations and Descriptive measures; Standard Probability Distributions; Correlation and regression analysis.
UNIT-III: Hypothesis testing; Markov Models, Cluster Analysis: Hierarchical and Non-Hierarchical methods.
UNIT-IV: Phylogenetic Analysis Tools: Maximum Likelihood, Parsimony methods.

Practical

- Computational exercises on Random Sampling
- Construction and representation of frequency distributions
- Descriptive measures
- Probability distribution

Suggested Readings

Gupta SC & Kapoor VK. 2000. *Fundamentals of Mathematical Statistics: A Modern Approach*. S. Chand & Co.

Warren JE & Gregory RG. 2005. *Statistical Methods in Bioinformatics*. Springer.

BIF 506 CONCEPTS IN COMPUTING 2+2 SEM - I

Objective

The objective of this course is to introduce the basic concepts of computing with introduction to OS, graphics, networking and client-server technologies.

Theory

UNIT-I: Fundamentals of Computing; Introduction to Operating Systems: WINDOWS, UNIX/Linux operating systems; Computer Security (hacking, cracking), Computer Viruses.

UNIT-II: Computer Graphics**:** Visualization techniques - Software and Hardware, Interactive Graphics; Viewing in three dimension; Raster algorithms; Rendering; Animation; Image Processing with emphasis on biological systems.

UNIT-III: Computer Networking, Security of the network, Fire-walls, Network Goals, Applications Network, Network architecture, Hierarchical networks, Ethernet and TCP/IP family of protocols.

UNIT-IV: Use of INTERNET and WWW, Internet services.

Practical

- MS-Windows
- Linux, UNIX
- Network design
- Internet search
- Graphics and animation

Suggested Readings

David FR. 1997. *Procedural Elements for Computer Graphics*. WCB/McGraw-Hill.

Foley JD & Van Dam A. 1982. *Fundamentals of Interactive Computer Graphics*. Addison-Wesley.

James FK & Keith WR. 2006. *Computer Networking: A Top-Down Approach Featuring the Internet*. Prentice Hall.

Siever E. 2005. *Linux in a Nutshell*. O'Reilly.

BIF 507 PROGRAMMING LANGUAGES FOR BIOINFORMATICS 2+2 SEM - I

Objective

Programming is a very significant area for bioinformatics and this course gives an understanding for logics of programming and command-line and graphical GDIs.

Theory

UNIT-I: Programming in C*:* Pointers, pointers to functions, macro programming in C, graphs, data structure - linked list, stack, queue, binary trees, threaded binary trees.

UNIT-II: File and exception handling in C, Programming in Visual Basic*:* Introduction to Application Development using Visual Basic; Working with Code and Forms.

UNIT-III: Variables, Procedures and Controlling Program Executor; Standard Controls; Data Access Using Data Control; Connecting to Database using VB.

UNIT-IV: Introduction to JAVA, variables, constants, control structures, input output, classes. Jar and Java applets.

Practical

- Programming in C and Visual basic with special reference to database linking
- Small Java applets

Suggested Readings

Brian WK & Ritchie DM. 1988. *C Programming Language*. Prentice Hall.

Kanetkar. 2002. *Let us C*. BPB Publ.

Microsoft Developers Network (MSDN Digital Library). 2006. Microsoft.

BIF 508/ MBB 502/ BIOCHEM 504 **FUNDAMENTALS OF MOLECULAR BIOLOGY** **3+0** **SEM - I**

(To be taught jointly by Bioinformatics, Biochemistry and Molecular Biology & Biotechnology)

Objective

To familiarize the students with the basic cellular processes at molecular level.

Theory

UNIT-I: Historical developments of molecular biology; nucleic acids as genetic material, chemistry, structure and properties of DNA and RNA.

UNIT-II: Genome organization in prokaryotes and eukaryotes; repetitive and non-repetitive DNA, satellite DNA; DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, nucleases and restriction enzymes; site directed mutagenesis, molecular mechanism of mutation, DNA repair mechanisms.

UNIT-III: Ribosomes structure and function, organization of ribosomal proteins and RNA genes, transcription, RNA editing, RNA processing, etc; Genetic code, aminoacyl tRNA synthasesô inhibitors of replication, transcription and translation.

UNIT-IV: Translation and post translational modifications; Regulation of gene expression in prokaryotes and eukaryotes.

Suggested Readings

Lewin B. 2008. *Gene IX*. Peterson Publications/ Panima.

Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publ.

Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. W.H. Freeman.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene*. 6th Ed. Pearson Edu. International.

BIF 509/ STAT 533 **MATHEMATICS FOR BIOLOGICAL SCIENCES** **2+0** **SEM - I**

(To be taught by Statistics)

Objective

To understand and apply fundamental concepts of mathematics as applicable in Biology and to acquaint about theoretical concepts of algebra and geometry and numerical methods.

Theory

UNIT-I: Coordinate geometry with basic concepts of 2D and 3D geometry, Vector algebra ï Addition and subtraction of vectors, Dot and cross product, Scalar triple product.

UNIT-II: Matrix algebra: basic definitions, matrix operations, transpose of a matrix, inverse of matrix, eigen values, Boolean algebra. Geometric and Arithmetic Progression.

UNIT-III: Solution of equation by bisection method, Iteration method, Newton Raphson method, numerical differentiation.

UNIT-IV: Numerical integration- Trapezoidal rule, Simpsonôs 1/3 and 3/8 rules, Runga Kutta method of nth order. Fast Fourier transformation.

Suggested Readings

Babu CA & Seshan CR. 2006. *New Engineering Mathematics*. Narosa Publ.

Datta KB. 2002. *Matrix and Linear Algebra*. Prentice Hall.

Narayan S. 1980. *Matrix Algebra*. S. Chand & Co.

Rao S. 2006. *Numerical Methods for Scientists and Engineers*. Prentice Hall.

BIF 510/ MBB 512/ BIOCHEM 506 **IMMUNOLOGY AND MOLECULAR DIAGNOSTICS** **2+1** **SEM - II**

(To be taught by Veterinary Microbiology)

Objective

To discuss the application of various immunological and molecular diagnostic tools.

Theory

UNIT-I: History and scope of immunology; Components of immune system: organs, tissues and cells, Immunoglobulin structure and functions; Molecular organization of immunoglobulins and classes of antibodies.

UNIT-II: Antibody diversity; antigens, haptens, antigen-antibody interactions; immunoregulation and tolerance; Allergies and other hypersensitive responses; Immunodeficiency; Vaccines.

UNIT-III: Application of immunology, immunological techniques, Principles of ELISA and its applications; Monoclonal antibodies and their uses, molecular diagnostics; Introduction to the basic principles of molecular technology and techniques used for pathogen detection.

UNIT-IV: Basics and procedures of PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing etc, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

- Preparation of buffers and reagents
- Serological tests such as bacterial slide agglutination, latex agglutination and agar gel immunodiffusion
- Immunoassays including ELISA, western blotting, and fluorescent antibody test
- Hybridoma technique for production of monoclonal antibodies
- Recombinant protein antigen- production and immunization of laboratory animals
- Extraction of DNA/RNA from pathogenic microorganisms, PCR, genotyping, diagnosis, etc.

Suggested Readings

Bloom BR & Lambert P-H. 2002. *The Vaccine Book*. Academic Press.

Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease*. Humana Press.

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby's Immunology*. WH Freeman.

Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.

Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.

Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology.* Elsevier.

Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.

Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.

Spinger TA, 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

BIF 511 INTRODUCTION TO DATABASE SYSTEMS 2+1 SEM - II

Objective

To familiarize the concept of RDBMS and to apply the database techniques to biological databanks.

Theory

UNIT-I: Data Abstraction; Data Models; Instances and Schemes; E-R Model - Entity and entity sets; Relations and relationship sets; E-R diagrams; Reducing E-R Diagrams to tables; Network Data Model: Basic concepts; Hierarchical Data Model: Basic Concepts.

UNIT-II: Multimedia Databases - Basic Concepts and Applications; Indexing and Hashing; Basic concepts (ISAM, B+ Tree indexed files, B Tree indexed files, Static Hash functions, Dynamic Hash functions); Text Databases; Introduction to Distributed Database Processing, Data Security.

UNIT-III: MySQL/MS-Access - Select Statements; Data Definition Statements; Data Manipulation Statements; Data Control Statements; Other Database Objects (Views, Sequences, Synonyms); Introduction to Application Development using Visual Basic; Working with Code and Forms; Variables.

UNIT-IV: Procedures and Controlling Program Executor; Standard Controls; Data Access Using Data Control; Connecting to Oracle Database using Visual Basic.

Practical

- Practical exercise using MySQL

- Design of database in MS-Access and MySQL
- Database linking

Suggested Readings

Date CJ. 1986. *Introduction to Database Systems*. Addison-Wesley.
Korth H & Silberschatz A. 2002. *Database System Concepts*. McGraw- Hill.
Martin D. 1986. *Advanced Database Techniques*. MIT Press.

BIF 512 COMPUTATIONAL AND SYSTEM BIOLOGY 2+2 SEM - II

Objective

To understand the computational aspects of structural biology; to familiarize the usage of software for 3D structures of nucleic acids and proteins and to translate the sequence to protein structure.

Theory

UNIT-I: Methods of single crystal X-ray Diffraction of macromolecules, NMR of macromolecules Anatomy of Proteins - Ramachandran plot, Secondary structures, Motifs, Domains, Tertiary and quaternary structures.

UNIT-II: Anatomy of DNA: A, B, Z DNA, DNA bending etc.; RNA structure; Structure of Ribosome; Principles of Protein Folding; Structural data banks - Protein Data Bank, Cambridge small molecular crystal structure data bank.

UNIT-III: Methods for Prediction of Secondary and Tertiary structures of Proteins, DNA, RNA, Fold recognition, *Ab initio* methods for structure prediction; Homology modeling, Methods for comparison of 3D structures of proteins.

UNIT-IV: Molecular interactions of Protein ï Protein with special reference to signal transduction and antigen-antibody interaction, Protein - DNA, Protein - carbohydrate, DNA - small molecules. System modeling and metabolomicsï concepts and principles.

Practical

- Usage of software for above topics
- Molecular Visualization tools: RasMol, QMol, Swiss PDB, Pymol
- Biomolecular Interaction Databases: BIND, DIP
- Structure Similarity Search Tools: CN3D, Vast Search

Suggested Readings

Fall CP. 2002. *Computational Cell Biology*. Springer.
Tsai CS. 2003. *Computational Biochemistry*. John Wiley & Sons.
Waterman MS. 1995. *Introduction to Computational Biology: Maps, Sequences and Genomes*. CRC Press.

BIF 513 BIOMOLECULAR SEQUENCE ANALYSIS 1+1 SEM - I

Objective

To understand the local and multiple alignment concepts and to carry out multiple sequence alignment.

Theory

UNIT-I: Analysis of protein and nucleic acid sequences, multiple alignment programs.

UNIT-II: Development of programs for analysis of nucleic acid sequences, Use of EMBOSS package.

UNIT-III: Phylogenetic analysis ï Elements of phylogenetic analysis, tree interpretation, tree data analysis, alignment ï building data model.

UNIT-IV: Extraction of phylogenetics data sets, Distance and character based methods.

Practical

- EMBOSS
- File Format Converter Tools: BABEL, ReadSeq
- Phylogenetic Analysis Tools: Phylip, NTSYS, PAUP
- CLUSTALW/CLUSTALX

Suggested Readings

Baxevanis AD & Ouellettee BFF. 2001. *Bioinformatics: a Practical Guide to the Analysis of Genes and Proteins*. Wiley Interscience.
Mount DW. 2001. *Bioinformatics: Sequence and Genome Analysis*. Spring Harbor, CSHL Press.
Nei M & Kumar S. 2000. *Molecular Evolution and Phylogenetics*. Oxford Univ. Press.

Salemi M & Vandamme AM. 2003. *The Phylogenetic Handbook – A Practical Approach to DNA and Protein Phylogeny*. Oxford Univ. Press.

BIF 514 DYNAMIC WEB-DESIGN 1+2 SEM - I

Objective

This course teaches the basic principles and application of various technologies used in creation of dynamic web content.

Theory

UNIT-I: *PERL:* Strings, Numbers, and Variables. Variable Interpolation, Basic Input and Output, File handles, Making Decisions, Conditional Blocks, Loops, Combining Loops with Input, Standard Input and Output, Finding the Length of a Sequence File.

UNIT-II: Pattern Matching, Extracting Patterns, Arrays, Arrays and Lists, Split and Join, Hashes, A Real-World Example, BioPERL; Applications.

UNIT-III: Creation, hosting and maintenance of web-site using HTML, XML, ASP, JSP.

UNIT-IV: Creation, hosting and maintenance of web-site PHP, PERL and CGI.

Practical

- Creation of Web-based applications, interactive and dynamic webpages
- Connecting databases using CGI scripting
- Creation and maintenance of web-sites using HTML, XML, ASP, PHP, PERL and CGI
- Retrieval of specific information from web-sites using CGI scripts

Suggested Readings

Moorhouse M & Barry P. 2004. *Bioinformatics, Biocomputing and Perl: An Introduction to Bioinformatics*. John Wiley & Sons.

Tisdall JD. 2001. *Beginning Perl for Bioinformatics*. O'Reilly.

BIF 515 BIOLOGICAL DATABANKS AND DATA MINING 1+2 SEM - II

Objective

To understand the biological databases ï types and formats and to learn the retrieval, deposition and analysis of sequences and structures from biological databanks.

Theory

UNIT-I: Data warehousing, data capture, data analysis; Introduction to Nucleic Acid and Protein Data Banks; Nucleic acid sequence data banks: Genbank, EMBL nucleotide sequence data bank.

UNIT-II: AIDS Virus sequence data bank, rRNA data bank, Protein sequence data banks: NBRF-PIR, SWISSPROT, Signal peptide data bank; Database Similarity Searches.

UNIT-III: BLAST, FASTA, PSI-BLAST algorithms; Pair wise sequence alignment - NEEDLEMAN and Wunsch, Smith Waterman algorithms; Multiple sequence alignments - CLUSTAL, Patterns, motifs and Profiles in sequences.

UNIT-IV: Derivation and searching; Derived Databases of patterns, motifs and profiles: Prosite, Blocks, Prints-S, Pfam, etc.; Primer Design.

Practical

- Gene Information Resources
- Protein Information Resources
- Structural Databases
- Sequence Analysis and Database Similarity Search Tools: BLAST, PHI-BLAST, PSI-BLAST, FASTA, EMBOSS, CLUSTAL, TCOFFEE
- Use of similarity, homology and alignment tools

Suggested Readings

Letovsky S. (Ed).1999. *Bioinformatics: Databases and Systems*. Kluwer.

LeÛn D & Markel S. 2003. *Sequence Analysis in a Nutshell: A Guide to Common Tools and Databases*. OÕReilly.

NCBI(www.ncbi.nlm.nih.gov).

PUBMED (www.pubmedcentral.nih.gov) and database web-sites.

BIF 516 MOLECULAR MODELLING AND DRUG DESIGN 2+2 SEM - I

Objective

To understand the Modelling of small molecules; to understand the computational chemistry principles and to familiarize the role of computers in drug-discovery process.

Theory

UNIT-I: Concepts of Molecular Modelling, Molecular structure and internal energy, Application of molecular graphics.

UNIT-II: Energy minimization of small molecules, Use of Force Fields and MM methods, Local and global energy minima. Techniques in MD and Monte Carlo. Simulation for conformational analysis, *Ab initio*, DFT and semiempirical methods.

UNIT-III: Design of ligands, Drug-receptor interactions, Classical SAR/QSAR, Docking of Molecules.

UNIT-IV: Role of computers in chemical research; Structure representation, SMILES; Chemical Databases, 2D and 3D structures, reaction databases, search techniques, similarity searches; Chemoinformatics tools for drug discovery.

Practical

- Modelling Tools: MODELLER, Geno3D
- Docking Tools: Chimera, Dock, AutoDock Tools, GRAMM, Hex, ArgusLab
- 3D-Structure Optimization Tools: CHEMSKETCH, CHEM 3D, ISIS Draw, CHEMDRAW

Suggested Readings

Bunin BA. 2006. *Chemoinformatics: Theory, Practice and Products*. Springer.

Gasteiger J & Engel T. 2003. *Chemoinformatics: A Textbook*. Wiley-VCH.

Hinchliffe A. 2003. *Molecular Modelling for Beginners*. John Wiley & Sons.

Leach AR. 1996. *Molecular Modelling: Principles and Applications*. Longman.

BIF 517/ MBB 508 **GENOMICS AND PROTEOMICS** **2+1** **SEM - I**

(To be taught jointly by Bioinformatics and Molecular Biology & Biotechnology)

Objective

To familiarize the students about the genomic and proteomic concepts and usage of various algorithms and programmes in analysis of genomic and proteomic data.

Theory

UNIT-I: Genomics: Whole genome analysis and comparative genomics, classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly and annotation.

UNIT-II: Functional genomics: Candidate gene identification, DNA chips, Mutants and RNAi, Metabolomics for elucidating metabolic pathways, etc.

UNIT-III: Proteomics - Introduction to basic proteomics technology, Bio-informatics in Proteomics, Gene to Protein Function: a Roundtrip, Proteome analysis.

UNIT-IV: Linkage analysis, genotyping analysis, pharmacogenomics, human/plant genome and science after genomic era; Applications of genomics and proteomics in agriculture, human health and industry.

Practical

- Gene Prediction Tools: GENSCAN, GRAIL, FGENESH
- NCBI Genomic Resources
- Proteomics Tools: EXPASY, CDART

Suggested Readings

Azuaje F & Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*. John Wiley & Sons.

Brown TA. 2007. *Genome III*. Garland Science Publ.

Campbell AM & Heyer L. 2004. *Discovery Genomics, Proteomics and Bioinformatics*. Pearson Edu.

Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.

Jollès P & Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.

Kamp RM. 2004. *Methods in Proteome and Protein Analysis*. Springer.

Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.

Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II. Wiley CVH.

BIF 518 PHARMACOGENOMICS AND IPR 2+1 SEM - II

Objective

To understand the translation of Bioinformatics into commercial gains; to familiarize the concepts of microarray ï data acquisition and analysis and learn the IPR issues in Biological sciences with special emphasis on bioinformatics.

Theory

UNIT-I: Bioinformatics companies, Genomes, transcriptomes and proteomes ï their applications in medicine and agriculture, disease monitoring, profile for therapeutic molecular targeting.

UNIT-II: Diagnostic drug discovery and genomics. Pharmacogenomics and its application. SNPs and their applications. Microarray and genome wide expression analysis: Introduction to basic microarray technology, Bioinformatics in microarrays, Getting started ï target selection.

UNIT-III: Customised microarray design, Image processing and quantification, Normalization and filtering, Exploratory statistical analysis, Public Microarray data resources.

UNIT-IV: Patenting and data generation from patent literature for commercial benefits. IPR, and bioinformatics. Bioinformatics patents.

Practical

- Microarray Analysis Tools: MAGICTool
- Stanford Microarray Database
- Gene Expression Omnibus
- Creation of an On-line company

Suggested Readings

Blalock EM. 2003. *A Beginner's Guide to Microarrays*. Springer.

Catania M. 2006. *An A-Z Guide to Pharmacogenomics*. American Association for Clinical Chemistry.

Chakraborty C & Bhattachary A. 2005. *Pharmacogenomics.* Biotech Books.

Stekel D. 2003. *Microarray Bioinformatics*. Cambridge University Press.

BIOINFORMATICS

List of Journals

- Bioinformatics - Oxford University Press
- BMC Bioinformatics - BioMed Central
- Briefings in Bioinformatics - Oxford University Press
- Briefings in Functional Genomics and Proteomics - Oxford University Press
- Computers in Biology and Medicine ï Elsevier
- Journal of Bioinformatics and Computational Biology (JBCB) ï World Scientific Publishers
- Journal of Biomedical Informatics ï Elsevier
- Journal of Computational Biology - Mary Ann Liebert, Inc. publishers
- Journal of Molecular Modelling ï Springer
- Nucleic Acids Research ï Oxford Press
- Protein Engineering, Design and Selection *(PEDS)* ï Oxford Press

e-Resources

- Bioinformatics.Org: The Open-Access Institute - http://bioinformatics.org/
- European Molecular Biology Network - http://www.embnet.org/
- European Bioinformatics Institute -http://www.ebi.ac.uk/
- The European Molecular Biology Laboratory - http://www.embl.org/
- International Society for Computational Biology - http://www.iscb.org/
- National Center for Biotechnology Information - http://www.ncbi.nlm.nih.gov/
- ExPASy Proteomics Server - http://us.expasy.org/
- Mouse Genome Informatics - http://www.informatics.jax.org/
- Center for Molecular Modeling - http://cmm.info.nih.gov/modeling/
- RCSB PDB - http://www.rcsb.org/pdb
- Bioinformatics resources - http://www.biochem.ucl.ac.uk/bsm/BCSB/bioinfo_resources/bioinform_res.htm
- South African National Bioinformatics Institute - http://www.sanbi.ac.za/
- Swiss Institute of Bioinformatics - http://www.isb-sib.ch/
- Protein Structure Prediction Center - http://predictioncenter.llnl.gov/
- Programs for Genomic Applications -http://www.nhlbi.nih.gov/resources/pga/
- Computational Molecular Biology At NIH - http://molbio.info.nih.gov/molbio/
- Gene Ontology Home - http://www.geneontology.org/
- All About The Human Genome Project (HGP) - http://www.genome.gov/
- UCSC Genome Browser - http://genome.ucsc.edu/

BOTANY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
BOT 501*	ALGAE	2+1	I
BOT 502*	ARCHEGONIATE	2+1	I
BOT 503*	MORPHOLOGY, MORPHOGENESIS AND TAXONOMY OF ANGIOSPERMS	3+1	I
BOT 504*	PLANT EMBRYOLOGY	2+1	II
BOT 505*	PLANT ANATOMY	2+1	II
BOT 506*	PLANT ECOLOGY	2+1	II
BOT 507	ECONOMIC BOTANY	2+1	II
BOT 591	MASTERôS SEMINAR	1	I, II
BOT 599	MASTERôS RESEARCH	20	I, II
BOT 601**	REPRODUCTIVE BIOLOGY OF ANGIOSPERMS	2+1	I
BOT 602	APPLIED PLANT EMBRYOLOGY	3+1	II
BOT 603	CONTEMPORARY PLANT ANATOMY	2+1	I
BOT 604	ADVANCED PLANT ECOLOGY	2+1	II
BOT 605	RECENT TOPICS IN BOTANY	3+0	I
BOT 691	DOCTORAL SEMINAR I	1	I, II
BOT 692	DOCTORAL SEMINAR II	1	I, II
BOT 699	DOCTORAL RESEARCH	45	I, II
SERVICE COURSE			
VSC 506	SYSTEMATIC OF VEGETABLE CROPS (IN PART)	1+1	I

*Compulsory for Masterôs programme; **Compulsory for Doctoral programme
Courses open to students of other departments/colleges: BOT 503 to BOT 507

BOTANY

Course Contents

BOT 501 ALGAE 2+1 SEM - I

Objective

The objective of this course is to acquaint the learner with biodiversity among the members of algae. The focus is on comparative morphology and reproduction study at the class level and their phylogeny and evolutionary relationship.

Theory

UNIT-I: General introduction, brief history and classification of algae.

UNIT-II: A comparative morphology- Habit and habitat, range of thallus structure, cellular organization, and general course of reproduction met within the algae.

UNIT-III: Cyanophyceae and Chlorophyceae- occurrence, thallus organization, mode of reproduction and phylogeny.

UNIT-IV: Bacillariophyceae and Xanthophyceae- Distinguishing characters, thallus and cell organization, reproduction and phylogeny.

UNIT-V: Phaeophyceae and Rhodophyceae- Distinguishing characters, comparative morphology and thallus organization, reproduction and phylogeny.

UNIT-VI: Evolutionary tendency of thallus and origin of sex in algae.

UNIT-VII: Economic importance of algae.

Practical

Examination of representative genera of algae to study their morphology and reproductive structures, field collection and observation

Suggested Readings

Fritsh FE . 1979. *The Structure and Reproduction of Algae*. Vols. I-II. Vikas Publ. House.

Kumar HD & Singh HN. 1982. *A Text Book of Algae*. Affiliated East-West Press (Reprint, 1990).

Morris I. 1968. *An Introduction to Algae.* Cambridge Univ. Press.

Prescott GW. 1965. *The Algae: A Review*. Thomas Nelson & Sons.

Sambamurty AVSS. 2005. *A Text Book of Algae*. IK International Pvt. Ltd.

Smith GM . 1955. *Cryptogamic Botany*. Vols. I-II. Tata McGraw Hill.

BOT 502 ARCHEGONIATE 2+1 SEM - I

Objective

To familiarize the students with biodiversity among the members of archegoniate. The focus is on comparative study of life cycles, phylogeny and evolutionary trends and inter-linkages.

Theory

UNIT-I: Introduction, general characters and classification of Bryophytes.

UNIT-II: Life history, important characters, phylogeny, evolutionary trends and inter-linkages among Bryophytes. Takakiales, Calobryales, Jungermanniales, Metzeriales, Sphaerocarpales, Monocleales, Marchantiales, Anthocerotales, Sphagnales, Andreales, Funariales, Buxbaumiales, Polytrichales, Dawsoniales.

UNIT-III: Introduction, general characters and classification of Pteridophytes and inter-linkage with Bryophytes. Life history, important characters, phylogeny, evolutionary trends and inter-linkages among Pteridophytes. Psilophytales, Psilotales, Lycopodiales, Selaginellales, Heterospory and origin of seed habit, Equisetales, Marattiales, Ophioglossales, Filicales, organization of stele.

UNIT-IV: Introduction, general characters, classification of gymnosperms and inter-linkage with Pteridophytes. Life cycle, important characters, phylogeny, evolutionary trends and inter-linkage among Gymnosperms. Pteridospermales, Bennettitales, Pentoxylales, Cordaitales, Cycadales, Ginkgoales, Coniferales, Taxales, Gnetales.

Practical

Study of structure and morphology of vegetative and reproductive organs of the representative species of above classes.

Suggested Readings

Bhatnagar SP & Mitra A. 1996. *Gymnosperms*. New Age.

Biswas C & Johri BM. 1997. *The Gymnosperms*. Narosa.
Parihar NS. 1963. *An Introduction to Embryophyta. Vol. I Bryophyta*. Central Book Depot.
Parihar NS. 1965. *An Introduction to Embryophyta. Vol. II Pteridophyta*. Central Book Depot.
Sambamurty AVSS. 2005. *A Text Book Bryophytes, Peridophytes, Gymnosperm and Paleobotany*. IK International Pvt. Ltd.
Sporne KR. 1965. *The Morphology of Gymnosperm*. IB Publ.
Sporne KR. 1975. *The Morphology of Pteridophytes*. IB Publ.

BOT 503 MORPHOLOGY, MORPHOGENESIS AND TAXONOMY OF ANGIOSPERMS 3+1 SEM - I

Objective

The objective of this course is to acquaint the learner with the concepts of plant organs development, rules, regulations and tools of angiosperms taxonomy.

Theory

UNIT-I: Concepts of morphology of flower and its different parts, their phylogeny and evolutionary tendencies. Morphogenesis of plant organs.

UNIT-II: Principles of Taxonomyï Taxonomic structure, hierarchy, concept of species. Classificationï types and historical development of classificatory systems. Plant character, kind and nature of characters and character weighting.

UNIT-III: Nomenclature- vernacular names, polynomials and binomial nomenclature, codes of nomenclature, ICBN and its preamble and major rules.

UNIT-IV: Systematic position of some selected families on the basis of phylogeny and their economic importance.

UNIT-V: Chemotaxonomy, cytotaxonomy and palynology in relation to taxonomy.

UNIT-VI: Numerical taxonomy.

Practical

Study of characters of representative genera in the laboratory and field, herbarium collection.

Suggested Readings

Cutter EG. 1969. *Plant Anatomy, Experiment and Interpretation, Part I, Cell and Tissue*. Edward Arnold.
Cutter EG. 1971. *Plant Anatomy, Experiment and Interpretation, Part II, Organs*. Edward Arnold.
Lawrence GHM. 1951. *Taxonomy of Vascular Plants*. MacMillan.
Shukla P & Misra SP. 1995. *An Introduction to Taxonomy of Angiosperms*. Vikas Publ. House.
Singh V & Jain DK. 1981. *Taxonomy of Angiosperms*. Rastogi Publ.
Wardlaw CM. 1968. *Morphogenesis in Plants*. Methuen.

BOT 504 PLANT EMBRYOLOGY 2+1 SEM - II

Objective

The course aims at providing basic knowledge of structural, developmental and functional aspects of microsporogenesis, megasporogenesis and embryogenesis. Focus is also on barriers to fertilization, apomixis and *in vitro* culture of sexual explants.

Theory

UNIT-I: History of plant embryology, development and structure of microsporangium, development and structure of male gametophyte, pollen physiology, pollen preservation and male sterility.

UNIT-II: Development and structure of ovule/megasporangium, development and structure of female gametophytes.

UNIT-III: Pollination, fertilization, self-incompatibility, development of endosperm, embryo and seed.

UNIT-IV: Polyembryony and apomixis, parthenocarpy and parthenogenesis.

UNIT-V: *In vitro* culture of embryo, embryo rescue after wide hybridization and its application, anther and pollen, somatic hybridization, endosperm culture and production of triploids.

Practical

Study of micro- and mega-sporogenesis, embryo, endosperm and seed coat through dissection and microtomy, embryo and anther culture.

Suggested Readings

Bhojwani S.S. & Bhatnagar S.P. 1992. *The Embryology of Angiosperms*. Vikas Publ. House.

Maheshwari P. 1960. *Embryology of Angiosperms*. McGraw Hill.

Stanley R.G. & Linskens H.F. 1974. *Pollen: Biology, Biochemistry Management*. Springer-Verlag.

BOT 505 PLANT ANATOMY 2+1 SEM - II

Objective

The objective of this course is to acquaint the learner with the internal structure and development of plant organs.

Theory

UNIT-I: Structure and development of cell wall layers, pits and chemical nature of cell wall.

UNIT-II: Apical meristemï different theories and cellular differentiation.

UNITS III: Cambiumï its organization, structure, cell division and growth and seasonal activity. Structure and formation of secondary tissue ï xylem and phloem, annual rings, sap and heart wood.

UNIT-IV: Periderm, commercial cork, bark and rhytidome and anomalous secondary growth.

UNIT-V: Abscission- mechanism and its hormonal control.

UNIT-VI: Vascular transition between root and shoot.

UNIT-VII: Anatomy in relation to taxonomy.

Practical

Study of anatomy of root, stem, leaf and flower through microtomy, maceration and clearing technique. Study of normal and abnormal secondary growth.

Suggested Readings

Esau K. 1965. *Plant Anatomy*. 2nd Ed. Wiley Eastern.

Pandey BP. 1993. *Plant Anatomy.* S. Chand & Co.

BOT 506 PLANT ECOLOGY 2+1 SEM - II

Objective

The objective of this course is to develop an understanding of the level of biological organization, fundamentals of ecosystem and plant communities.

Theory

UNIT-I: Definitions and different levels of biological organization.

UNIT-II: Ecosystem concept, components of ecosystem- producers, consumers, detrivores and decomposers. Trophic structure- trophic levels, food chain, food web, ecological pyramids.

UNIT-III: Functions of ecosystem- energy flow, productivity and biogeochemical cycling.

UNIT-IV: Classification of ecosystem- natural and artificial ecosystem, agro-ecosystem, terrestrial and aquatic ecosystem.

UNIT-V: Habitat and niche, plant enviroment.

UNIT-VI: Ecological adaptations, population ecology, ecotypes and ecads.

UNIT-VII: Plant communities, ecological succession- kinds and process of natural succession, serial and climax communities.

UNIT-VIII: Enviromental pollution- air, water and soil- sources, effects and methods of control. Conservation and management of resources.

Practical

Measurement of climatic and edaphic factors; quantitative and qualitative analysis of vegetation.

Suggested Readings

Ambasht RS. 1990. *A Text Book of Plant Ecology*. Students Friends & Company.

Kormondy EJ. 2000. *Concepts of Ecology*. Prentice Hall.

Sharma PD. 1997. *Ecology and Environment*. Rastogi Publ.

BOT 507 ECONOMIC BOTANY 2+1 SEM - II

Objective

To acquaint the learner with the different plant resources for welfare of human beings.

Theory

UNIT-I: Plant sources of diversity and their global distribution, Vavilovian law and parallel variation.

UNIT-II: Quarantine principles, method of introduction and acclimatization.

UNIT-III: Origin, distribution, classification and utilization of crops of following groupsï cereals, pulses, fibers and sugar.

UNIT-IV: Sources of forest products and cultivation- tannins and dyes, gums and resins, rubber and latex and paper pulp.

UNIT-V: Study of important fumigatories, masticatories and beverages such as tobacco, betel, areca nut, tea, coffee and cocoa.

UNIT-VI: Botanical name, family, plant parts and yield of ingredient of the important medicinal plants.

UNIT-VII: Brief account of non-traditional economic plants- jojoba and guayale.

UNIT-VIII: Utilization of byproducts of cropsï cotton stalks, paddy husks and coconut fibers.

Practical

Study of plant specimens of economic importance and their acquaintance with their products. Exploration, collection and preservation of economically important plants and their products.

Suggested Readings

Hill AF. 1952. *Economic Botany*. 2nd Ed. McGraw-Hill.

Kochar SL. 1981. *Economic Botany in the Tropics*. MacMillan.

Pandey BP. 1992. *Economic Botany*. S. Chand & Co.

BOT 601 REPRODUCTIVE BIOLOGY OF ANGIOSPERMS 2+1 SEM - I

Objective

The course aims at providing update knowledge of ultrastructural and functional aspects of development of male, female gametophytes, endosperm and embryo in addition to pollination, fertilization, apomixis and self-incompatibility.

Theory

UNIT-I: Ultrastructural aspects of anther development and microsporogenesis, ultrastructural studies in relation to development of male gametophyte and mechanism of tip growth of pollen tube, metabolic constituents of pollen and their significance in relation to germination.

UNIT-II: Ultrastructural aspects of development of ovule and megasporogenesis, discussion on distribution of callose and its significance during megasporogenesis and female gametophyte development, ultrastructural studies in relation to development of embryo sac and concept of female germ unit.

UNIT-III: Pollination, concept of co-evolution of biotic pollinators and floral morphs.

UNIT-IV: Ultrastructure and types of stigma and style, pollen-pistil interaction, path of pollen tube and current concepts of directionality of tube growth, double fertilization and its significance.

UNIT-V: Plant reproduction under environmental stresses.

UNIT-VI: Morphogenesis of endosperm and its structural adaptations in relation to its nutritive role, ultrastructural changes in egg associated with fertilization and preparation to embryo development. Types of embryogenesis. Ultrastructural details of embryo suspensor, seed coat development.

UNIT-VII: Polyembryony- its origin, causes, experimental induction and practical value, parthenocarpy- types, mechanism and artificial induction.

UNIT-VIII: Apomixis-causes and significance,self-incompatibility and its molecular basis.

Practical

Developmental studies of pollen, embryo, fruit and seed of selected crop plants through dissection, microtomy, clearing technique and histochemical tests.

Suggested Readings

Johri BM.1984. *Embryology of Angiosperms*. Springer Verlag.

Raghavan V. 1997. *Molecular Embryology of Flowering Plants*. Cambridge Univ. Press.

Shivanna KR & Johri BM. 1985. *The Angiosperm Pollen, Structure and Function*. Wiley Eastern.
Shivanna KR & Sawhney VK. 1997. *Pollen Biotechnology for Crop Production and Improvement*. Cambridge Univ. Press.

BOT 602 APPLIED PLANT EMBRYOLOGY 3+1 SEM - II

Objective

The focus is to acquaint the learner with the applied aspects of plant embryology and *in vitro* culture of reproductive explants in relation to crop improvement.

Theory

UNIT-I: Pollen collection- purpose, quantities available, factors affecting pollen availability. Methods of collection, pollen preservation- concept, principle, methods of preservation, causes of decreased viability, methods of testing viability, biochemical constituents of pollen and their significance, nutritive requirements of pollen germination, factors affecting germination.

UNIT-II: Pollen allergen- plant sources, chemistry of allergen, preparation of extract, human reactions- skin test, provocation test and histamine release test, persorption.

UNIT-III: Male sterility- types, genetical and biochemical basis of sterility, male sterility through recombinant DNA technology, chemical induction of male sterility, and use of sterility in hybrid programme.

UNIT-IV: *In vitro* pollination and implications in crop improvement, *In vitro* culture of anthers, and pollen and its techniques, pollen embryos, their morphogenesis into plants, diplodization, uses of haploids in crop improvement programme, *In vitro* culture of young embryos and endosperm-nutritional requirements, its application, embryo-endosperm relationship, organogenesis, factors affecting growth and differentiation.

UNIT-V: Protoplast culture, embryogenesis and regeneration, protoplast fusion and somatic hybridization, induction of somaclonal variations and its practical utility.

UNIT-VI: *In vitro* methods applicable to agriculture crops, forest trees, medicinal plants and biosynthesis of secondary metabolites.

UNIT-VII: Assignments on current topics of applied plant embryology.

Practical

Studies of different methods of pollen collection and preservation, culturing of anthers, pollen and young embryos using various culturing media and study of differentiation and development.

Suggested Readings

Johri BM. 1982. *Experimental Embryology of Vascular Plants*. Narosa.
Ottaviano E, Mulcahy DL, Sari-Gorla M & Mulacahy GB. 1992. *Angiosperm Pollen and Ovules*. Springer Verlag.
Raghavan V. 1997. *Molecular Embryology of Flowering Plants*. Cambridge Univ. Press.
Shivanna KR & Sawhney VK. 1997. *Pollen Biotechnology for Crop Production and Improvement*. Cambridge Univ. Press.

BOT 603 CONTEMPORARY PLANT ANATOMY 2+1 SEM - I

Objective

The objective of this course is to acquaint the learner with contemporary advancements in plant anatomy.

Theory

UNIT-I*:* Ultrastructure in relation to growth and differentiation in plants.

UNIT-II: Study of development and factors controlling the development of cell, tissue and organ and environmental and nutritional factors in relation to structure and development of plant tissue and organ.

UNIT-III: Experimental studies in relation to differentiation of meristem, xylem and phloem.

UNIT-IV: Origin, distribution and functions of secretary structures and wound healing.

UNIT-V: Studies of compatible and incompatible graft union.

UNIT-VI: Developmental anatomy of fruits and seeds.

Practical

Study of structure of cell wall and anatomy of various plant organs through histochemical methods and clearing, maceration and microtome preparation.

Suggested Readings

Fahn A. 1967. *Plant Anatomy*. Pergamon Press.
Wardlaw CM. 1968. *Morphogenesis in Plants*. Methuen.

BOT 604 ADVANCED PLANT ECOLOGY 2+1 SEM - II

Objective

The objective of this course is to acquaint with the advanced knowledge of the plant-environment interactions, biodiversity and its conservation.

Theory

UNIT-I: Principles of ecosystem, energy dynamics and stability.
UNIT-II: Limiting factors and plant community.
UNIT-III: Environmental factors in relation to plant growth, competition, conditions and prevalent factors in arid and semiarid regions of India. Systems analysis.
UNIT-IV: World biota, floristic regions of India and biodiversity.
UNIT-V: Plant and soil conservation.
UNIT-VI: Environmental pollution and plant growth.

Practical

Detailed study of vegetation in different environmental conditions, study of stabilization of sand dunes in relation to survival, productivity, competition and succession.

Suggested Readings

Kormondy EJ. 2000. *Concepts of Ecology*. Prentice Hall.
Negi SS. 1993. *Biodiversity and its Conservation in India*. Indus Publ. Co.
Odum EP. 1983. *Basic Ecology*. Saunders.

BOT 605 RECENT TOPICS IN BOTANY 3+0 SEM - I

Objective

To acquaint the learner with contemporary advancement in different fields of Botany.

Theory

UNIT-I: Synthetic seeds, cryopreservation- principles and its application.
UNIT-II: Gene expression in regulating meristem functions.
UNIT-III: Pollen expressed genes and their regulation, pollen pigments, signal transduction during fertilization, isolation of sexual units and *in vitro* fertilization.
UNIT-IV: Atmospheric ozone and its impact on plants, Global warming.
UNIT-V: Ecological implication of genetically modified crops, biodiversity in relation to WTO.

Suggested Readings

Bensen EE. 1995. *Plant Conservation Biotechnology- Cryopreservation. In: Biotechnology in Agriculture and Forestry* (Ed. YPS Bajaj) Vol. XXXII. Springer Verlag.
Kartha KK. 1985. *Cryopreservation of Plant Cells and Organs*. CRC Press.
Kormondy EJ. 2000. *Concepts of Ecology*. Prentice Hall.
Taiz L & Zieger E. 2006. *Plant Physiolog*. 2nd Ed. Sinauer Associates.

BOTANY

List of Journals

- American Journal of Botany
- Annals of Botany
- Biologia Plantarum
- Canadian Journal of Plant Sciences
- Canadian Journal of Botany
- Current Science
- *In vitro* Cellular & Developmental Biology - Plant
- Indian Journal of Agricultural Sciences
- Indian Journal of Plant Physiology
- Indian Journal of Biotechnology
- Journal of Experimental Biology
- Journal of Experimental Botany
- Journal of Indian Botanical Society
- Nature
- Physiologia Plantarum
- Phytomorphology
- Plant Science
- Plant Cell Biotechnology and Molecular Biology
- Plant Cell Reports
- Plant Cell,Tissue and Organ Culture
- Planta
- Proceedings Indian Academy of Sciences (Plant Sciences)
- Proceedings National Academy Sciences (USA)
- Science

Broad Topics for Master's and Doctoral Research

- Reproductive biology of crop plants under abiotic stress
- Isolation and characteristics of stress tolerance cell lines in culture
- Micro propagationï medicinal and ornamental plants
- Differentiation in callus culture and secondary metabolites
- Anatomical studies in relation to stress and morphogenesis
- Eco-physiology
- Ecology of plants of semi-arid areas
- Any other topic related to contemporary study in botany

CHEMISTRY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
CHEM 501	QUANTUM CHEMISTRY STATISTICAL MECHANICS	3+0	I
CHEM 502*	THERMODYNAMICS	2+0	II
CHEM 503*	CHEMICAL KINETICS AND SURFACE CHEMISTRY	2+0	I
CHEM 504	SPECTROSCOPY	2+1	I
CHEM 505	EXPERIMENTS IN PHYSICAL CHEMISTRY	0+2	I
CHEM 506	GENERAL PHYSICAL AND COLLOIDAL CHEMISTRY	3+0	II
CHEM 507	CHEMISTRY OF POLYMERS	3+0	I
CHEM 508*	BASIC CONCEPTS OF INORGANIC CHEMISTRY	2+0	I
CHEM 509	CHEMISTRY OF TRANSITION METALS	2+1	II
CHEM 510*	COORDINATION CHEMISTRY, REACTION MECHANISM AND INORGANIC POLYMERS	2+1	I
CHEM 511	NUCLEAR CHEMISTRY	3+0	II
CHEM 512*	PHYSICAL ORGANIC CHEMISTRY	2+0	I
CHEM 513	REACTIONS, REAGENTS AND PHOTOCHEMISTRY	3+0	II
CHEM 514*	NATURAL PRODUCT CHEMISTRY	2+0	I
CHEM 515	DRUGS AND DYES	3+0	II
CHEM 516	BIO-ORGANIC CHEMISTRY	3+0	II
CHEM 517	SYNTHESIS AND CHARACTERIZATION OF ORGANIC COMPOUNDS	0+2	II
CHEM 518	CHEMISTRY OF PESTICIDES	2+1	II
CHEM 519	PHYSICAL CHEMISTRY	3+0	I
CHEM 520	INORGANIC CHEMISTRY	3+0	II
CHEM 521	ORGANIC CHEMISTRY	2+1	I
CHEM 591	MASTERôS SEMINAR	1	1, II
CHEM 599	MASTERôS RESEARCH	20	I, II
CHEM 601** CHEM 602** OR CHEM 603** CHEM 604** OR CHEM 605** CHEM 606*	TOPICS OF CURRENT INTEREST ADVANCED PHYSICAL CHEMISTRY ORGANO-METALLIC CHEMISTRY BIOINORGANIC CHEMISTRY ORGANIC SYNTHESIS SPECTROSCOPY IN ORGANIC CHEMISTRY	3+0 3+0 3+0 3+0 3+0 3+0	I II I II I II
CHEM 607	CONSTITUTION OF INORGANIC COMPOUNDS AND DYNAMICS OF INORGANIC REACTIONS	3+0	I
CHEM 608	GREEN CHEMISTRY	2+0	II
CHEM 691	DOCTORAL SEMINAR I	1	I, II
CHEM 692	DOCTORAL SEMINAR II	1	I, II
CHEM 699	DOCTORAL RESEARCH	45	I, II
SERVICE COURSES			
CHEM 522***	GENERAL CHEMISTRY	3+0	I
CHEM 523***	CHEMISTRY OF CLOTHING MATERIALS	2+2	II

*Compulsory for Masterôs programme; ** Compulsory for Doctoral programme (Students have to take at least 3 courses of 600 series with one pair out of Chem-601 & 602, Chem-603 & 604 and Chem-605 & 606 as compulsory and third course from either any remaining pair or from Chem-607 and Chem-608).

Students opting Chemistry as minor/supporting subject must take one course as pre-requisite (non-credit) from Chem-519, Chem-520 and Chem-521. For Home Science PG students as minor/supporting credit courses pre-requisite Chem-519, Chem-520 and Chem-521 not required.

*** For Home Science PG students as minor/supporting credit courses.

CHEMISTRY

Course Contents

CHEM 501 QUANTUM CHEMISTRY-STATISTICAL MECHANICS 3+0 SEM - I

Objective

To acquaint the students regarding the basic concept of quantum chemistry, atomic spectra, Boltzmann distribution function and Bose-Einstein statistics.

Theory

UNIT-I: Historiocal background and the postulates of quantum mechanics; mathematical consideration and solution of hydrogen.

UNIT-II: Atomic structure approximate methods and atomic spectra.

UNIT-III: Boltzmann distribution function; general relationships translational, rotational and vibrational motions, equilibrium constants.

UNIT-IV: Application of partition functions.

UNIT-V: Bose-Einstein statistics and Fermi-Dirac statistics, application to radiation and electron gas in metals.

Suggested Readings

Atkin PW. 1996. *Elements of Physical Chemistry.* Oxford Univ. Press.

Glasstone S. 1968. *A Text Book of Physical Chemistry*. MacMillan Press.

CHEM 502 THERMODYNAMICS 2+0 SEM - II

Objective

This Course will impart knowledge to students about the concepts of thermodynamics, involvement of heat in different chemical and biological processes.

Theory

UNIT-I: Brief resume of the concepts of free energy, entropy and laws of thermodynamics, partial molar properties; thermodynamics of ideal and real gases and gas mixtures.

UNIT-II: Thermodynamics of ideal and non-ideal binary solutions; activities and activity coefficients of electrolytes.

UNIT-III: Derivation of phase rule and its application to multi-component systems; non-equilibrium thermodynamis entropy.production in irreversible process. Phenomenological equations.

UNIT-IV: Membrane permeability, membrane transport involving biochemical reactions, phenomonological equation in non-linear regions.

UNIT-V: Thermodynamics of living systems, metabolic and biosynthetic reactions, ATP production during biochemical process of various types, applications of irreversible thermodynamics in biological processes.

Suggested Readings

Atkin. PW. 1996. *Elements of Physical Chemistry.* Oxford Univ. Press.

Glasstone S. 1968. A *Text Book of Physical Chemistry*. The MacMillan Press.

CHEM 503 CHEMICAL KINETICS AND SURFACE CHEMISTRY 2+0 SEM - I

Objective

By learning chemical kinetics and surface chemistry, students will be able to learn the kinetics and mechanism of different types of reactions, distribution law, phase rule and partial molar volume etc.

Theory

UNIT-I: Theories of reaction rates, collisions theory, transition state theory, theory of unimolecular reactions-Lindemann`s mechanism; rate constants of fast reactions - relaxations, stop-flow and flash photolysis techniques.

UNIT-II: Mechanism of free radical reactions, hydrogen-bromine reaction, photochemical decomposition, polymerisation, explosion, ionic reactions.

UNIT-III: Complex reactions-electron transfer reactions, consecutive, opposing reactions; kinetics of catalytic reactions, acid base catalysis, effect of pH and salt effects.
UNIT-IV: Enzyme, catalysis: adsorption-types of adsorption . Freundlich`s adsorption isotherm, Langmuirs adsorption isotherm and its limitations.
UNIT-V: B.E.T adsorption isotherm; chemi sorption, kinetics of surface reaction and their mechanism.

Suggested Readings

Atkin PW. 1996. *Elements of Physical Chemistry.* Oxford Univ. Press.
Gurtu JN. 1990 *Chemical Kinetics*. Pragati Prakashan, Meerut.

CHEM 504 SPECTROSCOPY 2+1 SEM - I

Objective

Spectroscopy is an important tool to determine the structures of molecules. This course will impart knowledge to the students about the NMR, Raman and laser spectroscopy.

Theory

UNIT-I: Molecular structure-molecular orbital methods for H2+ and H2 molecule; the valence bond description of H2; electron spin functions; correlation diagram for diatomic molecules.
UNIT-II: Huckel method for calculating resonance energy; rotation and vibration of molecules-linear and non-linear molecules, derivations of energy levels, selection rules.
UNIT-III: Rotational vibrational spectroscopy-rotational and vibrational level corrections; electron spectroscopy.
UNIT-IV: Raman Spectroscopy. Laser Raman spectroscopy.
UNIT-V: Nuclear Magnetic Resonance Spectroscopy; FTNMR.

Practical

Applications of spectroscopy for structural studies.

Suggested Readings

Dyre John R. 1984. *IR Spectroscopy.* Prentice Hall of India.
Jagmohan 2000. *Organic Spectroscopy.* Narosa.
William Camp 1987. *Organic Spectroscopy.* ELBS. Longman.

CHEM 505 EXPERIMENTS IN PHYSICAL CHEMISTRY 0+2 SEM - I

Objective

An exclusive practical course to teach the students about the different analytical techniques like potentiometry, refractometry, polarography, flame photometry and chromatography etc.

Practical

Conductivity; potentiometry; pH metry, polarography; amperometric titration, Spectrophotometry: flame-photometry; Refractometry; cryoscopic and ebulliosopic measurements; Chromatography, Distribution Law; Measurement of viscosity.

Suggested Readings

Salzberg Morrow 1988. *Experiments in Physical Chemistry*. Academic Press.
Viswanathan R. 1993. *Practical Physical Chemistry*. Indian Book Co.

CHEM 506 GENERAL PHYSICAL AND COLLOIDAL CHEMISTRY 3+0 SEM - II

Objective

It is important to know the basic concepts of general physical chemistry and colloidal chemistry. This course will impart knowledge to students about physical and Colloidal Chemistry.

Theory

UNIT-I: Thermochemistry: Heat changes at constant pressure and constant volume.Thermochemical laws, and Kirchoff`s equation.
UNIT-II: Chemical Equilibrium: Introduction, chemical equilibrium constant, thermodynamic derivation of law of chemical equilibrium. Vant Hoff equation. Experimental methods. Catalysis.
UNIT-III: Kinetics: First and second order reactions.Electrochemistry: phenomena of electrolysis, Faraday`s Laws of electrolysis, conductance of electrolytes.

UNIT-IV: Theory of electrolytes, migration of ions, transport number. Simple treatment of e.m.f of cell. Pits measurement by indicatory and electrometric methods. Control and utility of pH in textile wet processing. Electrochemical theory of corrosion.

UNIT-V: Colloid Chemistry: Theoretical properties of colloidal systems, intrerfacial phenomena, practice kinetics, electrical properties, viscosity. Lyophobic and lyophilic solutions, gels and emulsions developed from above properties.

Suggested Readings

Atkin PW. 1996. *Elements of Physical Chemistry*. Oxford Univ. Press.
Mahan BH. 1978. *University Chemistry*. Indian Book Co.

CHEM 507 CHEMISTRY OF POLYMERS 3+0 SEM - I

Objective

Objective of this course is to teach the students about the chemistry of some important polymer, techniques of polymerization and application of polymerization.

Theory

UNIT-I: Classification of polymers, molecular weights, physical properties of polymers, mechanism of polymerization.

UNIT-II: Chemistry of some industrially important polymers.

UNIT-III: Epoxy and phenolic resins. Copolymerisation.

UNIT-IV: Techniques of polymerisation. Appliction of polymers to textiles.

UNIT-V: Essential properties of fibre forming polymers. Structure and degradation products of cellulose and their determination.

Suggested Readings

Heymour 1975. *Polymer Chemistry.* ELBS.
James E Marck 1989. *Inorganic Polymers*. John Wiley.
Kricheldorf H. *et al*. 2005. *Handbook of Polymer Synthesis*. 2nd Ed. CRC Press.
Ravve A. 2000. *Principles of Polymer Chemistry*. 2nd Ed. Kluwer.
Sandler & Karo W. 1991. *Polymer Syntheses*. 2nd Ed. Vol. I. Academic Press.

CHEM 508 BASIC CONCEPTS OF INORGANIC CHEMISTRY 2+0 SEM - I

Objective

Objective of this course is to teach the students about the basic concepts of inorganic chemistry, Wave function, s, p, d, f, VB, MO and VSEPR theories, inorganic free radicals.

Theory

UNIT-I: Review of the atomic structure-wave mechanical approach, wave functions for hydrogen atom, radial distribution curves for s, p, d and f orbitals, angular wave functions for s, p, d and f orbitals-their significance and use.

UNIT-II: Slater-type orbitals;effective nuclear charge; use of radial distribution curves to explain order of filing of orbitals in many electron system; review of chemical bond.

UNIT-III: Application of VB,MO and VSEPR theories in explaining the structure of simple molecules.

UNIT-IV: Rules for classification of molecules into point groups, group multiplication tables, degenerate and non-degenerate point groups, rules for fundamental vibrations.

UNIT-V: Inorganic free radicals-their general reactions, preparation and uses; measurement of free radical concentration and decomposition rate.

Suggested Readings

Cotton FA & Wilkinson G. 1977. *Advanced Inorganic Chemistry*. John Wiley.
Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry*. S. Nagin & Co.

CHEM 509 CHEMISTRY OF TRANSITION METALS 2+1 SEM - II

Objective

To acquaint the students regarding the different physical and chemical properties of transitional metal.

Theory

UNIT-I: Transition elements-Hundôs rule and spectroscopic energy states; magnetism in transition meta chemistry orgin and nature of paramagnetism, diamagnetism, erromagnetism and anti-ferro-magnetism.

UNIT-II: Magnetic susceptibility and magnetic moment calculations, elements of 2nd and 3rd row transition series; chemistry of iso- and heteropolyacids and anions of Mo and W; the metal -metal bonds.

UNIT-III: General remarks on different physical and chemical properties .compunds with two centered metal meta bonds; metal clusters, occurrence, electronic structure, oxidation states, stereo chemistry.

UNIT-IV: Magnetic and spectral properties of lanthanideôs and actinides; lanthanides contraction, separation of lanthanides and actinides.

UNIT-V: Chemistry of rare elements francium, technitium, rehenium.

Practical

Potentimetric determination of formation constants of 3d-series transition metal ions.

Suggested Readings

Earshaw & Harrington 1990. *Chemistry of Transitional Elements*. John Wiley & Sons.
Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry*. S. Nagin & Co.

CHEM 510 CO-ORDINATION CHEMISTRY, REACTION MECHANISM AND INORGANIC POLYMERS 2+1 SEM - I

Objective

This will impart knowledge to the students about the bonding in coordination compounds, their mechanisms and properties of inorganic polymers.

Theory

UNIT-I: The theories of bonding in coordination compunds -valence bond theory, electroneutrality principle and back-bonding, crystal field theory and its application for understanding magnetic and spectral properties of metal complexes, structural effects of crystal field splitting (ionic radii, Jahn-Teller effect).

UNIT-II: Thermodynamical effects of crystal field splitting (hydration, ligation and lattice energies). Limitations of crystal field theory; adjusted crystal field theory (ligand field theory); appplictiom of molecular orbital theory of square planar, tetrahedral and octahedral complexes; stability of complexes-methods of determination.

UNIT-III: Factors influencing stability; substitution reactions in octahedral complexes and associated stereochemical changes, redox reactions in coordination compounds and their mechanism.

UNIT-IV: Transition metal complexes of pi acceptor ligands; inorganic polymers based upon homoatomic and heteroatomic structures.

UNIT-V: Polymers containing boron and nitrogen, addition polymers of borazines, Polymeric phosphorus compounds and condensed phosphates.

Practical

Preparation of inorganic complexes like Co{Hg(SCN) 4], Hg[Co(SCN) 4], Co(NH3)5Cl]Cl2, [Cu(Gly)2], Preparation of [Co(NH3)5NO2]Cl2, [Co(acae)3], K4[Co2(C2O4)4(OH)2], K2[Cu(C2O4)2], [Co(NH3)4]SO4 and Na3 [Co(NO2)6], Determination of magnetic characteristic of above complexes, Analysis of alloys using conventional physical and chemical techniques, Complexometric titrations.

Suggested Readings

James E Marck 1989. *Inorganic Polymers*. John Wiley & Sons.
Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry.* S. Nagin & Co.
Wilson J. 1989. *New Methods of Analytical Chemistry.* Prentice Hall.

CHEM 511 NUCLEAR CHEMISTRY 3+0 SEM - II

Objective

This course will impart knowledge to the students regarding the nuclear particles, disintegration series, half life, radio isotopes-their production and application in industries, agriculture, medicines and research.

Theory

UNIT-I: Nuclear particles-stable and unstable; nuclear binding energy and mass defect; nuclear forces and stability-shell and liquid drop models; natural and artificial radio-activity.

UNIT-II: Disintegration series, disintegration rate and half life; types of nuclear reactions-nuclear fission and nuclear fusion.

UNIT-III: Radio isotopes-their production and application in industry, agriculture, medicine and research.

UNIT-IV: Principle of working of GM counters and scintillation counters; types of nuclear reactors; nuclear wastes and their disposal.

UNIT-V: Boranes preparation, structure and bonding, borane anions and carboranes, metal complexes of carborane anions, boranes with hetero atoms other than carbon.

Suggested Readings

Harvey BG 1985. *Nuclear Chemistry.* Prentice Hall.

Karl Heinrich Lieser 2001. *Nuclear and Radiochemistry: Fundamentals and Applications.* Wiley VCH.

Lefort M. 1996. *Nuclear Chemistry*. D. Van Nostrad Co.

CHEM 512 PHYSICAL ORGANIC CHEMISTRY 2+0 SEM - I

Objective

To acquaint the students regarding the stereo chemistry of the molecule, cofuguration, conformation, reaction intermediates and tracer techniques etc.

Theory

UNIT-I: Stereochemistry and conformation analysis-conformation and configuration, geometrical and optical isomers, methods of resolution, asymmetric synthesis.

UNIT-II: ORD and CD; aromaticy; steric effects; reactive intermediates, carbocations, carbanions, free radicals, carbenes, arynes, nitrenes.

UNIT-III: Organic reaction mechanism: substitution, addition, elimination and rearrangement reactions.

UNIT-IV: Substituent isotope solvent and kinetic salt effects, tracer technique. Hamett equation, non-classical carbonium ions.

UNIT-V: Neighbourning group participation; pericyclic reactions and molecular orbital symmetry.

Suggested Readings

Finar IL. 1969. *Organic Chemistry.* EBLS Longman.

Morrison RT & Boyd RN. 1969. *Organic Chemistry*. Prentice Hall.

CHEM 513 REACTIONS, REAGENTS AND PHOTOCHEMISTRY 3+0 SEM - II

Objective

To understand reactions, reagents and photochemistry, is very important. By learning this course students will learn regarding the reaction mechanism of different name reactions, reagents and about the reactions which proceed by light.

Theory

UNIT-I: Backman, Claisen, Fries, Wagner-Meerwein rearrangement; Claisen condensation, Dieckmann, Reformatsky, Curtius, Friedel-crafts, Mannich, Michael, Pekin.

UNIT-II: Kolbes, Reimer Tiemann, Hofmann, diels Alder, Arndt Eistert, Wittig reactions, Aldol condensation, Benzilic acid and Benzidine rearrangements, Acetoacetic, malonic ester and Grignard syntheses.

UNIT-III: Reagents in organic syntheses- Cu, CuX, Zn, Mg, Li, ZnCl2 AlCl3 aluminum alkoxide, LiAlH4, Na, RONa, Ni, SeO2, BX3, NaBH4, CH2 N2,HIO4.

UNIT-IV: Organiometallic compounds.

UNIT-V: Photochemistry-Energy levels, quantum yield, photochemistry of simple organic molecules, Barton reaction.

Suggested Readings

Finar IL. 1969. *Organic Chemistry*. EBLS Longman.

Singh SP & Mukherjee M. 1992. *Organic Chemistry*. Wiley Eastern.

CHEM 514 NATURAL PRODUCT CHEMISTRY 2+0 SEM - I

Objective

Objective of this course is to impart the knowledge to the students about the isolation, structure determination and chemical properties of different type of natural products-like alkaloids, terpenea flavones coumarins etc.

Theory

UNIT-I: Structures and syntheses of terpenes-geraneol, citral amyrins, a-terpeneol, a -pinene, camphor, squalene and abietic acid; isoprene rule; biogenesis of mono, di-and tri terpenoids.

UNIT-II: Synthesis and biogenesis of ß-carotene, steroidscholesterol ergosterol, sex hormones, progesterone, testosterone, cortisone; plant hormones: auxin B and A, kinetin, abscisic acid, gibberllins.

UNIT-III: Alkaloids- general structural determination, atropine, quinine, reserpine, morphine, nicotine, epherdrine, cocaine.

UNIT-IV: Acetogenins-anthocyanins,flavones, flavonols, isoflavones, quinones, chalcones.

UNIT-V: Coumarins, euxanthones, biogenesis of flavonoids; porphyrins, haemin, chlorophyll; structures of starch and cellulose.

Suggested Readings

Aggarwal OP. 1984. *Natural Product Chemistry*. Goel Publ. House.

Finar IL. 1969. *Organic Chemistry.* EBLS Longman.

Kalsi PS. 1983. *Chemistry of Natural Product*. Kalyani Publ.

CHEM 515 DRUGS AND DYES 3+0 SEM - II

Objective

The objective of this course is to impart knowledge to the students regarding the principles of drug design and QSAR, Chemistry of antibiotics,antimalarials, CNS depressant, sedatives analgesic anticancer agents etc. and dyes.

Theory

UNIT-I: Principles of drugs design and QSAR; chemistry of antibiotics, sulpha drugs, antimalarials, anthelmantics.

UNIT-II: CNS depresants and stimulants, hypnotics, sedatives, tranquilisers, analeptics, hellucinogens, diuretics.

UNIT-III: CVS agents, antiallergic, analgesics, anti-inflammatory.

UNIT-IV: Antifertility and anticancer agents, prostaglandins and vitamins.

UNIT-V: Chemistry of some important classes of dyes; colour and chemical constitution.

Suggested Readings

Ashutosh Kar 1993. *Medicinal Chemistry*. Wiley Eastern.

Chatwal GR. 1984. *Synthetic Organic Chemistry*. Himalya Publ.

Foy D & Williams DA. 1995. *Principles of Medicinal Chemistry.* Lippincott Williams & Wilkins.

Thomas L Lemke, David A Williams & Victoria F Roche.2008. *Foye's Principles of Medicinal Chemistry*. Lippincott Williams & Wilkins.

CHEM 516 BIO-ORGANIC CHEMISTRY 3+0 SEM - II

Objective

To acquaint the students about the structure and function of biomolecules like proteins and enzymes etc.

Theory

UNIT-I: Structures and functions of biomolecules in living system. Elementary structure and function of proteins and nucleic acids.

UNIT-II: Bioorganic chemistry of aminoacids and phosphates.

UNIT-III: Mechanism of enzyme action, enzyme models, host-guest complexation chemistry, Enzyme inhibitory reactions.

UNIT-IV: Enzyme design using steroid template and remote functionalisation.

UNIT-V: Chemistry of lipids and membranes, transport phenomenon, ionophores. Structure and function of cell membrane.

Suggested Readings

Calvin M. 1984. *Bioorganic Chemistry.* WH Freeman.

Dugas H Penhes 1976. *Bio Organic Chemistry.* Springer Verlag.

CHEM 517 SYNTHESIS AND CHARACTERIZATION OF ORGANIC COMPOUNDS 0+2 SEM - II

Objective

By learning this course students will learn about the techniques used in separation and identification of organic compounds.

Practical

UNIT-I: Separation and identification of the components of a binary organic mixture.
UNIT-II: Synthetic preparations involving two steps.
UNIT-III: Quantitative analysis of phenol, aniline.
UNIT-IV: Quantitative analysis of sulphur, nitrogen.
UNIT-V: Isolation experiments.

Suggested Readings

Clark HT. 1971. *Organic Analysis*. Orient Longman.
Vishnoi NK. 1985. *Advanced Practical Organic Chemistry.* Vani Educational Books, Delhi.
Vogel IL.1969. *A Text Book of Practical Organic Chemistry*. ELBS Longman.

CHEM 518 CHEMISTRY OF PESTICIDES 2+1 SEM - II

Objective

Objective of this course is to teach the students about the details of pesticides, testing of pesticidal formulations from point of view of their quality etc.

Theory

UNIT-I: Classification of pesticides on the basis of function, mode of entry and mode of action; chemistry and structural activity relationship of different pesticidal compounds.
UNIT-II: Insecticides-organochlorines, organo-phosphates, carbamates, pyrethrtoids, rotenones and stereochemistry of botanicals.
UNIT-III : Fungicides-Inorganics, dithiocarbamates, phthalimides-organophosphates, diazoles and Exathions.
UNIT-IV: Herbicides-phenoxy compounds, substituted ureas, sulfynyl ureas, triazenes, bipyridylium compounds and dinitroanilines.
UNIT-V: Metabolic pathways of some important compounds of each chemical group.

Practical

Testing of pesticidal formulations from point of view of their quality; Estimation of active principles of pesticides employing different analytical techniques in different matrices, Determination of pesticide residues in different commodities by GLC.

Suggested Readings

György Matolcsy, Miklós Nádasy, Viktor 1988. *Pesticide Chemistry*. Elsevier.
Handa SK. 2000. *Principles of Pesticide Chemistry*. Agrobios.
Kenneth A Hassall 1982. *The Chemistry of Pesticides*. Verlag Chemie.
Perry AS. *Insecticides in Agriculture, Environment and Perspective.* Springer Verlag.
Unger TA. 1996. *Pesticide Synthesis Handbook*. William Andrew.
Weinheim, F.R.G. Matsmura.1980. *Text Book on Insecticides*. CRC Press.

CHEM 519 PHYSICAL CHEMISTRY 3+0 SEM - I

Objective

To acquaint the student about the different orders of different reactions; thermodynamics and elctrochemistry.

Theory

UNIT-I: Reaction kinetics-rate equation, order of the reaction, reaction rate theories.
UNIT-II: Laws of thermodynamics, enthalpy, entropy, free energy, heat capacity, partialmolar quantities etc.
UNIT-III: Electrochemistry, electrochemical cells, oxidation reduction potential.
UNIT-IV: Activity, ionic strength and determination of activity coefficients.

Suggested Readings

Glasstone S. 1968. *Text Book of Phyical Chemistry*. The MacMillan Press.
Gurdeep Raj 1988. *Advanced Physical Chemistry*. Krishna Publ., Meerut.

CHEM 520 INORGANIC CHEMISTRY 3+0 SEM - II

Objective

Objective of this course is to teach the students about inorganic chemistry.

Theory

UNIT-I: Quantum mechanical concept of atomic structure, determination of groups, state terms of free atoms and ions.

UNIT-II: Wave mechanical concept, Schrodinger wave equation and its significance.

UNIT-III: Review of chemical bond, valence bond and molecular orbital theories of covalent bond.

UNIT-IV:Hybridization; electron deficient compounds; acids and bases-review of Arrhenius and Bronsted-Lowry theories, Lewis concept, Usanovich concept.

Suggested Readings

Cotton & Wilkinson 1977. *Advanced Inorganic Chemistry*. John Wiley.

CHEM 521 ORGANIC CHEMISTRY 2+1 SEM - I

Objective

To acquaint the students about the different natural products and heterocyclics.

Theory

UNIT-I: Classification, general properties, method of isolatoion and structural elucidation of natural products such as terpenes.

UNIT-II: Steroids, alkaloids and carbohydrates.

UNIT-III: Heterocyclics.

UNIT-IV:Rubber; physical concepts of organic chemistry.

Practical

Identification and preparation of organic compounds.

Suggested Readings

Finar IL. 1969. *Organic Chemistry*. ELBS Longman.

CHEM 522 GENERAL CHEMISTRY 3+0 SEM - I

(For H. Sc. as credit course)

Objective

The course will impart knowledge to the students regarding general chemistry.

Theory

UNIT-I: Idea of inductive, electromeric and mesomeric effects hyperconjugation and hybridisation.

UNIT-II: Introduction to nucleophilic and electrophilic substitution reactions. Substitution reactions of free radicals.

UNIT-III: Electrophilic and nucleophilic addition reactions. Mechanism of elimination reaction (E1, E2).

UNIT-IV: Structural, geometrical and optical isomerism, chirality, elements of symmetry.

UNIT-V: Transition metal complexes: Basic concepts and their applications to complexes of tetrahedral and octahedral geometry. Complexes containing metal-carbon bonds.

UNIT-VI: Wetting agents, cross-linking agents, finishing and printing agents. Soaps and detergents: General properties and analysis.

Suggested Readings

Peterskyes. 1966. *Reaction Mechanism of Organic Chemistry*. ELBS.

Chatwal JR. 1984. *Synthetic Organic Chemistry.* Himalaya Publ.

CHEM 523 CHEMISTRY OF CLOTHING MATERIALS 2+2 SEM - II

(For H.Sc. as credit course)

Objective

This course will impart knowledge to the students about the chemistry of clothing materials.

Theory

UNIT-I: Classification and chemistry of dyes and their intermediates.

UNIT-II: Colour and chemical constitution.

UNIT-III: Chemistry and application of dyes for man made and natural fibres. Theory of dyeing, photochemistry of dyes.
UNIT-IV: Optical brightening agents.
UNIT-V: Chemistry of pigments. Mechanism of dyeing on specified fibres.

Pactical

Identification of intermediates and derivatives used in dyes. Preparation and isolation of dyes. Determination of copper number, methylene number and carboxylic group in degraded cellulose.

Suggested Readings

Chatwal, JR. 1984. *Chemistry of Dyes*. Himalaya Publ.

CHEM 601 TOPICS OF CURRENT INTEREST 3+0 SEM - I

Objective

This course will impart knowledge to the students regarding the details of polymer chemistry, catalyst and solid state chemistry.

Theory

UNIT-I: Chemicals that produce monomers, monomer polymerization, phase transfer in monomers, characterization.
UNIT-II: Macromolecules: Polyacetal, polyaldehydes, polyalkylenes, polyamino and polycarbonates.
UNIT-III: Catalysis: Polymerization catalysis, catalyst support, clay compounds, basic catalysts, autoexhaust catalysis and curing agents.
UNIT-IV: Solid state chemistry: Crystallographic system, polymorphism , spacelattice and attraction and repulsion.

Suggested Readings

Charles E Carraher Jr. 2005. *Seymour/Carraher's Polymer Chemistry.* Marcel Decker.
Gurdeep Raj 1988. *Advanced Physical Chemistry*. Krishna Publ., Meerut.
Seymour RB.1978. *Polymer Chemistry*. Academic Press.

CHEM 602 ADVANCED PHYSICAL CHEMISTRY 3+0 SEM - II

Objective

After going through this course students will be able to learn the detail of the application of computer in chemistry, advanced quantum mechanics and spectroscopy.

Theory

UNIT-I: Application of computers in Chemistry.
UNIT-II: Advanced quantum mechanics.
UNIT-III: Spectroscopy-II.
UNIT-IV: Solid state chemistry.

Suggested Readings

Glasstone S. 1968. *Text Book of Phyical Chemistry*. The MacMillan Press.
Gurdeep Raj 1988. *Advanced Physical Chemistry*. Krishna Prakashan, Meerut.
William Camp 1987. *Organic Spectroscopy*. ELBS Longman.
Selected reviews and articles from Journals/Periodicals.

CHEM 603 ORGANOMETALLIC CHEMISTRY 3+0 SEM - I

Objective

The objective of this course is to acquaint the students regarding the Synthesis, structure and properties of organometallic compounds.

Theory

UNIT-I: Introduction, synthesis and structure of metal alkyls, metal aryls, metal carbonyls, metal carbenes and metal carbines.
UNIT-II: Complexes with chain *pi* donor ligands and cyclic *pi* donor ligands; reaction pathways-association reactions.
UNIT-III: Substitution reactions, addition and elimination reactions, rearrangement reactions.
UNIT-IV: Catalysis involving organometallic compounds-olefin hydrogenation, hydroformylation, the Wacker process.
UNIT-V: Polymerization, the Fischer-Trospsch process, cyclo-oligomerisetion of olefins and acetylenes etc.

Suggested Readings

Chatwal G & Yadav HS. *Organometallic Chemistry.* Krishna Prakashan, Meerut.
Finar IL. 1969. *Organic Chemistry.* ELBS Longman.

CHEM 604 BIO-INORGANIC CHEMISTRY 3+0 SEM - II

Objective

This course will impart knowledge to the students about the inorganic elements in biological system, their importance and mechanism of electron transfer reaction.

Theory

UNIT-I: Inorganic elements in biological systems; importance of alkali and alkaline earth metals, ions and ligands affecting the stability of complexes.

UNIT-II: Coordinating sites in biologically important ligands such as purines, pyrimidines, nucleosides, nucleotides, amino-acids and peptides.

UNIT-III: Metalloenzymes and metal activated enzyme, metal complexes as oxygen carriers-haemoglobin, myoglobin; nonporphyrin.

UNIT-IV: Oxygen carriers-hemocyanin and hermarythrin; synthetic oxygen carriers non-redox metallo-enzymes.

UNIT-V: Mechanism of electron transfer reactions in metal complexes as drugs and anticancer agents.

Suggested Readings

Gurdeep Raj 1988. *Advanced Physical Chemistry.* Krishna Prakashan.

Miessler GL. 1992. *Inorganic Chemistry*. Pearson Edu.

Puri BR & Sharma LR. 1985. *Principles of Inorganic Chemistry*. S. Nagin & Co.

CHEM 605 ORGANIC SYNTHESIS 3+0 SEM - I

Objective

By learning this course students will acquaint about the synthesis of different heterocyclic compounds and different types of polymerizationreactions.

Theory

UNIT-I: Synthesis and synthetic equivalents, formation of C-C, C-N and C-halogen bonds, Multi step synthetic strategy and catalysis, 3-7 membered heterocycles.

UNIT-II: Synthesis and reactivity of furan, thiophene, pyrrole, pyridine, quinoline, isoquinoline and indole.

UNIT-III: Skraup synthesis, Fisher indole synthesis.

UNIT-IV: Natural and synthetic polymers.

UNIT-V: Different types of polymerization reactions, rubber, nylon and polyester.

Suggested Readings

Finar IL. 1969. *Organic Chemistry*. ELBS Longman.

Ireland RE. 1988. *Organic Synthesis*. Prentice Hall.

CHEM 606 SPECTROSCOPY IN ORGANIC CHEMISTRY 3+0 SEM - II

Objective

The objective of this course is to impart knowledge to the students regarding the latest spectroscopic techniques like 13CNMR, 15NNMR, 19FNMR, GCMS, FABMS, UV and IR.

Theory

UNIT-I: UV-principle, solvents and their effects, chromophores, auxochromes, effect of conjugation, absorptions in polyenes , dienes, haloketones, enones, aldehydes, unsaturated acids, esters, benzenoid aromatics, heterocycles.

UNIT-II: IR-absorption process, functional group and finger print regions, combination and overtone bands, Fermi resonance interpretation.

UNIT-III: 1H NMR-principle, resonance, chemical shifts, shielding and deshielding, equivalence of protons, splitting, n+1 rule, coupling constant, interpretations, shift reagents.

UNIT-IV: Ideas of 13C NMR, 15N NMR,19F NMR , 31P NMR, MS-metastable ion, nitrogen rule, molecular mass determination, reaction pathways, fragmentation patterns, retro Diels Alder fission, McLafferty rearrangement, fragmentation in hydrocarbons, alcohols, phenols, ethers, aldehydes, isomer, ester, carboxylic acids, amines, nitro,amides, nitriles.

UNIT-V: GCMS, CIMS, FABMS; Electron Spin Resonance (ESR).

Suggested Readings

Jag Mohan 2000. *Organic Spectroscopy*. Narosa Publ.

Silverstein S. 1977. *Spectroscopic Identification of Organic Compounds*. John Wiley & Sons.

William Camp 1987. *Organic Spectroscopy.* ELBS Longman.

CHEM 607 CONSTITUTION OF INORGANIC COMPOUNDS AND DYNAMICS OF INORGANIC REACTIONS 3+0 SEM - I

Objective

By learning this course the students will be able to understand the symmetry of crystals, classes, structure and X-ray diffraction etc.

Theory

UNIT-I: Symmetry of crystals, crystal system, classes of crystals, types of lattices, lattice energy, point group and space groups, symmetry parameters, defects in solids.

UNIT-II: Structure of some typical binary and ternary compounds, structure of silicates, polyacids and their salts.

UNIT-III: Introduction to determination of crystal structure by Xray diffraction, electron diffraction and neutron diffraction techniques.

UNIT-IV: Thermodynamics.

UNIT-V: Kinetics and spontaneity of reaction, Frost diagram and its relation to spontaneity and application in the prediction of chemical reactions.

Suggested Readings

Cotton & Wilkinson 1977. *Advanced Inorganic Chemistry*. John Wiley.

Glasstone S. 1968. *Text Book of Physical Chemistry*. The MacMillan Press.

CHEM 608 GREEN CHEMISTRY 2+0 SEM - II

Objective

The objective of this course is to impart knowledge to the students about the chemistry and chemical technology of different environmental issues.

Theory

UNIT-I: Concept of green chemistry. Chemistry and Chemical Technology of Waste, pollution, effluent and other environmental issue which are caused by chemical manufacturing.

UNIT-II: Novel synthetic techniques. Organic reactions involving reduction of raw material/solvent usage, milder operating conditions.

UNIT-III: Use of catalyst towards green chemistry. Reactions that uses heterogeneous or homogeneous catalyst leading to green scenario. Use of Bio catalyst in reactions which make environment clean and friendly. Use of new reagents and solvents which are benign, environmentally friendly. Method of benign synthesis.

UNIT-IV: Energy and renewable resources. Alternate energy sources. Use of renewable raw material includes ethanol & biodieset etc.

UNIT-V: Inharent safly processes that are milder: use of less toxic solvents, do not produce dangerous intermediate, side products, chemicals: Industrial examples.

Suggested Readings

Doble M & Kumar A. 2007. *Green Chemistry & Engineering.* Elsevier.

Gilberts M.M 1997. *Introduction to Environmental Engineering and Science.* Prentice Hall.

CHEMISTRY

List of Journals

- Accounts of Chemical Research
- ACS Chemical Biology
- Analytical Chemistry
- Bioconjugate Chemistry
- Bulletin of the Chemical Society of Japan (Chemical Society of Japan)
- Chemical and Engineering News
- Chemical Health and Safety
- Chemical Innovation (formerly CHEMTECH) (ceased publ. December 2001)
- Chemical Research in Toxicology
- Chemical Reviews
- Chemistry Letters
- Chemistry of Materials
- Crystal Growth and Design
- Energy and Fuels
- Environmental Science and Technology
- Industrial and Engineering Chemistry Research
- Inorganic Chemistry
- Journal of Agricultural and Food Chemistry
- Journal of Chemical and Engineering Data
- Journal of Chemical Education
- Journal of Chemical Information and Computer Science (now Journal of Chemical Information and Modeling and Journal of Chemical Theory and Computation)
- Journal of Chemical Information and Modeling
- Journal of Chemical Theory and Computation
- Journal of Combinatorial Chemistry
- Journal of Medicinal Chemistry
- Journal of Natural Products
- Journal of Organic Chemistry
- Journal of Physical and Chemical Reference Data (Now distributed by the AIP)
- Journal of Physical Chemistry A
- Journal of Physical Chemistry B
- Journal of Physical Chemistry C
- Journal of the American Chemical Society
- Langmuir
- Macromolecules
- Modern Drug Discovery
- Molecular Pharmaceutics
- Nano Letters
- Organic Letters
- Organic Process Research and Development
- Organometallics
- Today's Chemist at Work

e-Resources

- http://library.olivet.edu/pubserv/ins/chemistry/index.html
- http://www.chemistry.org/portal/Chemistry
- http://www.chemweb.com/
- http://www.iupac.org/dhtml_home.html
- http://www.atsdr.cdc.gov/

- http://chemfinder.cambridgesoft.com/
- http://www.cdc.gov/niosh/npg/npg.html
- http://ull.chemistry.uakron.edu/erd/
- http://physchem.ox.ac.uk/MSDS/
- http://www.energy.gov/
- http://www.pnl.gov/energyscience/
- http://www.epa..gov
- http://webbook.nist.gov/chemistry/
- http://physics.nist.gov/cuu
- http://physics.nist.gov/PhysRefData/Elements/cover.html
- http://www.chemsoc.org/viselements/
- http://www.webelements.com/
- http://www.americanelements.com/
- http://www.stanford.edu/~glassman/chem/index.htm
- http://www.shef.ac.uk/~chem/chemputer/
- http://antoine.frostburg.edu/chem/senese/101/index.shtml
- http://lrc-srvr.mps.ohio-state.edu/under/chemed/chemed.htm
- http://www.chem.purdue.edu/gchelp/vsepr/
- http://www.chemistry.ohio-state.edu/organic/flashcards/
- http://www.monomerchem.com/display4.html
- http://www.chemhelper.com/
- http://www.ilpi.com/organomet/index.html
- http://www.organicworldwide.net/tutorial.html
- http://www.cis.rit.edu/htbooks/nmr/bnmr.htm
- http://web.umr.edu/~jstoffer/Spectroscopy/protonNMR.html
- http://www.spectroscopynow.com/Spy/basehtml/SpyH/
- http://science.widener.edu/svb/molecule/molecule.html
- http://info.bio.cmu.edu/courses/biochemmols/bcmolecules.html
- http://www.umass.edu/microbio/rasmol/
- http://www.cnn.com/TECH/space/
- http://www.newscientist.com/
- http://www.sciencedaily.com/
- http://www.sciencemag.org/netwatch/
- http://www.sciencenews.org/
- http://dailynews.yahoo.com/h/sc
- http://www.akiti.ca/
- http://www.nobel.se/chemistry/
- http://www.chemistry.co.nz/stain_frame.htm
- http://www.twinkiesproject.com

Suggested Broad Research Areas for Master's and Doctoral Research

- Natural Products Chemistry
- Bioefficacy of chemical compounds
- Development of Agro chemicals
- Synthetic chemistry
- Environmental studies: chemical and physical aspect
- Synthesis of chemicals using microwaves

MICROBIOLOGY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
MICRO 501*	PRINCIPLES OF MICROBIOLOGY	3+1	I
MICRO 502*	MICROBIAL PHYSIOLOGY AND METABOLISM	3+1	II
MICRO 503*	MICROBIAL GENETICS	2+1	I
MICRO 504*/ ❶ SOILS 506	SOIL MICROBIOLOGY	2+1	I
MICRO 505/MBB506*	MICROBIAL BIOTECHNOLOGY	2+1	II
MICRO 506	FOOD AND DAIRY MICROBIOLOGY	2+1	II
MICRO 507	BACTERIOPHAGES	1+1	II
MICRO 508	ENVIRONMENTAL MICROBIOLOGY	2+1	I
MICRO 509**	PLANT MICROBE INTERACTIONS	3+0	II
MICRO510	INDUSTRIAL MICROBIOLOGY	2+1	I
MICRO 511	BIOFERTILIZER TECHNOLOGY	2+1	II
MICRO512	CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY	2+0	I
MICRO 591	MASTERôS SEMINAR	1	I, II
MICRO 599	MASTERôS RESEARCH	20	I, II
MICRO 601**	ADVANCES IN FERMENTATION	2+1	I
MICRO 602**	ADVANCED MICROBIAL PHYSIOLOGY	3+0	II
MICRO 603**	REGULATION OF MICROBIAL BIOSYNTHESIS	2+0	II
MICRO 604**	CURRENT TOPICS IN SOIL MICROBIOLOGY	3+0	II
MICRO 691	DOCTORAL SEMINAR I	1	I, II
MICRO 692	DOCTORAL SEMINAR II	1	I, II
MICRO 699	DOCTORAL RESEARCH	45	I, II

*Compulsory for Masterôs programme; ** Compulsory for Doctoral programme

Ph.D. students who have done M.Sc. (Microbiology) from other universities/institutes will be required to take 500 series compulsory courses required for M.Sc., if not taken earlier.

❶ To be taught jointly by Microbiology and Soil Science

MICROBIOLOGY

Course Contents

MICRO 501 PRINCIPLES OF MICROBIOLOGY 3+1 SEM - I

Objective

To teach the students about basics in development of microbiology, difference in prokaryotes and eukaryotic cell. Classification of prokaryotes.

Theory

UNIT-I: Development of microbiology in the 18th and 19th century. Morphology, structure and function of prokaryotic and eukaryotic cell. Archea. Classification of prokaryotes ï Basic principles and techniques used in bacterial classification.

UNIT-II: Evolutionary relationship among prokaryotes. Phylogenetic and numerical taxonomy. Use of DNA and r-RNA sequencing in classifications.

UNIT-III: Study of major groups of bacteria belonging to Gracilicutes, Firmicutes, Tanericutes and Mendosicutes.

UNIT-IV: Viruses ï morphology, classification and replication of plant, animal and bacterial viruses. Cultivation methods of viruses. Immune response ï specific and non-specific resistance. Normal microflora of human body; some common bacterial and viral diseases of humans and animals.

Practical

Methods of isolation, purification and maintenance of microorganisms from different environments (air, water, soil, milk and food). Enrichment culture technique ï isolation of asymbiotic, symbiotic nitrogen fixing bacteria. Isolation of photosynthetic bacteria. Use of selective media, antibiotic resistance and isolation of antibiotic producing microorganisms. Morphological, physiological and biochemical characterization of bacteria.

Suggested Readings

Brock TD.1961. *Milestones in Microbiology*. Infinity Books.

Pelczar MJ, Chan ECS & Kreig NR. 1997. *Microbiology: Concepts and Application*. Tata Mc Graw Hill.

Stainier RY, Ingraham JL, Wheelis ML & Painter PR. 2003. *General Microbiology*. Macmillan.

Tauro P, Kapoor KK & Yadav KS. 1996. *Introduction to Microbiology* Wiley Eastern.

MICRO 502 MICROBIAL PHYSIOLOGY AND METABOLISM 3+1 SEM -II

Objective

To teach students about cell cycle, growth and practical training on methods to determine microbial growth.

Theory

UNIT-I: Structure, function, biosynthesis and assembly of various cellular components of prokaryotes. Transport of solutes across the membrane.

UNIT-II: Microbial growth. Cell cycle and cell division, EMP, HMP, ED, TCA pathways, Aerobic and anaerobic respiration. Fermentative metabolism. Biosynthesis of macromolecules. Regulation of microbial metabolism.

UNIT-III: Effect of chemicals and other environmental factors on growth. Morphogenesis and cellular differentiation.

UNIT-IV: Important metabolic patterns in photoautotrophs, photoheterotrophs, chemoautotrophs and chemoheterotrophs.

Practical

Use of simple technique in laboratory (Colorimetry, Centrifugation, Electrophoresis and GLC). Determination of viable and total number of cells. Measurement of cell size. Gross cellular composition of microbial cell. Growth ï Factors affecting growth. Sporulation and spore germination in bacteria. Protoplasts formation. Induction and repression of enzymes.

Suggested Readings

Doelle HW. 1969. *Bacterial Metabolism*. Academic Press.
Gottschalk G. 1979. *Bacterial Metabolism.* Springer Verlag.
Moat AG. 1979. *Microbial Physiology*. John Wiley & Sons.
Sokatch JR. 1969. *Bacterial Physiology and Metabolism.* Academic Press.

MICRO 503 MICROBIAL GENETICS 2+1 SEM - I

Objective

To acquaint the learners regarding molecular concepts of bacteria and viruses and impact of gene cloning on human welfare.

Theory

UNIT-I: Procaryotic, Eucaryotic and Viral genome. Replication of Eucaryotic, Procaryotic and Viral DNA. Structure, classification and replication of Plasmids.

UNIT-II: Molecular basis of mutation. Biochemical genetic and gene mapping by recombination and complementation. Fine gene structure analysis. Fungal genetics.

UNIT-III: Gene transfer in bacteria through transduction, transformation and conjugation and gene mapping by these processes. Transposable elements.

UNIT-IV: Gene cloning and gene sequencing. Impact of gene cloning on human welfare. Regulation of gene expression. Recent advances in DNA repair and mutagenesis, Genetic basis of cancer and cell death.

Practical

Inactivation of microorganisms by different mutagens. Production, isolation and characterization of mutants. Determination of mutation rate. Isolation, characterization and curing of plasmids. Transfer of plasmid by conjugation, electroporation. Tetrad and random spore analysis.

Suggested Readings

Birge EA. 1981. *Bacterial and Bacteriophage Genetics*. Springer Verlag.
Gardner JE, Simmons MJ & Snustad DP. 1991. *Principles of Genetics*. John Wiley & Sons.
Larry, Synder & Wendy 1997. *Molecular Genetics of Bacteria.* ASM Publ.
Lewin B. 2000. *Gene*. Vols. VI-IX. Oxford University Press.
Maloy A & Friedfelder D. 1994. *Microbial Genetics*. Narosa Publ.
Scaife J, Leach D & Galizzi A. 1985. *Genetics of Bacteria*. Academic Press.
Watson, Hoppkins, Roberts, Steitz & Weiner 1987. *Molecular Biology of the Gene.* 4th Ed. The Benjamin/ Cummings Publ. Co.
William Hayes 1981. *Genetics of Bacteria*. Academic Press.

MICRO 504 / SOIL 506 SOIL MICROBIOLOGY 2+1 SEM - I

(To be taught jointly by Microbiology and Soil Science)

Objectives

Objective of this course is to teach students regarding basics of microbiology related to soil including biogeochemical cycles, plant growth promoting rhizobacteria, microbial interactions in soil and other soil activities.

Theory

UNIT-I: Soil biota, Soil microbial ecology, types of organisms in different soils; Soil microbial biomass; Microbial interactions: unculturable soil biota.

UNIT-II: Microbiology and biochemistry of root - soil interface; phyllosphere, Biofertilizers, soil enzyme activities and importance.

UNIT-III: Microbial transformations of nitrogen, phosphorus, sulphur, iron and manganese in soil. Biochemical composition and biodegradation of soil organic matter and crop residues.

UNIT-IV: Biodegradation of pesticides, Organic wastes and their use for production of biogas and manures; Biotic factors in soil development.

Practical

Determination of soil microbial population; Soil microbial biomass; Decomposition studies in soil, Soil enzymes; Measurement of important soil microbial processes such as ammonification, nitrification. N_2 fixation, S oxidation, P solubilization and mineralization of other micro-nutrients; Study of rhizosphere effect.

Suggested Readings

Martin Alexander 1977. *Soil Microbiology*. John Wiley.
Paul EA. 2007. *Soil Microbiology, Ecology and Biochemistry*. 3rd Ed. Academic Press.

Sylvia *et al.* 2005. *Principles and Applications of Soil Microbiology*. 2nd Ed. Pearson Edu.
Van Elsas JD, Trevors JT & Wellington EMH. 1997. *Modern Soil Microbiology*. Marcel Dekker.

MICRO 505/MBB506 MICROBIAL BIOTECHNOLOGY 2+1 SEM - II

(To be taught jointly by MBB&B & Microbiology)

Objective

To familiarize students about microbial processes/systems/activities for development of industrially important products/ processes.

Theory

UNIT-I: Introduction, scope and historical development; Isolation, screening, genetic improvement and maintenance of industrially important microorganisms.

UNIT-II: Types of fermentation systems; Bioreactor designs and operations; Production of primary and secondary metabolites e.g. alcohol, organic acids, organic solvents, amino acids, enzymes, antibiotics.

UNIT-III: Production of fermented beverages, single cell protein; Recombinant DNA technology based products; Biotransformation.

UNIT-IV: Overproduction of metabolites; Metabolic pathway engineering of microbes for production of novel products for industry; Downstream processing; Immobilization of cells/enzymes.

UNIT-IV: Industrial biotechnology for pollution control, treatment of industrial and other wastes; Production of ecofriendly chemicals, e. g. biopesticides, bioinsecticides , biofertilizers, biofuels etc.

Practical

Isolation of industrially important microorganisms, their maintenance and improvement. Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Study of bioreactors and their operation. Production of biofertilizers. Immobilization of cells and enzymes, study of their kinetic behaviour.

Suggested readings

Cruger W & Cruger A. 2004. *Biotechnology - A Textbook of Industrial Microbiology.* Panima.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Ward OP. 1989. *Fermentation Biotechnology*. Prentice Hall.

MICRO 506 FOOD AND DAIRY MICROBIOLOGY 2+1 SEM - II

Objective

To familiarize the students with food microbiology including fermented food, dairy, food preservation, detection of food borne diseases, their control measures.

Theory

UNIT-I: Introduction and scope; Food Microbiology ï A many faceted science; Interrelationship of food microbiology with other sciences; Perspectives on food safety and Food Biotechnology.

UNIT-II: Factors of special significance in Food Microbiology ï Principles influencing microbial growth in foods; Spores and their significance; Indicator organisms and Microbiological criteria; Microbial spoilage of foods- meat, milk, fruits, vegetables and their products; Food poisoning and food borne pathogenic bacteria.

UNIT-III: Food fermentation; Fermented dairy, vegetable, meat products; Preservatives and preservation methods ï physical methods, chemical preservatives and natural antimicrobial compounds. Bacteriocins and their applications; Biologically based preservation systems and probiotic bacteria.

UNIT-IV: Advanced techniques in detecting food borne pathogens and toxins. Hurdle technology and Hazard analysis. Critical control point systems in controlling microbiological hazards in foods.

Practical

Statutory, recommended and supplementary tests for microbiological analysis of various foods: Baby foods, canned foods, milk and dairy products, eggs, meat, vegetables, fruits, cereals, surfaces, containers and water.

Suggested Readings

Bibek Ray. 1996. *Fundamentals of Food Microbiology*. CRC Press.
Frazier WC & Westhoff DC. 1991. *Food Microbiology*. 3rd Ed. Tata McGraw Hill.
George J Banwart. 1989. *Basic Food Microbiology*. AVI.
James M Jay. 1987. *Modern Food Microbiology*. CBS.

Peppler HJ & Perlman D.1979. *Microbial Technology*. 2nd Ed. Academic Press.

MICRO 507 BACTERIOPHAGES 1+1 SEM - II

Objective

To familiarize students about phages and phage- bacterial interaction.

Theory

UNIT-I: Historical developments and classification of bacteriophages.

UNIT-II: Physiology, biochemistry, enzymology and molecular biology of phage-bacterial interactions.

UNIT-III: Structure, functions and life cycles of different DNA, RNA, lytic and lysogenic phages.

UNIT-IV: Phages in the development of molecular biology and genetic engineering.

Practical

Titration of phages and bacteria. Absorption of phages. Preparation of phage stocks. Isolation of new phages and phage resistant bacteria. One step growth curve, phage bursts. Induction of lambda etc.

Suggested Readings

Birge EA. 2000. *Bacterial and Bacteriophage Genetics.* SpringerVerlag.

Mathew CK. 1972. *Bacteriophage Biochemistry*. Am. Chemical Soc.

Mathew CK, Kutter EM, Mosig G & Berget P. 1988. *Bacteriophage T4*. Plenum Press.

Nancy T & Trempy J. 2004. *Fundamental Bacterial Genetics*. Blackwell.

Stent SG. 1963. *Molecular Biology of Bacterial Viruses*. WH Freeman.

Winkler J, Ruger W & Wackernagel W. 1979. *Bacterial, Phage and Molecular Genetics - An Experimental Course.* Narosa.

Winkler U & Ruhr W. 1984. *Bacteria, Phage and Molecular Genetics*. ALA.

MICRO 508 ENVIRONMENTAL MICROBIOLOGY 2+1 SEM - I

Objective

To teach and create awareness regarding environment, water, soil, air pollution and bioremediation.

Theory

UNIT-I: Scope of environmental Microbiology. An overview of microbial niches in global environment and microbial activities. Microbiology of air, outdoor and indoor environment in relation to human, animal and plant health and economic activities.

UNIT-II: Microbiology of natural waters. Environmental pollution ï Deleterious and beneficial role of microorganisms. Environmental microbiology in public health. Microorganism in extreme environments, Environmental determinants that govern extreme environment- Air water interface, extreme of pH, Temperature, Salinity, Hydrostatic pressure.

UNIT-III: Microbial technology in pollution abatement, waste management and resource recovery in metal, petroleum and bioenergy fields. Biofuels. Global environmental problems.

UNIT-IV: Microbial upgradation of fossils fuels and coal gas. Microbial interaction in rumen and gastrointestinal tract. Biodeterioration and Bioremediation. Biodegradation of xenobiotic compounds.

Practical

Analysis of natural waters, waste waters and organic waste in relation to water pollution assessment, pollution strength and resource quantification; Quality control tests, waste treatment and anaerobic digestion; Demonstration of waste water treatment processes such as activated sludge processes, biofilter and fluidized bed process.

Suggested Readings

Campbell R. 1983. *Microbial Ecology*. Blackwell.

Hawker LE & Linton AH. 1989. *Microorganisms Function, Form and Environment*. 2nd Ed. Edward Arnold.

Maier RM, Pepper IL & Gerba CP. 2009. *Environmental Microbiology*. 2nd Ed. Academic Press.

Mitchell R. 1992. *Environmental Microbiology*. John Wiley & Sons.

Richards BN. 1987. *Microbes of Terrestrial Ecosystem*. Longman.

MICRO 509 PLANT-MICROBE INTERACTIONS 3+0 SEM - II
(Pre-requisite Micro 503/Micro 504)

Objective

To familiarize the students with the biochemical or biophysical mechanisms, genetics, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces of beneficial and pathogenic plant microbe interactions. Molecular analysis of relevant factors in the plant and microbes and components that modulate plant-microbe interactions for soil and plant health for sustaining crop productivity.

Theory

UNIT-I: Different interfaces of interactions - Plant-microbe, microbe-microbe, soil-microbe, soil-plant-microbe interactions leading to symbiotic (rhizobial & mycorrhizal), associative, endophytic and pathogenic interactions. Types of ecosystems: Concept and dynamics of ecosystem, Food chain and energy flow, Microbial communities in the soil. Community dynamics and population interactions employing DGGE, TGGE, T-RFLP.

UNIT-II: Quorum sensing in bacteria, flow of signals in response to different carbon or other substrates and how signals are recognized.

UNIT-III: Methodology/resources to study plant microbe interaction - recombinant inbred lines, biosensors, transcriptome profiling, metabolic profiling, genomics, proteomics and advanced microscopy, spectroscopy of different interfaces.

UNIT-IV: Plant & microbial gene expression and signal exchange, global and specific regulators for different interactions. Molecular diversity of microbes, plants and their interactions including transgenic microbes and plants.

Suggested Readings

Kosuge T & Nester EW. 1989. *Plant-Microbe Interactions: Molecular and Genetic Perspectives*. Vols I-IV. McGraw Hill.

Verma DPS & Kohn TH. 1984. *Genes Involved in Microbe-Plant Interactions.* Springer Verlag.

MICRO 510 INDUSTRIAL MICROBIOLOGY 2+1 SEM - I
(Pre-requisite Micro 504/Micro 506)

Objective

To expose the students to the commercial exploitation of microorganisms for production of useful products. Focus will be on understanding of the techniques involved and the application of microorganisms for agribusiness purpose.

Theory

UNIT-I: Biofermentor; Production of wine, beer, lactic acid, acetic acid (vinegar), citric acid, antibiotics, enzymes, vitamins and single cell proteins. Biofuels: Production of ethanol, biogas and hydrogen production.

UNIT-II: Brief introduction to bacterial, fungal and insect diseases. Introduction to phytopathogens, symptoms, pathogenesis. Types of chemicals/pesticides used for disease control. Vaccines. Biocontrol agents and Biopesticides. Scope of biocontrol agents in control of plant diseases, nematodes and insect pests. Molecular aspects of plant pathogens - host interactions, host defense mechanisms, disease forecasting and assesment of losses, prevention of epidemics, and disease control. Detailed study of the representative examples of plant diseases caused by fungi and bacteria.

UNIT-III: Bioplastics and biopolymers: Microorganisms involved in synthesis of biodegradable plastics, other pigments, Biosensors: Development of biosensors to detect food contamination and environment pollution, Biodiversity: Structural, biochemical and molecular systematics, Numerical taxonomy. Magnitude and distribution of biodiversity.

UNIT-IV: Biofertilizers, Genetic engineering of microbes for enhanced pesticide degradation. Mechanisms of pesticide degradation by microbes. Biomining: Coal, mineral and gas formation, prospecting for deposits of crude, oil and gas, recovery of minerals from low-grade ores.

Practical

Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery. Detection of food-borne pathogens, pesticide degradation. Demonstration of biogas production. Production of biocontrol agents.

Suggested Readings

Alexander M. 1977. *Soil Microbiology*. John Wiley.
Hawker LE & Linton AH. 1989. *Microorganisms Function, Form and Environment*. 2nd Ed. Edward Arnold.
James M Jaq 1987. *Modern Food Microbiology*. CBS.
Paul EA. 2007. *Soil Microbiology, Ecology and Biochemistry*. 3rd Ed Academic Press.
Stanbury PF & Whitaker A. 1987. *Principles of Fermentation Technology.* Pergamon Press.
Sylvia DM, Fuhrmann JJ, Hartlly PT & Zuberer D. 2005. *Principles and Applications of Soil Microbiology*. 2nd Ed. Pearson Prentice Hall Edu.

MICRO 511 BIOFERTILIZER TECHNOLOGY 2+1 SEM - II

Objective

To familiarize the students and even farmers with mass scale production of different agriculturally important microorganisms which are being used as biofertilizers for maintaining the soil and plant health for sustaining crop productivity and their importance in organic farming.

Theory

UNIT-I: Different Agriculturally important beneficial microorganisms ï free living, symbiotic (rhizobial, mycorrhizal, actinorhizal), associative and endophytic nitrogen fixers including cyanobacteria, taxonomic classification, nodule formation, competitiveness and quantification of N_2 fixed.

UNIT-II: Microorganisms involved in phosphorus solubilisation: bacteria and fungi including mycorrhiza; potassium solubilizing bacteria and fungi including mycorrhiza. Plant growth promoting rhizobacteria. Mechanism of plant growth promotion.

UNIT-III: Microorganisms involved in biological control of plant diseases. Biocontrol agents and bio-pesticides, microbial inoculants, mechanisms of disease suppression. Recycling of organic waste and compositing, bioremediation and other related agents.

UNIT-IV: Agriculturally important beneficial microorganisms - selection, establishment, competitiveness, crop productivity, soil & plant health, mass scale production and quality control of bio-inoculants. Biofertilizer inoculation and microbial communities in the soil.

Practical

Isolation of symbiotic, asymbiotic, associative nitrogen-fixating bacteria. Development and production of efficient beneficial microorganisms, Determination of beneficial properties in important bacteria to be used as biofertilizer, Nitrogen fixing activity, indole acetic acid (IAA), siderophore production etc, Bioinoculant production and quality control.

Suggested Readings

Alexander M. 1977. *Soil Microbiology*. John Wiley.
Bergerson FJ. 1980. *Methods for Evaluating Biological Nitrogen Fixation.* John Wiley & Sons.
Kannaiyan S, Kumar K & Govindarajan K. 2007. *Biofertilizers Technology*. Saujanya Books.
Mahendra Rai. 2006. *Handbook of Microbial Biofertilizer*. Ist Ed. Springer.
Sylvia DM, Fuhrmann JJ, Hartlly PT & Zuberer D. 2005. *Principles and Applications of Soil Microbiology.* 2nd Ed. Pearson Prentice Hall Edu.
Van Elsas JD, Trevors JT & Wellington EMH. 1997. *Modern Soil Microbiology*. CRC Press.
Yadav AK, Ray Chaudhuri S & Motsara MR. 2001. *Recent Advances in Biofertilizer Technology*. Society for Promotion and Utilisation of Resources and Technology.

MICRO 512 CYANOBACTERIAL AND ALGAL BIOTECHNOLOGY 2+0 SEM - I

Objective

To teach students about this upcoming fascinating field of microbes develoed at a faster pace, mainly due to photoautotrophic nature of Cyanobacteria, their ability to survive under a variety of habitats and wide diversity of thallus structure and functions. Their importance for mankind is enormous including their role as biofertilizers, nutraceuticals, experimental models, dyes, biofuels and a variety of biochemicals regarding structure, molecular evolution and properties of cyanobacteria and algae.

Theory

UNIT-I: Introduction to Cyanobacteria and algae. Definition, occurrence and distribution, thallus structure, reproduction, life cycles, origin and evolution of Cyanobacteria, molecular evolution; role of algae in evolution of land plants and horizontal transfer of genes.

UNIT-II: Algal pigments, storage products, carbon metabolism, photosynthesis. Algal culturing and cultivation. Culture types, culture conditions, culture vessels, culture media, sterilization, culture methods, synchronous cultures, photobioreactors, algal density and growth, seaweed cultivation.

UNIT-III: Cyanobacterial and algal fuels, Fine chemicals (restriction enzymes etc) and nutraceuticals from algae; UV absorbing pigments Industrial products from macro algae - seaweed biotechnology, sustainable aquaculture. Ecology of algae - distribution in soil and water; primary colonizers, carbon sequestration and cycling in soil and water. Cellular differentiation and nitrogen fixation, nitrogen metabolism.

UNIT-IV: Algae in pollution - as pollution indicators, eutrophication agents and role in Bioremediation. Cyanobacterial and algal toxins, allelopathic interactions, Algae in global warming and environmental sustainability. Cyanobacteria and selected microalgae in agriculture ï biofertilizers & algalization; soil conditioners; reclamation of problem soils.

Suggested Readings

Ahluwalia AS. 2003. *Phycology: Principles, Processes and Applications*. Daya Publ.

Barsanti L & Gualtieri P. 2006. *Algae: Anatomy, Biochemistry and Biotechnology*. Taylor & Francis, CRC Press.

Carr NG & Whitton BA. 1982. *The Biology of Cyanobacteria*. Blackwell.

Herrero A & Flores E. 2008. *The Cyanobacteria Molecular Biology, Genomics and Evolution*. Calster Academic Press.

Kumar HD. 2005. *Introductory Phycology.* East West Press.

Linda E Graham & Lee W Wilcox. 2000. *Algae*. Prentice Hall.

Robert A Andersen. 2005. *Algal Culturing Techniques.* Academic Press.

Venkataraman LV & Becker EW. 1985. *Biotechnology and Utilization of Algae: the Indian Experience*. DST.

MICRO 601 ADVANCES IN FERMENTATION 2+1 SEM - I

Objective

To teach students regarding fermentation industry using industrially useful microorganisms including yeast technology.

Theory

UNIT-I: An overview of fermentation - current status of fermentation industry. Fermentor design, high performance bioreactors, mass and energy transfer in bioreactors. Instrumentation and control in fermentors ï on line measurements systems, computer application.

UNIT-II: Media for microbial fermentation; Criteria in media formulation. An overview of downstream processing.

UNIT-III: New strategies for isolation of industrially important microbes and their genetic manipulations; Microbial production of health care products. Antibiotic fermentation research; steroid transformation.

UNIT-IV: Recent developments on production of primary and secondary metabolites, Treatment of biological wastes, microbial inoculants and enzymes for waste treatment.

UNIT-V: Yeast technology ï classification, genetics, strain improvement for brewing, baking and distilleries and topics of current interest in fermentations.

Practical

Industrially important microbes and their genetic manipulations, Fermentation by improved strains of yeast for production of alcohol and beer, Microbial production of important antibiotics, enzymes and organic acids, Bioremediation of industrial effluents.

Suggested Readings

Peppler HJ & Perlman D. 1979. *Microbial Technology.* 2nd Ed. Academic Press.

Reed G. 1987. *Presscott & Dunn's Industrial Microbiology.* 4th Ed. CBS.

Stanbury PF & Whitaker A. 1987. *Principles of Fermentation Technology*. Pergamon Press.

Wiseman A. 1983. *Principles of Biotechnology.* Chapman & Hall.

MICRO 602 ADVANCED MICROBIAL PHYSIOLOGY 3+0 SEM - II

Objective

To acquaint students with current topics in molecular microbiology.

Theory

UNIT-I: Origin, evolution, structure, function and molecular aspects of various cell components.

UNIT-II: Differentiation in bacteria, slime molds, yeasts.

UNIT-III: Molecular biology of bioluminescence, bacterial virulence. Heat shock response. Extracellular protein secretion in bacteria.

UNIT-IV: Topics of current interest in molecular microbiology.

Suggested Reading

Selected articles from journals.

MICRO 603 REGULATION OF MICROBIAL BIOSYNTHESIS 2+0 SEM - II

Objective

Course imparts thorough knowledge about the synthesis of biomolecules in microorganisms by various pathways and their regulation.

Theory

UNIT-I: Regulation of initiation, termination and anti-termination of transcription. Global regulation and differentiation by sigma factor. Regulatory control in bacteria : inducible and biosynthetic pathways.

UNIT-II: Ribosomal RNA and ribosomal proteins regulation under stress condition. Specific regulatory systems; SOS regulatory control; Antisense RNA regulation of gene expression.

UNIT-III: Oxidative stress control. Fermentative and respiratory regulatory pathways. Regulation of cell cycle. Lytic and lysogenic cascade.

UNIT-IV: Global nitrogen control and regulation of nitrogen fixation and other recent topics of regulatory systems of current interest.

Suggested Readings

Selected articles from journals**.**

MICRO 604 CURRENT TOPICS IN SOIL MICROBIOLOGY 3+0 SEM - II

Objective

To make students learn the latest trends in Soil Microbiology like diversity, biological control and bioremediation.

Theory

UNIT-I: Molecular ecology and biodiversity of soil microorganisms; Survival and dispersal of microorganisms.

UNIT-II: Microbial successions and transformation of organic matter; Role of microorganisms in soil fertility.

UNIT-III: Bioremediation of polluted soils; pesticide degradation. Biological control of fungal pathogens and insects.

UNIT-IV: Other topics of current interest.

Suggested Readings

Selected articles from journals.

MICROBIOLOGY

List of Journals

- Advances in Microbial Physiology
- Annual Review of Genetics/Biochemistry
- Annual Review of Microbiology
- Applied and Environmental Microbiology
- Biology and Fertility Soils
- Indian Journal of Microbiology
- Journal of Bacteriology
- Journal of Basic Microbiology
- Microbiology and Molecular Biology Reviews
- Nature/Science/EMBO Journal
- Reviews in Microbiology and Biotechnology
- Soil Biology and Biochemistry
- Trends in Biotechnology
- Trends in Microbiology
- Trends in Plant Sciences

e-Resources

- **Books**
  - http://www.aw-bc.com/microplace/
  - http://www.personal.psu.edu/jel5/micro/index.htm
  - http://microbiology.ucsc.edu/
- **Sites**
  - http://www.suite101.com/links.cfm/microbiology
  - http://www.microbeworld.org/resources/links.aspx
  - http://www.asm.org/
  - http://www.microbiologyiworld.com/
  - http://www.sciencemag.org/cgi/collection
  - http://www.latrobe.edu.au/microbiology/links
  - www.uwstout.edu/lib/subjects/microbi
  - http://www.aemtek.com
- **Journal related to Microbiology**
  - http://www.fems-microbiology.org/website/nl/default.asp
  - http://www.blackwellpublishing.com/journal
  - http://www.springer.com/
  - http://www.e-journals.org/microbiology/
  - http://pubs.nrc-cnrc.gc.ca/
  - http://www.elsevier.com/
  - http://www.academicjournals.org/ajmr/
  - http://www.horizonpress.com/gateway/journals.html
  - http://www.scielo.br/bjm
  - http://www.jmb.or.kr/
- **Latest in microbiology- Microbiology News**
  - http://microbiologybytes.wordpress.com/
  - http://www.topix.net/science/microbiolog

Suggested Broad Topics for Master's and Doctoral Research

- **Molecular Microbiology**
  - Microbial diversity
  - Meta genomics
  - Improvement of beneficial microorganisms (Nitrogen fixers, PGPR, AM fungi, Endophytic bacteria/fungi, Phosphate solubilizers etc.)
- **Environmental Microbiology**

- Biocontrol (PGPR, Termite control, Pathogenic fungi control)
- **Biofuels**
  - ÅBiogas, alcohol production
- **Bioremediation**
  - Waste management, Bioremediation of industrial effluents and agrochemicals
  - Composting
- **Microbial Biotechnology**
  - Biofertilizers (Nitrogen fixers, Phosphate solubilizers, PGPR, BGA, VAM, Endophytic bacteria/fungi and composting etc)
  - Secondary metabolites including industrially important enzymes, amino acids
  - Citric acid and lactic acid fermentations
- **Food Microbiology**
  - Improvenment and industrial exploitation of microorganisms
  - Fermented foods

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
MBB 501*	PRINCIPLES OF BIOTECHNOLOGY	3+0	I
MBB 502*/ ❶ BIOCHEM 504/ BIF 508	FUNDAMENTAL OF MOLECULAR BIOLOGY	3+0	I
MBB 503	MOLECULAR CELL BIOLOGY	3+0	II
MBB 504	PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION	2+1	II
MBB 505*	TECHNIQUES IN MOLECULAR BIOLOGY - I	0+3	I
MBB 506/MICRO 505	INDUSTRIAL BIOTECHNOLOGY	2+1	II
MBB 507	MOLECULAR BREEDING	2+0	II
MBB 508/ ❷ BIF 517	GENOMICS & PROTEOMICS	2+1	I
MBB 509	TECHNIQUES IN MOLECULAR BIOLOGY - II	0+3	II
MBB 510	BIOSAFETY, IPR AND BIOETHICS	2+0	I
MBB 511/ ❸ ABT 616	ANIMAL BIOTECHNOLOGY	3+0	I
MBB 512/ ❹ BIOCHEM 506/ BIF 510	IMMUNOLOGY AND MOLECULAR DIAGNOSTICS	2+1	II
MBB 513	NANO-BIOTECHNOLOGY	3+0	I
MBB 514/ ❺ FST 519	FOOD BIOTECHNOLOGY	2+1	I
MBB 515/ ❻ FSC 509	BIOTECHNOLOGY OF HORTICULTURAL CROPS	2+1	II
MBB 553*/ ❼ STAT 534/ FST 531/ SOC 512	BIOSTATISTICS AND COMPUTERS	2+1	I
MBB 555/ ❽ BIF 501/ ABT 608/ FSC 604	INTRODUCTION TO BIOINFORMATICS	2+1	I
MBB 556	ENVIRONMENTAL BIOTECHNOLOGY	3+0	II
MMB 591	MASTERõS SEMINAR	1	I, II
MMB 599	MASTERõS RESEARCH	20	I, II
MBB 601	ADVANCES IN PLANT MOLECULAR BIOLOGY	3+0	I
MBB 602	ADVANCES IN GENETIC ENGINEERING	3+0	I
MBB 603	ADVANCES IN MICROBIAL BIOTECHNOLOGY	3+0	II
MBB 604/ ❻ VSC 604/ FLA 605	ADVANCES IN CROP BIOTECHNOLOGY	3+0	I
MBB 605/ ❾ BIOCHEM 606/ PP 602	ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS	3+0	II
MBB 606	COMMERCIAL PLANT TISSUE CULTURE	2+0	I
MBB 607/ ❸ ABT 707	ADVANCES IN ANIMAL BIOTECHNOLOGY	2+0	II
MBB 691	DOCTORAL SEMINAR I	1	I, II

MBB 692	DOCTORAL SEMINAR II	1	I, II
MMB 699	DOCTORAL RESEARCH	45	I, II
SERVICE COURSE			
PSMA 606	BIOTECHNOLOGY IN PLANTATION CROPS AND SPICES	1+1	II
PP 603	MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS (IN PART)	2+1	I

* Compulsory for Masterôs programme; Compulsory for Doctoral programme - Any two courses of 600 series + Compulsory courses of M. Sc., if not studied earlier

To be taught by: ❶ Bioinformatics, Biochemistry, Molecular Biology & Biotechnology; ❷ Bioinformatics, Molecular Biology & Biotechnology; ❸ Animal Biotechnology; ❹ Veterinary Microbiology; ❺ Molecular Biology & Biotechnology; ❻ Molecular Biology & Biotechnology; ❼ Statistics; ❽ Bioinformatics, Molecular Biology & Biotechnology; ❾ Biochemistry, Molecular Biology & Biotechnology, Plant Physiology

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Course Contnts

MBB 501 PRINCIPLES OF BIOTECHNOLOGY 3+0 SEM - I

Objective

To familiarize the students with the fundamental principles of Biotechnology, various developments in Biotechnology and its potential applications.

Theory

UNIT-I: History, scope and importance; DNA structure, function and metabolism.

UNIT-II: DNA modifying enzymes and vectors; Methods of recombinant DNA technology; Nucleic acid hybridization; Gene libraries; PCR amplification; Plant and animal cell and tissue culture techniques and their applications.

UNIT-III: Molecular markers and their applications; DNA sequencing; Applications of gene cloning in basic and applied research; Genetic engineering and transgenics; Introduction to Genomics, transcriptomics and proteomics.

UNIT-IV: General application of biotechnology in Agriculture, Medicine, Animal husbandry, Environmental remediation, Energy production and Forensics; Public perception of biotechnology; Bio-safety and bioethics issues; Intellectual property rights in biotechnology.

Suggested Readings

Becker JM, Coldwell GA & Zachgo EA. 2007. *Biotechnology – a Laboratory Course*. Academic Press.

Brown CM, Campbell I & Priest FG. 2005. *Introduction to Biotechnology*. Panima Publ.

Brown TA. *Gene Cloning and DNA Analysis*. 5th Ed. Blackwell Publ.

Dale JW & von Schantz M. 2002. *From Genes to Genomes: Concepts and Applications of DNA Technology*. John Wiley & Sons.

Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.

Sambrook J, Fritsch T & Maniatis T. 2001. *Molecular Cloning – a Laboratory Manual*. 2nd Ed. Cold Spring Harbour Laboratory Press.

Singh BD. 2007. *Biotechnology Expanding Horiozon*. Kalyani Publ.

MBB 502/ BIOCHEM 504/ BIF508 FUNDAMENTALS OF MOLECULAR BIOLOGY 3+0 SEM - I

(To be taught jointly by Molecular Biology & Biotechnology, Biochemistry and Bioinformatics)

Objective

To familiarize the students with the basic cellular processes at molecular level.

Theory

UNIT-I: Historical developments of molecular biology; nucleic acids as genetic material, chemistry, structure and properties of DNA and RNA.

UNIT-II: Genome organization in prokaryotes and eukaryotes; repetitive and non-repetitive DNA, satellite DNA; DNA replication, DNA polymerases, topoisomerases, DNA ligase, reverse transcriptase, nucleases and restriction enzymes; site directed mutagenesis, molecular mechanism of mutation, DNA repair mechanisms.

UNIT-III: Ribosomes structure and function, organization of ribosomal proteins and RNA genes, transcription, RNA editing, RNA processing, etc; Genetic code, aminoacyl tRNA synthasesô inhibitors of replication, transcription and translation.

UNIT-IV: Translation and post translational modifications; Regulation of gene expression in prokaryotes and eukaryotes.

Suggested Readings

Lewin B. 2008. *Gene IX*. Peterson Publ. / Panima.

Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett.

Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. W.H. Freeman.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008.*Molecular Biology of the Gene*. 6th Ed. Pearson Edu.

MBB 503 MOLECULAR CELL BIOLOGY 3+0 SEM - II

Objective

To familiarize the students with the cell biology at molecular level.

Theory

UNIT-I: General structure and constituents of cell; Similarities and distinction between plant and animal cells; Cell wall, cell membrane, structure and composition of biomembranes, cell surface related functions.

UNIT-II: Structure and function of major organelles: Nucleus, Chloroplasts, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles, etc.

UNIT-III: Organellar genomes and their manipulation; Ribosomes in relation to cell growth and division; Cyto-skeletal elements.

UNIT-IV: Cell division and regulation of cell cycle; Membrane transport; Transport of water, ion and biomolecules; Signal transduction mechanisms; Protein targeting.

Suggested Readings

Gupta PK. 2003. *Cell and Molecular Biology*. 2nd Ed. Rastogi Publ.

Lodish H. 2003. *Molecular Cell Biology*. 5th Ed. W.H. Freeman & Co.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.

MBB 504 PLANT TISSUE CULTURE AND GENETIC TRANSFORMATION 2+1 SEM - II

Objective

To familiarize the students and provide hands on training on various techniques of plant tissue culture, genetic engineering and transformation.

Theory

UNIT-I: History of plant cell and tissue culture; Culture media; Various types of culture; callus, suspension, nurse, root, meristem, etc.; *In vitro* differentiation: organogenesis and somatic embryogenesis; Plant growth regulators: mode of action, effects on *in vitro* culture and regeneration; Molecular basis of plant organ differentiation.

UNIT-II: Micropropagation; Anther and microspore culture; Somaclonal variation; *In vitro* mutagenesis; *In vitro* fertilization; *In vitro* germplasm conservation; Production of secondary metabolites; Synthetic seeds.

UNIT-III: Embryo rescue and wide hybridization; Protoplast culture and regeneration; Somatic hybridization: protoplast fusion, cybrids, asymmetric hybrids, etc.

UNIT-IV: Methods of plant transformation; Vectors for plant transformation; Genetic and molecular analyses of transgenics; Target traits and transgenic crops; Biosafety issues, testing of transgenics, regulatory procedures for commercial approval.

Practical

- Laboratory set-up.
- Preparation of nutrient media; handling and sterilization of plant material; inoculation, subculturing and plant regeneration.
- Anther and pollen culture.
- Embryo rescue.
- Suspension cultures and production of secondary metabolites.
- Protoplast isolation, culture and fusion.
- Gene transfer using different methods, reporter gene expression, selection of transformed tissues/plants, molecular analysis.

Suggested Readings

Bhojwani SS. 1983. *Plant Tissue Culture: Theory and Practice*. Elsevier.

Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.

Dixon RA. 2003. *Plant Cell Culture*. IRL Press.

George EF, Hall MA & De Klerk GJ. 2008. *Plant Propagation by Tissue Culture*. Agritech Publ.

Gupta PK. 2004. *Biotechnology and Genomics*. Rastogi Publ.

Herman EB. 2005-08. *Media and Techniques for Growth, Regeneration and Storage*. Agritech Publ.

Pena L. 2004. *Transgenic Plants: Methods and Protocols*. Humana Press.

Pierik RLM. 1997. *In vitro Culture of Higher Plants*. Kluwer.
Singh BD. 2007. *Biotechnology: Expanding Horiozon.* Kalyani.

MBB 505 TECHNIQUES IN MOLECULAR BIOLOGY-I **0+3** **SEM - I**

(Pre-requisite MBB 501)

Objective

To provide hands-on training on basic molecular biology techniques.

Practical

UNIT-I: Good lab practices; Biochemical techniques: Preparation of buffers and reagents, Principle of centrifugation, Chromatographic techniques (TLC, Gel Filtration Chromatography, Ion exchange Chromatography, Affinity Chromatography).

UNIT-II: Gel electrophoresis- agarose and PAGE (nucleic acids and proteins); Growth of bacterial culture and preparation of growth curve; Isolation of plasmid DNA from bacteria; Growth of lambda phage and isolation of phage DNA; Restriction digestion of plasmid and phage DNA; Isolation of high molecular weight DNA and analysis.

UNIT-III: Gene cloning ï Recombinant DNA construction, transformation and selection of transformants; PCR and optimization of factors affecting PCR.

UNIT-IV: Dot blot analysis; Southern hybridization; Northern hybridization; Western blotting and ELISA; Radiation safety and non-radio isotopic procedure.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. John Wiley.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.
Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: A Laboratory Manual*. Cold Spring Harbour Laboratory Press.

MBB 506/MICRO 505 INDUSTRIAL BIOTECHNOLOGY **2+1** **SEM - II**

(To be taught jointly byMBB&B & Microbiology)

Objective

To familiarize students about microbial processes/systems/activities for the development of industrially important products/ processes.

Theory

UNIT-I: Introduction, scope and historical developments; Isolation, screening and genetic improvement and maintenance of industrially important organisms.

UNIT-II: Types fermentation systems; Bioreactor designs and operations; Production of primary and secondary metabolites e.g alcohol, organic acids, organic solvents, amino acids, enzymes, antibiotics.

UNIT-III: Production of fermented beverages, single cell protein; Recombinant DNA technology based products, Biotransformation.

UNIT-IV*:* Overproduction of metabolites; Metabolic engineering of microbes for production of novel products for industry; Downstream processing; Immobilization of cells/enzymes.

UNIT-V: Industrial biotechnology for pollution control, treatment of industrial and other wastes, Production of eco-friendly chemicals e.g biopesticides, bio-insecticides, bio-fertilizers, bio-fuels, etc.

Practical

- Isolation of industrially important microorganisms, their maintenance and improvement.
- Production of industrial compounds such as alcohol, beer, citric acid, lactic acid and their recovery.
- Study of bio-reactors and their operations.
- Production of biofertilizers.
- Immobilization of cells and enzymes, studies on its kinetic behavior.

Suggested Readings

Cruger W & Cruger A. 2004. *Biotechnology – A Textbook of Industrial Microbiology,* Panima.
Huffnagle GB & Wernick S. 2007. *The Probiotics Revolution: The Definitive Guide to Safe, Natural Health*. Bantam Books.
Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Primrose SB. 2001. *Molecular Biotechnology*. Panima.
Ward OP. 1989. *Fermentation Biotechnology*, Prentice Hall.

MBB 507 MOLECULAR BREEDING 2+0 SEM - II

Objective

To familiarize the students about the use of molecular biology tools in plant breeding.

Theory

UNIT-I: Principles of plant breeding; Breeding methods for self and cross pollinated crops; Heterosis breeding; Limitations of conventional breeding; Aspects of molecular breeding.

UNIT-II: Development of sequence based molecular markers - SSRs and SNPs; Advanced methods of genotyping; Mapping genes for qualitative and quantitative traits.

UNIT-III: QTL mapping using structured populations; AB-QTL analysis; Association mapping of QTL; Fine mapping of genes/QTL; Map based gene/QTL isolation and development of gene based markers; Allele mining by TILLING and Eco-TILLING; Use of markers in plant breeding.

UNIT-IV: Marker assisted selection (MAS) in backcross and heterosis breeding; Transgenic breeding; Foreground and background selection; MAS for gene introgression and pyramiding: MAS for specific traits with examples.

Suggested Readings

Chittaranjan K. 2006-07. *Genome Mapping and Molecular Breeding in Plants.* Vols. I-VII. Springer.
Newbury HJ. 2003. *Plant Molecular Breeding*. Blackwell Publ.
Weising K, Nybom H, Wolff K & Kahl G. 2005. *DNA Fingerprinting in Plants: Principles, Methods and Applications*. Taylor & Francis.

MBB 508/ GENOMICS AND PROTEOMICS 2+1 SEM - I
BIF 517 (To be taught jointly by Molecular Biology & Biotechnology and Bioinformatics)

Objective

To familiarize the students about the genomic and proteomic concepts and usage of various algorithms and programmes in analysis of genomic and proteomic data.

Theory

UNIT-I: Genomics: Whole genome analysis and comparative genomics, classical ways of genome analysis, large fragment genomic libraries; Physical mapping of genomes; Genome sequencing, sequence assembly and annotation.

UNIT-II: Functional genomics: Candidate gene identification, DNA chips, Mutants and RNAi, Metabolomics for elucidating metabolic pathways, etc.

UNIT-III: Proteomics - Introduction to basic proteomics technology, Bio-informatics in Proteomics, Gene to Protein Function: a Roundtrip, Proteome analysis.

UNIT-IV: Linkage analysis, genotyping analysis, pharmacogenomics, human/plant genome and science after genomic era; Applications of genomics and proteomics in agriculture, human health and industry.

Practical

- Gene Prediction Tools: GENSCAN, GRAIL, FGENESH
- NCBI Genomic Resources
- Proteomics Tools: EXPASY, CDART

Suggested Readings

Azuaje F & Dopazo J. 2005. *Data Analysis and Visualization in Genomics and Proteomics*. John Wiley & Sons.
Brown TA. 2007. *Genome III*. Garland Science Publ.
Campbell AM & Heyer L. 2004. *Discovery Genomics, Proteomics and Bioinformatics*. Pearson Edu.
Gibson G & Muse SV. 2004. *A Primer of Genome Science*. Sinauer Associates.
Jollès P & Jörnvall H. 2000. *Proteomics in Functional Genomics: Protein Structure Analysis*. Birkhäuser.
Kamp RM. 2004. *Methods in Proteome and Protein Analysis*. Springer.
Primrose SB & Twyman RM. 2007. *Principles of Genome Analysis and Genomics*. Blackwell.
Sensen CW. 2005. *Handbook of Genome Research*. Vols. I, II. Wiley CVH.

MBB 509 TECHNIQUES IN MOLECULAR BIOLOGY -II **0+3** **SEM - II**

(Pre-requisite MBB 505)

Objective

To provide hands-on training on various molecular techniques used in molecular breeding and genomics.

Practical

UNIT-I: Construction of gene libraries; Synthesis and cloning of cDNA and RTPCR analysis; Real time PCR and interpretation of data.

UNIT-II: Molecular markers (RAPD, SSR, AFLP etc) and their analysis; Case study of SSR markers (linkage map, QTL analysis etc); SNP identification and analysis; Microarray studies and use of relevant software.

UNIT-III: Proteomics (2D gels, mass spectrometry, etc.); RNAi (right from designing of construct to the phenotyping of the plant); Yeast 1 and 2-hybrid interaction.

UNIT-IV: Generation and screening of mutants; Transposon mediated mutagenesis.

Suggested Readings

Ausubel FM, Brent R, Kingston RE, Moore DD, Seidman JG, Smith JA & Struhl K. 2002. *Short Protocols in Molecular Biology*. Wiley.

Caldwell G, Williams SN & Caldwell K. 2006. *Integrated Genomics: A Discovery-Based Laboratory Course*. John Wiley.

Sambrook J, Russel DW & Maniatis T. 2001. *Molecular Cloning: a Laboratory Manual.* Cold Spring Harbour Laboratory Press.

MBB 510 BIOSAFETY, IPR AND BIOETHICS **2+0** **SEM - I**

Objective

To discuss about various aspects of biosafety regulations, IPR and bioethic concerns arising from the commercialization of biotech products.

Theory

UNIT-I: Biosafety and risk assessment issues; Regulatory framework; National biosafety policies and law, The Cartagena protocol on biosafety, WTO and other international agreements related to biosafety, Cross border movement of germplasm; Risk management issues - containment.

UNIT-II: General principles for the laboratory and environmental biosafety; Health aspects; toxicology, allergenicity, antibiotic resistance, etc; Impact on environment: gene flow in natural and artificial ecologies; Sources of gene escape, tolerance of target organisms, creation of superweeds/superviruses, etc.

UNIT-III: Ecological aspects of GMOs and impact on biodiversity; Monitoring strategies and methods for detecting transgenics; Radiation safety and nonradio isotopic procedure; Benefits of transgenics to human health, society and the environment.

UNIT-IV: The WTO and other international agreements; Intellectual properties, copyrights, trademarks, trade secrets, patents, geographical indications, etc; Protection of plant variety and farmers right act; Indian patent act and amendments, patent filing; Convention on biological diversity; Implications of intellectual property rights on the commercialization of biotechnology products.

Suggested Readings

Singh BD. 2007. *Biotechnology: Expanding Horizon*. Kalyani.

http://patentoffice.nic.in

www.wipo.org

www.dbtindia.nic.in

www.dbtbiosafety.nic.in

MBB 511/ ABT 616 ANIMAL BIOTECHNOLOGY **3+0** **SEM - I**

(To be taught by Animal Biotechnology)

Objective

Intended to provide an overview and current developments in different areas of animal biotechnology.

Theory

UNIT-I: Structure of animal cell; History of animal cell culture; Cell culture media and reagents, culture of mammalian cells, tissues and organs, primary culture, secondary culture, continuous cell lines, suspension cultures, somatic cell cloning and hybridization, transfection and transformation of cells, commercial scale production of animal cells, application of animal cell culture for *in vitro* testing of drugs, testing of toxicity of environmental pollutants in cell culture, application of cell culture technology in production of human and animal viral vaccines and pharmaceutical proteins.

UNIT-II: Introduction to immune system, cellular and hormonal immune response, history of development of vaccines, introduction to the concept of vaccines,conventional methods of animal vaccine production, recombinant approaches to vaccine production, hybridoma technology, phage display technology for production of antibodies, antigen-antibody based diagnostic assays including radioimmunoassays and enzyme immunoassays, immunoblotting, nucleic acid based diagnostic methods, commercial scale production of diagnostic antigens and antisera, animal disease diagnostic kits, probiotics.

UNIT-III: Structure of sperms and ovum, cryopreservation of sperms and ova of livestock, artificial insemination, super ovulation, *in vitro* fertilization, culture of embryos, cryopreservation of embryos, embryo transfer, embryo-spliting, embryo sexing, transgenic manipulation of animal embryos, different applications of transgenic animal technology, animal viral vectors, animal cloning basic concept, cloning from- embryonic cells and adult cells, cloning of different animals, cloning for conservation for conservation endangered species, ethical, social and moral issues related to cloning, *in situ* and *ex situ* preservation of germplasm, *in utero* testing of foetus for genetic defects, pregnancy diagnostic kits, anti-fertility animal vaccines, gene knock out technology and animal models for human genetic disorders.

UNIT-IV: Introduction to different breeds of cattle, buffalo, sheep, goats, pigs, camels, horses, canines and poultry, genetic characterization of livestock breeds, marker assisted breeding of livestock, introduction to animal genomics, different methods for characterization of animal genomes, SNP, STR, QTL, RFLP, RAPD, genetic basis for disease resistance, Transgenic animal production and application in expression of therapeutic proteins. Immunological and nucleic acid based methods for identification of animal species, detection of meat adulteration using DNA based methods, detection food/feed adulteration with animal protein, identification of wild animal species using DNA based methods using different parts including bones, hair, blood, skin and other parts confiscated by anti-poaching agencies.

Suggested Readings

Gordon I. 2005. *Reproductive Techniques in Farm Animals*. CABI.

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby Immunology*. WH Freeman.

Kun LY. 2006. *Microbial Biotechnology*. World Scientific.

Levine MM, Kaper JB, Rappuoli R, Liu MA, Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.

Lincoln PJ & Thomson J. 1998. *Forensic DNA Profiling Protocols*. Humana Press.

Portner R. 2007. *Animal Cell Biotechnology*. Humana Press.

Spinger TA. 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

Twyman RM. 2003. *Advanced Molecular Biology*. Bios Scientific.

MBB 512/ BIOCHEM 506/ BIF 510 **IMMUNOLOGY AND MOLECULAR DIAGNOSTICS** **2+1** **SEM - II**

(To be taught by Veterinary Microbiology)

Objective

To discuss the application of various immunological and molecular diagnostic tools.

Theory

UNIT-I: History and scope of immunology; Components of immune system: organs, tissues and cells, Immunoglobulin structure and functions; Molecular organization of immunoglobulins and classes of antibodies.

UNIT-II: Antibody diversity; antigens, haptens, antigens- antibody interactions; immunoregulation and tolerance; Allergies and other hypersensitive responses; Immunodeficiency; Vaccines.

UNIT-III: Application of immunology, immunological techniques, Principles of ELISA and its applications; Monoclonal antibodies and their uses, molecular diagnostics;

Introduction to the basic principles of molecular technology and techniques used for pathogen detection.

UNIT-IV: Basics and procedures of PCR, PCR based and hybridization based methods of detection, microarrays based detection, multiplexing etc, detection of soil borne and seed born infections, transgene detection in seed, planting material and processed food, molecular detection of varietal impurities and seed admixtures in commercial consignments.

Practical

- Preparation of buffers and reagents.
- Serological tests such as bacterial slide agglutination, latex agglutination and agar gel immunodiffusion.
- Immunoassays including ELISA, western blotting, and fluorescent antibody test.
- Hybridoma technique for production of monoclonal antibodies.
- Recombinant protein antigen- production and immunization of laboratory animals.
- Extraction of DNA/RNA from pathogenic microorganisms, PCR, genotyping, diagnosis, etc.

Suggested Readings

Bloom BR & Lambert P-H. 2002. *The Vaccine Book*. Academic Press.

Elles R & Mountford R. 2004. *Molecular Diagnosis of Genetic Disease*. Humana Press.

Kindt TJ, Goldsby RA & Osbrne BA. 2007. *Kuby's Immunology*. WH Freeman.

Levine MM, Kaper JB, Rappuoli R, Liu MA & Good MF. 2004. *New Generation Vaccines*. 3rd Ed. Informa Healthcare.

Lowrie DB & Whalen R. 2000. *DNA Vaccines*. Humana Press.

Male D, Brostoff J, Roth DB & Roitt I. 2006. *Immunology.* Elsevier.

Rao JR, Fleming CC & Moore JE. 2006. *Molecular Diagnostics*. Horizon Bioscience.

Robinson A & Cranage MP. 2003. *Vaccine Protocols*. 2nd Ed. Humana Press.

Spinger TA, 1985. *Hybridoma Technology in Biosciences and Medicine*. Plenum Press.

MBB 513 NANO-BIOTECHNOLOGY 3+0 SEM - I

Objective

Understanding the molecular techniques involved in structure and functions of nano-biomolecules in cells such as DNA, RNA and proteins.

Theory

UNIT-I: Introduction to Biomacromolecules: The modern concepts to describe the conformation and dynamics of biological macromolecules: scattering techniques, micromanipulation techniques, drug delivery applications etc.

UNIT-II: Cellular engineering: signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation.

UNIT-III: Chemical, physical and biological properties of biomaterials and bioresponse: biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins); Aerosol properties, application and dynamics; Statistical Mechanics in Biological Systems.

UNIT-IV: Preparation and characterization of nanoparticles; Nanoparticular carrier systems; Micro- and Nano-fluidics; Drug and gene delivery system; Microfabrication, Biosensors, Chip technologies, Nano- imaging, Metabolic engineering and Gene therapy.

Suggested Readings

Nalwa HS. 2005. *Handbook of Nanostructured Biomaterials and their Applications in Nanobiotechnology*. American Scientific Publ.

Niemeyer CM & Mirkin CA. 2005. *Nanobiotechnology*. Wiley Interscience.

MBB 514/ FOOD BIOTECHNOLOGY 2+1 SEM - I
FST 519 (To be taught by Molecular Biology & Biotechnology)

Objective

This is a special course designed for students of FST to acquaint with the fundamentals and application of biotechnology in relation to raw materials for food processing, nutrition, food fermentations, waste utilization and better use of genetic resources.

Theory

UNIT-I: Prospects of biotechnology- definition, history, scope and applications, Application of biotechnology in food (food industries), pharmaceuticals and agriculture, food/plant waste utilization, biogas plants; organisms and their utilization for the production of fermented foods and beverages.

UNIT-II: Structure and function of nucleic acids; Recombinant DNA technology: restriction and other DNA modifying enzymes, vectors, DNA libraries, gene cloning, PCR, gene expression, etc.

UNIT-III: Applications of genetical control mechanism in industrial fermentation process, (induction, manipulation and recombination); Biomass production by using various microorganisms; Cell and tissue culture, Secondary metabolites synthesis; Transgenic organisms (GMOs): methods, applications, safety aspects, etc.

UNIT-IV: Biotechnology for enhancing quality attributes of food; Enzyme biotechnology; Enzyme immobilization techniques and their applications in food industry; Microbial transformations; Potential impact and future aspects of biotechnology in food industry.

Practical

Study of auxotroph, Micropropogation through tissue culture, Strain improvement through U.V. mutation, Mutagenesis using chemical mutagens (ethidium bromide), Isolation and analysis of genomic DNA from *E.coli* and *Bacillus cereus,* Isolation of protoplasts, Introduction to the techniques of ELISA / Southern blot / DNA fingerprinting / Agarose gel electrophoresis, etc.

Suggested Readings

Bains W. 1993. *Biotechnology from A to Z*. Oxford Univ. Press.

Joshi VK & Pandey A.1999. *Biotechnology: Food Fermentation*. Vols. I, II. Education Publ.

Knorr D.1982. *Food Biotechnology*. Marcel Dekker.

Lee BH. 1996. *Fundamentals of Food Biotechnology*. VCH.

Perlman D. 1977-1979. *Annual Reports of Fermentation Processes*.

Prescott SC & Dunn CG. 1959. *Industrial Microbiology*. McGraw Hill.

Ward OP. 1989. *Fermentation Biotechnology*. Prentice Hall.

MBB 515/ FSC 509 **BIOTECHNOLOGY OF HORTICULTURAL CROPS** **2+1** **SEM - II**

(To be taught by Molecular Biology & Biotechnology)

Objective

Understanding the principles, theoretical aspects and developing skills in biotechnology of horticultural crops.

Theory

UNIT-I : Harnessing bio-technology in horticultural crops, influence of plant materials, physical, chemical factors and growth regulators on growth and development of plant cell, tissue and organ culture.

UNIT-II: Callus culture ï types, cell division, differentiation, morphogenesis, organogenesis, embryogenesis, artificial seeds.

UNIT-III: Use of bioreactors and *in vitro* methods for production of secondary metabolites, suspension culture, nutrition of tissues and cells, regeneration of tissues, ex vitro, establishment of tissue cultured plants, rapid clonal propagation.

UNIT-IV: Physiology of hardening - hardening and field transfer, organ culture ï meristem, embryo, anther, ovule culture, embryo rescue, somaclonal variation, haploids, *in vitro* mutation, , cryopreservation.

UNIT-V: Wide hybridization, *in vitro* pollination and fertilization, protoplast culture and fusion, identification of somatic hybrids and cybrids, genetic engineering and transformation, use of molecular markers, achievements of biotechnology in horticultural crops.

Practical

An exposure to low cost, commercial and homestead tissue culture laboratories, media preparation, inoculation of explants for clonal propagation, callus induction and culture, regeneration of plantlets from callus, sub-culturing, techniques on anther, ovule, embryo culture, somaclonal variation, protoplast isolation and culture, genetic transformation.

Suggested Readings

Bajaj YPS. (Ed.). 1989. *Biotechnology in Agriculture and Forestry*. Vol. V, *Fruits*. Springer.

Brown TA. 2001. *Gene Cloning and DNA Analysis and Introduction.* Blackwell Publ.
Chopra VL & Nasim A. 1990. *Genetic Engineering and Biotechnology – Concepts, Methods and Applications.* Oxford & IBH.
Gorden H & Rubsell S. 1960. *Hormones and Cell Culture*. AB Book Publ.
Keshavachandran R & Peter KV. 2008. *Plant Biotechnology: Tissue Culture and Gene Transfer*. Orient & Longman (Universal Press).
Keshavachandran R, Nazeem PA, Girija D, John PS & Peter KV. 2007. *Recent Trends in Biotechnology of Horticultural Crops*. Vols. I, II. New India Publ. Agency.
Parthasarathy VA, Bose TK, Deka PC, Das P, Mitra SK & Mohanadas S. 2001. *Biotechnology of Horticultural Crops*. Vols. I-III. Naya Prokash.
Pierik RLM. 1987. *In vitro Culture of Higher Plants*. Martinus Nijhoff Publ.
Skoog F & Miller CO. 1957. *Chemical Regulation of Growth and Formation in Plant Tissue Culture in vitro. Symp. Soc. Exp. Biol.* 11: 118-131.
Vasil TK, Vasi M, While DNR & Bery HR.1979. *Somatic Hybridization and Genetic Manipulation in Plants. Plant Regulation and World Agriculture*. Planum Press.
Williamson R. 1981-86. *Genetic Engineering*. Vols. I-V. Academic Press.

MBB 553/ STAT534/ FST531/ SOC512 **BIOSTATISTICS AND COMPUTERS** **2+1** **SEM - I**

(To be taught by Statistics)

Objective

This is a course of applied Statistics to be taken by M.Sc. students of Biotechnology, FST and Sociology departments of CoBS&H. They are exposed to various statistical methods to analyze their experimental data.

Theory

UNIT-I: Aims, scope and idea of elementary statistics; Measures of central tendency and dispersion, skewness and kurtosis.

UNIT-II: Concept of probability and probability laws, mathematical expectation, moments, moments generating function; Standard probability distributions- Binomial, Poisson and Normal distributions.

UNIT-III: Tests of significance based on Z, χ^2, t and F statistics; Correlation and regression, curve fitting by least squares methods.

UNIT-IV: Basic principles, organization and operational aspects of computers, operating systems. Introduction to MS-Office, MS-Word, MS-Excel. Statistical Data analysis based on above topics through MS-Excel.

Practical

- Data analysis using probability, test of significance
- Correlation and regression analysis
- Usage of MS-Windows
- Exercises on test processing, spreadsheet and DBMS
- SPSS

Suggested Readings

Agarwal BL. 2003. *Basic Statistics*. New Age.
Gupta SP. 2004. *Statistical Methods*. S. Chand & Sons.
Dutta NK. 2002. *Fundamentals of Bio-Statistics*. Kanishka Publ.,Wiley Eastern.

MBB 555/ BIF 501/ ABT 608/ FSC 604 **INTRODUCTION TO BIOINFORMATICS** **2+1** **SEM - I**

(To be taught jointly by Molecular Biology & Biotechnology, Bioinformatics)

Objective

To impart an introductory knowledge about the subject of bioinformatics to the students studying any discipline of science.

Theory

UNIT-I: Introduction, biological databases ï primary, secondary and structural, Protein and Gene Information Resources ï PIR, SWISSPROT, PDB, genebank, DDBJ. Specialized genomic resources.

UNIT-II: DNA sequence analysis, cDNA libraries and EST, EST analysis, pairwise alignment techniques, database searching, multiple sequence alignment.

UNIT-III: Secondary database searching, building search protocol, computer aided drug design ï basic principles, docking, QSAR.

UNIT-IV: Analysis packages ï commercial databases and packages, GPL software for Bioinformatics, web-based analysis tools.

Practical

- Usage of NCBI resources
- Retrival of sequence/structure from databases
- Visualization of structures
- Docking of ligand receptors
- BLAST exercises.

Suggested Readings

Attwood TK & Parry-Smith DJ. 2003. *Introduction to Bioinformatics*. Pearson Edu.

Rastogi SC, Mendiratta N & Rastogi P. 2004. *Bioinformatics: Concepts, Skills and Applications*. CBS.

MBB 556 ENVIRONMENTAL BIOTECHNOLOGY 3+0 SEM - II

Objective

To apprise the students about the role of biotechnology in environment management for sustainable eco-system and human welfare.

Theory

UNIT-I: Basic concepts and environmental issues; types of environmental pollution; problems arising from high-input agriculture; methodology of environmental management; air and water pollution and its control; waste water treatment - physical, chemical and biological processes; need for water and natural resource management.

UNIT-II: Microbiology and use of micro-organisms in waste treatment; biodegradation; degradation of Xenobiotic, surfactants; bioremediation of soil & water contaminated with oils, pesticides & toxic chemicals, detergents etc; aerobic processes (activated sludge, oxidation ditches, trickling filter, rotating drums, etc); anaerobic processes: digestion, filteration, etc.

UNIT-III: Renewable and non-Renewable resources of energy; energy from solid waste; conventional fuels and their environmental impact; biogas; microbial hydrogen production; conversion of sugar to alcohol; gasohol; biodegradation of lignin and cellulose; biopesticides; biofertilizers; composting; vermiculture, etc.

UNIT-IV: Treatment schemes of domestic waste and industrial effluents; food, feed and energy from solid waste; bioleaching; enrichment of ores by microorganisms; global environmental problems: ozone depletion, UV-B, greenhouse effects, and acid rain; biodiversity and its conservation; biotechnological approaches for the management environmental problems.

Suggested Readings

Evans GM & Furlong JC. 2002. *Environmental Biotechnology: Theory and Application*. Wiley International.

Jordening H-J & Winter J. 2006. *Environmental Biotechnology: Concepts and Applications*. Wiley-VCH Verlag.

MBB 601 ADVANCES IN PLANT MOLECULAR BIOLOGY 3+0 SEM - I

(Pre-requisite MBB 501)

Objective

To discuss the specialized topics and recent advances in the field of plant molecular biology.

Theory

UNIT-I: *Arabidopsis* in molecular biology, Forward and Reverse Genetic Approaches, Transcriptional and post-transcriptional regulation of gene expression, isolation of promoters and other regulatory elements.

UNIT-II: RNA interference, Transcriptional gene silencing, Transcript and protein analysis, use of transcript profiling to study biological systems.

UNIT-III: Hormone regulatory pathways: Ethylene, Cytokinin, Auxin and ABA, SA and JA; ABC Model of Floral Development, Molecular basis of self incompatibility, Regulation of flowering: photoperiod, vernalization, circadian rhythms.

UNIT-IV: Molecular biology of abiotic stress responses: Cold, high temperature, submergence, salinity and drought; Molecular Biology of plant-pathogen interactions, molecular biology of *Agrobacterium* Infection, Molecular biology of *Rhizobium* infection (molecular mechanisms in symbiosis), Programmed cell death in development and defense.

Suggested Readings

Buchanan B, Gruissen W & Jones R. 2000. *Biochemistry and Molecular Biology of Plants*. American Society of Plant Physiologists, USA.

Lewin B. 2008. *Gene IX.* Peterson Publications/ Panima.

Malacinski GM & Freifelder D. 1998. *Essentials of Molecular Biology*. 3rd Ed. Jones & Bartlett Publ.

Nelson DL & Cox MM. 2007. *Lehninger's Principles of Biochemistry*. WH Freeman & Co.

Watson JD, Bakee TA, Bell SP, Gann A, Levine M & Losick R. 2008. *Molecular Biology of the Gene.* 6th Ed. Pearson Edu.

MBB 602 ADVANCES IN GENETIC ENGINEERING 3+0 SEM – I

(Pre-requisite MBB 501)

Objective

To discuss the specialized topics and advances in field of genetic engineering and their application in plant improvement.

Theory

UNIT-I: General overview of transgenic plants; Case studies: Genetic engineering of herbicide resistance, Transgenic plants resistant to insects/pests, Genetic engineering of abiotic stress tolerance, Engineering food crops for quality, Genetically engineered pollination control, Induction of male sterility in plants.

UNIT-II: Molecular farming of plants for applications in veterinary and human medicine systems: Boosting heterologous protein production in transgenics, Rapid production of specific vaccines, High-yield production of therapeutic proteins in chloroplasts.

UNIT-III: Recent developments in plant transformation strategies; Role of antisense and RNAi-based gene silencing in crop improvement; Regulated and tissue-specific expression of transgenes for crop improvement; Gene stacking; Pathway engineering; Marker-free transgenic development strategies; High throughput phenotyping of transgenic plants.

UNIT-IV: Field studies with transgenic crops; Environmental issues associated with transgenic crops; Food and feed safety issues associated with transgenic crops; Risk assessment of transgenic food crops.

Suggested Readings

Christou P & Klee H. 2004. *Handbook of Plant Biotechnology*. John Wiley & Sons.

Specific journals mentioned later.

MBB 603 ADVANCES IN MICROBIAL BIOTECHNOLOGY 3+0 SEM - II

(Pre-requisite MBB 501)

Objective

To discuss specialized topics about industrially important microorganisms.

Theory

UNIT-I: Fermentative metabolism and development of bioprocessing technology, processing and production of recombinant products; isolation, preservation and improvement of industrially important microorganisms.

UNIT-II: Immobilization of enzymes and cells; Batch, plug flow and chemostate cultures; Computer simulations; Fed-batch and mixed cultures; Scale-up principles; Down stream processing etc.

UNIT-III: Current advances in production of antibiotics, vaccines, and biocides; Steroid transformation; Bioreactors; Bioprocess engineering; Production of non-microbial origin products by genetically engineered microorganisms.

UNIT-IV: Concept of probiotics and applications of new tools of biotechnology for quality feed/food production; Microorganisms and proteins used in probiotics; Lactic acid bacteria as live vaccines; Factors affecting delignification; Bioconversion of substrates, anti-nutritional factors present in feeds; Microbial detoxification of aflatoxins; Single cell protein, Bioinsecticides; Biofertilizers; Recent advances in microbial biotechnology.

Suggested Readings

Specific journals and published references.

MBB 604/ VSC604/ FLA 605 **ADVANCES IN CROP BIOTECHNOLOGY** **3+0** **SEM – I**

(Pre-requisite MBB 501)

Objective

To discuss specialized topics on the application of molecular tools in breeding of specific crops.

Theory

UNIT-I: Conventional versus non-conventional methods for crop improvement; Present status and recent developments on available tissue culture, transformation, molecular marker and genomic tools for crop improvement.

UNIT-II: Genetic engineering for resistance against abiotic (drought, salinity, flooding, temperature, etc) and biotic (insect pests, fungal, viral and bacterial diseases, weeds, etc) stresses; Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation and nutrient uptake efficiency; Genetic engineering for quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc); edible vaccines, etc.

UNIT-III: Molecular breeding: constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples on marker assisted selection of qualitative and quantitative traits.

UNIT-IV: Discussion on application of molecular, transformation and genomic tools for the genetic enhancement in some major cereal, legume, oilseed, vegetable and horticultural crops.

Suggested Readings

Specific journals and published references.

MBB 605/ BIOCHEM 606/ PP 602 **ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS** **3+0** **SEM - II**

(Pre-requisite MBB 501)
(To be taught jointly by Molecular Biology & Biotechnology, Biochemistry, Plant Physiology)

Objective

To discuss recent advances and applications of functional genomics and proteomics in agriculture, medicine and industry.

Theory

UNIT-I: Genome sequencing and functional genomics; Human, animal, plant, bacterial and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters; etc.

UNIT-II: Functional analysis of genes; RNA-mediated interference; gene knockoffs; Gene traps/ T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast-two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comparative genomics; Genome evolution, speciation and domestication etc.

UNIT-III: Proteomics: protein annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/ management, etc.

UNIT-IV: Metabolic pathway engineering, Discussion on selected papers on functional genomics, metabolomics, proteomics, integrative genomics etc.

Suggested Readings

Specific journals and published references.

MBB 606 COMMERCIAL PLANT TISSUE CULTURE 2+0 SEM – I

(Pre-requisite MBB 501)

Objective

To discuss the commercial applications of plant tissue culture in agriculture, medicine and industry.

Theory

UNIT-I: Micropropagation of commercially important plant species; plant multiplication, hardening, and transplantation; genetic fidelity; scaling up and cost reduction; bioreactors; synthetic seeds; management and marketing.

UNIT-II: Production of useful compounds via biotransformation and secondary metabolite production: suspension cultures, immobilization, examples of chemicals being produced for use in pharmacy, medicine and industry.

UNIT-III: Value-addition by transformation; development, production and release of transgenic plants; patent, bio-safety, regulatory, environmental and ethic issues; management and commercialization.

UNIT-IV: Some case studies on success stories on commercial applications of plant tissue culture. Visits to some tissue culture based commercial units/industries.

Suggested Readings

Specific journals and published references.

MBB 607/ ABT707 ADVANCES IN ANIMAL BIOTECHNOLOGY 2+0 SEM - II

(To be taught by Animal Biotechnology)

(Pre-requisite MBB 501)

Objective

Intended to provide cutting edge knowledge on advances in different areas of animal biotechnology.

Theory

UNIT-I: Advances in animal cell culture technology, suspension culture technology, advances in commercial scale productions of mammalian cells.

UNIT-II: Advances in cell cloning and cell hybridization, advances in monoclonal antibody production technology, Advances in diagnostic technology, Computational vaccinology, reverse genetics based vaccines.

UNIT-III: Advances in embryo manipulation, knock out and knock in technology, advances in animal cloning technology, stem cell technology, Advances in development of animal models for human diseases using transgenic animal technology.

UNIT-IV: Advances in genetic basis for animal disease resistance, Molecular methods for animal forensics, Advances in animal genomics, proteomics.

Suggested Readings

Selected articles from journals.

PLANT MOLECULAR BIOLOGY & BIOTECHNOLOGY

List of Journals

- Advances in Botanical Research
- Advances in Enzyme Regulation
- Advances in Enzymology
- Advances in Genetics
- Agricultural and Biological Research
- Analytical Biochemistry
- Annals of Botany
- Archives of Biochemistry and Biophysics
- Archives of Microbiology
- Biochemical and Biophysical Research Communication
- Biochemical Genetics
- Biochemistry
- Biotechnology and Bioengineering
- Critical Reviews in Plant Sciences
- Crop Science
- EMBO Journal
- Euphytica
- Genetic and Plant Breeding
- Genome
- Indian Journal of Genetics and Plant Breeding
- Journal of Biotechnology
- Journal of Experimental Botany
- Journal of General Microbiology
- Journal of Heredity
- Journal of Plant Biochemistry and Biotechnology
- Journal of Plant Biology
- Molecular and Cellular Biochemistry
- Molecular Breeding
- Molecular Genetics and Genomics
- Nature
- Nature Biotechnology
- Plant Cell
- Plant Molecular Biology
- Plant Physiology
- Plant Physiology and Biochemistry
- Proceedings of The National Academy of Sciences (USA)
- Science
- Trends in Biochemical Sciences
- Trends in Biotechnology
- Trends in Cell Biology
- Trends in Food Science and Technology
- Trends in Genetics
- Trends in Microbiology
- Trends in Plant Sciences

e-Resources

- National Center for Biotechnology Information
  - http://www.ncbi.nlm.nih.gov/
- The World Wide Web Virtual Library: Biotechnology.
  - http://www.cato.com/biotech/

- The Transgenic/Targeted Mutation Database (TBASE)
  - http://www.bis.med.jhmi.edu/Dan/tbase/tbase.html
- Primer on Molecular Genetics
  - http://www.bis.med.jhmi.edu/Dan/DOE/intro.html.
- Bioportal
  - http://bioportal.gc.ca/english/BioPortalHome.asp
- Access Excellence
  - http://www.gene.com/ae
- BioTech Biosources Database: Indiana University
  - http://biotech.chem.indiana.edu/
- Information Systems for Biotechnology
  - http://gophisb.biochem.vt.edu/
- All About The Human Genome Project (HGP)
  - http://www.genome.gov/
- *Human Genome Project at the Sanger Institute*
  - http://www.sanger.ac.uk/HGP/
- UCSC Genome Browser
  - http://genome.ucsc.edu/
- Gramene
  - www.gramene.org/
- The Institute for Genomic Research
  - www.tigr.org

Suggested Broad Topics for Master's and Doctoral Research

- Micropropagation of important crop plants, cash crops, ornamentals, forest and horticultural trees, medicinal and aromatic plants.
- Development of transgenics in field crops for resistance against biotic and abiotic stresses, and to improve the nutritional quality, etc.
- DNA fingerprinting of important plant species and germplasm.
- Development of molecular markers (SNP, SSR, transposable elements, etc) and their utilization for genetic diversity and phylogenetic analysis.
- Molecular mapping and marker-assisted selection for major-gene traits in crop species.
- Value-addition including biopesticides, biofertilizers, biofuels, biodegradable plastics, secondary metabolites, etc.
- Genome sequencing and functional analysis of genes of important organisms.
- Allele mining, proteomics, genomics and metabolic engineering for crop improvement.
- Immobilization of enzymes/microorganisms.
- Protein engineering.
- To develop crops with improved mineral (Fe, Zn, Vitamin A, etc) bioavailbility.
- Biodiversity and conservation of endangered plant species.
- Bioprocess engineering and down stream processing.

PLANT PHYSIOLOGY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
PP 501	PRINCIPLES OF PLANT PHYSIOLOGY	4+0	I
PP 502*	PLANT DEVELOPMENTAL BIOLOGY ï PHYSIOLOGICAL AND MOLECULAR BASIS	3+0	II
PP 503*	PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES	3+1	I
PP 504*	HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT	2+1	II
PP 505	PHYSIOLOGY OF GROWTH AND YIELD AND MODELING	1+1	II
PP 506	GENOME ORGANIZATION IN HIGHER PLANTS	2+1	I
PP 507	MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION	2+1	II
PP 508	PHYSIOLOGY OF CROP PLANTS ï SPECIFIC CASE STUDIES	2+0	II
PP 509*	PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS, RESPIRATION AND NITROGEN ASSIMILATION	3+1	I
PP 510*	MINERAL NUTRITION	2+1	II
PP 511/ ❶ SST 509	SEED PHYSIOLOGY	1+1	I
PP 591	MASTERôS SEMINAR	1	I, II
PP 599	MASTERôS RESEARCH	20	I, II
PP 601**	SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES	3+0	I
PP 602**/ ❷ MBB 605/ BIOCHEM 606	ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS	3+0	II
PP 603	MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS	2+1	I
PP 604**	TECHNIQUES IN PLANT PHYSIOLOGY	1+2	II
PP 605	CLIMATE CHANGE AND CROP GROWTH	2+0	I
PP 606	POST HARVEST PHYSIOLOGY	2+1	I
PP 607	WEED PHYSIOLOGY AND HERBICIDE ACTION	1+1	II
PP 608	ADVANCED SEED PHYSIOLOGY	2+1	II
PP 691	DOCTORAL SEMINAR I	1	I, II
PP 692	DOCTORAL SEMINAR II	1	I, II
PP 699	DOCTORAL RESEARCH	45	I, II

*Compulsory for Masterôs programme; **Compulsory for Doctoral programme

All courses open to the students of other Colleges/ Departments, however PP 501 is compulsory for students of COA taking Plant Physiology as minor/ supporting

To be taught by ❶ Plant Physiology and Seed Science Technology; ❷jointly by Molecular Biology & Biotechnology, Biochemistry and Plant Physiology

PLANT PHYSIOLOGY

Course Contents

PP 501 PRINCIPLES OF PLANT PHYSIOLOGY 4+0 SEM - I

Objectives

To acquaint the students with the basic concepts of plant physiology and their application in agriculture.

Theory

UNIT-I: Cell organelles and their physiological functions, structure and physiological functions of cell wall, cell inclusions; cell membrane structure and functions.

UNIT-II: Soil and plant water relations, water and its role in plants, properties and functions of water in the cell water relations-cell water terminology, water potential of plant cells.

UNIT-III: Mechanism of water uptake by roots-transport in roots, aquaporins, movement of water in plants ï Mycorhizal association on water uptake.

UNIT-IV: Water loss from plants-Energy balance-Solar energy input-energy dissipation at crop canopy level- evapotranspiration transpirationï Driving force for transpiration, plant factors influencing transpiration rate.

UNIT-V: Stomata structure and function ï mechanism of stomatal movement, antitranspirants.

UNIT-VI: Physiology of water stress in plants: Influence of water stress at cell, organ, plant and canopy levels. Indices for assessment of drought resistance.

UNIT-VII: The role of mineral nutrients in plant metabolism: Essential elements, classification based on function of elements in plants.

UNIT-VIII: Uptake of mineral elements in plants ï Mechanisms of uptake-translocation of minerals in plants.

UNIT-IX: Physiological and metabolic functions of mineral elements, critical levels, deficiency symptoms, nutrient deficiency and toxicity. Foliar nutrition.

UNIT X: Photosynthesis and its importance in bio productivity. Photochemical process, photochemical reactions, CO_2 reduction in Calvin cycle, supplementary pathway of C fixation in C4 and CAM plants and its significance.

UNIT XI: Photorespiration and its relevance. Photosynthesis - effect of environmental factors on photosynthetic rates. Translocation of photosynthates and its importance in sink growth.

UNIT XII: Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

UNIT XIII: Nitrogen metabolism: Inorganic nitrogen species (N_2, NO_3 and NH_3) and their reduction to aminoacids, protein synthesis and nucleic acids.

UNIT XIV: Lipid metabolism- Storage, protective and structural lipids. Biosynthesis of fattyacids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defence mechanism.

UNIT XV: Growth and differentiation. Mechanism of seed and bud dormancy. Hormonal concept of growth and differentiation, plant growth hormones and their physiological role, synthetic growth regulators, growth retardants., apical dominanace, senescence, fruit growth, abscission.

UNIT XVI: Photo morphogenesis: Photo receptors, phytochrome, cryptochrome, physiology of flowering- Photoperiodism and Vernalisation.

Suggested Readings

Hopkins WG. *Introduction to Plant Physiology*. John Wiley & Sons.

Salisbury FB & Ross C. *Plant Physiology.* CBS.

Taiz L & Zeiger E. *Plant Physiology.* Sinauer Associates. 2006; 4th Ed., Springer.

PP 502 PLANT DEVELOPMENTAL BIOLOGY – PHYSIOLOGICAL AND MOLECULAR BASIS 3+0 SEM - II

Objective

To explain about basic physiological and molecular processes concerning various facets of growth and development of plants.

Theory

UNIT-I: Plant Biodiversity, Concept of evolution in plants.

UNIT-II: Cell organelles, and their physiological functions, structure and physiological functions of cell wall, cell inclusions and cell membranes.

UNIT-III: General Aspects ï Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth.

UNIT-IV: Seed Germination and Seedling Growth ï Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth.

UNIT-V: Shoot, Leaf and Root Development ï Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages.

UNIT-VI: Floral Induction and Development ï Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination.

UNIT-VII: Seed Development and Dormancy ï Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy.

UNIT-VIII: Senescence and Programmed Cell Death (PCD) ï Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants.

UNIT-IX: Light Control of Plant Development ï Discovery of phytochromes and cryptochromes, their structure, biochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants.

Suggested Readings

Datta K 2007. *Plant Physiology*. Mittal Publ.

Srivastava LM. 2002. *Plant Growth and Development: Hormones and Environment*. Academic Press

Taiz L & Zeiger E. 2006. *Plant Physiology*. 4th Ed. Sinauer Associates.

Wareing PF & Phillips IDJ. 1981. *Growth and Differentiation in Plants*. 3rd Ed. Pergamon Press.

Wilkins MB. 1969. *Physiology of Plant Growth and Development.* Tata McGraw-Hill.

PP 503 PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES **3+1** **SEM - I**

Objective

To apprise the students regarding the effects of abiotic stresses to plant and its molecular basis.

Theory

UNIT-I: Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses.

UNIT-II: Water potential in the soil-plant air continuum. Mechanism of water uptake by roots- transport in roots, aquaporins, movement of water in plants. Development of water deficits, energy balance concept. Drought-characteristic features.

UNIT-III: Transpiration and its regulation ï stomata structure and functions, mechanism of stomatal movement.

UNIT-IV: Physiological processes affected by drought. Drought resistance mechanisms: Escape, Dehydration postponement (Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, osmoprotectants, stress proteins. Water use efficiency as a drought resistant trait.

UNIT-V: Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products.

UNIT-VI: Stress and hormones- ABA as a signaling molecule- cytokinin as a negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD catalase etc.).

UNIT-VII: High temperature stress: Tolerance mechanisms- role of membrane lipids in high temperature tolerance. Functions of HSPs.

UNIT-VIII: Chilling stress: Effects on physiological processes.Crucial role of membrane lipids.

UNIT-IX: Salinity: Species variation in salt tolerance. Salinity effects at ï Cellular and whole plant level, tolerance mechanisms. Salt tolerance in ï Glycophytes and halophytes, Breeding for salt resistance.

UNIT X: Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

Practical

Measurement of water status of plants, determination of osmotic potential by vapour pressure and freezing point depression, Determination of soil water potential and content by psychrometry and other systems. Stress imposition and quantification, stomatal conductance. Canopy temperature as a reflection of transpiration and root activity, Water use-efficiency determination at whole plant and single leaf level, Root- shoot signals-ABA and cytokinin effect on stomatal behavior, Heat tolerance and membrane integrity. Sullivans heat tolerance test, chilling tolerance- Galactolipase and free fatty acid levels as biochemical markers for chilling damage, Cold induced inactivation of O_2 evolution of chloroplasts- as a screening technique for chilling tolerance.

Suggested Readings

Hopkins WG. *Introduction to Plant Physiology* . John Wiley & Sons.

Salisbury FB & Ross C. *Plant Physiology.* CBS.

Taiz L & Zeiger E. *Plant Physiology.* Sinauer Associates, 2006; 4th Ed., Springer.

PP 504 HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT 2+1 SEM - II

Objective

To apprise the students about structure and function of plant growth regulators on growth and development of plants.

Theory

UNIT-I: Definition and classifiacation of plant growth regulators- Hormones, endogenous growth substances and synthetic chemicals, Endogenous growth regulating substances other than hormones. tricontanol, Phenols ï polyamines, jasmonates, concept of death hormone.

UNIT-II: Site of synthesis, biosynthetic pathways and metabolism and the influence on plant growth development of individual group of hormones- Auxins, Gibberelins, Cytokinins, Abscisic acid, Ethylene and Brassinosteroids.

UNIT-III: Hormone mutants and transgenic plants in understanding role of hormones.

UNIT-IV: Signal perception, transduction, and effect at functional gene level of different hormones- Auxins- cell elongation, Gibberellins - germination of dormant seeds, cytokinins- cell division, retardation of senescence of plant parts, Abscisic acid-stomatal closure and induction of drought resistance, Ethylene- fruit ripening.

UNIT-V: Interaction of hormones in regulation of plant growth and development processes. Rooting of cuttings- Flowering. Apical dominance, molecular aspects of control of reproductive growth and development.

UNIT-VI: Synthetic growth regulators- Classification, their effect on plant growth and development. Practical utility in agriculture and horticulture.

UNIT-VII: Secondary metabolites and their significance in plant defense mechanism.

Practical

Quantification of Hormones- Principles of bioassays, physico chemical techniques and immunoassay, Extraction of hormones from plant tissue. Auxins- bioassays- auxins effect on rooting of cuttings, abscission, apical dominance, Gibberellins- bioassays-GA effect on germination of dormant seeds, cytokinin- bioassays- estimation using immunoassay technique cytokinin effect on apical dormance and senescence, ABA bioassays- estimation using immunoassay technique. ABA effect on stomatal movement, Ethylene bioassays, estimation using physico chemical techniques- effect on breaking dormancy in sunflower and groundnut.

Suggested Readings

Hopkins WG. *Introduction to Plant Physiology.* John Wiley & Sons.

Salisbury FB & Ross C. *Plant Physiology.* CBS.

Taiz L & Zeiger E. *Plant Physiology.* Sinauer Associates, 2006; 4th Ed., Springer.

PP 505 PHYSIOLOGY OF GROWTH AND YIELD AND MODELING 1+1 SEM - II

Objective

To impart knowledge regarding crop growth analysis and different yield prediction models.

Theory

UNIT-I: Crop growth analysis, key growth parameters. Analysis of factors limiting crop growth and productivity- the concept of rate limitation .

UNIT-II: Phenology- Growth stages, internal and external factors influencing flowering. Photoperiodic and thermo-periodic responses and the concept of Degree days and crop growth duration.

UNIT-III: Canopy architecture, light interception, energy use efficiency of different canopies. LAI, LAD. concept of optimum LAI.

UNIT-IV: Source-sink relationships. Translocation of photosynthates and factors influencing transport of sucrose. Physiological and molecular control of sink activity ï partitioning efficiency and harvest index.

UNIT-V: Plant growth analysis techniques, yield structure analysis, theoretical and actual yields.

UNIT-VI: Plant ideotypes.

UNIT-VII: Simple physiological yield models- Duncanôs. Monteithôs, and Passiouraôs.

UNIT-VIII: Crop growth models-empirical models testing and yield prediction.

Practical

Plant sampling for leaf area and biomass estimation; analysis of growth and yield parameters ï LAD, NAR. CGR, LAI, LAR, SLA portioning efficiency HI, Measurement of light interception, light extinction coefficient, energy utilization efficiency based energy intercepted, and realized, Computer applications in plant physiology, crop productivity and modeling.

Suggested Readings

Goudriaan J & Van Laar HH. 1995. *Modelling Potential Crop Growth Processes*. (Textbook with Exercises) Series: *Current Issues in Production Ecology,* Vol.II. Kluwer.

Hunt R. *Plant Growth Curve-The Fundamental Approach to Plant Growth Analysis*. Edward Arnold.

John H, Thornley M & Johnson IR. *Plant and Crop Modeling: A Mathematical Approach to Plant and Crop Physiology*. Blackburn Press.

Vos J, Marcelis LFM, Visser PHBD, Struik PC & Evers JB. (Eds.). 2007. *Functional-Structural Plant Modelling in Crop Production*. Vol. XXII. Springer.

PP 506 GENOME ORGANIZATION IN HIGHER PLANTS 2+1 SEM - I

Objective

To impart basic concept on genome organization in prokaryotic and eukaryotic system.

Theory

UNIT-I: Introduction: Basic discoveries in molecular genetics; basic concepts on genome organization and its replication in prokaryotic systems including cyanobacteria; genome organization in diploids, tetraploids, autoptetraploids and polyploids.

UNIT-II: Gene & gene expression: Diversity in DNA polymerases; control of plasmid copy number; Regulation of transcription in prokayotes; Promoters and terminators; Positive and negative control of transcription; Repression and activation-operon concept.

UNIT-III: Mitochondrial and chloroplastic genome organization and regulation of gene expression.

UNIT-IV: Eukaryotic genome structure: Organization and replication; control of gene expression-transcription and post-transcriptional; promoter analysis; concept of cis elements; transcription factors, function and role of RNA polymerases.

UNIT-V: Genetic code and translation-deciphering the genetic code; Codon bias; tRNAs, ribosomes; Initiation and termination of translation; Translational and post-translational controls; Attenuation; Suppressor tRNAs.

UNIT-IV: Mobile genetic elements; Structure and function of transposable elements; Mechanism of transposition; Special features of retroptransposans; Repair and recombination.

Practical

Culturing and transformation of bacteria; genomic DNA and plasmid DNA isolation from bacteria, restriction enzyme digestion and analysis by agarose gel electrophoresis, isolation of genomic DNA and RNA from plants and quantification; Culture of bactriophage; studis on lytic and lysogenic phages.

Suggested Readings

Johnson AB, Lewis J Raff, M Roberts K & Walter P. *Molecular Biology of the Cell*. 3rd Ed. Garland Science.

PP 507 MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION 2+1 SEM - II

Objective

To impart knowledge about cellular basis of growth and morphogenesis in plants.

Theory

UNIT-I: Morphogenesis: The cellular basis of growth and morphogenesis cytodifferentiation., photomorphogenesis.

UNIT-II: The cell cycle-cell division and cell organization, cell structure, tissue and organ differentiation. Control of cell division and differentiation in selected cell types, Introductory history, morphogenesis and cellular totipotency.

UNIT-III: In vitro culture of embryo, embryo rescue after wide hybridization and its application, anther and pollen, somatic hybridization, endosperm culture and production of triploids.

UNIT-IV: Plant transformation through Agrobacterium tumefaciens (Monocots & Dicots), Root ï formation using *A. rhizogenes*.

Practical

In vitro culture of different explants such as leaf, stem, shoot apex, cotyledonary nodes, Effect of growth regulators auxin, cytokinin, ethylene on callus induction, organogenesis, somatic embryogenesis, effect of growth condition such as temperature and photoperiod on organogenesis.

Suggested Readings

Bajaj YPS. (Ed.). 1991. *Biotechnology in Agriculture and Forestry*. Vol. XIV. Springer-Verlag.

Bhojwani SS & Bhatnagar SP. 1997. *The Embryology of Angiosperms*. Vikas Publ.

Johri BM.1982. *Experimental Embryology of Vascular Plants*. Springer Verlag.

Rajdan MK. 1993. *Plant Tissue Culture*. Oxford & IBH.

PP 508 PHYSIOLOGY OF CROP PLANTS – SPECIFIC CASE STUDIES 2+0 SEM - II

Objective

To impart knowledge of physiological aspects of different crop plants.

Theory

UNIT-I: Crop physiological aspects of rice, wheat, maize, sorghum, millets, sugarcane, pulses, oil seeds, cotton and potato Crops. Six to Eight Species could be chosen based on local importance.

UNIT-II: Crop specific topics.

UNIT-III: Seed dormancy, photoperiodic and thermoperiodic responses.

UNIT-IV: Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

Suggested Readings

Gardner FP, Pearce RB & Mitchell RL 1988. *Physiology of Crop Plants*. Scientific Publ.

Pessaraki M. *Handbook of Plant and Crop Physiology*. CRC Press.

Selected reviews and articles from Periodicals and Journals.

PP 509 PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS, RESPIRATION AND NITROGEN ASSIMILATION **3+1** **SEM - I**

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory

UNIT-I: Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere.

UNIT-II: Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield.

UNIT-III: Photosynthetic carbon reduction cycle and its regulation. CO_2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic macrophages (SAM), C_4, CAM and single celled C_4 organisms, C_3-C_4 intermediates. Ecological significance of CCM.

UNIT-IV: Rubisco structure, assembly and kinetics, photorespiration and its significance.

UNIT-V: Carbon fluxes between chloroplast and cytoplasm and Carbon fixation as a diffusive process, the concept of r_a, r_s and r_m. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc.

UNIT-VI: Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity ï transgenics. Conceptual approaches of expressing C_4 photosynthesis genes in C_3 species.

UNIT-VII: Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and no-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept.

UNIT-VIII: Prospects of improving photo synthetic rate and productivity ï potential traits of photosynthesis- biotechnological approaches.

UNIT-IX: Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance.

UNIT X: Nitrogen assimilation in photosynthesizing cells ï NO_3^-, NO_2^- reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its re-assimilation and NUE.

UNIT XI: Lipid metabolism-storage, protective and structural lipids. Biosynthesis of fatty acids,diacyl and triacyl glycerol.

Practical

Extraction and separation of plant pigments, Isolation of chloroplasts ETC reactions- O_2 evolution, Determination of rubisco content (western and ELISA), activity and activation state, Enzymatic determination of starch and sucrose, Determination of photosynthetic rates ï gas exchange. A, g_s, C_i, A/g_s, C/g_s- intrinsic WUE by gas exchange rates. Light, CO_2, VPD response curves, Determination of photorespiration by gas exchange- (TPS-APS). Genotypic/species differences in photosynthetic rates. Measurement of radiation, Eu% light interception, Determination of NH_4^+, reduction of inorganic nitrogen species.

Suggested Readings

Hopkins WG & Huner NPA. 2004. *Introduction to Plant Physiology*. John Wiley & Sons.

Oxlade E & Lawler G. *Plant Physiology: The Structure of Plants Explained (Studymates in Focus)*. John Wiley & Sons.

Salisbury FB & Ross C. *Plant Physiology*. CBS.

Taiz L & Zeiger E. *Plant Physiology*. Sinauer Associates, 2006; 4th Ed., 2007, Springer.

PP 510 MINERAL NUTRITION **2+1** **SEM - II**

Objective

To impart knowledge about physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation.

Theory

UNIT-I: Overview of essential mineral elements, kinetics of nutrient uptake by plants. Biological actions influencing nutrient availability near the root system.

UNIT-II: Nutrient uptake by root cells, long distance transport in plants and movement into developing grains. Nutrient transport from vegetative to reproductive organs during reproductive stage of growth and maturity.

UNIT-III: Molecular mechanism of ion uptake, ion transporters, specific examples of transporters for Nitrate, Phosphate, Potassium and other nutrients. Multiple transporters for a single ion and their functional regulation.

UNIT-IV: Molecular physiology of micronutrient acquisition. Examples of genes encoding mineral ion transporters. Strategies plants adopt to acquire and transport minerals under deficient levels.

UNIT-V: Physiological and molecular mechanisms underlying differential nutrient efficiency in crop genotypes, Examples of Phosphorous, Iron and Zinc efficient crop varieties.

UNIT-VI: Breeding crop varieties for improved nutrient efficiency. Plant responses to mineral toxicity.

Practical

Physiological and biochemical changes in plants under nutrient sufficiency and deficiency levels. Quantification of pigment levels, enzyme activities.

Suggested Readings

Epstein E. & Bloom AJ. 2004. *Mineral Nutrition of Plants: Principles and Perspectives*. Sinauer Associate.

Marschner H. 1995. *Mineral Nutrition of Higher Plants*. Academic Press.

Taiz L & Zeiger E. *Plant Physiology.* Sinauer Associates, 2006; 4th Ed., Springer.

PP 511/ SST 509 **SEED PHYSIOLOGY** **1+1** **SEM - I**

(To be taught by Botany & Plant Physiology and Seed Science & Technology)

Objective

To provide an insight into physiological processes governing seed quality and its survival.

Theory

UNIT-I: Physiology of seed development and maturation; chemical composition, synthesis and accumulation of seed reserves, induction of desiccation tolerance, hormonal regulation of seed development.

UNIT-II: Seed germination; factors affecting germination; role of embryonic axis; growth hormones and enzyme activities, effect of age, size and position of seed on germination. Physiological processes during seed germination; seed respiration, breakdown of stored reserves in seeds, mobilization and inter-conversion pathways. Seed dormancy- types, significance, mechanism, endogenous and exogenous factors regulating dormancy, role of phytochrome and PGR, genetic control of dormancy.

UNIT-III: Seed viability and longevity, pre and post-harvest factors affecting seed viability ; seed ageing ; physiology of seed deterioration ; lipid peroxidation and other viability theories; means to prolong seed viability; mechanism of desiccation sensitivity and recalcitrance with respect to seed longevity.

UNIT-IV: Seed vigour and its concept, vigour test methods, factors affecting seed vigour, physiological basis of seed vigour in relation to crop performance and yield. Seed invigoration and its physiological and molecular control.

Practical

Proximate analysis of chemical composition of seed; methods of testing viability; kinetics of seed imbibition and solute leakage; seed germination and dormancy breaking methods; seed invigoration and priming treatments; accelerated ageing and controlled deterioration tests; enzymatic activities and respiration during germination and effect of accelerated ageing; vigour testing methods etc.

Suggested Readings

Agrawal PK & Dadlani M. (Eds.). 1992. *Techniques in Seed Science and Technology*. South Asian Publ.

Baskin CC & Baskin JM. 1998. *Seeds: Ecology, Biogeography and Evolution of Dormancy and Germinatio*n. Academic Press.

Basra AS. 2006. *Handbook of Seed Science and Technolog*y. Food Product Press.
Bench ALR & Sanchez RA. 2004. *Handbook of Seed Physiolog*y. Food Product Press.
Bewley JD & Black M. 1982. *Physiology and Biochemistry of Seeds in Relation to Germinatio*n. Vols. I, II. Springer Verlag.
Bewley JD & Black M. 1985. *Seed: Physiology of Seed Development and Germinatio*n. Plenum Press.
Copeland LO & Mc Donald MB. 1995. *Principles of Seed Science and Technolog*y. 3rd Ed. Chapman & Hall.
Khan AA. 1977. *Physiology and Biochemistry of Seed Dormancy and Germinatio*n. North Holland Co.
Kigel J & Galili G. (Eds.). *Seed Development and Germinatio*n. Marcel Dekker.
Murray DR. 1984. *Seed Physiology.* Vols. I, II. Academic Press.
Sadasivam S & Manickam A. 1996. *Biochemical Method*s. 2nd Ed. New Age.

PP 601 SIGNAL PERCEPTIONS AND TRANSDUCTION AND REGULATION OF PHYSIOLOGICAL PROCESSES 3+0 **SEM - I**

Objective

To impart the knowledge about signaling of hormones and regulation of physiological processes.

Theory

UNIT-I: General aspects: Introduction to signaling-Long range (Diffusible) signaling and short range (contact) signaling. Components of signaling-Upstream components: receptor and ligands concept-types of ligands and its relevance-receptor kinases-Two component sensing system. Down stream components: G.proteins-second messengers-Cyclic AMP, adenylate cyclase cascade, cyclic GMP, calcium-calmodulin-Kinases-Effector molecules (transcription factor).

UNIT-II: Hormone signaling: Hormone binding receptors-Transduction process. Effector molecules and gene expression.

UNIT-III: Specific signaling pathways of Auxins, Cytokinisn, Gibberllins, Ethylene, ABA, Brassinosteroids which leads to formative effects. The cross talk in the signaling of different hormones-significance of studies with hormone action mutants.

UNIT-IV: Light signaling: Perception of light-pigments involved-activation of phytochrome/cryptochrome (study of mutants). Light signal transduction-Multiple signaling cascades-identification of signaling components through mutant analysis-changes in gene expression.

UNIT-V: Abiotic stress signaling: Sensing of environmental factors (Temperature-Osmoticum-Ionic stress) Activation of specific molecules and secondary messengers-Activation of Down stream components-leading to stress gene expression. Case studies with different abiotic stresses.

UNIT-VI: Cross talk between signaling pathways.

UNIT-VII: Signal perception and transduction in plant defense responses: Role of salicylic acid and active oxygen species.

UNIT-VIII: Signaling cascade during leaf senescence, abscission, flowering and tuberization.

UNIT-IX: Transcription factor as signaling regulatory tools for improving growth processes-Case studies: Tbi- lateral branch development, Shi 4- grain shattering, GA1-Dwarfing.MADS, KNOX- flowering development, HAT 4- Shade development, AP2-EREBP- biotic/abiotic stresses.

Suggested Readings

Selected articles from various journals.

PP 602/ MBB 605/ BIOCHEM 606 ADVANCES IN FUNCTIONAL GENOMICS, PROTEOMICS AND METABOLOMICS 3+0 **SEM - I**

(Pre-requisite MBB 501)
(To be taught jointly by Molecular Biology & Biotechnology, Biochemistry and Plant Physiology)

Objective

To impart knowledge about physiological process of plant at molecular level.

Theory

UNIT-I: Genome sequencing and functional genomics; Human, animal, plant, bacterial and yeast genome projects; genome annotation; *ab initio* gene discovery; functional annotation and gene family clusters etc.

UNIT-II: Functional anlalysis of genes; RNA-mediated interefence; gene knockoffs; Gene traps/T-DNA insertion lines; homologous recombination; microarray profiling; SAGE; SNPs/variation; yeast- two hybrid screening; gene expression and transcript profiling; EST contigs; EcoTILLING; allele/gene mining; synteny and comaparative genomics; Genome evolution, speciation and domestication etc.

UNIT-III: Proteomics; protein annotation; protein separation and 2D PAGE; mass spectroscopy; protein microarrays; protein interactive maps; structural proteomics: protein structure determination, prediction and threading, software and data analysis/management etc.

UNIT-IV: Metabolic pathway engineering, Discussion on selected papers on functional genocmis, metabolomics, proteomics, integrative genomics etc.

Suggested Readings

Selected articles from various journals.

PP 603 MOLECULAR APPROACHES FOR IMPROVING PHYSIOLOGICAL TRAITS 2+1 SEM - I

(Unit I to be taught by Molecular Biology & Biotechnology)

Objective

To impart knowledge to improve the physiological traits using molecular approaches.

Theory

UNIT-I: Molecular breeding; constructing molecular maps; integrating genetic, physical and molecular maps; diversity assessment and phylogenetic analysis; molecular tagging of genes/traits; selected examples of marker assisted selection of qualitative and quantitative traits.

UNIT-II: Strategies for QTL introgression and Marker Assisted Selection (MAS). Map based cloning of novel genes and alleles. Allele mining.

UNIT-III: Transgenic approaches in improving physiological processes- Introduction to GMOs and application in crop improvement; gene mining, sequence structure, identification of candidate genes for various physiological processes associated with specific traits (such as stress tolerance) and their potential benefits in transgenic crops.

UNIT-IV: Cloning full-length candidate genes, stress inducible promoters, strategies to clone and characterize and make constructs for specific crops, gene stacking strategies, tissues specific expression and functional validation of genes.

UNIT-V: Transformation of crop plants-Agrobacterium and use of other organisms for transformation-particle gun transformation and other methods.

UNIT-VI: Selection of transformants-molecular analysis on the basis of qRT-PCR, Southern, Northern analysis and immunoassays; estimatioin of copy number. Concept of desirable number of independent events.

UNIT-VII: Evaluation of transgenics on basis of empirical/physiological /biochemical process under specific conditions on the basis of gene function. Generation of T1 populations, event characterization and generation of molecular data as per the regulatory requirements.

UNIT-VIII: Issues related to Biosafety and Registration of Transgenic Agricultural Organisms, methods to detect GMOs from agricultural products.

Practical

Phenotyping approaches for the different physiological traits. Genotyping options using gene-scan systems. Development of SSR, SNP and SCAR markers, resolution of polymorphism on agarose gels and PAGE, genotyping using a DNA sequencing machine, scoring of gels and assessment of polymorphism, Molecular biology ï genomic/plasmid DNA isolation, RNA Isolation, Transformation in model system, Crop transformation ï Agrobacterium mediated transformation (*in planta* & *in vitro*), Evaluation of transgenics ï semiquantitative & quantitative RT-PCR, southern blot, northern blot western blot and ELISA, biochemical/physiological assay based on the function of gene & testing LOD.

Suggested Readings

Selected articles from various journals.

PP 604 TECHNIQUES IN PLANT PHYSIOLOGY 1+2 SEM - II

Objectives

To impart recent practical training to study various physiological processes in plants.

Theory

UNIT-I: Recent experimental techniques to study various physiological processes, Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements, plant water indices, canopy temperature depression (C.T.D.,) Relative stress injury (RSI%). Stomatal conductance, Transpirational efficiency, chlorophyll and anthocyanin content. Assessment of nutrient deficiency by use of leaf color chart.

UNIT-II: Estimation of water use efficiency at whole plant and single leaf level. Use of stable isotopes to understand physiological processes.

UNIT-III: Radio isotopes in plant biology.

UNIT-IV: Tools and techniques (molecular and biochemical) to study physiological processes and to screen & assess stress responses in plants, such as (a) DNA & RNA isolation, cDNA synthesis & library construction, semi quantitative & quantitative RT-PCR, Northern blot, immunoassays; (b) techniques for defined physiological processes.

UNIT-V: Methods to phenotype germplasm for specific physiological traits.

UNIT-VI: Quantification of mineral nutrients using advanced instruments like AAS & ICP.

UNIT-VII: Instrumentation: Acquaintance of the operation of specific instruments important in physiological research like Mass spec., DNA sequencer, spectro-fluorometer, oxygen electrode, etc.

Practical

Photosynthetic gas exchange measurements, light and CO2 response curves-determination of relative limitations to photosynthesis; chlorophyll fluorescence measurements, Assessment of nutrient deficiency by use of leaf color chart. Estimation of water use efficiency at whole plant and single leaf level. Use of stable and radioactive isotopes to understand physiological processes ï Canopy temperature depression (CTD) ï evaluation of various plant water indices like RWC (Relative water content), Leaf water retention (LWR %), and water retention capability (WRC%), Relative Stress injury(RSI), evaluation of stress indices(Heat susceptibility index, heat response index). DNA & RNA isolation, cDNA synthesis & library construction, semiquantitative & quantitative RT-PCR, Northern blot, immunoassays; techniques for defined physiological processes, Quantification of mineral nutrients using advanced instruments like AAS. Extraction isolation and estimation of plant growth regulators.

Suggested Readings

Dhopte MA & Manuael Livera M. 1986. *Useful Techniques For Plant Scientists*. Forum for Plant Physiologists, R D G, Akola.

PP 605 CLIMATE CHANGE AND CROP GROWTH 2+0 SEM - I

Objective

To impart knowledge about climate change and its implication to crop growth.

Theory

UNIT-I: History and evidences of climate change and its implications. Effect of climate change on monsoons, hydrological cycle and water availability.

UNIT-II: Natural and anthropogenic activities and agricultural practices on GHG production, Monitoring of greenhouse gases and their influence on global warming and climate change, Ozone depletion leading to increased ionizing radiations and its implications on crop growth.

UNIT-III: Long-term and short-term projections of climate change effects on natural vegetations and ecosystems, crop-pest interaction, area shift, food production and supply.

UNIT-IV: Approaches to mitigate climate change through studies on plant responses.

UNIT-V: Direct and indirect effects of climate change on plant processes ï phenology, net carbon assimilation, water relations, grain development and quality, nutrient acquisition and yield.

UNIT-VI: Conventional and biotechnological approaches to improve the crop adaptation to climate change. Relevance of ñGenome wide mutantsò to identify genes/processes for improved adaptation to changing environments.

UNIT-VII: International conventions and global initiatives on Carbon sequestration, carbon trading.

Suggested Readings

Reddy KR & Hodges HF. 2000. *Climate Change and Global Crop Productivity*. CABI.
Watson RT, Zinyowera MC & Moss RH. 1998. *The Regional Impacts of Climate Change- An Assessment of Vulnerability.* Cambridge Univ. Press.

PP 606 POST HARVEST PHYSIOLOGY 2+1 SEM - I

Objective

To impart knowledge about physiological changes during senescence and ripening.

Theory

UNIT-I: Environmental factors influencing senescence, ripening and post harvest life of flowers, vegetables and seeds.
UNIT-II: Molecular mechanism of senescence and ageing. Physiological, biochemical and molecular aspects of senescence and fruit ripening.
UNIT-III: Senescence associated genes and gene products.
UNIT-IV: Functional and ultra structural changes in chloroplast membranes, mitochondria and cell wall during senescence and ripening.
UNIT-V: Regulatory role of ethylene in senescence and ripening, ethylene biosynthesis, perception and molecular mechanism of action.
UNIT-VI: Post harvest changes in seed and tubers biochemical constituentsø quality parameters. Effect of environmental factors on post harvest changes in seed and tubers.
UNIT-VII: Biotechnological approaches to manipulate ethylene biosynthesis and action.
UNIT-VIII: Alternate post harvest methodology and quality attributes. Scope for genetic modification of post harvest life of flowers and fruits.
UNIT-IX: Uses of GM crops and ecological risk assessment.

Practical

Physiological and biochemical changes during senescence and ripening, Estimation of ethylene during senescence and ripening, determination of Reactive Oxygen Species and scavenging enzymes, Measurement of dark and alternate respiration rates during senescence and ripening. Estimation of ripening related enzyme activity, Cellulases, pectin methyl esterases, polygalacturonase etc.

Suggested Reasdings

Brecht JK & Weichmann J. 2003. *Post Harvest Physiology and Pathology of Vegetables*. CRC Press.

PP 607 WEED PHYSIOLOGY AND HERBICIDE ACTION 1+1 SEM - II

Objective

To apprise students regarding weed and crop competition, and physiological and molecular aspects of herbicides.

Theory

UNIT-I: Weed biology, ecology and physiology. Weed and crop competition, allelo-chemicals, their nature and impact. Weed-seed physiology.
UNIT-II: Classification of herbicides and selectivity. Recent concepts on entry, uptake, translocation and metabolism of soil and foliar applied herbicides.Environmental and plant factors influencing entry, uptake and translocation of herbicides.
UNIT-III: Classification and chemistry of common herbicides. Physiological, biochemical and molecular mechanism of action of different groups of herbicides; ACC synthase inhibitors, ALS inhibitors, Mitotic inhibitors, Cellulose biosynthesis inhibitors, Inhibitors of fatty acid biosynthesis, inhibitors of Photosynthesis, Auxinic Herbicides, New herbicides,
UNIT-IV: Metabolic pathway of herbicide degradation in plants and soil. Herbicide adjuvants and their classification.
UNIT-V: Molecular mechanism of action of herbicide synergists and antagonists.
UNIT-VI: Physiological and molecular mechanism of herbicide selectivity.
UNIT-VII: Herbicide resistant crops; transgenic & tissue culture approaches to develop herbicide tolerant varieties.

Practical

Adjuvants and their effect on spray droplets, chemical entry and transport. Determination of physiological and biochemical processes like photosynthesis, respiration, cell division, Protein & fatty acid synthesis, membrane permeability as affected by herbicides.

Quantification of pigment levels in leaves, specific enzyme activities affected by herbicides. Demonstration of translocation type of herbicides by radio labeling studies.

Suggested Readings

Devine MD, Duke SO & Fedtake C. 1993. *Physiology of Herbicide Action*. Prentice Hall.

Monaco Thomas J, Weller Steve C & Ashton Floyd M. 2002. *Weed Science- Principles and Practices*. Wiley.

PP 608 ADVANCED SEED PHYSIOLOGY 2+1 SEM - II

Objective

To apprise students regarding seed germination, dormancy and physiological processes involved in regulation of seed development.

Theory

UNIT-I: Seed and fruit development, seed and fruit abortion, proximate mechanism of seed and fruit abortion. Hereditary and environmental effect on seed development. Gene imprints and seed development.

UNIT II: Importance of seeds, seed structure and function, physiological and biochemical changes, environmental influences, physiology of seed and fruit development; seed and fruit abortion and means to overcome it; proximate mechanisms of seed and fruit abortion.

UNIT-III: Structure of seeds and their storage resources, seed developmental patterns and source of assimilates for seed development.

UNIT-IV: Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds and their biosynthesis.

UNIT-V: Seed respiration, mitochondrial activity. Seed ageing, Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis.

UNIT-VI: Control processes in mobilization of stored resources. Role of embryonic axes. Gibberllin and a-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage. Role of LEA proteins.

UNIT-VII: Seed viability. Physiology of and means to prolong seed viability. Seed vigour: concept, importance, measurement; invigoration: methods and physiological basis of it. Seed dormancy, types and regulation. Means to overcome seed dormancy.

Practical

Determination of seed storage proteins. Sink drawing ability of ovules, empty ovule technique. Alpha-amylase activity in germinating seeds. Role of GA in inducing amylase activity. Role of embryo in GA induced a-amylase activity. Protease and lipase activity in germinating seeds. Seed viability test and accelerated ageing test. Seed hardening/osmotic priming of seeds. seed respiration rates. Seed viability losses through membrane leakage studies.

Suggested Readings

Bewley JD & Black M. 1985. *Seed Physiology of Development and Germination*. Plenum Publ.

Copeland LO & McDonald MB. *Principles of Seed Sciences and Technology*. Burgers Publ. Co.

PLANT PHYSIOLOGY

List of Journals

- American Journal of Botany
- Annals of Arid Zone
- Annual Review of Plant Physiology and Plant Molecular Biology
- Australian Journal of Agricultural Research
- Australian Journal of Biological Sciences
- Australian Journal of Botany
- Australian Journal of Plant Physiology
- Biochemie und Physiologie der Pflanzen
- Biologia Plantarum
- Botanical Gazette
- Botanical Review
- Canadian Journal of Agricultural Research
- Canadian Journal of Botany
- Canadian Journal of Plant Science
- Communications in Soil Science and Plant Analysis
- Current Science
- Environmental and Experimental Botany
- Euphytica
- Experimental Agriculture
- Experimental Cell Biology
- Functional Plant Biology
- Indian Journal of Agriculture
- Indian Journal of Experimental Biology
- Indian Journal of Plant Physiology
- International Journal of Botany
- Japanese Journal of Crop Science
- Journal of Agricultural and Scientific Research
- Journal of Agricultural Science
- Journal of Arid Environment
- Journal of Experimental Botany
- Journal of Plant Biology
- Journal of Plant Nutrition
- Nature
- New Physiologist
- Physiologia Plantarum
- Physiology and Molecular Biology of Plants
- Plant and Cell Physiology
- Plant and Soils
- Plant Cell, Tissue and Organ Culture
- Plant Growth Regulator abstracts
- Plant Physiology and Biochemistry
- Plant Science
- Plant Science (India)
- Science Journal
- Seed Science and Technology
- Seed Science Research
- Soil Science and Plant Nutrition
- Soviet Plant Physiology
- Trends in Plant Science
- Tropical Agriculture

e-Resources

- www.Bioone Online Journals The Arabiopsis Book.
- www. Botany on line:
- www.Ingenta Connect Physiologia Plantarum
- www.new.phytologist.org.
- www.plant physiol.org.
- www.mpiz-Kolen.mpg.de.
- www.Science Direct.
- www.Scientia Agricolo.
- www.wiley interscience.

Suggested Broad Topics for Master's and Doctoral Research

- Environmental stress physiology- Salt, Drought, Heat, Freezing, and Heavy Metal
- Nodulation and nitrogen fixation in leguminous plants
- Physiology of senescence and abscission in crop plants especially in cotton
- Phytoremediation, especially with reference to salt and heavy metal stress
- Ecophysiology of tree species to evaluate bio-drainage potential of plants under waterlogged saline area
- Growth and development of crop plants
- Mineral nutrition in crop plant
- Application of plant growth regulators to improve crop productivity
- Photosynthesis, respiration and related processes for crop improvement
- Post harvest Physiology of fruits & vegetabales

SOCIOLOGY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
SOC 501*	CLASSICAL SOCIOLOGICAL TRADITIONS	3+0	I
SOC 502*	THEORETICAL PERSPECTIVES IN SOCIOLOGY	3+0	II
SOC 503*	METHODOLOGY OF SOCIAL RESEARCH	2+1	II
SOC 504*	RURAL SOCIETY IN INDIA	4+0	I
SOC 505	SOCIOLOGY OF CHANGE AND DEVELOPMENT	3+0	I
SOC 506	COMMUNITY DEVELOPMENT AND LEADERSHIP	3+0	II
SOC 507	POPULATION DYNAMICS AND ENVIRONMENT	3+0	I
SOC 508	SCIENCE, TECHNOLOGY AND SOCIETY	3+0	II
SOC 509*	SOCIAL PSYCHOLOGY	3+0	II
SOC 510	SOCIETY IN INDIA	3+0	II
SOC 511	FUNDAMENTALS OF RURAL SOCIOLOGY	2+0	II
SOC 512/ ❶ STAT 534/ MBB 553/ FST 531	BIOSTATISTICS AND COMPUTERS	2+1	I
SOC 591	MASTERôS SEMINAR	1	I, II
SOC 599	MASTERôS RESEARCH	20	I, II
SOC 601**	SOCIOLOGICAL THEORY OF TODAY	3+0	II
SOC 602	COMPARATIVE SOCIOLOGY	3+0	I
SOC 603**	ADVANCED ANALYTICAL SOCIAL PSYCHOLOGY	3+0	II
SOC 604**	SOCIOLOGY OF AGRICULTURAL AND RURAL DEVELOPMENT	3+0	I
SOC 691	DOCTORAL SEMINAR I	1	I, II
SOC 692	DOCTRORAL SEMINAR II	1	I, II
SOC 699	DOCTORAL RESEARCH	45	I, II

* Compulsory for Masterôs programme; **Compulsory for Doctoral programme

❶ To be taught by Statistics

SOCIOLOGY

Course Contents

SOC 501 CLASSICAL SOCIOLOGICAL TRADITIONS 3+0 SEM - I

Objective

Acquaintance with the writing of prominent social thinkers with theoretical insights to know, analyze and interpret the social scenario.

Theory

UNIT-I: Historical socio-economic background of emergence of the Sociology.

UNIT-II: Marxian theory of social change- dialectical materialism, materialistic interpretation, class conflict, alienation, and political power.

UNIT-III: Contribution of Emile Durkhiem- social disintegration as a legacy of industrial revolution, division of labour, theory of suicide, religion and contribution to methodology of sociology, sociology as a science.

UNIT-IV: Max weberôs contribution to sociological thoughts- theory of social action, protestant ethics and emergence of capitalism, theory of authority, bureaucracy, class and power, contribution to the methodology of social science.

UNIT-V: Vilfredo Paretoôs contribution: logico-experimental method, theory of Residuals and Derivatives, theory of social change and circulation of elites.

Suggested Readings

Abraham FM. 1998. *Modern Sociological Theory– An Introduction*. Oxford Univ. Press.

Coser LA. 1977. *Master of Sociological Thoughts*. Harcourt Brace.

Giddens A. 1977. *Capitalism and Modern Social Theory – Analysis of Writings of Marx, Durkheim and Weber*. Cambridge Univ. Press.

SOC 502 THEORETICAL PERSPECTIVES IN SOCIOLOGY 3+0 SEM - II

Objective

To introduce to the substantive, theoretical and methodological issues which have shaped the sociological thinking.

Theory

UNIT-I: Level of theorization in sociology relationships between theory and research.

UNIT-II: Structural ï functionalism and post-structuralism- contribution of SF Nadel, T Parsons, RK Merton, C Levis Strauss.

UNIT-III: Conflict theory: Contribution of K Marx, R. Dahrendorf, R.L. Coser and the critical theory of neo-Marxism.

UNIT-IV: Interactionist perspective- symbolic interactionism, phenomenological sociology and ethno-methodology.

UNIT-V: Recent trends in sociological theory.

Suggested Readings

Abraham FM. 1997. *Modern Sociological Theory – An Introduction*. Oxford Univ. Press.

Turner JL. 1995. *The Structure of Sociological Theory*. 4th Ed. Rawat Publ.

Zeitlin IM. 1998. *Rethinking Sociology: Critique of Contemporary Theory*. Indian Ed. Rawat Publ.

SOC 503 METHODOLOGY OF SOCIAL RESEARCH 2+1 SEM - II

Objective

Aim is to provide exposure to the fundamentals of various research techniques and methods (both quantitative and qualitative).

Theory

UNIT-I: Positivism, phenomenology, ethnomethodology and symbolic interactionism, interpretative understanding. Logic of inquiry in social science research, inductive and deductive, theory building, objectivity/ value neutrality and hypothesis.

UNIT-II: Quantitative methods and survey research: Assumptions of quantification and measurement, survey techniques, operationalisation and research design, sampling design, questionnaire construction, interview schedule, measurement and scaling, reliability and validity, limitations of survey.

UNIT-III: Qualitative research techniques: Technique and methods of qualitative research, participant observation/ethnography, interview guide, case study method, content analysis, oral history, narratives, life history, genealogy. Methodological dilemmas and issues in qualitative research, encounters and experiences in field work, qualitative data format and processing, validity and reliability in qualitative research.

UNIT-IV: Methods and use of macro-statistics and secondary source (Durkheimôs suicide, Census, NSS), Triangulation- Mixing qualitative and quantitative methodologies, social research, action research participatory research, application of computers in social research e.g. SPSS, ethical issues in social research.

Practical

Use of computers for statistical analysis data, field based survey for collection and analysis of social science data etc.

Suggested Readings

Bose Pradip Kumar 1995. *Research Methodology*. ICSSR.

Mukherjee PN. (Eds). 2000. *Methodology in Social Research: Dilemmas and Perspectives*. Sage.

Punch Keith 1986. *Introduction to Social Research*. Sage.

Srinivas MN & Shah AM. 1979. *Field Worker and the Field*. Oxford.

SOC 504 RURAL SOCIETY IN INDIA 4+0 SEM - I

Objective

To provide sociological understanding of rural social struture, change and development in India.

Theory

UNIT-I: Rural society in India as agrarian and peasant social structure, basic characteristics of peasant and agrarian society.

UNIT-II: Family, caste, religion, habitat and settlement. Debates of mode of production and agrarian relation-tenancy lands and labour, agrarian legislation and rural social structure.

UNIT-III: Rural poverty, emigration, landless labour.

UNIT-IV: Planned change for rural society, Panchayati Raj, local self government and community development programmes and rural development strategies.

UNIT-V: Major agrarian movements in India ï A critical analysis, globalisation and its impact on agriculture, water and agriculture, irrigation management and practices.

Suggested Readings

Berch Berberoque (Ed). 1992. *Class, State and Development in India*. Sage.

Desai AR. 1977. *Rural Sociology in India*. Popular Prakashan.

Dhanagare DN. 1988. *Peasant Movements in India*. OUP.

Radhakrishanan P. 1989. *Peasant Struggles: Land Reforms and Social Change in Malabar*. Sage.

SOC 505 SOCIOLOGY OF CHANGE AND DEVELOPMENT 3+0 SEM - I

Objective

To prepare the students for professional career development planning and to address in particular the Indian experience of social change and development.

Theory

UNIT-I: Meaning and forms of social change: evolution, progress, transformation, change in social structure.

UNIT-II: Theories and factors of social change: linear, cyclical, deterministic and technological.

UNIT-III: Social change in contemporary India, trend of change and processes of change ï Sanskritization, westernization, modernization and socialization.

UNIT-IV: Changing concepts of development, economic growth, human development, social development, sustainable development and the question of socio-cultural sustainability, themes of development and underdevelopment modernization theory, centro periphery, world system and unequal exchange, paths and agencies of development.

UNIT-V: Social structure and development, culture and development and Indian experience of development.

Suggested Readings

Desai AR. 1985. *India's Path of Development, Marxist Approach*. Popular Prakashan.
Giddings Anthony 1990. *The Consequences of Modernity*. Polity Press.
Srinivas MN. 1966. *Social Change in Modern India*. Univ. of Berkeley.

SOC 506 COMMUNITY DEVELOPMENT AND LEADERSHIP 3+0 SEM - II

Objective

To acquaint students in community development and leadership process in order to promote PRIs in the villages.

Theory

UNIT-I: Concept of community development ï structure and functions of rural groups, principles of community organization, process and elements of decision marking, type of decision markers and art of making decision.

UNIT-II: Agricultural and modern institutional policies and programmes of community development and process of achieving them.

UNIT-III: Social-cultural obstacles in community development programmes.

UNIT-IV: Social groups ï nature and types, characteristics, functions and forms of interaction in small groups.

UNIT-V: Leadership: concept, types, characteristics and theories, relationship between leadership and community development, patterns of leadership and group relationships, women empowerment and community development, changing pattern of rural leadership.

Suggested Readings

Davis Kingsley. 1965. *Human Society*. MacMillan.
Dube SC. 1990. *Society in India*. National Book Trust.
Gouldner AW. (Ed). 1950. *Studies in Leadership*. Harper & Bros.

SOC 507 POPULATION DYNAMICS AND ENVIRONMENT 3+0 SEM - I

Objective

To acquaint students about population dynamics and environment in the Indian context.

Theory

UNIT-I: Population and society ï interface between population size and social development, concepts and measurement of population trends in India and world-population pyramid of India, social implications of age and sex in India and population projections of the world.

UNIT-II: Population theories and their criteria, classical and non classical theories, their demographic theories, and Malthusian theory.

UNIT-III: Demographic processes: fertility, mortality and migration and their influence on population.

UNIT-IV: Population planning and control. Family and reproductive health depopulation a problem. Merits and demerits of depopulation. Population policy of government of India ï A critical appraisal ï Problems of implementing growth control measures causes for success and failures. Social dimensions of population and health education ï population as an issue in a plural society.

UNIT-V: Environment issues pertaining to population, water, sanitation, pollution, energy, housing and urban development and rural poverty. Social impact assessment of environmental issues. Development, displacement, relocation and environmental problems, environment, technology and society.

Suggested Readings

Bose, Ashish 1991. *Demography Diversity of India*. BR Publ. Corp.
Gadgil Madhav & Ramchandra Guha 1996. *Ecology and Equity: The Use and Abuse of Nature in Contemporary India*. Guha.
Giddens Anthony 1996. Global Problems and Ecological Crisis. In: *Introduction to Sociology*. 2nd Ed. WW Norton & Co.
Premi MK et al. 1983. *An Introduction to Social Demography*. Vikas Publ. House.
Rajendra Sharma 1997. *Demography and Population Problems*. Atlantic Publ.
Srivastava DS. 1994. *Demography and Population Studies*. Vikas.

SOC 508 SCIENCE, TECHNOLOGY AND SOCIETY 3+0 SEM - II

Objective

To enable the students to understand the issues relating to science, technology and society in India both in the historical and globalization contexts.

Theory

UNIT-I: The study of science ï its importance, relationship between society and science and vice-versa. Science as a social system. Norms of science. Relationship between science and technology concept of innovation, dispersion, succession and convergence.

UNIT-II: Relationship and problems of technology and culture, dynamics of technology affecting agriculture, industry, family, communication.

UNIT-III: Cultural lag and problems of human adjustment and mental health, impact of technology on rural social life.

UNIT-IV: Globalization and liberalization and their impact on Indian science and technology. WTO and issues related to intellectual property rights. MNCs and Indian industry. Political economy of science and technology at the national and international levels.

Suggested Readings

Allen FR. 1957. *Technology and Social change*. Applenton Century Office.

Krishna VV & Bhatnagar SS. 1993. *Science, Technology and Development*. Wiley Eastern.

Rahman A. 1972. *Trimurti: Science, Technology and Society – A Collection of Essays*. Peoples Publ. House.

SOC 509 SOCIAL PSYCHOLOGY 3+0 SEM - II

Objective

The course of Social Psychology aims at enabling the student to understand how individual behaviour is influenced by social and cultural environment and how to analyze the social behaviour in context of social-psychological theories; as well as realize how the knowledge of social psychology can be helpful in solving the social issues/problems.

Theory

UNIT-I: Historical Background: Development of social psychology as a modern discipline; trends/traditions of social, psychological, sociological, societal and applied; culture and social psychology; relationship with social sciences; theoretical perspectives.

UNIT-II: Relationship and Group Processes: Human relationship; social motivation; Pro-social behaviors; Aggression; Social emotions; Group dynamics: Meaning and formation of group, decision making and problem solving, group level behaviour.

UNIT-III: Personality and culture: Meaning and nature of personality; Meaning and nature of culture; Relationship of personality with culture; Personality assessment.

UNIT-IV: Influence Processes: Social perception and social cognition; Social power and political process; Mass media communication and attitude change in Indian context; Propaganda and brain washing; Leadership styles and effectiveness.

UNIT-V: Applied Social Psychology: Inter group relationship; Poverty; Gender issues; Social institutions; Problems of social change; Population issues; Social movement (urban-rural); society and technology.

Suggested Readings

Aronson E, Ellsworth P, Carlsmith JM & Gonzales MH. 1990. *Methods of Research in Social Psychology*. McGraw-Hill.

Billig M. 1976. *Social Psychology and Inter Group Relations*. Academic Press.

Feidman RS. 1985. *Social Psychology: Theories, Research and Application.* McGraw-Hill.

Lindsey G & Aronson E. (Eds). 1985. *The Handbook of Social Psychology.* Random House.

Misra G. (Ed). 1990. *Applied Social Psychology in India*. Sage.

Semin GR & Fieder K. (Eds). 1996. *Applied Social Psychology*. Sage.

SOC 510 SOCIETY IN INDIA 3+0 SEM - II

Objective

To provide comprehensive, integrated and empirically-based profile of Indian society to students.

Theory

UNIT-I: Indian Society: Unity in Diversity, Varnashrama System, Caste-features, functions and changing aspects, caste, class, casteism, marriage, family and kinship - tradition and change. Tribal, rural and urban society in India.

UNIT-II: Tribal society, geographical distribution of Tribes, Clan, totemism, Taboo, Witchcraft, Magic.

UNIT-III: Religion, Law and Polity; Technology and Economy, Tribal Development; Rural Society, Village Community - Tradition and Change, Rural Economy, Rural Power Structure: Panchayati Raj, Rural Development, Rural Urban Interactions.

UNIT-IV: Urban Society; Urban Centres - Traditional and Modern, Urban Ecology and Demography, Urbanization and Urbanism, Urban Renewal - Urban Planning and Development, Urban Government. Nation-Building; Society and the State.

UNIT-V: Social Background of Indian Nationalism, Nation-building and its problems, Political parties and new elites, Problems of minorities.

UNIT-VI: Underprivileged Sections in India: Women, Scheduled Castes, Scheduled Tribes, Other Backward groups, Role of Social Legislation.

Suggested Readings

Desai AR. 1959. *Social Background of Indian Nationalism*. Popular Prakashan.

Dube SC. 1990. *Indian Society*. National Book Trust.

Kingsley D. 1965. *Human Society*. MacMillan.

SOC 511 FUNDAMENTALS OF RURAL SOCIOLOGY 2+0 SEM - II

Objective

To provide sociological understanding of rural society.

Theory

UNIT-I: Rural sociology- concept, scope, importance and relationship with extension education, basic sociological concepts.

UNIT-II: Social change- meaning, process and theories; Culture- concept, types, structure, patterns, problems, cultural; Relativism and cultural lag, cultural integration and its role in development.

UNIT-III: Social stratification- concept, structure, role Groups- concept, types and dynamics, role in extension work; Leadership- concept, types, styles, theories and principles and its; Implication for development.

UNIT-IV: Social structure, social organizations and social system- concept; Differences, types, their role in development; Social sanctions and deviance.

Suggested readings

Desai AR. 1979. *Rural Sociology in India*. Popular Prakashan.

Chitambar JB. 1997. *Introductory Rural Sociology*. Wiley Eastern.

SOC 512/ STAT 534/ MBB 553/ FST 531 BIOSTATISTICS AND COMPUTERS 2+1 SEM - I

(To be taught by Statistics)

Objective

This is a course of applied Statistics to be taken by M.Sc. students of Biotechnology, FST and Sociology department of C.O.B.Sc.& H. They are exposed to various statistical methods to analyze their experimental data.

Theory

UNIT-I: Aim, scope and idea of elementary statistics; Measures of central tendency and dispersion, skewness and kurtosis.

UNIT-II: Concept of probability and probability laws, mathematical expectation, moments, moments generating function; Standard probability distributions-Binomial, Poisson and Normal distributions.

UNIT-III: Tests of significance based on Z, χ^2, t and F statistics; Correlation and regression, curve fitting by least squares methods.

UNIT-IV Basic principles, organization and operational aspects of computers, operating systems. Introduction to MS-Office, MS-Word, MS-Excel. Statistical Data analysis based on above topics through MS-Excel.

Practical

- Data analysis using probability, test of significance
- Correlation and regression analysis
- Usage of MS-Windows
- Exercises on test processing, spreadsheet and DBMS
- SPSS

Suggested Readings

Agarwal BL. 2003. *Basic Statistics*. New Age.
Dutta NK. 2002. *Fundamentals of Bio-Statistics*. Kanishka Publ.
Gupta SP. 2004. *Statistical Methods*. S. Chand & Sons.

SOC 601 SOCIOLOGICAL THEORY OF TODAY 3+0 SEM - II

Objective

The course is intended to introduce the students about the latest theoretical and methodological issues which have shaped the present day sociological thinking.

Theory

UNIT-I: Nature, type and scope of sociological theory, relationship between theory and research.

UNIT-II: Structuralism and post-structralism: M. Foucault, Neo-functionalism: J. Alexander.

UNIT-III: Conflict and social change: R. Collins- The critical theory and Neo-Marxism- The Frankfurt school, structuralism Marxism: L. Althusser- Hegemony: A. Gramscu.

UNIT-IV: Advances in symbolic interactionism- Phenomenological sociology- Ethnomethodology.

UNIT-V: Recent trends in sociological theorizing structuration: Anthony Giddeus-Habitus and field: Bourdieu- Postmodernism- Semiotics- Convergence.

Suggested Readings

Abrahim FM. 1998. *Modern Sociological Theory – An Introduction*. Oxford Univ. Press.
Collins Randall 1997. *Sociological Theory*. Rawat.
Ritzer George 1992. *Sociological Theory*. McGraw-Hill.
Zeitlin Irving M. 1998. *Rethinking Sociology: A Critique of Contemporary Theory*. Rawat.

SOC 602 COMPARATIVE SOCIOLOGY 3+0 SEM - I

Objective

To sensitize the students to the salience of the comparative perspective in sociology by highlighting historical and social context of its development.

Theory

UNIT-I: The salience of the comparative perspective in the social sciences in general and in sociology in particular, indices of comparison, culture, nation, class, gender.

UNIT-II: Historical and social context of the emergence and growth of sociology in the West, Asia and Africa.

UNIT-III: Central themes in comparative sociology, modernity; development, diversity, pluralism and multiculturalism, nation-state, environment, gender and globalization.

UNIT-IV: Evolution and development of various institutions of simple and advanced societies: their modes of social stratification and organizing principles of social life.

UNIT-V: The Indian context: The bearing of the colonial context on the development of sociology in India: Focus on national and regional concern.

Suggested Readings

Beteille Andre 1987. *Essays in Comparative Sociology*. Oxford Univ. Press.
Dubey SC. 1988. *Modernization and Development: the Search for Alternative Paradigm*. Vistar.
Oommen TK & Mukherjee PN. (Eds). 1986. *Indian Sociology: Reflections and Introspections*. Popular Prakashan.
Saraswati BN. 1994. *Interface of Cultural Identity and Development*. Indira Gandhi National Center of Arts.

SOC 603 ADVANCED ANALYTICAL SOCIAL PSYCHOLOGY 3+0 SEM - II

Objective

The course of Advanced Analytical Social Psychology provides student a deep understanding of human behavioural aspects. It includes how the human behaviour (in relation to society) and personality can be assessed and studied with the help of techniques and methods used in Psychology, and how the psychological problems are solved.

Theory

UNIT-I: Evolution and expansion of Advanced Analytical Social Psychology; Its nature and scope.

UNIT-II: Overview of theoretical approaches of social behaviour; psychoanalytical theory of S. Freud, individual psychology of Adler and Jung, Jungôs analytical theory; foundations of human behaviour; psychodynamics of behavior; Id, Ego, Superego; defense mechanisms/ major and minor mental mechanisms.

UNIT-III: Psychological disorders: Nature of disorders, symptoms, causes, differences of psycho-neurosis and psychosis; treatment/solution of disorders; stress and stress management.

UNIT-IV: Individual and Society: socialization and process of socialization; personality development, assessment of personality; prevention and reformation of juvenile delinquency.

UNIT-V: Group dynamics: social groups; social perception and social interaction; mass behavior; Individual, society (urban-rural) and technology.

Suggested Readings

Coleman JC. 1970. *Abnormal Psychology and Modern life*. Taraporevale DB & Sons.

Misra G. (Ed). 1998. *Applied Social Psychology*. Sage.

Pandey J. 2000-2001. *Psychology in India Revisited: Developments in the Discipline*. Vols. I-III. Sage.

Tiwari G. 1983. *Abnormal Psychology; A Dynamic Approach*. Vinod Pustak Mandir.

Selected articles from journals.

SOC 604 SOCIOLOGY OF AGRICULTURAL AND RURAL DEVELOPMENT 3+0 SEM - I

Objective

To acquaint the students about agriculture and rural development in the post-independent era.

Theory

UNIT-I: Critical evaluation of rural and agricultural development policies and programmes. Peasant problems and movements. Agrarian legislation and rural social structure.

UNIT-II: Agricultural and rural problems ï rural poverty, indebtedness and suicide, environment and sustainability institutional organization and crime.

UNIT-III: Globalization and its impact on agrarian, social values, social structure, social policy.

UNIT-IV: Five year plans and social action for rural and agricultural development, social, psychological and cultural variables in planned development.

UNIT-V: Policies, planning and administration concerning development of women, child and youth. Constraints in implementation of rural development policies, programmes.

Suggested Readings

Beach Beaberoque (Ed). 1992. *Class, State and Development in India*. Sage.

Bhalla GS & Singh 2001. *Indian Agriculture – Four Decades of Development*.

Kartar Singh 1996. *Rural Development – Principles, Policies and Management*. Sage.

SOCIOLOGY

List of Journals

- American Sociological Review
- Annual Review of Psychology
- Asian Journal of Social Psychology
- Contribution to Indian Sociology
- Demography India
- Economic and Political Weekly
- European Journal of Social Psychology
- ICSSR Research Quarterly
- Indian Journal of Social Work
- Indian Psychological Abstracts and Reviews
- Indian Sociological Bulletin
- Journal of Applied Social Psychology
- Journal of Social Issues
- Kurukshetra
- Man and Development
- Manpower Journal (NIRD)
- Psychology and Developing Societies
- Rural India
- Rural Sociology
- Social Welfare
- Yojna

Broad Topics for Master's and Doctoral Research

- Diversification in agriculture
- Impact of agricultural innovations
- Problems of agrarian society
- PRIsô and social transformation
- Agrarian social structure and change
- Demographic dynamics, social mobility and migration
- Women empowerment and rural social change
- Mass-media and agrarian society
- Consumer rights and agrarian society
- Farmersô empowerment through agro-processing units

STATISTICS

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
STAT 551	MATHEMATICAL METHODS-I	3+0	I
STAT 552	MATHEMATICAL METHODS-II	2+0	II
STAT 560	PROBABILITY THEORY	2+0	I
STAT 561	STATISTICAL METHODS	2+1	I
STAT 562	STATISTICAL INFERENCE	2+1	II
STAT 563	MULTIVARIATE ANALYSIS	2+1	I
STAT 564	DESIGN OF EXPERIMENTS	2+1	II
STAT 565	THEORY OF SAMPLING TECHNIQUES	2+1	I
STAT 566	STATISTICAL GENETICS	2+1	I
STAT 567	REGRESSION ANALYSIS	2+1	I
STAT 568	STATISTICAL COMPUTING	1+1	II
STAT 569	TIME SERIES ANALYSIS	2+1	II
STAT 570	ACTUARIAL STATISTICS	2+0	II
STAT 572	ECONOMETRICS	2+0	I
STAT 573	STATISTICAL QUALITY CONTROL	2+0	II
STAT 574	STOCHASTIC PROCESSES	2+0	II
STAT 575	DEMOGRAPHY	2+0	I
STAT 576	STATISTICAL METHODS FOR LIFE SCIENCESS	2+0	I
STAT 577	STATISTICAL ECOLOGY	2+0	I
STAT 591	MASTERôS SEMINAR	1	I, II
STAT 599	MASTERôS RESEARCH	10	I, II
STAT 601	ADVANCED STATISTICAL COMPUTING	2+1	I
STAT 602	SIMULATION TECHNIQUES	2+1	II
STAT 603	OPTIMIZATION TECHNIQUE	1+1	II
STAT 604	MEASURE THEORY AND INFORMATION THEORY	2+0	I
STAT 611	ADVANCED STATISTICAL METHODS	1+1	I
STAT 612	ADVANCED STATISTICAL INFERENCE	3+0	II
STAT 613	ADVANCED DESIGN OF EXPERIMENTS	2+0	I
STAT 614	ADVANCED SAMPLING TECHNIQUES	2+0	I
STAT 615	ADVANCED STATISTICAL GENETICS	2+0	II
STAT 616	STATISTICAL MODELING	1+1	II
STAT 617	ADVANCED TIME SERIES ANALYSIS	1+1	II
STAT 618	ADVANCED STOCHASTIC PROCESSES	2+0	I

STAT 619	SURVIVAL ANALYSIS	2+0	II
STAT 621	ADVANCED MULTIVARIATE ANALYSIS	2+1	I
STAT 651	RECENT ADVANCES IN THE FIELD OF SPECIALIZATION	3+0	I, II
STAT 691	DOCTORAL SEMINAR I	1	I, II
STAT 692	DOCTORAL SEMINAR II	1	I, II
STAT 699	DOCTORAL RESEARCH	45	I, II

SERVICE COURSES			
STAT 501/ FST 451	MATHEMATICAL METHODS FOR APPLIED SCIENCES	2+0	I
STAT 511	STATISTICAL METHODS FOR APPLIED SCIENCES	3+1	I, II
STAT 512	EXPERIMENTAL DESIGNS	2+1	II
STAT 513	SAMPLING TECHNIQUES	2+1	II
STAT 521	APPLIED REGRESSION ANALYSIS	2+1	II
STAT 532/ BIF 505	STATISTICS FOR BIOLOGICAL SCIENCES	2+1	I
STAT 533/ BIF 509	MATHEMATICS FOR BIOLOGICAL SCIENCES	2+0	I
STAT 534/ MBB 553/ FST 531/ SOC 512	BIOSTATISTICS AND COMPUTERS	2+1	I

Compulsory courses for M. Sc.

i) Stat 551 and Stat 552 from supporting subject

ii) Stat 560 to Stat 569 from major subject

Compulsory courses for Ph. D.

i) Stat 602 and Stat 603/ Stat 604 from supporting subject.

ii) Minimum of two 600 series courses from major subject, but may also take 500 series courses if not studied during Masterôs program.

NOTE: Major courses in statistics Course no. Stat 566, Stat 567, Stat 569, Stat 573 are also open for PG student of other department.

Minimum Credit Requirements:

	M. Sc.	**Ph. D.**
Major	36	18
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	10	45
Total	61	78
Non Credit Compulsory Courses	05	05 (If not studied in M. Sc.)

STATISTICS

Course Contents

STAT 551 MATHEMATICAL METHODS – I 3+0 SEM - I

Objective

This course lays the foundation of all other courses of Statistics / Agricultural Statistics discipline by preparing them to understand the importance of mathematical methods in research. The students would be exposed to the basic mathematical tools of real analysis, calculus, differential equations and numerical analysis. This would prepare them to study their main courses that involve knowledge of Mathematics.

Theory

UNIT-I: Real Analysis: Convergence and divergence of infinite series, use of comparison tests -DôAlembertôs Ratio - test, Cauchyôs nth root test, Raabeôs test, Kummerôs test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjesô transformation, multiple integrals.

UNIT-II: Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurinôs series. Application of derivatives, Lôhospitalôs rule. Integration of rational, irrational and trigonometric functions. Application of integration.

UNIT-III: Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

UNIT-IV: Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

Suggested Readings

Bartle RG. 1976. *Elements of Real Analysis*. John Wiley.

Chatterjee SK. 1970. *Mathematical Analysis*. Oxford & IBH.

Gibson GA. 1954. *Advanced Calculus*. Macmillan.

Henrice P. 1964. *Elements of Numerical Analysis*. John Wiley.

Hildebrand FB. 1956. *Introduction to Numerical Analysis*. Tata McGraw Hill.

Priestley HA. 1985. *Complex Analysis*. Clarenton Press.

Rudin W. 1985. *Principles of Mathematical Analysis*. McGraw Hill.

Sauer T. 2006. *Numerical Analysis With CD-Rom*. Addison Wesley.

Scarborough JB. 1976. *Numerical Mathematical Analysis*. Oxford & IBH.

Thompson. Thomas GB Jr. & Finney RL. 1996. *Calculus*. 9th Ed. Pearson Edu.

STAT 552 MATHEMATICAL METHODS – II 2+0 SEM - II

Objective

This is another course that supports all other courses in Statistics / Agricultural Statistics. The students would be exposed to the advances in Linear Algebra and Matrix theory. This would prepare them to study their main courses that involve knowledge of Linear Algebra and Matrix Algebra.

Theory

UNIT-I: Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidtôs orthogonalization, Galois field - Fermatôs theorem and primitive elements. Linear transformations. Graph theory: Concepts and applications.

UNIT-II: Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, rank and inverse of matrices. Special matrices ï idempotent, symmetric, orthogonal. Eigen values and eigen vectors. Spectral decomposition of matrices.

UNIT-III: Unitary, Similar, Hadamard, Circulant, Helmertôs matrices. Kronecker and Hadamard product of matrices, Kronecker sum of matrices. Sub-matrices and partitioned matrices, Permutation matrices, full rank factorization, Grammian root of a symmetric matrix. Solutions of linear equations, Equations having many solutions.

UNIT-IV: Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Spectral decomposition of matrices, Inverse and Generalized inverse of partitioned matrices, Differentiation and integration of matrices, Quadratic forms.

Suggested Readings

Aschbacher M. 2000. *Finite Group Theory*. Cambridge University Press.

Deo N. 1984. *Graph Theory with Application to Engineering and Computer Science*. Prentice Hall of India.

Gentle JE. 2007. *Matrix Algebra: Theory, Computations and Applications in Statistics*. Springer.

Graybill FE.1961. *Introduction to Matrices with Applications in Statistics*. Wadsworth Publ.

Hadley G. 1969. *Linear Algebra*. Addison Wesley.

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Robinson DJS. 1991. *A Course in Linear Algebra with Applications*. World Scientific.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Seber GAF. 2008. *A Matrix Handbook for Statisticians*. John Wiley.

STAT 560 PROBABILITY THEORY 2+0 SEM - I

Objective

This is a fundamental course in Statistics. This course lays the foundation of probability theory, random variable, probability distribution, mathematical expectation, etc. which forms the basis of statistics. The students are also exposed to law of large numbers and central limit theorem.

Theory

UNIT-I: Basic concepts of probability, probability measure. Axiomatic approach to probability. Properties of probability based on axiomatic definition. Addition and multiplication theorems. Conditional probability and independence of events. Bayes theorem.

UNIT-II: Random variables: definition of random variable, discrete and continuous, functions of random variables. Probability mass function and Probability density function, Distribution function and its properties. Notion of bivariate random variables, bivariate distribution function and its properties. Joint, marginal and conditional distributions. Independence of random variables. Transformation of random variables (two dimensional cases only). Mathematical expectation: Mathematical expectation of functions of a random variable. Raw and central moments and their relation, covariance, skewness and kurtosis. Addition and multiplication theorems of expectation. Definition of moment generating function, cumulating generating function, probability generating function and statements of their properties.

UNIT-III: Conditional expectation and conditional variance. Characteristic function and its properties. Inversion and uniqueness theorems. Chebyshev, Cauchy-Schwartz, Jenson, Holderôs and Minkowskyôs inequalities. Sequence of random variables and modes of convergence (convergence in distribution, in probability, almost surely, and quadratic mean) and their interrelations. Statement of Slutskyôs theorem.

UNIT-IV: Laws of large numbers: WLLN, Bernoulli and Khintchinôs WLLN. Kolmogorov inequality, Kolmogorovôs SLLNs. Central Limit theorem: Demoivre-Laplace CLT, Lindberg ï Levy CLT, Liapounov CLT, Statement of Lindeberg-Feller CLT and simple applications.

Suggested Readings

Ash RB. 2000. *Probability and Measure Theory*. 2nd Ed. Academic Press.

Billingsley P. 1986. *Probability and Measure*. 2nd Ed. John Wiley.

Capinski M & Zastawniah. 2001. *Probability Through Problems*. Springer.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Feller W. 1972. *An Introduction to Probability Theory and its Applications*. Vols. I., II. John Wiley.

Loeve M. 1978. *Probability Theory*. 4th Ed. Springer.

Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.

Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

STAT 561 STATISTICAL METHODS 2+1 SEM - I

Objective

This course lays the foundation of probability distributions and sampling distributions and their application which forms the basis of Statistical Inference. Together with probability theory, this course is fundamental to the discipline of Statistics. The students are also exposed to correlation and regression, and order statistics and their distributions. Categorical data analysis is also covered in this course.

Theory

UNIT-I: Descriptive statistics, probability distributions: Discrete probability distributions ~ Bernoulli, Binomial, Poisson, Negative-binomial, Geometric and Hyper Geometric, uniform, multinomial ~ Properties of these distributions and real life examples. Continuous probability distributions -rectangular, exponential, Cauchy, normal, gamma, beta of two kinds, Weibull, lognormal, logistic, Pareto. Properties of these distributions. Probability distributions of functions of random variables.

UNIT-II: Concepts of compound, truncated and mixture distributions (definitions and examples). Pearsonian curves and its various types. Sampling distributions of sample mean and sample variance from Normal population, central and nonï central chi-Square, t and F distributions, and their properties and inter relationships.

UNIT-III: Concepts of random vectors, moments and their distributions. Bivariate Normal distribution - marginal and conditional distributions. Distribution of quadratic forms. Cochran theorem. Correlation, rank correlation, correlation ratio and intra-class correlation. Regression analysis, partial and multiple correlation and regression.

UNIT-IV: Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient. Association between attributes. Variance Stabilizing Transformations.

UNIT-V: Order statistics, distribution of r-th order statistics, joint distribution of several order statistics and their functions, marginal distributions of order statistics, distribution of range, median, etc.

Practical

Fitting of discrete distributions and test for goodness of fit; Fitting of continuous distributions and test for goodness of fit; Fitting of truncated distribution; Computation of simple, multiple and partial correlation coefficient, correlation ratio and intra-class correlation; Regression coefficients and regression equations; Fitting of Pearsonian curves; Analysis of association between attributes, categorical data and log-linear models.

Suggested Readings

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.

Arnold BC, Balakrishnan N & Nagaraja HN. 1992. *A First Course in Order Statistics*. John Wiley.

David HA & Nagaraja HN. 2003. *Order Statistics*. 3rd Ed. John Wiley.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Huber PJ. 1981. *Robust Statistics*. John Wiley.

Johnson NL, Kotz S & Balakrishnan N. 2000. *Continuous Univariate Distributions*. John Wiley.

Johnson NL, Kotz S & Balakrishnan N. 2000. *Discrete Univariate Distributions*. John Wiley.

Marek F. 1963. *Probability Theory and Mathematical Statistics*. John Wiley.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. John Wiley.

Rohatgi VK & Saleh AK Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

STAT 562 STATISTICAL INFERENCE 2+1 SEM - II

Objective

This course lays the foundation of Statistical Inference. The students would be taught the problems related to point and confidence interval estimation and testing of hypothesis. They would also be given the concepts of nonparametric and sequential test procedures and elements of decision theory.

Theory

UNIT-I: Concepts of point estimation: unbiasedness, consistency, efficiency and sufficiency. Statement of Neymanôs Factorization theorem with applications. MVUE, Rao-Blackwell theorem, completeness, Lehmann-Scheffe theorem. Fisher information,

Cramer-Rao lower bound and its applications.

UNIT-II: Moments, minimum chi-square, least square and maximum likelihood methods of estimation and statements of their properties. Interval estimation-Confidence level, Confidence Interval using pivots and shortest length Confidence Interval. Confidence Interval for the parameters of Normal, Exponential, Binomial and Poisson distributions.

UNIT-III: Fundamental notions of hypothesis testing-statistical hypothesis, statistical test, critical region, types of errors, test function, randomized and non-randomized tests, level of significance, power function, most powerful tests: Neyman-Pearson fundamental lemma, UMP tests for one parameter exponential families. Concept of consistency, unbiasedness and invariance of tests. Likelihood Ratio tests, statement of asymptotic properties of LR tests with applications (including homogeneity of means and variances).Relation between confidence interval estimation and testing of hypothesis.

UNIT-IV: Notions of sequential vs fixed sample size techniques. Waldôs SPRT for testing simple null hypothesis vs simple alternative. Termination property of SPRT, SPRT for Binomial, Poisson, Normal and Exponential distributions. Concepts of loss, risk and decision functions, admissible and optimal decision functions, estimation and testing viewed as decision problems, conjugate families, Bayes and Minimax decision functions with applications to estimation with quadratic loss.

UNIT-V: Non-parametric tests: Sign test, Wilcoxon signed rank test, Runs test for randomness, Kolmogorov ï Smirnov test for goodness of fit, Median test and Wilcoxon-Mann-Whitney U-test. Chi-square test for goodness of fit and test for independence of attributes. Kruskal ï Wallis and Friedmanôs tests. Spearmanôs rank correlation and Kendallôs Tau tests for independence.

Practical

Methods of estimation - Maximum Likelihood, Minimum c^2 and Moments; Confidence Interval Estimation; MP and UMP tests; Large Sample tests; Non-parametric tests, Sequential Probability Ratio Test; Decision functions.

Suggested Readings

Box GEP & Tiao GC. 1992. *Bayesian Inference in Statistical Analysis*. John Wiley.

Casela G & Berger RL. 2001. *Statistical Inference*. Duxbury Thompson Learning.

Christensen R. 1990. *Log Linear Models*. Springer.

Conover WJ. 1980. *Practical Nonparametric Statistics*. John Wiley.

Dudewicz EJ & Mishra SN. 1988. *Modern Mathematical Statistics*. John Wiley.

Gibbons JD. 1985. *Non Parametric Statistical Inference*. 2nd Ed. Marcel Dekker.

Kiefer JC. 1987. *Introduction to Statistical Inference*. Springer.

Lehmann EL. 1986. *Testing Statistical Hypotheses*. John Wiley.

Lehmann EL. 1986. *Theory of Point Estimation*. John Wiley.

Randles RH & Wolfe DS. 1979. *Introduction to the Theory of Nonparametric Statistics*. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Rohatgi VK & Saleh AK. Md. E. 2005. *An Introduction to Probability and Statistics*. 2nd Ed. John Wiley.

Rohtagi VK. 1984. *Statistical Inference*. John Wiley.

Sidney S & Castellan NJ Jr. 1988. *Non Parametric Statistical Methods for Behavioral Sciences*. McGraw Hill.

Wald A. 2004. *Sequential Analysis*. Dover Publ.

STAT 563 MULTIVARIATE ANALYSIS 2+1 SEM - I

Objective

This course lays the foundation of Multivariate data analysis. Most of the data sets in agricultural sciences are multivariate in nature. The exposure provided to multivariate data structure, multinomial and multivariate normal distribution, estimation and testing of parameters, various data reduction methods would help the students in having a better understanding of agricultural research data, its presentation and analysis.

Theory

UNIT-I: Concept of random vector, its expectation and Variance-Covariance matrix. Marginal and joint distributions. Conditional distributions and Independence of random vectors. Multinomial distribution. Multivariate Normal distribution, marginal and conditional distributions. Sample mean vector and its distribution. Maximum likelihood estimates of mean vector and dispersion matrix. Tests of hypothesis about mean vector.

UNIT-II: Wishart distribution and its simple properties. Hotellingôs T^2 and Mahalanobis D^2 statistics. Null distribution of Hotellingôs T^2. Raoôs U statistics and its distribution. Wilksô ɤ criterion and statement of its properties. Concepts of discriminant analysis, computation of linear discriminant function, classification between k (Ó2) multivariate normal populations based on LDF and Mahalanobis D^2.

UNIT-III: Principal Component Analysis, factor analysis. Canonical variables and canonical correlations. Cluster analysis, similarities and dissimilarities, Hierarchical clustering. Single and Complete linkage methods.

UNIT-IV: Path analysis and computation of path coefficients, introduction to multidimensional scaling, some theoretical results, similarities, metric and non metric scaling methods.

Practical

Maximum likelihood estimates of mean-vector and dispersion matrix; Testing of hypothesis on mean vectors of multivariate normal populations; Cluster analysis, Discriminant function, Canonical correlation, Principal component analysis, Factor analysis; Multivariate analysis of variance and covariance, multidimensional scaling.

Suggested Readings

Anderson TW. 1984. *An Introduction to Multivariate Statistical Analysis*. 2nd Ed. John Wiley.

Arnold SF. 1981. *The Theory of Linear Models and Multivariate Analysis*. John Wiley.

Giri NC. 1977. *Multivariate Statistical Inference*. Academic Press.

Johnson RA & Wichern DW. 1988. *Applied Multivariate Statistical Analysis*. Prentice Hall.

Kshirsagar AM. 1972. *Multivariate Analysis*. Marcel Dekker.

Muirhead RJ. 1982. *Aspects of Multivariate Statistical Theory*. John Wiley.

Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Rencher AC. 2002. *Methods of Multivariate Analysis*. 2nd Ed. John Wiley.

Srivastava MS & Khatri CG. 1979. *An Introduction to Multivariate Statistics*. North Holland.

STAT 564 DESIGN OF EXPERIMENTS 2+1 SEM - II

Objective

Design of Experiments provides the statistical tools to get maximum information from least amount of resources. This course is meant to expose the students to the basic principles of design of experiments. The students would also be provided with mathematical background of various basic designs involving one-way and two way elimination of heterogeneity and their characterization properties. This course would also prepare the students in deriving the expressions for analysis of experimental data.

Theory

UNIT-I: Elements of linear estimation, Gauss - Markoff Theorem . Testing of linear hypothesis,analysis of variance, partitioning of degrees of freedom.

UNIT-II: Orthogonality, contrasts, mutually orthogonal contrasts, analysis of covariance; Basic principles of design of experiments, uniformity trials, size and shape of plots and blocks.

UNIT-III: Basic designs - completely randomized design, randomized complete block design and Latin square design; orthogonal Latin squares, mutually orthogonal Latin squares (MOLS), Youden square design, Graeco- Latin squares.

UNIT-IV: Balanced incomplete block (BIB) design ï general properties and analysis without and with recovery of intra block information, construction of BIB designs. Partially balanced incomplete block designs with two associate classes - properties, analysis and construction, Lattice designs, alpha designs, cyclic designs, augmented designs, general analysis of block designs.

UNIT-V: Factorial experiments, confounding in symmetrical factorial experiments (2^n and 3^n series), partial and total confounding, fractional factorials, asymmetrical factorials.

UNIT-VI: Designs for fitting response surface; Cross-over designs. Missing plot technique; Split plot and Strip plot design; Groups of experiments; Sampling in field experiments.

Practical

Determination of size and shape of plots and blocks from uniformity trials data; Analysis of data generated from completely randomized design, randomized complete block design;

Latin square design, Youden square design; Analysis of data generated from a BIB design, lattice design, PBIB designs; 2^n, 3^n factorial experiments without and with confounding; Split and strip plot designs, repeated measurement design; Missing plot techniques, Analysis of covariance; Analysis of Groups of experiments,. Sampling in field experiments.

Suggested Readings

Chakrabarti MC. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ. House.

Cochran WG & Cox DR. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Dey A & Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.

Dey A 1986. *Theory of Block Designs*. Wiley Eastern.

Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.

John JA & Quenouille MH. 1977. *Experiments: Design and Analysis*. Charles & Griffin.

Kempthorne O. 1976. *Design and Analysis of Experiments*. John Wiley.

Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

Kshirsagar AM 1983. *A Course in Linear Models*. Marcel Dekker.

Montgomery DC. 2005. *Design and Analysis of Experiments*. John Wiley.

Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.

Searle SR. 1971. *Linear Models*. John Wiley.

Street AP & Street DJ. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publ. Design Resources Server. Indian Agricultural Statistics Research Institute(ICAR), New Delhi-110012, India. www.iasri.res.in/design.

STAT 565 THEORY OF SAMPLING TECHNIQUES 2+1 SEM - I

Objective

This course is meant to expose the students to the techniques of drawing representative samples from various populations and then preparing them on the mathematical formulations of estimating the population parameters based on the sample data. The students would also be exposed to the real life applications of sampling techniques and estimation of parameters.

Theory

UNIT-I: Sample survey vs complete survey, probability sampling, sample space, sampling design, sampling strategy; Inverse sampling; Determination of sample size; Confidence-interval; Simple random sampling, Estimation of population proportion, Stratified random sampling, Number of strata and optimum points of stratification.

UNIT-II: Ratio and regression methods of estimation, Cluster sampling, Systematic sampling, Multistage sampling with equal probability, Separate and combined ratio estimator, Double sampling, Successive sampling ï two occasions**.**

UNIT-III: Non-sampling errors ï sources and classification, Non-response in surveys, Imputation methods, Randomized response techniques, Response errors ï interpenetrating sub-sampling.

UNIT-IV: Sampling with varying probabilities with and without replacement, PPS sampling, Cumulative method and Lahiriôs method of selection, HorvitzThompson estimator, Ordered and unordered estimators, Sampling strategies due to Midzuno-Sen and Rao-Hartley-Cochran. Inclusion probability proportional to size sampling, PPS systematic sampling, Multistage sampling with unequal probabilities, Self weighting design PPS sampling.

UNIT-V: Unbiased ratio and regression type estimators, Multivariate ratio and regression type of estimators.

Practical

Determination of sample size and selection of sample; Simple random sampling, Inverse sampling, Stratified random sampling, Cluster sampling, systematic sampling; Ratio and regression methods of estimation; Double sampling, multi-stage sampling, Randomized response techniques; Sampling with varying probabilities.

Suggested Readings

Cassel CM, Sarndal CE & Wretman JH. 1977. *Foundations of Inference in Survey Sampling*. John Wiley.

Chaudhari A & Stenger H. 2005. *Survey Sampling Theory and Methods*. 2nd Ed. Chapman & Hall.
Chaudhari A & Voss JWE. 1988. *Unified Theory and Strategies of Survey Sampling*. North Holland.
Cochran WG. 1977. *Sampling Techniques*. John Wiley.
Hedayat AS & Sinha BK. 1991. *Design and Inference in Finite Population Sampling*. John Wiley.
Kish L. 1965. *Survey Sampling*. John Wiley.
Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Society, Calcutta.
Raj D & Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ.
Sarndal CE, Swensson B & Wretman J. 1992. *Models Assisted Survey Sampling*. Springer.
Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.
Thompson SK. 2000. *Sampling*. John Wiley.

STAT 566 STATISTICAL GENETICS 2+1 SEM - I

Objective

This course is meant to prepare the students in applications of statistics in quantitative genetics and breeding. The students would be exposed to the physical basis of inheritance, detection and estimation of linkage, estimation of genetic parameters and development of selection indices.

Theory

UNIT-I: Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, combined estimation, disturbed segregation.

UNIT-II: Gene and genotypic frequencies, Random mating and Hardy -Weinberg law, Application and extension of the equilibrium law, Fisherôs fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, Theory of path coefficients.

UNIT-III: Concepts of inbreeding, Regular system of inbreeding. Forces affecting gene frequency - selection, mutation and migration, equilibrium between forces in large populations, Random genetic drift, Effect of finite population size.

UNIT-IV: Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning, Effect of inbreeding on quantitative characters, Sex-linked genes.

UNIT-V: Correlations between relatives, Heritability, Repeatability and Genetic correlation. Response due to selection, Selection index and its applications in plants and animals improvement programmes, Correlated response to selection.

UNIT-VI: Variance component approach and linear regression approach for the analysis of GE interactions. Measurement of stability. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

Practical

Test for the single factor segregation ratios, homogeneity of the families with regard to single factor segregation; Detection and estimation of linkage parameter by different procedures; Estimation of genotypic and gene frequency from a given data. Hardy-Weinberg law; Estimation of changes in gene frequency due to systematic forces, inbreeding coefficient, genetic components of variation, heritability and repeatability coefficient, genetic correlation coefficient; Examination of effect of linkage, epistasis and inbreeding on mean and variance of metric traits; Mating designs; Construction of selection index including phenotypic index, restricted selection index. Correlated response to selection.

Suggested Readings

Bailey NTJ. 1961. *The Mathematical Theory of Genetic Linkage.* Clarendon Press.
Balding DJ, Bishop M & Cannings C. 2001. *Hand Book of Statistical Genetics*. John Wiley.
Crow JF & Kimura M. 1970. *An Introduction of Population Genetics* Theory. Harper & Row.
Dahlberg G. 1948. *Mathematical Methods for Population Genetics*. Inter Science Publ.

East EM & Jones DF. 1919. *Inbreeding and Outbreeding*. J B Lippincott.
Ewens WJ. 1979. *Mathematics of Population Genetics*. Springer.
Falconer DS. 1985. *Introduction to Quantitative Genetics*. ELBL.
Fisher RA. 1949. *The Theory of Inbreeding*. Oliver & Boyd.
Fisher RA. 1950. *Statistical Methods for Research Workers*. Oliver & Boyd.
Fisher RA. 1958. *The Genetical Theory of Natural Selection*. Dover Publ.
Kempthorne O. 1957. *An Introduction to Genetic Statistics*. The Iowa State Univ. Press.
Lerner IM. 1950. *Population Genetics and Animal Improvement*. Cambridge Univ. Press.
Lerner IM. 1954. *Genetic Homeostasis*. Oliver & Boyd.
Lerner IM. 1958. *The Genetic Theory of Selection*. John Wiley.
Li CC. 1982. *Population Genetics*. The University of Chicago Press.
Mather K & Jinks JL. 1977. *Introduction to Biometrical Genetics*. Chapman & Hall.
Mather K & Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
Mather K. 1949. *Biometrical Genetics*. Methuen.
Mather K. 1951. *The Measurement of Linkage in Heredity*. Methuen.
Narain P. 1990. *Statistical Genetics*. Wiley Eastern.

STAT 567 REGRESSION ANALYSIS 2+1 SEM - I

Objective

This course is meant to prepare the students in linear and non-linear regression methods useful for statistical data analysis. They would also be provided a mathematical foundation behind these techniques and their applications in agricultural data.

Theory

UNIT-I: Simple and Multiple linear regressions, assumptions of regression Least squares fit, Properties and examples. Polynomial regression: Use of orthogonal polynomials.

UNIT-II: Regression diagnostics and transformations; Examination of residuals ~ Studentized residuals, applications of residuals in detecting outliers. Lack of fit, Pure error. Testing of homoscedasticity, independence and normality of errors. Use of R^2 for examining goodness of fit.

UNIT-III: Concept of multicollinearity, Analysis of multiple regression models, estimation and testing of regression parameters, sub-hypothesis testing, restricted estimation.

UNIT-IV: Weighted least squares method: Properties, and examples. Box-Cox family of transformations. Use of dummy variables, Selection of variables: Forward selection, Backward elimination. Stepwise and Stagewise regressions.

UNIT-V: Introduction to non-linear models, nonlinear estimation, Least squares for nonlinear models.

Practical

Multiple regression fitting with three and four independent variables; Estimation of residuals, their applications in outlier detection, distribution of residuals; Test of homoscedasticity, and normality, Box-Cox transformation; Restricted estimation of parameters in the model, hypothesis testing, Step wise regression analysis; Least median of squares norm, Orthogonal polynomial fitting.

Suggested Readings

Barnett V & Lewis T. 1984. *Outliers in Statistical Data*. John Wiley.
Belsley DA, Kuh E & Welsch RE. 2004. *Regression Diagnostics-Identifying Influential Data and Sources of Collinearity*. John Wiley.
Chatterjee S, Hadi A & Price B. 1999. *Regression Analysis by Examples*. John Wiley.
Draper NR & Smith H. 1998. Applied Regression Analysis. 3rd Ed. John Wiley.
McCullagh P & Nelder JA. 1999. *Generalized Linear Models*. 2nd Ed. Chapman & Hall.
Montgomery DC, Peck EA & Vining GG. 2003. *Introduction to Linear Regression Analysis*. 3rd Ed. John Wiley.
Rao CR. 1973. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

STAT 568 STATISTICAL COMPUTING 1+1 SEM - II

Objective

This course is meant for exposing the students in the concepts of computational techniques. Various statistical packages would be used for teaching the concepts of computational techniques.

Theory

UNIT-I: Introduction to statistical packages and computing: data types and structures, pattern recognition, classification, graphical methods.

UNIT-II: ANOVA, regression and categorical data methods; Matrix computations in linear models. Analysis of discrete data.

UNIT-III: Numerical methods, numerical optimization, graphical techniques, numerical approximations, numerical integration and Monte Carlo methods.

UNIT-IV: Spatial statistics; spatial sampling; Randomized clinical trials, techniques in the analysis of survival data and longitudinal studies, Approaches to handling missing data.

Practical

Data management, Graphical representation of data, Descriptive statistics; General linear models ~ fitting and analysis of residuals, outlier detection; Categorical data analysis, analysis of discrete data, analysis of binary data; Numerical algorithms; Spatial modeling, cohort studies; Clinical trials, analysis of survival data; Handling missing data.

Suggested Readings

Agresti A. 2002. *Categorical Data Analysis*. 2nd Ed. John Wiley.

Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.

Geisser S. 1993. *Predictive Inference: An Introduction.* Chapman & Hall.

Gelman A & Hill J. 2006. *Data Analysis Using Regression and Multilevel/Hierarchical Models*. Cambridge Univ. Press.

Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics - Concepts and Methods*. Springer.

Han J & Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.

Hastie T, Tibshirani R & Friedman R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.

Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.

Miller RG Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley.

Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.

Ross S. 2000. *Introduction to Probability Models*. Academic Press.

Ryan BF & Joiner BL. 1994. *MINITAB Handbook*. 3rd Ed. Duxbury Press.

Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.

Snell EJ. 1987. *Applied Statistics: A Handbook of BMDP Analyses*. Chapman & Hall.

Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.

Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

STAT 569 TIME SERIES ANALYSIS 2+1 SEM - II

Objective

This course is meant to teach the students the concepts involved in time series data. They would also be exposed to components of time series, stationary models and forecasting/ projecting the future scenarios based on time series data. It would also help them in understanding the concepts involved in time series data presentation, analysis and interpretation.

Theory

UNIT-I: Components of a time-series. Autocorrelation and Partial autocorrelation functions, Correlogram and periodogram analysis.

UNIT-II: Autoregressive, Moving average and Mixed processes. Autoregressive integrated moving average processes.

UNIT-III: Model identification: Objectives, Techniques, and Initial estimates. Model estimation and forecasting: Least squares estimates. Seasonal models. Intervention analysis models and Outlier detection.

UNIT-IV: Problem and Construction of index numbers and their tests; fixed and chain based index numbers; Construction of cost of living index number.

UNIT-V: Demand analysis ï Demand and Supply Curves; Determination of demand curves from market data. Engelôs Law and the Engelôs Curves, Incomdistribution and method of its estimation, Paretoôs Curve, Incominequality measures.

Practical

Time series analysis, autocorrelations, correlogram and periodogram; Linear stationary model; Linear non-stationary model; Model identification and model estimation; Intervention analysis and outliers detection.

Suggested Readings

Box GEP, Jenkins GM & Reinsel GC. 2007. *Time Series Analysis: Forecasting and Control*. 3rd Ed. Pearson Edu.

Brockwell PJ & Davis RA. 2002. *Introduction to Time Series and Forecasting*. 2nd Ed. Springer.

Chatterjee S, Hadi A & Price B.1999. *Regression Analysis by Examples*. John Wiley.

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Johnston J. 1984. *Econometric Methods*. McGraw Hill.

Judge GG, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.

Montgomery DC & Johnson LA. 1976. *Forecasting and Time Series Analysis*. McGraw Hill.

Shumway RH & Stoffer DS. 2006. *Time Series Analysis and its Applications: with R Examples*. 2nd Ed. Springer.

STAT 570 ACTUARIAL STATISTICS 2+0 SEM - II

Objective

This course is meant to expose to the students to the statistical techniques such as probability models, life tables, insurance and annuities. The students would also be exposed top practical applications of these techniques in computation of premiums that include expenses, general expenses, types of expenses and per policy expenses.

Theory

UNIT-I: Insurance and utility theory, models for individual claims and their sums, survival function, curtate future lifetime, force of mortality.

UNIT-II: Life table and its relation with survival function, examples, assumptions for fractional ages, some analytical laws of mortality, select and ultimate tables.

UNIT-III: Multiple life functions, joint life and last survivor status, insurance and annuity benefits through multiple life functions evaluation for special mortality laws. Multiple decrement models, deterministic and random survivorship groups, associated single decrement tables, central rates of multiple decrement, net single premiums and their numerical evaluations.

UNIT-IV: Distribution of aggregate claims, compound Poisson distribution and its applications.

UNIT-V: Principles of compound interest: Nominal and effective rates of interest and discount, force of interest and discount, compound interest, accumulation factor, continuous compounding.

UNIT-VI: Insurance payable at the moment of death and at the end of the year of death-level benefit insurance, endowment insurance, deferred insurance and varying benefit insurance, recursions, commutation functions.

UNIT-VII: Life annuities: Single payment, continuous life annuities, discrete life annuities, life annuities with monthly payments, commutation functions, varying annuities, recursions, complete annuities-immediate and apportionable annuities-due.

UNIT-VIII: Net premiums: Continuous and discrete premiums, true monthly payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Payment premiums, apportionable premiums, commutation functions, accumulation type benefits. Net premium reserves: Continuous and discrete net premium reserve, reserves on a semi-continuous basis, reserves based on true monthly premiums, reserves on an apportionable or discounted continuous basis, reserves at fractional durations, allocations of loss to policy years, recursive formulas and differential equations for reserves, commutation functions.

UNIT-IX: Some practical considerations: Premiums that include expenses-general expenses types of expenses, per policy expenses. Claim amount distributions, approximating the individual model, stop-loss insurance.

Suggested Readings

Atkinson ME & Dickson DCM. 2000. *An Introduction to Actuarial Studies*. Elgar Publ.

Bedford T & Cooke R. 2001. *Probabilistic Risk Analysis*. Cambridge.

Booth PM, Chadburn RG, Cooper DR, Haberman S & James DE. 1999. *Modern Actuarial Theory and Practice*. Chapman & Hall.

Borowiak Dale S. 2003. *Financial and Actuarial Statistics: An Introduction*. Marcel Dekker.
Bowers NL, Gerber HU, Hickman JC, Jones DA & Nesbitt CJ. 1997. *Actuarial Mathematics*. 2nd Ed. Society of Actuaries, Ithaca, Illinois.
Daykin CD, Pentikainen T & Pesonen M. 1994. *Practical Risk Theory for Actuaries*. Chapman & Hall.
Klugman SA, Panjer HH, Willmotand GE & Venter GG. 1998. *Loss Models: From data to Decisions*. John Wiley.
Medina PK & Merino S. 2003. *Mathematical Finance and Probability: A Discrete Introduction*. Basel, Birkhauser.
Neill A. 1977. *Life Contingencies*. Butterworth-Heinemann.
Rolski T, Schmidli H, Schmidt V & Teugels J. 1998. *Stochastic Processes for Insurance and Finance*. John Wiley.
Rotar VI. 2006. *Actuarial Models. The Mathematics of Insurance*. Chapman & Hall/CRC.
Spurgeon ET. 1972. *Life Contingencies*. Cambridge Univ. Press.

STAT 572 ECONOMETRICS 2+0 SEM - I

Objective

This course is meant for training the students in econometric methods and their applications in agriculture. This course would enable the students in understanding the economic phenomena through statistical tools and economics principles.

Theory

UNIT-I: Representation of Economic phenomenon, relationship among economic variables, linear and non linear economic models, single equation general linear regression model, basic assumptions, Ordinary least squares method of estimation for simple and multiple regression models; summary statistics correlation matrix, co-efficient of multiple determination, standard errors of estimated parameters, tests of significance and confidence interval estimation. BLUE properties of Least Squares estimates. Chow test, test of improvement of fit through additional regressors. Maximum likelihood estimation.

UNIT-II: Heteroscedasticity, Auto-correlation, Durbin Watson test, Multicollinearity. Stochastic regressors, Errors in variables, Use of instrumental variables in regression analysis. Dummy Variables. Distributed Lag models: Koyckôs Geometric Lag scheme, Adaptive Expectation and Partial Adjustment Mode, Rational Expectation Models and test for rationality.

UNIT-III: Simultaneous equation model: Basic rationale, Consequences of simultaneous relations, Identification problem, Conditions of Identification,Indirect Least Squares, Two-stage least squares, K-class estimators,Limited Information and Full Information Maximum Likelihood Methods, Three stage least squares, Generalized least squares, Recursive models, SURE Models. Mixed Estimation Methods, use of instrumental variables, pooling of cross-section and time series data, Principal Component Methods.

Suggested Readings

Croxton FE & Cowden DJ. 1979. *Applied General Statistics*. Prentice Hall of India.
Johnston J. 1984. *Econometric Methods*. McGraw Hill.
Judge GC, Hill RC, Griffiths WE, Lutkepohl H & Lee TC. 1988. *Introduction to the Theory and Practice of Econometrics*. 2nd Ed. John Wiley.
Kmenta J. 1986. *Elements of Econometrics*. 2nd Ed. University of Michigan Press.
Koop G. 2007. *Introduction to Econometrics*. John Wiley.
Maddala GS. 2001. *Introduction to Econometrics*. 3rd Ed. John Wiley.
Pindyck RS & Rubinfeld DL. 1998. *Econometric Models and Economic Forecasts*. 4th Ed. McGraw Hill.
Verbeek M. 2008. *A Guide to Modern Econometrics*. 3rd Ed. John Wiley.

STAT 573 STATISTICAL QUALITY CONTROL 2+0 SEM - II

Objective

This course is meant for exposing the students to the concepts of Statistical Quality Control and their applications in agribusiness and agro-processing industries. This course would enable the students to have an idea about the statistical techniques used in quality control. students who do not have sufficient background of Statistical Methods.

Theory

UNIT-I: Introduction to Statistical Quality Control; Control Charts for Variables ï Mean, Standard deviation and Range charts; Statistical basis; Rational subgroups.
UNIT-II: Control charts for attributes- ónpô, ópô and ócô charts.
UNIT-III: Fundamental concepts of acceptance, sampling plans, single, double and sequential sampling plans for attributes inspection.
UNIT-IV: Sampling inspection tables for selection of single and double sampling plans.

Suggested Readings

Cowden DJ. 1957. *Statistical Methods in Quality Control*. Prentice Hall of India.
Dodge HF & Romig HG. 1959. *Sampling Inspection Tables*. John Wiley.
Duncan A.J. 1986. *Quality Control and Industrial Statistics*. 5th Ed. Irwin Book Co.
Grant EL & Leavenworth RS. 1996. *Statistical Quality Control*. 7th Ed. McGraw Hill.
Montgomery DC. 2005. *Introduction to Statistical Quality Control*. 5th Ed. John Wiley.
Wetherhil G.B. 1977. *Sampling Inspection and Quality Control*. Halsted Press.

STAT 574 STOCHASTIC PROCESSES 2+0 SEM - II

Objective

It is a basic course on Stochastic Processes explaining the random phenomena in different fields of study. The students will be exposed to various forms of Markov Chains and their algebraic treatment. The continuous time stochastic process viz Poisson process, birth and death process etc. along with their applications will also be taught.

Theory

UNIT-I: Introduction to stochastic processes ï classification according to state and parameter space. Markov process, time-homogeneity, Chapman-Kolmogorov equations.
UNIT-II: Markov chains ï classification of states. Transient and recurrent states. Regular and irreducible chains. Algebraic treatment of finite Markov chains. Discrete branching process.
UNIT-III: Absorbing Markov chain, canonical form of transition probability matrix of a Markov chain, Fundamental matrix, probabilities of absorption from transient states into recurrent classes in a finite Markov chain, mean time to absorption.
UNIT-IV: Ergodic state and Ergodic chains, stationary distribution of a Markov chain, Random walk and gamblers ruin problems.
UNIT-V: Continuous time stochastic processes. Poisson process, birth and death process, migration process and their applications in queue and epidemics.

Suggested Readings

Bharucha-Reid AT. 1960. *Elements of the Theory of Markov Processes and their Applications*. Mc Graw-Hill.
Bhat BR. 2000. *Stochastic Models: Analysis and Applications*. New Age International.
Chiang CL. 1980. *An Introduction to Stochastic Processes and their Applications*. Krieger.
Cox DR & Miller HD.1977. *The Theory of Stochastic Processes*. Chapman & Hall.
Karlin S & Taylor HM. *First course to Stochastic Processes*. Academic Press.
Kemeny JG & Snell JL.1960. *Finite Markov Chains*. Van Nosts.
Medhi J. 2001. *Stochastic Processes*. 2nd Ed. Wiley Eastern Limited.
Parzen E. 1962. *Stochastic Processes*. Holden-Day.

STAT 575 DEMOGRAPHY 2+0 SEM - I

Objective

This course is meant for training the students in measures of demographic indices, estimation procedures of demographic parameters. Students would also be exposed to population projection techniques and principles involved in bioassays.

Theory

UNIT-I: Introduction to vital statistics, crude and standard mortality and morbidity rates, Estimation of mortality, Measures of fertility and mortality, period and cohort measures.
UNIT-II: Life tables and their applications, methods of construction of abridged life tables, Increment-Decrement Life Tables.
UNIT-III: Stationary and stable populations, Migration and immigration. Application of stable population theory to estimate vital rates, migration and its estimation. Demographic

relations in Nonstable populations. Measurement of population growth, Lotka's model (deterministic) and intrinsic rate of growth, Measures of mortality and morbidity.

UNIT-IV: Principle of biological assays, parallel line and slope ratio assays, choice of doses and efficiency in assays quantal responses, probit and logit transformations, epidemiological models.

Suggested Readings

Cox DR. 1957. *Demography.* Cambridge Univ. Press.

Finney DJ. 1981. *Statistical Methods in Biological Assays*. Charles Griffin.

Fleiss JL. 1981. *Statistical Methods for Rates and Proportions*. John Wiley.

Lawless JF. 1982. *Statistical Models and Methods for Lifetime Data*. John Wiley.

MacMahon B & Pugh TF. 1970. *Epidemiology- Principles and Methods*. Little Brown, Boston.

Mann NR, Schafer RE & Singpurwalla ND. 1974. *Methods for Statistical Analysis of Reliability and Life Data*. John Wiley.

Newell C. 1988. *Methods and Models in Demography*. Guilford Publ.

Preston S, Heuveline P & Guillot M. 2001. *Demography: Measuring and Modeling Population Processes*. Blackwell Publ.

Rowland DT. 2004. *Demographic Methods and Concepts*. Oxford Press.

Siegel JS & Swanson DA. 2004. *The Methods and Material of Demography*. 2nd Ed. Elsevier.

Woolson FR. 1987. *Statistical Methods for the Analysis of Biomedical Data*. John Wiley.

STAT 576 STATISTICAL METHODS FOR LIFE SCIENCES 2+0 SEM - I

Objective

This course focuses on statistical methods for discrete data collected in public health, clinical and biological studies including survival analysis. This would enable the students to understand the principles of different statistical techniques useful in public health and clinical studies conducted.

Theory

UNIT-I: Proportions and counts, contingency tables, logistic regression models, Poisson regression and log-linear models, models for polytomous data and generalized linear models.

UNIT-II: Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications. Analysis of survival time data using parametric and nonparametric models, hypothesis testing, and methods for analyzing censored (partially observed) data with covariates. Topics include marginal estimation of a survival function, estimation of a generalized multivariate linear regression model (allowing missing covariates and/or outcomes).

UNIT-III: Proportional Hazard model: Methods of estimation, estimation of survival functions, time-dependent covariates, estimation of a multiplicative intensity model (such as Cox proportional hazards model) and estimation of causal parameters assuming marginal structural models.

UNIT-IV: General theory for developing locally efficient estimators of the parameters of interest in censored data models. Rank tests with censored data. Computing techniques, numerical methods, simulation and general implementation of biostatistical analysis techniques with emphasis on data applications.

UNIT-V: Newton, scoring, and EM algorithms for maximization; smoothing methods; bootstrapping; trees and neural networks; clustering; isotonic regression; Markov chain Monte Carlo methods.

Suggested Readings

Biswas S. 1995. *Applied Stochastic Processes. A Biostatistical and Population Oriented Approach*. Wiley Eastern Ltd.

Collett D. 2003. *Modeling Survival Data in Medical Research*. Chapman & Hall.

Cox DR & Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.

Hosmer DW Jr. & Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.

Klein JP & Moeschberger ML. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.

Kleinbaum DG & Klein M 2005. *Survival Analysis. A Self Learning Text*. Springer.

Kleinbaum DG & Klein M. 2005. *Logistic Regression*. 2nd Ed. Springer.
Lee ET. 1992. *Statistical Methods for Survival Data Analysis*. John Wiley.
Miller RG. 1981. *Survival Analysis*. John Wiley.
Therneau TM & Grambsch PM. 2000. *Modeling Survival Data: Extending the Cox Model*. Springer.

STAT 577 STATISTICAL ECOLOGY 2+0 SEM - I

Objective

This course is meant for exposing the students to the importance and use of statistical methods in collections of ecological data, species-abundance relations, community classification and community interpretation.

Theory

UNIT-I: Ecological data, Ecological sampling; Spatial pattern analysis: Distribution methods, Quadrant-variance methods, Distance methods.

UNIT-II: Species-abundance relations: Distribution models, Diversity indices; Species affinity: Niche-overlap indices, interspecific association, interspecific covariation.

UNIT-III: Community classification: Resemblance functions, Association analysis, Cluster analysis; Community Ordination: Polar Ordination, Principal Component Analysis, Correspondence analysis, Nonlinear ordination.

UNIT-IV: Community interpretation: Classification Interpretation and Ordination Interpretation.

Suggested Readings

Pielou EC. 1970. *An introduction to Mathematical Ecology*. John Wiley.
Reynolds JF & Ludwig JA. 1988. *Statistical Ecology: A Primer on Methods and Computing*. John Wiley.
Young LJ, Young JH & Young J. 1998. *Statistical Ecology: A Population Perspective*. Kluwer.

STAT 601 ADVANCED STATISTICAL COMPUTING 2+1 SEM - I

Objective

This is an advanced course in Statistical Computing that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences and use of statistical packages.

Theory

UNIT-I: Measures of association. Structural models for discrete data in two or more dimensions. Estimation in complete tables. Goodness of fit, choice of a model. Generalized Linear Model for discrete data, Poisson and Logistic regression models. Log-linear models.

UNIT-II: Elements of inference for cross-classification tables. Models for nominal and ordinal response.

UNIT-III: Computational problems and techniques for robust linear regression, nonlinear and generalized linear regression problem, tree-structured regression and classification, cluster analysis, smoothing and function estimation, robust multivariate analysis.

UNIT-IV: Analysis of incomplete data: EM algorithm, single and multiple imputations. Markov Chain, Monte Carlo and annealing techniques, Neural Networks, Association Rules and learning algorithms.

UNIT-V: Multivariate tests of linear hypotheses, multiple comparisons, confidence regions, growth curve models, dose-response models.

Practical

Analysis of qualitative data; Generalized linear for correlated data; Generalized linear models for discrete data; Robust methods of estimation and testing of non-normal data; Robust multivariate analysis; Cluster analysis; Analysis of Incomplete data; Classification and prediction using artificial neural networks; Markov Chain; Analysis of data having random effects using Linear mixed effects models; Analysis of data with missing observations; Applications of multiple comparison procedures; Building Simultaneous confidence intervals; Fitting of growth curve models to growth data; Fitting of dose-response curves and estimation of parameters.

Suggested Readings

Everitt BS & Dunn G. 1991. *Advanced Multivariate Data Analysis*. 2nd Ed. Arnold.

Geisser S. 1993. *Predictive Inference: An Introduction*. Chapman & Hall.

Gentle JE, Härdle W & Mori Y. 2004. *Handbook of Computational Statistics -Concepts and Methods*. Springer.

Han J & Kamber M. 2000. *Data Mining: Concepts and Techniques*. Morgan.

Hastie T, Tibshirani R & Friedman R. 2001. *The Elements of Statistical Learning: Data Mining, Inference and Prediction*. Springer.

Kennedy WJ & Gentle JE. 1980. *Statistical Computing*. Marcel Dekker.

Miller RG Jr. 1986. *Beyond ANOVA, Basics of Applied Statistics*. John Wiley.

Rajaraman V. 1993. *Computer Oriented Numerical Methods*. Prentice-Hall.

Robert CP & Casella G. 2004. *Monte Carlo Statistical Methods*. 2nd Ed. Springer.

Ross S. 2000. *Introduction to Probability Models*. Academic Press.

Simonoff JS. 1996. *Smoothing Methods in Statistics*. Springer.

Thisted RA. 1988. *Elements of Statistical Computing*. Chapman & Hall.

Venables WN & Ripley BD. 1999. *Modern Applied Statistics With S-Plus*. 3rd Ed. Springer.

Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php. Design Resources Server: www.iasri.res.in.

SAS Online Doc 9.1.3: http://support.sas.com/onlinedoc/913/docMainpage.jsp

STAT 602 SIMULATION TECHNIQUES 2+1 SEM - II

Objective

This course is meant for students who have a good knowledge in Statistical Inference and Statistical Computing. This course would prepare students for undertaking research in the area of simulation techniques and their applications to agricultural sciences.

Theory

UNIT-I: Review of simulation methods; Implementation of simulation methods - for various probability models, and resampling methods: theory and application of the jackknife and the bootstrap.

UNIT-II: Randomization tests, analysis using computer software packages. Simulating multivariate distributions, MCMC methods and Gibbs sampling.

UNIT-III: ARMA and transfer-function models, spectral-domain regression. Simulated data sets to be analyzed using popular computer software packages

UNIT-IV: Stochastic simulation: Markov Chain, Monte Carlo, Gibbs' sampling, Hastings-Metropolis algorithms, critical slowing-down and remedies, auxiliary variables.

Practical

Simulation from various probability models; Resampling methods, jackknife and the bootstrap; Randomization tests; Simulating multivariate distributions, MCMC methods and Gibbs sampler; ARMA and transfer-function models, spectral-domain regression; Simulated data sets to be analyzed using popular computer software packages; Markov Chain, Monte Carlo, Gibbs' sampling.

Suggested Readings

Averill ML, Kelton D. 2005. *Simulation, Modeling and Analysis*. Tata McGraw Hill.

Balakrishnan N, Melas VB & Ermakov S. (Ed.). 2000. *Advances in Stochastic Simulation Methods*. Basel-Birkhauser.

Banks J. (Ed.). 1998. *Handbook of Simulation: Principles, Methodology, Advances, Applications and Practice*. John Wiley.

Brately P, Fox BL & Scharge LE. 1987. *A Guide to Simulation*. Springer.

Davison AC & Hinkley DV. 2003. *Bootstrap Methods and their Application*. Cambridge Univ. Press.

Gamerman D, Lopes HF & Lopes HF. 2006. *Markov Chain Monte Carlo: Stochastic Simulation for Bayesian Inference*. CRC Press.

Gardner FM & Baker JD. 1997. *Simulation Techniques Set*. John Wiley.

Gentle JE. 2005. *Random Number Generation and Monte Carlo Methods*. Springer.

Janacek G & Louise S. 1993. *Time Series: Forecasting, Simulation, Applications*. Ellis Horwood Series in Mathematics and its Applications.

Kleijnen J & Groenendaal WV. 1992. *Simulation: A Statistical Perspective*. John Wiley.

Kleijnen J. 1974 (Part I), 1975 (Part II). *Statistical Techniques in Simulation*. Marcel Dekker.

Law A & Kelton D. 2000. *Simulation Modeling and Analysis*. McGraw Hill.
Press WH, Flannery BP, Tenkolsky SA & Vetterling WT. 1986. *Numerical Recipes*. Cambridge Univ. Press.
Ripley BD. 1987. *Stochastic Simulation*. John Wiley.
Ross SM. 1997. *Simulation.* John Wiley.

STAT 603 OPTIMIZATION TECHNIQUES 1+1 SEM - II

Objective

This course is meant for exposing the students to the mathematical details of the techniques for obtaining optimum solutions under constraints for desired output. They will be taught numerical methods of optimization, linear programming techniques, non-linear programming and multiple objective programming. Students will also be exposed to practical applications of these techniques.

Theory

UNIT-I: Classical Optimization Techniques: Necessary Conditions for an Extremum. Constrained Optimization: Lagrange Multipliers, Statistical Applications. Optimization and Inequalities. Classical Inequalities, like Cauchy-Schwarz Inequality, Jensen Inequality and Markov Inequality.

UNIT-II: Numerical Methods of Optimization: Numerical Evaluation of Roots of Equations, Direct Search Methods, Sequential Search Methods -- Fibonacci Search Method. Random Search Method ï Method of Hooke and Jeeves, Simplex Search Method. Gradient Methods, like Newtonôs Method, and Method of Steepest Ascent. Nonlinear Regression and Other Statistical Algorithms, like Expectation ï Maximization Algorithm.

UNIT-III: Linear programming Techniques ï Simplex Method, Karmarkarôs Algorithm, Duality and Sensitivity Analysis. Zero-sum Two-person Finite Games and Linear Programming. Integer Programming. Statistical Applications.

UNIT-IV: Nonlinear Programming and its Examples. Kuhn-Tucker Conditions. Quadratic Programming. Convex Programming. Basics of Stochastic Programming. Applications. Elements of Multiple Objective Programming. Dynamic Programming, Optimal Control Theory ï Pontryaginôs Maximum Principle, Time-Optimal Control Problems.

Practical

Problems based on classical optimization techniques; Problems based on optimization techniques with constraints; Minimization problems using numerical methods; Linear programming (LP) problems through graphical method; LP problem by Simplex method; LP problem using simplex method (Two-phase method); LP problem using primal and dual method; Sensitivity analysis for LP problem; LP problem using Karmarkarôs method; Problems based on Quadratic programming; Problems based on Integer programming; Problems based on Dynamic programming; Problems based on Pontryaginôs Maximum Principle.

Suggested Readings

Rao SS. 2007. *Engineering Optimization: Theory and Practice*. 3rd Ed. New Age.
Rustagi JS. 1994. *Optimization Techniques in Statistics*. Academic Press.
Taha HA. 2007. *Operations Research: Introduction with CD*. 8th Ed. Pearson Edu.
Zeleny M. 1974. *Linear Multiobjective Programming*. Springer.

STAT 604 MEASURE THEORY AND INFORMATION THEORY 2+0 SEM - I

Objective

This course will cover the fundamental concepts of measure theory and information theory and their application in Statistics and Applied Mathematics.

Theory

UNIT-I: Elements of measure theory, classes of subsets, field, sigma field, minimal sigma field, Borel sets in R; measure, inter and outer measure and their properties, measurable sets and measurable functions of the Lebesgue integral, construction of Lebesgue measure in R^n comparison of Lebesgue and Riemann integral, Radon-Nikodym Theorem, Lebesgue Differentiation Theorem.

UNIT-II: Information Measures: Concepts of information and entropy, Various entropy measures and their properties, Relative entropy and Mutual Information and its relation with Entropy; Jensenôs, Information and and Fanoôs Inequalities.

UNIT-III: Entropy Optimization Principles: Janesô maximum entropy (MaxEnt) and Kullback-Leiberôs minimum cross entropy MinxEnt) principles and their applications in characterizing common probability distributions.

UNIT-IV: Data Compression: Basics of Coding Theory, Kraft inequality, optimal and non-optimal codes, Huffman codes and universal source coding, Block codes and convolution codes. Applications of coding theory in single and multi channel communication systems.

Suggested Readings

Abramson NM. 1963. *Information Theory and Coding*. McGraw-Hill.

Haral Cramer. 1962. *Mathematical Methods of Statistics*. Asia Publ. House.

Goon AM & Dasgupta B. 1985. *Outline of Probability and Statistics*, Vol-I World Class Prv. Ltd. Calcutta.

Kapur JN & Kesavan HK. 1992. *Entropy Optimization Principles with Applications*, Hamcourt Brace Jovanovich, Publ.

Kapoor JN.1989. *Manimum Entropy Model in Science & Engineering*. Wiley Eastern.

Kullback S .1968. *Information Theory and Statistics*. Dover, New York.. Reprint of 1959 edition published by Wiley.

Walter Rudin. 1976. *Principles of Mathematical Analysis*. 3rd Ed. McGraw-Hill.

Royden HL. 1993. *Real Analysis*. 4th Ed. Macmillan Publ.

Walter Rudin. 1966. *Real and Complex Analysis*. Tata McGraw Hill.

STAT 611 ADVANCED STATISTICAL METHODS 1+1 SEM - I

Objective

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT-I: Introduction to the theory and applications of generalized linear models, fixed effects, random effects and mixed effects models, estimation of variance components from unbalanced data. Unified theory of least squares, MINQUE, MIVQUE, REML.

UNIT-II: Quasi-likelihoods, and generalized estimating equations -logistic regression, over-dispersion, poisson regression,ridge regression,robust regression,least absolute deviation regression,M-estimatiors ,Non parametric regression, log-linear models, conditional likelihoods, generalized mixed models, and regression diagnostics.

UNIT-III: Fitting of a generalized linear model, mixed model and variance components estimation.

Practical

Fitting of Logistic regression, Poisson regression, ridge regression, robust regression, non-parametric regression.

Suggested Readings

Chatterjee S, Hadi A & Price B.1999. *Regression Analysis by Examples*. John Wiley.

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Rao CR. 1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Searle SR, Casella G & McCulloch CE. 1992. *Variance Components*. John Wiley.

Searle SR. 1971. *Linear Models*. John Wiley.

STAT 612 ADVANCED STATISTICAL INFERENCE 3+0 SEM - II

Objective

This course aims at describing the advanced level topics in statistical methods and statistical inference. This course would prepare students to have a strong base in basic statistics that would help them in undertake basic and applied research in Statistics.

Theory

UNIT-I: Robust estimation and robust tests, Robustness, M-estimates. L-estimates, asymptotic techniques, Bayesian inference.

UNIT-II: Loglinear models. Non-parametric estimation.

UNIT-III: Density Estimation: Density Estimation in the Exploration and Presentation of

Data. Survey of existing methods. The Kernel method for Univariate Data: Rosenblatts naïve estimator, its bias and variance. Consistency of general Kernel estimators, MSE and IMSE. Asymptotic normality of Kernel estimates of density. Estimation of distribution by method of kernels.

UNIT-IV: Consistency and asymptotic normality (CAN) of real and vector parameters. Invariance of consistency under continuous transformation. Invariance of CAN estimators under differentiable transformations, generation of CAN estimators using central limit theorem. Exponential class of densities, Cramer-Huzurbazar theorem, method of scoring.

UNIT-V: Efficiency: asymptotic relative efficiency and Pitmanôs theorem. Concepts and examples of Bahadur efficiency and Hodges-Lehmanns efficiency with examples. The concepts of Raoôs second order efficiency and Hodges-Lehmannôs Deficiency with examples. Rank tests, permutation tests, asymptotic theory of rank tests.

UNIT-VI: Inference on Markov Chains: Maximum likelihood estimation and testing of Transition Probability Matrix of a Markov Chain, testing for order of a Markov chain, estimation of functions of transition probabilities.

UNIT-VII: Concept of loss, risk and decision functions, admissible and optimal decision functions, a-priori and posteriori distributions, conjugate families. Bayes and Minimax decision rules and some basic results on them. Estimation and testing viewed as cases of decision problems. Bayes and Minimax decision functions with applications to estimation with quadratic loss function. Concept of Bayesian sequential analysis.

UNIT-VIII: U-Statistics: definitions of estimable parametric function, kernel, symmetric kernel and U-statistics. Variance and covariance of U-statistics. Hoeffdingôs decomposition of U-statistics ï examples. U-statistics based on sampling from finite populations and weighted U-statistics with examples. Some convergence results on U-statistics. Asymptotic normality of U-statistics with examples.

Suggested Readings

Casela G & Berger RL. 2001. *Statistical Inference*. Duxbury Thompson Learning.

Daniel W.1990. *Applied Nonparametric Statistics*. Houghton Mifflin, Boston.

DeGroot MH. 1970. *Optimal Statistical Decisions*. McGraw Hill.

Efron B & Tibshirani RJ. 1993. *An Introduction to Bootstrap*. Chapman Hall/CRC.

Ferguson TS. 1967. *Mathematical Statistics, A Decision Theoretic Approach*. Academic Press.

Gibbons JD & Chakraborty S. 1992. *Non-parametric Statistical Inference*. Marcel Dekker.

Gray HL & Schucany WR.1972. *The Generalized Jackknife Statistics*. Marcel Dekker.

Kale BK.1999. *A First Course on Parametric Inference*. Narosa Publ.

Prakasa Rao BLS. 1983. *Nonparametric Functional Estimation*. Academic Press.

Rao CR.1965. *Linear Statistical Inference and its Applications*. 2nd Ed. John Wiley.

Silverman BW. 1986. *Density Estimation for Statistics and Data Analysis*. Chapman & Hall.

Silvey SD. 1975. *Statistical Inference*. Chapman & Hall.

Tapia RA & Thompson JR. 1978. *Nonparametric Probability Density Estimation*. John Hopkins Univ. Press.

Tiku ML, TanWY & Balakrishnana N. 1986. *Robust Inference*. Marcel Dekker.

Wald A. 2004. *Sequential Analysis*. Dover Publ.

Wasserman L. 2006. *All of Nonparametric Statistics*. Springer.

STAT 613 ADVANCED DESIGN OF EXPERIMENTS 2+0 SEM - I

Objective

This is an advanced course in Design of Experiments that aims at describing some advanced level topics for students who wish to pursue research in this area. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT-I: General properties and analysis of block designs. Balancing criteria. m-associate PBIB designs, and their association schemes including lattice designs - properties and construction, Designs for test treatment ï control(s) comparisons; Nested block designs, Mating designs.

UNIT-II: General properties and analysis of two-way heterogeneity designs, Youden type designs, generalized Youden designs, Pseudo Youden design. Structurally Incomplete

block designs, Designs for two sets of treatments.

UNIT-III: Balanced factorial experiments - characterization and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal arrays, Mixed orthogonal arrays, balanced arrays, Fractional replication, Regular and irregular fractions.

UNIT-IV: Response surface designs - Symmetrical and asymmetrical factorials, Response optimization and slope estimation, Blocking. Canonical analysis and ridge analysis. Experiments with mixtures: design and analysis. Experiments with qualitative cum quantitative factors.

UNIT-V: Optimality criteria and optimality of designs, robustness of designs against loss of data, outliers, etc. Diagnostics in design of experiments.

Suggested Readings

Chakraborti MC. 1962. *Mathematics of Design and Analysis of Experiments*. Asia Publ. House.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Dey A & Mukerjee R. 1999. *Fractional Factorial Plans*. John Wiley.

Dey A 1986. *Theory of Block Designs*. Wiley Eastern.

Hall M Jr. 1986. *Combinatorial Theory*. John Wiley.

Hedayat AS, Sloane NJA & Stufken J. 1999. *Orthogonal Arrays: Theory and Applications*. Springer.

John JA & Quenouille MH. 1977. *Experiments: Design and Analysis*. Charles & Griffin.

Khuri AI & Cornell JA. 1996. *Response Surface Designs and Analysis*. 2nd Ed. Marcel Dekker.

Montgomery DC. 2005. *Design and Analysis of Experiments*. John Wiley.

Ogawa J. 1974. *Statistical Theory of the Analysis of Experimental Designs*. Marcel Dekker.

Parsad R, Gupta VK, Batra PK, Satpati SK & Biswas P. 2007. *Monograph on α-designs*. IASRI, New Delhi.

Raghavarao D. 1971. *Construction and Combinatorial Problems in Design of Experiments*. John Wiley.

Shah KR & Sinha BK. 1989. *Theory of Optimal Designs.* Lecture notes in Statistics. Vol. 54. Springer.

Street AP & Street DJ. 1987. *Combinatorics of Experimental Designs*. Oxford Science Publ.

Design Resources Server: www.iasri.res.in.

STAT 614 ADVANCED SAMPLING TECHNIQUES 2+0 SEM - I

Objective

This is an advanced course in Sampling Techniques that aims at describing some advanced level topics for students who wish to pursue research in Sampling Techniques. This course prepares students for undertaking research in this area.

Theory

UNIT-I: Controlled selection. Two way stratification, collapsed strata. Systematic sampling in two dimensions. Use of combinatorics in controlled selection. Integration of surveys - Lahiri and Keyfitzôs procedures.

UNIT-II: Variance estimation in complex surveys. Taylorôs series linearization, balanced repeated replication: Resampling methods:Jackknife& bootstrap.

UNIT-III: Unified theory of sampling from finite populations. UMV - Non-existence theorem and existence theorem under restricted conditions. Concept of sufficiency and likelihood in survey sampling. Admissibility and hyper-admissibility.

UNIT-IV: Inference under super population models - concept of designs and model unbiasedness, prediction approach. Regression analysis and categorical data analysis with data from complex surveys. Domain estimation. Small area estimation.

UNIT-V: Bayesian models with multi-stage sampling. Measurement error and small area estimation, Time series approach in survey sampling.

Suggested Readings

Berger JO. 1993. *Statistical Decision Theory and Bayesian Analysis*. Springer.

Bolfarine H & Zacks S. 1992. *Prediction Theory for Finite Population Sampling*. Springer.

Cassel CM, Sarndal CE & Wretman JH. 1977. *Foundations of Inference in Survey Sampling.* John Wiley.
Des Raj & Chandhok P. 1998. *Sample Survey Theory*. Narosa Publ. House.
Ghosh M & Meeden G. 1997. *Bayesian Method for Finite Population Sampling. Monograph on Statistics and Applied Probability*. Chapman & Hall.
Mukhopadhyay P. 1998. *Theory and Methods of Survey Sampling.* Prentice Hall of India.
Rao JNK. 2003. *Small Area Estimation*. John Wiley.
Sarndal CE, Swensson B & Wretman JH. 1992. *Model Assisted Survey Sampling*. Springer.

STAT 615 ADVANCED STATISTICAL GENETICS 2+0 SEM - II

Objective

This is an advanced course in Statistical Genetics that aims at describing some advanced level topics for students who wish to pursue research in Statistical Genetics. This course prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject in plant and animal breeding.

Theory

UNIT-I: Hardy-Weinberg law with multiple allelic systems, auto-tetraploids and self-sterility alleles. Complex cases of selection with two or more loci.

UNIT-II: Different approaches to study inbreeding process, methods of path coefficient, probability and generation matrix. Fisherôs approach to inbreeding. Stochastic process of gene frequency change, transition matrix approach using finite Markov chains, diffusion approximation, Steady decay and distribution of gene frequency, Probability of fixation of a gene, Conditional process - Markov chains and diffusion approaches, Distribution of time until fixation, random fluctuations in selection intensity, stationary distribution of gene frequency. Effective population size.

UNIT-III: Prediction and estimation of genetic merit. Best linear unbiased prediction, Use of mixed model methodology in analysis of animal and plant breeding experiments. Newer reproductive technology and its effect in genetic evaluation of individual merit. Estimation of genetic parameters - problemsrelating to computational aspects of genetic variance components, parameter estimation in variance component models for binary response data.

UNIT-IV: Identification of genes with large effects, Use of molecular markers (RFLP, PCR-AFLP, RAPD and SSR), Gene mapping and Quantitative trait loci.Molecular manipulation for genetic variability.

UNIT-V: Survival analysis and concept of censored observation in animal breeding. Phylogeny and analysis of molecular variance.

Suggested Readings

Crow JF & Kimura M. 1970. *An Introduction of Population Genetics Theory*. Harper & Row.
Ewens WJ. 1979. *Mathematical Population Genetics*. Springer.
Falconer DS. 1985. *Introduction to Quantitative Genetics*. ELBL.
Fisher RA. 1949. *The Theory of Inbreeding*. Oliver & Boyd.
Fisher RA. 1958. *The Genetical Theory of Natural Selection*. Dover Publ.
Haldane JBS. 1932. *The Causes of Evolution*. Harper & Bros.
Kempthorne O. 1957. *An Introduction to Genetic Statistics*. The Iowa State Univ. Press.
Lerner IM. 1950. *Population Genetics and Animal Improvement*. Cambridge Univ. Press.
Lerner IM. 1958. *The Genetic Theory of Selection*. John Wiley.
Li CC. 1982. *Population Genetics*. The University of Chicago Press.
Mather K & Jinks JL. 1982. *Biometrical Genetics*. Chapman & Hall.
Mather K. 1951. *The Measurement of Linkage in Heredity*. Methuen.
Nagilaki T. 1992. *Introduction to Theoretical Population Genetics*. Springer.
Narain P. 1990. *Statistical Genetics*. Wiley Eastern.

STAT 616 STATISTICAL MODELING 1+1 SEM - II

Objective

This is an advanced course in Statistical Methods that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in the area of empirical and

mechanistic models and nonlinear estimation and the replications in different disciplines of agricultural sciences.

Theory

UNIT-I: Empirical and mechanistic models. Nonlinear growth models like monomolecular, logistic, Gompertz, Richards and their applications in Agriculture and Fisheries.

UNIT-II: Nonlinear estimation: Least squares for nonlinear models, Methods for estimation of parameters like Linearization, Steepest, and Levenberg-Marquardtôs Reparameterization.

UNIT-III: Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterraôs principle and its applications. Gause competition model.

UNIT-IV: Compartmental modelling - First and second order input-output systems, Dynamics of a multivariable system.

Practical

Fitting of mechanistic non-linear models; Application of Schaefer and Fox non-linear models; Fitting of compartmental models.

Suggested Readings

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Efromovich S. 1999. *Nonparametric Curve Estimation*. Springer.

Fan J & Yao Q. 2003. *Nonlinear Time Series-Nonparametric and Parametric Methods*. Springer.

France J & Thornley JHM. 1984. *Mathematical Models in Agriculture*. Butterworths.

Harvey AC. 1996. *Forecasting, Structural Time Series Models and the Kalman Filter*. Cambridge Univ. Press.

Ratkowsky DA. 1983. *Nonlinear Regression Modelling: A Unified Practical Approach*. Marcel Dekker.

Ratkowsky DA. 1990. *Handbook of Nonlinear Regression Models*. Marcel Dekker.

Seber GAF & Wild CJ. 1989. *Non-linear Regression*. John Wiley.

Silverman BW. 1986. *Density Estimation for Statistics and Data Analysis*. Chapman & Hall.

STAT 617 ADVANCED TIME SERIES ANALYSIS 1+1 SEM - II

Objective

This is an advanced course in Time Series Analysis that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area. This also helps prepare students for applications of this important subject to agricultural sciences.

Theory

UNIT-I: Multivariate time series: modelling the mean, stationary VAR models: properties, estimation, analysis and forecasting, VAR models with elements of nonlinearity, Non-stationary multivariate time series: spuriousregression, co-integration, common trends.

UNIT-II: Volatility: Modelling the variance, The class of ARCH models: properties, estimation, analysis and forecasting, stochastic volatility, realized volatility,Extensions: IGARCH, ARCH-t, ARCD, Multivariate GARCH, Time-varying risk and ARCH-in-mean.

UNIT-III: Structural time-series modelling: State space models, Kalman filter. Local level model, Local linear trend model, Seasonal models, Cyclical models. Nonlinear time-series models: Parametric and nonparametric approaches. Autoregressive conditional heteroscedastic model and its extensions. Threshold and Functional coefficient autoregressive models.

Practical

Fitting of stationary and non stationary multivariate time series models.Analysis and forecasting:IGARCH ,ARCH-t ,ARCD,Multivariate GARCH ,time varying risk & ARCH-in-mean. Fitting of nonlinear time series models.

Suggested Readings

Box GEP, Jenkins GM & Reinsel GC. 2008. *Time Series Analysis: Forecasting and Control*. 3rd Ed. John Wiley.

Brockwell PJ & Davis RA. 1991. *Time Series: Theory and Methods*. 2nd Ed. Springer.

Chatfield C. 2004. *The Analysis of Time Series: An Introduction*. 6th Ed. Chapman & Hall/CRC.
Tong H. 1995. *Nonlinear Time Series: A Dynamical System Approach*. Oxford Univ. Press.

STAT 618 ADVANCED STOCHASTIC PROCESSES 2+0 SEM – I

Objective

This is advanced course on Stochastic Processes that aims at describing some advanced level topics in this area of research with a very strong potential of applications. This course also prepares students for undertaking research in this area.

Theory

UNIT-I: Discrete state continuous time Markov process: Kolmogorov difference ï differential equations. Birth and death process, pure birth process (Yule-Fury process). Immigration-Emigration process. Linear growth process, pure death process.
UNIT-II: Renewal process: renewal process when time is discrete and continuous. Renewal function and renewal density, Statements of Elementary renewal theorem and Key renewal theorem.
UNIT-III: Stochastic process in biological sciences: Markov models in population genetics, compartmental analysis, Deterministic and stochastic epidemic models. General epidemic models-Karmack and McKendrickôs threshold theorem, Recurrent epidemics.
UNIT-V: Elements of queueing process; the queuing model M/M/1: steady state behaviors.
UNIT-VI: Branching process: Galton-Watson branching process. Mean and variance of size of n^{th} generation, probability of ultimate extinction of a branching process, Fundamental theorem of branching process and applications.
UNIT-V: Wiener process- Wiener process as a limit of random walk, First passage time for Wiener process, Kolmogorov backward and forward diffusion equations and their applications.

Suggested Readings

Bharucha-Reid, AT 1960. *Elements of the Theory of Markov Processes and their Applications*. McGraw-Hill.
Bhat B.R. 2000. *Stochastic Models: Analysis and Applications*. New Age International.
Bhat.U.N. 1984. **Error! Hyperlink reference not valid.** John Wiley.
Chiang CL. 1980. *An Introduction to Stochastic Processes and their Applications*. Krieger.
Cox DR & Miller HD.1977. *The Theory of Stochastic Processes*, Chapman & Hall.
Karlin S & Taylor HM. *First Course to Stochastic Processes*. Academic Press.
Kemeny JG & Snell JL.1960. *Finite Markov Chains*. Van Nosts.
Parzen E. 1962. *Stochastic Processes*. Holden-Day.

STAT 619 SURVIVAL ANALYSIS 2+0 SEM – II

Objective

The course deals with the study of demographic profiles and survival times. In-depth statistical properties and analysis is an important component of this course.

Theory

UNIT-I: Measures of Mortality and Morbidity: Ratios and proportions, rates of continuous process, rates of repetitive events ,crude birth rate, Mortality measures used in vital statistics relationships between crude and age specific rates, standardized mortality ratios ,evaluation of person-year of exposed to risk in long term studies, prevalence and incidence of a disease, relative risk and odds ratio.
UNIT-II: Survival Distribution: Survival functions, hazard rate, hazard function, review of survival distributions: exponential, Weibull, Gamma, Rayleigh, Pareto, Lognormal~ IFR and TFRA, Gompertz and Makeham. Gompertz and logistic distributions.. Types of Censoring: Type I, Type II, random and other types of censoring, right and left truncated distributions, series and parallel system of failures. Life Tables, its fundamentals and

construction.

UNIT-III: Fitting Parametric Survival Distribution : Special form of survival function cumulative hazard function (CHF) plots, Nelson's method of ungrouped data, construction of the likelihood function for survival data, least squares fitting, fitting a Gompertz distribution to grouped data. Some tests of Goodness of fit: Graphical, Kolmogorov-Smirnov statistics for complete, censored and truncated data, Chi-Square test and Anderson-Darling A2-statistics. Comparison of Mortality Experiences: Comparison of two life tables, some distribution- free methods (two samples) for ungrouped data, Two samples Kolmogorov-Smirnov test, Wilcoxon test for complete data and modified Wilcoxon test for incomplete data .Gilbert and Gehan's test, mean and variance of Wilcoxon statistics, generalization of Gehan's test. Testing for Consistent Differences in Mortality : Mantel-Haenszel and log rank test. Generalized Mantel-Haenszel test (k-sample).

UNIT-IV: Concomitant Variables: General parametric model for hazard function with observed concomitant variables. Additive and multiplicative models of hazard rate functions. Estimating multiplicative models, selection of concomitant variables. Logistic linear model, Concomitant Variable regarded as random variable. Age of onset distributions: Models of onset distributions and their estimation. Gompertz distribution, parallel system and Weibull distribution, Fatal short models of failure. Two component series system.

Suggested Readings

Anderson B. 1990. *Methodological Errors in Medical Research*. Blackwell.

Armitage P & Berry G. 1987. *Statistical Methods in Medical Research*. Blackwell.

Collett D. 2003. *Modeling Survival Data in Medical Research*. Chapman & Hall.

Cox DR & Oakes D. 1984. *Analysis of Survival Data*. Chapman & Hall.

Elandt-Johnson RC & Johnson NL. 1980. *Survival Models and Data Analysis*. John Wiley.

Everitt BS & Dunn G. 1998. *Statistical Analysis of Medical Data*. Arnold.

Hosmer DW Jr. & Lemeshow S. 1999. *Applied Survival Analysis: Regression Modeling or Time to Event*. John Wiley.

Kalbfleisch JD & Prentice. RL 2002. *The Statistical Analysis of Failure Time Data*. John Wiley.

Klein JP & Moeschberger ML. 2003. *Survival Analysis: Techniques for Censored and Truncated Data*. Springer.

Kleinbaum DG & Klein M. 2002. *Logistic Regression*. Springer.

Kleinbaum DG & Klein M. 2005. *Survival Analysis*. Springer.

Lawless JF. 2003. *Statistical Models and Methods for Lifetime Data*. 2nd Ed. John Wiley.

Lee ET. 1980. *Statistical Methods for Survival Data Analysis*. Lifetime Learning Publ.

STAT 621 ADVANCED MULTIVARIATE ANALYSIS 2+1 SEM - I

Objective

This course will expose students to advanced multivariate techniques and their applications in biological and agricultural sciences. It also prepares students for conducting research in Applied Multivariate Analysis.

Theory

UNIT-I: Multivariate Distributions: Popular discrete and continuous multivariate distributions; Measures of multivariate Skewness and Kurtosis; Multivariate central limit theorem; Graphical representation of multivariate data.

UNIT-II: Multivariate Tests of Significance: Sampling distributions of mean , variance, T^2 and D^2 statistics, decomposition of D^2; Tests of Significance for equality of mean vectors with known and unknown covariance matrices; One-way and two-way MANOVA; Tests for sphereicity, equicorrelation and equality of distance and covariance matrices.

UNIT-III: Multivariate Correlation and Regression Analysis: Measures of multivariate association; sampling distribution of simple, partial and multiple correlation coefficients; multivariate regression model and its estimation; testing a general linear hypothesis in multivariate regression analysis.

UNIT-IV: Principal component and Factor Analysis: Extraction and properties of Principal Components, Stopping rule for number of Principal Components, Principal

Component analysis in regression, Robust Principal Components; variables selection in PCA; Orthogonal factor Model, Methods of factor extraction and rotation.

UNIT-V: Discriminant and canonical correlation Analysis: Discrimination when populations are known as well as under estimation; Fisherôs linear discriminant function and its applications in agriculture; Discarding variables in discriminant analysis; canonical correlation analysis and interpretation of canonical loadings and cross loadings; Redundancy coefficient.

Practical

Multivariate Association; Testing equality of two and several mean vectors; multivariate regression; MANOVA and PCA, Principal component regression; selection of variables; canonical correlation.

Suggested Readings

Anderson TW. 1984. *An Introduction to Multivariate Analysis*. John Wiley.ô

Johanson RA & Wicheran DW. 1996. *Applied Multivariate Statistical Analysis*. Prentice-Hall of India.

Mardia KV, Kent JT & Bibby JM. 1979. *Multivariate Analysis*. Academic Press.

Rencher AC. 2002. *Methods of Multivariate Analysis.* John Wiley.

Srivastava MS & Khatri GC. 1979. *An Introduction to Multivariate Statistics*. North Holland.

STAT 651 RECENT ADVANCES IN THE FIELD OF SPECIALIZATION 3+0 SEM - I, II

Objective

To familiarize the students with the recent advances in the areas of their specialization to prepare them for undertaking research.

Theory

Recent advances in the field of specialization - sample surveys / design of experiments /statistical genetics / statistical modeling / econometrics / statistical inference, etc. will be covered by various speakers from the University / Institute as well as from outside the University / Institute in the form of seminar talks.

SERVICE COURSES

STAT 501/ FST451 MATHEMATICAL METHODS FOR APPLIED SCIENCES 2+0 SEM - I

Objective

This course is meant for students who do not have sufficient background of Mathematics. The students would be exposed to elementary mathematics that would prepare them to study their main courses that involve knowledge of Mathematics. The students would get an exposure to differentiation, integration and differential equation.

Theory

UNIT-I: Variables and functions; limit and continuity. Specific functions. Differentiation: theorems of differentiation, differentiation of logarithmic, trigonometric, exponential and inverse functions, function of a function, derivative of higher order, partial derivatives. Application of derivatives in agricultural research; determination of points of inflexion, maxima and minima in optimization, etc.

UNIT-II: Integration as a reverse process of differentiation, methods of integration, reduction formulae, definite integral; Applications of integration in agricultural research with special reference to economics and genetics, engineering, etc.

UNIT-III: Vectors and vector spaces, Matrices, notations and operations, laws of matrix algebra; transpose and inverse of matrix; Eigen values and eigen vectors. Determinants - evaluation and properties of determinants, application of determinants and matrices in solution of equation for economic analysis.

UNIT-IV: Set theory-set operations, finite and infinite sets, operations of set, function defined in terms of sets.

Suggested Readings

Harville DA. 1997. *Matrix Algebra from a Statistician's Perspective*. Springer.

Hohn FE. 1973. *Elementary Matrix Algebra*. Macmillan.

Searle SR. 1982. *Matrix Algebra Useful for Statistics*. John Wiley.

Stewart J. 2007. *Calculus*. Thompson.
Thomas GB. Jr. & Finney RL. 1996. *Calculus.* 9th Ed. Pearson Edu.

STAT 511 STATISTICAL METHODS FOR APPLIED SCIENCES 3+1 SEM – I, II

Objective

This course is meant for students who do not have sufficient background of Statistical Methods. The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics. It would also help them in understanding the concepts involved in data presentation, analysis and interpretation. The students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.

Theory

UNIT-I: Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability, Random variable and mathematical expectation.

UNIT-II: Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications, concept of sampling distribution: chi-square, t and F distributions,. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

UNIT-III: Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting.

UNIT-IV: Non-parametric tests- sign, Wilcoxen, Mann-Whitney U-test. Kruskal-Wallis test, run test, Friedman two-way ANOVA by ranks. Kendallôs coefficient of concordance.

UNIT-V: Introduction to multivariate statistical analysis.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions ï Binomial, Poisson, Negative Binomial, Normal; Large sample tests, testing of hypothesis based on exact sampling distributions-chi-square, t and F; Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution; Correlation and regression analysis. Non-parametric tests.

Suggested Readings

Dillon WR & Goldstein M. 1984. *Multivariate Analysis - Methods and Applications*. John Wiley.
Goon AM, Gupta MK & Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
Goon AM, Gupta MK & Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
Hoel PG. 1971. *Introduction to Mathematical Statistics*. John Wiley.
Hogg RV & Craig TT. 1978. *Introduction to Mathematical Statistics*. Macmillan.
Morrison DF. 1976. *Multivariate Statistical Methods*. McGraw Hill.
Siegel S, Johan N & Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.

STAT 512 EXPERIMENTAL DESIGNS 2+1 SEM - II

Objective

This course is meant for students of College of Agriculture and Animal sciences. Designing an experiment is an integrated component of research in almost all sciences. The students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data.

Theory

UNIT-I: Need for designing of experiments, characteristics of a good design. Basic principles of designs-randomization, replication and local control.

UNIT-II: Uniformity trials, size and shape of plots and blocks; Analysis of variance; completely randomized design, randomized block design and Latin square design.

UNIT-III: Factorial experiments, (symmetrical as well as asymmetrical). Orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT-IV: Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications-Lattice design, alpha design-concepts, randomization procedure, analysis and interpretation of results.

UNIT-V: Bioassays-direct and indirect, indirect assays based on quantal dose response.

Practical

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law; Analysis of data obtained from CRD, RBD, LSD, LSD; Analysis of factorial experiments without and with confounding; Analysis with missing data; Split plot and strip plot designs; Transformation of data.

Suggested Readings

Cochran WG & Cox GM. 1957. *Experimental Designs*. 2nd Ed. John Wiley.

Dean AM & Voss D. 1999. *Design and Analysis of Experiments*. Springer.

Federer WT. 1985. *Experimental Designs*. Macmillan.

Fisher RA. 1953. *Design and Analysis of Experiments*. Oliver & Boyd.

Nigam AK & Gupta VK. 1979. *Handbook on Analysis of Agricultural Experiments*. IASRI Publ.

Pearce SC. 1983. *The Agricultural Field Experiment: A Statistical examination of Theory and Practice*. John Wiley.
Design Resources Server: www.iasri.res.in/design.

STAT 513 SAMPLING TECHNIQUES 2+1 SEM - II

Objective

This course is meant for students of College of Agriculture and Animal sciences. The students would be exposed to elementary sampling techniques. It would help them in understanding the concepts involved in planning and designing their surveys, presentation and analysis of survey data and presentation of results. This course would be especially important to the students of social sciences.

Theory

UNIT-I: Concept of sampling, sample survey vs complete enumeration, planning of sample survey, sampling from a finite population.

UNIT-II: Simple random sampling, sampling for proportion, determination of sample size; inverse sampling, Stratified sampling.

UNIT-III: Cluster sampling, PPS sampling, Multi-stage sampling, double sampling, systematic sampling; Use of auxiliary information at estimation as well as selection stages.

UNIT-IV: Ratio and regression estimators. Construction and analysis of survey designs, sampling and non-sampling errors; Preparation of questionnaire , Non-sampling errors.

Practical

Random sampling ~ use of random number tables, concepts of unbiasedness, variance, etc.; simple random sampling, determination of sample size; Exercises on inverse sampling, stratified sampling, cluster sampling and systematic sampling; Estimation using ratio and regression estimators; Estimation using multistage design, double sampling and PPS sampling.

Suggested Readings

Cochran WG. 1977. *Sampling Techniques*. John Wiley.
Murthy MN. 1977. *Sampling Theory and Methods*. 2nd Ed. Statistical Publ. Soc., Calcutta.
Singh D, Singh P & Kumar P. 1982. *Handbook on Sampling Methods*. IASRI Publ.
Sukhatme PV, Sukhatme BV, Sukhatme S & Asok C. 1984. *Sampling Theory of Surveys with Applications*. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.

STAT 521 APPLIED REGRESSION ANALYSIS 2+1 SEM - II

Objective

This course is meant for students of all disciplines including agricultural and animal sciences. The students would be exposed to the concepts of correlation and regression. Emphasis will be laid on diagnostic measures such as autocorrelation, multicollinearity and heteroscedasticity. This course would prepare students to handle their data for analysis and interpretation.

Theory

UNIT-I: Introduction to correlation analysis and its measures; Correlation from grouped data, Biserial correlation, Rank correlation; Testing of population correlation coefficients; Multiple and partial correlation coefficients and their testing.

UNIT-II: Problem of correlated errors; Auto correlation; Durbin Watson Statistics; Removal of auto correlation by transformation; Analysis of collinear data; Detection and correction of multicollinearity; Regression analysis; Method of least squares for curve fitting; Testing of regression coefficients; Multiple and partial regressions.

UNIT-III: Examining the multiple regression equation; Concept of weighted least squares; regression equation on grouped data; Various methods of selecting the best regression equation; regression approach applied to analysis of variance in one way classification.

UNIT-IV: Heteroscedastic models, Concept of nonlinear regression and fitting of quadratic, exponential and power curves; Economic and optimal dose, Orthogonal polynomial.

Practical

Correlation coefficient, various types of correlation coefficients, partial and multiple, testing of hypotheses; Multiple linear regression analysis, partial regression coefficients,

testing of hypotheses, residuals and their applications in outlier detection; Handling of correlated errors, multicollinearity; Fitting of quadratic, exponential and power curves, fitting of orthogonal polynomials.

Suggested Readings

Draper NR & Smith H. 1998. *Applied Regression Analysis*. 3rd Ed. John Wiley.

Ezekiel M. 1963. *Methods of Correlation and Regression Analysis*. John Wiley.

Kleinbaum DG, Kupper LL, Muller KE & Nizam A. 1998. *Applied Regression Analysis and Multivariable Methods*. Duxbury Press.

Koutsoyiannis A. 1978. *Theory of Econometrics*. Macmillan.

Kutner MH, Nachtsheim CJ & Neter J. 2004. *Applied Linear Regression Models*. 4th Ed. With Student CD. McGraw Hill.

STAT 532/ BIF 505 STATISTICS FOR BIOLOGICAL SCIENCES 2+1 SEM - I

Objective

To understand the basic principles of statistics and mathematics and their applications in relation to Biological system.

Theory

UNIT-I: Introduction to biological statistics, Principles of sampling from a population; Random sampling.

UNIT-II: Frequency distributions: Graphical representations and Descriptive measures; Standard Probability Distributions; Correlation and regression analysis.

UNIT-III: Hypothesis testing; Markov Models, Cluster Analysis: Hierarchical and Non-Hierarchical methods.

UNIT-IV: Phylogenetic Analysis Tools: Maximum Likelihood, Parsimony methods.

Practical

- Computational exercises on Random Sampling
- Construction and representation of frequency distributions
- Descriptive measures
- Probability distribution

Suggested Readings

Gupta SC & Kapoor VK. 2000. *Fundamentals of Mathematical Statistics: A Modern Approach*. S. Chand & Co.

Morrison DF. 1976. *Multivariate Statistical Methods*. MsGraw Hill.

Warren JE & Gregory RG. 2005. *Statistical Methods in Bioinformatics*. Springer.

STAT 533/ BIF 509 MATHEMATICS FOR BIOLOGICAL SCIENCES 2+0 SEM - I

Objective

To understand and apply fundamental concepts of mathematics as applicable in Biology and to acquaint about theoretical concepts of algebra and geometry and numerical methods.

Theory

UNIT-I: Coordinate geometry with basic concepts of 2D and 3D geometry, Vector algebra ï Addition and subtraction of vectors, Dot and cross product, Scalar triple product.

UNIT-II: Matrix algebra: basic definitions, matrix operations, transpose of a matrix, inverse of matrix, eigen values, Boolean algebra. Geometric and Arithmetic Progression.

UNIT-III: Solution of equation by bisection method, Iteration method, Newton Raphson method, numerical differentiation.

UNIT-IV: Numerical integration- Trapezoidal rule, Simpsonôs 1/3 and 3/8 rules, Runga Kutta method of nth order. Fast Fourier transformation.

Suggested Readings

Babu CA & Seshan CR. 2006. *New Engineering Mathematics*. Narosa Publ. House.

Datta KB. 2002. *Matrix and Linear Algebra*. Prentice Hall.

Narayan S. 1980. *Matrix Algebra*. S. Chand & Co.

Rao S. 2006. *Numerical Methods for Scientists and Engineers*. Prentice Hall.

STAT 534/ MBB 553/ FST 531/ SOC 512 **BIOSTATISTICS AND COMPUTERS** **2+1** **SEM - I**

Objective

This is a course of applied Statistics to be taken by M.Sc. students of Biotechnology, FST and Sociology department of C.O.B.Sc.& H. They are exposed to various statistical methods to analyze their experimental data.

Theory

UNIT-I: Aim, scope and idea of elementary statistics; Measures of central tendency and dispersion, skewness and kurtosis.

UNIT-II: Concept of probability and probability laws, mathematical expectation, moments, moments generating function; Standard probability distributions-Binomial, Poisson and Normal distributions.

UNIT-III: Tests of significance based on Z, χ^2, t and F statistics; Correlation and regression, curve fitting by least squares methods.

UNIT-IV: Basic principles, organization and operational aspects of computers,operating systems. Introduction to MS-Office, MS-Word, MS-Excel. Statistical Data analysis based on above topics through MS-Excel.

Practical

- Data analysis using probability, test of significance
- Correlation and regression analysis
- Usage of MS-Windows
- SPSS

Suggested Readings

Agarwal BL. 2003. *Basic Statistics*. New Age.

Gupta SP. 2004. *Statistical Methods*. S. Chand & Sons.

Daniel WW. 1987. *Biostatistics: A Foundation for Analysis in the Health Sciences*. John Wiley & Sons.

Dutta NK. 2002. *Fundamentals of Bio-Statistics*. Kanishka Publ.

STATISTICS

List of Journals

- American Statistician
- Annals of Institute of Statistical Mathematics
- Annals of Statistics
- Australian and New Zealand Journal of Statistics
- Biometrical Journal
- Biometrics
- Biometrika
- Bulletin of Calcutta Statistical Association
- Canadian Journal of Statistics
- Communication in Statistics (Simulation & Computation)
- Communication in Statistics (Theory & and Methods)
- Experimental Agriculture
- Institute of Mathematical Statistics Bulletin (IMSB)
- Journal of American Statistical Association
- Journal of Applied Statistics
- Journal of the Indian Society of Agricultural Statistics
- Journal of the International Statistical Review
- Journal of Statistical Planning and Inference
- Journal of Statistical Theory and Practice
- Journal of Statistics, Computer and Applications
- Journal of Royal Statistical Society, Series A
- Journal of Royal Statistical Society, Series B
- Journal of Royal Statistical Society, Series C
- Metrika
- Metron
- Scandinavian Journal of Statistics (Theory & Applied)
- Sankhya
- Statistica
- Statistical Science
- Statistics and Probability Letters
- Technometrics

e-Resources

- Design Resources Server. *Indian Agricultural Statistics Research Institute(ICAR), New Delhi 110 012, India*. www.iasri.res.in/design.
- Design Resources: www.designtheory.org
- Free Encyclopedia on Design of Experiments
- http://en.wikipedia.org/wiki/Design_of_experiments
- Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- Electronic Statistics Text Book: http://www.statsoft.com/textbook/stathome.html.
- Hadamard Matrices http://www.research.att.com/~njas/hadamard;
- Hadamard Matrices http://www.uow.edu.au/~jennie/WILLIAMSON/williamson.html.
- Course on Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.
- Learning Statistics: http://freestatistics.altervista.org/en/learning.php.
- Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.
- Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html.
- Statistical Calculators: http://www.graphpad.com/quickcalcs/index.cfm
- SAS Online Doc 9.1.3: http://support.sas.com/onlinedoc/913/docMainpage.jsp

Suggested Broad Topics for Master's and Doctoral Research

- Design and analysis of multi-response experiments
- Design and analysis of micro-array experiments
- Design and analysis of experiments for precision agriculture
- Design and analysis of agroforestry experiments
- Bayesian designing of experiments, Bayesian optimality and Bayesian analysis of experimental data
- Computer aided search of efficient experimental designs for various experimental settings
- Fractional factorials including search designs, supersaturated designs, computer experiments, etc.
- Statistical techniques in bioinformatics, biotechnology, microbiology, genomics, etc.
- Optimality aspects and robustness of designs against several disturbances under various experimental settings (single factor, multi-factor, nested classifications, etc.)
- Small area estimation
- Computer intensive techniques in sample surveys
- Analysis of survey data, regression analysis, categorical data analysis, analysis of complex survey data
- Assessment and impact survey methodologies, valuation of natural resources, its degradation, depletion, etc.
- Linear and non-linear modeling of biological and economical phenomena
- Non-linear time series modeling
- Non-linear stochastic modeling
- Forecast models for both temporal and spatial data
- Innovative applications of resampling techniques
- Applications of remote sensing, GIS, ANN etc. in modeling various phenomena
- Econometric models for risk, uncertainty, insurance, market analysis, technical efficiency, policy planning, etc.
- Statistical studies on value addition to crop produce

COMPUTER SECTION

Course Structure

(Service Courses for Minor /Supporing Credits of other departments)

COURSE NO.	COURSE TITLE	CREDITS	SEM
COMP 501/ AG ECON 516	COMPUTER PROGRAMMING IN STATISTICAL RESEARCH	2+1	I / II
COMP 502/ FST 532	COMPUTER FUNDAMENTALS	1+2	I
COMP 503	PROGRAMMING THROUGH óCô	2+1	II
COMP 504	SCIENTIFIC DATA PROCESSING	1+2	II

COMPUTER SECTION

Course Contents

COMP 501/ AG ECON 516 — COMPUTER PROGRAMMING IN STATISTICAL RESEARCH — 2+1 — SEM - I, II

Objective

To acquaint and equip the students about the basic concepts of Computers and programming in FORTRAN for Solving Statistical/Scientific problems.

Theory

UNIT-I: Introduction to Computers, Types of Computers , Computer generations and classifications , Computer peripherals , Memory units, Control units, Arithmetic and Logic unit, Secondary storage. Computer codes and Arithmetic; Binary system , Octal and Hexadecimal number system, Conversion to decimal system.

UNIT-II: Computer softwares ï Machine language , Assembly language , high level language , Compilers , Interpreters and System utilities, Flowcharting and programming, Debugging , testing and Types of errors.

UNIT-III: Formulation of Algorithm, Elements of FORTRAN language, constants and variables, Operations and symbols, Expressions, Common mathematical functions.

UNIT-IV: Arithmetic assignment statement, Input, Output and FORMAT statements, termination statements, GO TO, Computed GO TO, Arithmetic IF and Logical IF statements, Type statement, Complex and Logical variables, DOUBLE PRECISION variables.

UNIT-V: Subscribed variables, Dimension statement, DO statement, Statement function; FUNCTION and SUBROUTINE subprogram, EQUIVALENCE , COMMON and DATA statements.

Practical

Development of computer programs in FORTRAN for the measures of central tendency, measures of dispersion , correlation and regression , simple testing of significance and analysis of CRD and RBD.

Suggested Readings

Rajaraman V. *Computer Programming in FORTRAN.*
Ram Kumar. *Programming in FORTRAN-77.*
Sharma KD. *Programming in FORTRAN.*

COMP 502/ FST 532 — COMPUTER FUNDAMENTALS — 1+2 — SEM - I

Objective

To acquaint and equip the students about the basic concepts of Computers and Solving their day-to-day information processing problems using the computer application softwares.

Theory

UNIT-I: Introduction to computer organization, computer generations, input-output units; computer memory system; system and application softwares; Fundamental concepts of operating systems, Booting process, file and directory concepts through DOS and Windows.

UNIT-II: Introduction to Word Processors; Creating and editing files in MS Word, designing and formatting Word-documents.

UNIT-III: Introduction to spreadsheets, menus and capabilities of MS-Excel, using inbuilt mathematical and statistical functions in Excel, modification and editing of Excel work sheets, creating and editing graphs, introduction to macros -programming, data import and export.

UNIT-IV: Introduction to DBMS, creating, retrieving and updating files, sorting, indexing and using multiple files, creating and printing reports under the Data base package.

Practical

Operating system commands and exercises pertaining to the above mentioned packages.

Suggested Readings

Balagurusamy E. *Office Automation and Word Processing*.
Courter. *Microsoft Office 2000*.
Jaggi VP & Jain Sushma. *Introductory Computer Science*.
Suresh K Basandra. *Computers Today*.

COMP 503 PROGRAMMING THROUGH 'C' 2+ 1 SEM - II

Objective

To acquaint and equip the students about the basic concepts of Computer programming in C language.

Theory

UNIT-I: Basic concepts of data structures, Types of files and their organization; Introduction to sorting and searching techniques; Introduction to programming languages, compilers, interpreters and system utilities, debugging and programming errors.

UNIT-II: óCô language: Brief historical introduction, essential features of óCô; constants and variables, Character set and data types in óCô; Arithmetic, relational, Logical, Assignment and Bitwise Operators and Expressions in óCô; Decision making and Branching ; FOR, WHILE and DO Statements.

UNIT-III: Arrays and initialization , higher dimensional arrays and matrices functions; Character test; Recursive functions and user-defined functions.

UNIT-IV: Structures and character strings; Pointers and their uses in structures; Dealing mixed data and printing and formatted outputs.

Practical

Developing programs for mathematical and statistical problems.

Suggested Readings

Balagurusamy E. *Object-Oriented Programming with C++*.
Gottfried Byron S. *A Schaum's Outline of Theory and Problems of programming with 'C'*.
Mullich & Cooper Herbert L. *The Spirit of C an Introduction to Modern Programming*.

COMP 504 SCIENTIFIC DATA PROCESSING 1+ 2 SEM - I

Objective

To acquaint and equip the students about the basic concepts of Statistical Package SPSS/SAS for Solving their Scientific / Data processing problems.

Theory

UNIT-I: Introduction to Statistical Package (SPSS/SAS); Defining, entering and editing data in this software, opening of data files and data management; using the output viewer for results/output.

UNIT-II: Data transformation and statistical analysis pertains to central tendency & dispersion, Analysing combinations of categorical data, Continuous data analysis using t-tests and testing relationships between categorical variables.

UNIT-III: Analysing combinations of continuous variables using correlations; Editing charts, Generating tabulated reports, charts with exploring the complete plotting, reporting and presentation features pertains to distributions and trends, descriptive statistics and complex statistical analysis.

UNIT-IV: Handling the other statistical procedures like: Linear models, Correlation, Regrssion, ANOVA, Log-linear, classify, data reduction, scaling, Non-parametric tests, Time series, Survival, Multiple response etc.

UNIT-V: Introduction to runnig procedures from a Syntex Windows, Advanced Statistical tools and some other modules of the software.

Practical

Creating, Edinting, Analysing and Manipulating scientif data using the above mentioned techniques of statuistics available in the software.

Suggested Readings

Foster Jeremy. *Data Analysis using SPSS for Windows: A Beginner's Guide.*

Kinnear & Gray Colin. *SPSS for Windows made Simple*. *SPSS Manual* at http://www.spss.com

ZOOLOGY

Course Structure

COURSE NO.	COURSE TITLE	CREDITS	SEM
ZOO 501 *	COMPARATIVE ANIMAL ANATOMY	3+1	I
ZOO 502*	TAXONOMY AND SYSTEMATICS OF ANIMALS	2+1	I
ZOO 503*,***	ENVIRONMENTAL BIOLOGY AND WILDLIFE CONSERVATION	2+1	I
ZOO 504*	ANIMAL PHYSIOLOGY AND BEHAVIOUR	3+1	I
ZOO 505	METHODOLOGY AND DEVELOPMENTAL BIOLOGY	2+2	II
ZOO 506***	APIDOLOGY	2+1	II
ZOO 507	FUNDAMENTALS OF VERMICULTURE	2+1	II
ZOO 508	MAMMOLOGY	2+1	II
ZOO 509	PRINCIPLES OF ARACHNOLOGY	2+1	II
ZOO 591	MASTERõS SEMINAR	1	I, II
ZOO 599	MASTERõS RESEARCH	20	I, II
ZOO 601**	ADVANCES IN ANIMAL BEHAVIOUR	3+0	II
ZOO 602**	FUNCTIONS OF ECOSYSTEM	3+0	II
ZOO 603	ADVANCED ACAROLOGY	2+1	I
ZOO 604	ADVANCES IN APIDOLOGY	3+0	I
ZOO 605	ADVANCES IN VERMICULTURE	3+0	I
ZOO 691	DOCTORAL SEMINAR-I	1	I, II
ZOO 692	DOCTORAL SEMINAR-II	1	I, II
ZOO 699	DOCTORAL RESEARCH	45	I, II

*Compulsory for Master's programme ; **Compulsory for Doctoral programme
***Courses open for the students of other departments as minor and supporting subjects

ZOOLOGY

Course Contents

ZOO 501 COMPARATIVE ANIMAL ANATOMY 3+1 SEM - I

Objective

To give details of the functional and evolutionary modification in various systems of invertebrates and vertebrates.

Theory

UNIT-I: Integumentary, skeletal and the muscular systems.
UNIT-II: Nervous system including the sense organs and endocrine glands.
UNIT-III: Transport and exchange systems (digestive, circulatory systems).
UNIT-IV: Transport and exchange systems (respiratory and excretory systems).
UNIT-IV: Reproductive system, aerodynamics in relation to flight in insects/birds and mammals.

Practical

Dissection and study of the representative types from invertebrates and vertebrates; preparations of whole mounts with reference to the systems in theory; study of histological slides.

Suggested Readings

Hymen LH.1951. *Invertebrates*. McGraw Hill.
Romer AS. 1965. *Vertebrate Body*. WB Saunders.
Walter HE & Sayles CP. *Biology of Vertebrates: Comparative Study of Man and his Animal Allies*. 3rd Ed. MacMillan.

ZOO 502 TAXONOMY AND SYSTEMATICS OF ANIMALS 2+1 SEM - I

Objective

To introduce fundamental concepts and patterns in systematics in terms of exposure to animal diversity, classification, identification and nomenclature, and their application in biology.

Theory

UNIT-I: General introduction, taxonomy and nomenclature, taxonomic categories and hierarchy.
UNIT-II: Principles and methods of nomenclature; keys, their kinds and uses.
UNIT-III: Introduction to numerical, biochemical and cytological taxonomy.
UNIT-IV: Classification of non-chordates and chordates upto orders and important families, with distinguishing characters and examples.

Practical

Collection and preservation of certain animals; study of local fauna and their identification; identification of animals using keys; taxonomy of animals based on biochemical and cytological techniques.

Suggested Readings

Mayer E, Linsley EG & Usinger RL. 1953. *Methods and Principles of Systematic Zoology*. McGraw Hill.
Odum EP. 1971. *Fundamentals of Ecology*. WB Saunders.
Proccer EL., 1973. *Comparative Animal Physiology*. WB Saunders.
Salim Ali 1983. *Handbook of Birds of India and Pakistan*. Oxford Univ. Press.
Welty Joel Carl 1982. *Life of Birds*. WB Saunders.

ZOO 503 ENVIRONMENTAL BIOLOGY AND WILDLIFE CONSERVATION 2+1 SEM - I

Objective

Due to man engineered activities, our environment is being fastly degraded and many wild species are becoming extinct. Basic aspects and implications of these changes are needed to be disseminated among the students.

Theory

UNIT-I: Definition and scope of environment, ecology, environmental biology; community; ecosystems, their types, properties and characteristics.
UNIT-II: Population, its characteristics: density, natality, mortality, age distribution, biotic potential, dispersion, population growth forms, population regulation, population interactions.
UNIT-III: Production, decomposition, bioenergetics, food chains, food webs, biogeoochemical and nutrient cycles, ecological succession.
UNIT-IV: Environment, limiting factors, environmental pollution.
UNIT-V: Wild life; concepts and principles of wild life management, conservation and control, legislation, wildlife parks and sanctuaries.

Practical

Introduction to the ecological equipments, measurement of ecological parameters, productivity, population density and species diversity in different ecosystems; determination of LD50 and LC50 values; visit to zoo/sanctuary or other habitats.

Suggested Readings

Krebs CJ. 1989. *Ecological Methodology*. Harper & Row.
Odum EP. 1971. *Fundamentals of Ecology*.WB Saunders.
Remmert H. 1980. *Ecology: A Text Book*. Springer Verlag.
Singh MP & Day S. 2004. *Bioresources and Genepool Conservation*. Daya Publ.
Smith RL. 1977. *Elements of Ecology and Field Biology*. Harper & Row.
Stilling PD. 1996. *Ecology: Theories and Applications*. Prentice Hall.

ZOO 504 ANIMAL PHYSIOLOGY AND BEHAVIOUR 3+1 SEM - I

Objective

To develop insight into various functional aspects of animals with reference to their habits and adaptations, as well as to introduce important aspects of instinctive and learned behaviours.

Theory

UNIT-I: Physiology of nutrition, thermoregulation, cellular immunity.
UNIT-II: Neural, humoral and pharmacological regulation of cardio-vascular activities.
UNIT-III: Neural integration, interneural communication; importance of specialized nerve cells.
UNIT-IV: Physiology of endocrine glands, hormonal receptors; physiology of reproduction and hormonal control of reproductive behaviour.
UNIT-V: Origin and evolution of behaviour, instinct and learning; modes of communication, significance of biorhythms.

Practical

Some biochemical estimations, buffer systems; demonstration of some hormonal functions; recording of action potentials; kymographic study of muscle contractions and heart beat; study of some behavioural aspects such as instinctive movements, orientation responses; maze learning in rats and activity rhythms in animals.

Suggested Readings

Davson H & Segal MB. 1978. *Introduction to Physiology*. Academic Press.
Dewsbury Donald A. 1978. *Comparative Animal Behaviour*. McGraw-Hill.
Ewrt JP. 1980. *Neurophysiology*. Springer Verlag.
Hill RW & Wise GA. 1989. *Animal Physiology*. Harper & Row.
Mohan P Arora 2003. *Animal Physiology*. Himalayan Publ.
Peter Marler & William J Hamilton 1966. *Mechanisms of Animal Behaviour*. John Wiley & Sons.
Proccer EL. 1973. *Comparative Animal Physiology*. WB Saunders.

ZOO 505 METHODOLOGY AND DEVELOPMENTAL BIOLOGY 2+2 SEM - II

Objective

A brief introduction to microtomic and ultramicrotomic techniques along with the details of development biology.

Theory

UNIT-I: Introduction to microtomic and ultramicrotomic techniques.
UNIT-II: Patterns of reproduction, and differentiation and morphogenesis.
UNIT-III: Fertilization, differentiation, growth and early development in mammals.

UNIT-IV: Nucleo-cytoplasts relationship and neurotransmitters.

UNIT-V: Structural and functional development of endocrine glands and the development of immune system.

Practical

Study of normal development with reference to normal tables of developmental stages of fish/frog/ toad; histology of developing embryo using serial sectioning technique; study of organogenesis-histogenesis of some organs in fish, frog/toad; morpho-histology of gonads of some seasonal breeders; observations on live gametes; study of regeneration in planaria/hydra/earthworm; tail and limb regeneration in frog, tadpoles; tail regeneration in lizards; observation on normal metamorphosis in frog, tadpoles; effect of thiourea, thyroxin and prolactins, taxidermy.

Suggested Readings

Balinsky BI. 1970. *An Introduction to Embryology*. Saunders.

Gilbert SR. 2010. *Developmental Biology*. 9th Ed. Sinauer Assoc.

Slack JMW. 2005. *Essential Developmental Biology*. 2nd Ed. Wiley Blackwell Publ.

ZOO 506 APIDOLOGY 2+1 SEM - II

Objective

Bees are beneficial insects and make an integral part of the ecosystem, including agro-ecosystem. Knowledge about these insects is important.

Theory

UNIT-I: Classification of Apoidea, their distribution and biology, morphology and anatomy of bees.

UNIT-II: Natural history, social organization, colony life, thermoregulation and nesting behaviour of bees.

UNIT-III: Behaviour, nutrition, reproduction and physiological adaptations in bees.

UNIT-IV:Diseases, pests, predators and enemies of bees.

UNIT-IV: Foraging dynamics of bees, energetics of pollination, managed pollination, safety of bees against pesticides.

Practical

Identification of different kinds of bees and their castes, management and domestication of solitary and social bees, nesting behaviour of different bees, comparative differences in thermoregulation in social bees, artificial feeding, measurement of total population and other parameters of the colony; chromatographic studies of different honeys and nectars, foraging behaviour of bees.

Suggested Readings

Adey M, Walker P & Walker PT. 1986. *Pest Control Safe for Bees*. lBRA.

Brown R. 1988. *Honeybees: A Guide to Management*. Crowood Press.

Dadant & Sons 1993. *The Hive and the Honeybee*. Dadant & Sons.

Eva Crane 1990. *Bees and Beekeeping*. Heine-mann Newnes.

Free lB. 1993. *Insect Pollination of Crops*. Academic Press.

Howe Rl & Howe WE. 1980. *Practical Beekeeping*. Sage Publ.

Michener CD.1 974. *The Social Behaviour of the Bees*. Cambridge Univ. Press.

Sammataro D & Avitabile A. 1986. *The Beekeeper Handbook*. MacMillan.

Sardar S. 1982. *Beekeeping in India*. ICAR.

Sihag RC. 1995, 1997. *Pollination Biology* . Vols. I-III. Rajendra Sci. Publ.

Smith FG. 1965. *Beekeeping in the Tropics*. Longmans.

Snodgrass RE. 1956. *Anatomy of the Honey bee*. Comstock Publ.

Stephen Rere 1998. *Introduction to Bee-keeping*. Vikas Publ.

ZOO 507 FUNDAMENTALS OF VERMICULTURE 2+1 SEM - II

Objective

Earthworms play an important role in the quick bio-degeration and mineralization of organic wastes, especially the crop residues.

Theory

UNIT-I: Introduction to earthworms, their taxonomy and nomenclature.

UNIT-II: Distribution, ecology and the food habits of earthworms.

UNIT-III: Vermiculture-the use of earthworms and their influence on soil structure, composition and infiltration.

UNIT-IV: Role of earthworms in agro-ecosystems, land reclamation and sustainable soil fertility.

UNIT-V:Methods of vermicomposting, changes during vermicomposting, chemical composition of vermicast and the economics of vermiculture.

Practical

Earthworms-their type study; their identification and classification, methods of sampling/collection and population estimation, study of different life stages of earthworms and their culturing, food preferences of earthworms, methods of vermicomposting, chemical changes in organic matter due to earthworms activity.

Suggested Readings

Edwards CA & Bater JE. 1977. *Biology of Earthworms*. Chapman & Hall.

Edwards CA. 1998. *Earthworm Ecology*. CRC Press.

Sultan A Ismail. 1997. *Vermicology- the Biology of Earthworms*. Orient Longman.

ZOO 508 MAMMOLOGY 2+1 SEM - II

Objective

Exposure to the interaction of mammals with their environment, including activity and behaviour; adaptations, metabolism of population, communication and migration in mammals.

Theory

UNIT-I: Activity and behaviour of mammals.

UNIT-II: Adaptations in mammals.

UNIT-III: Metabolism of population.

UNIT-IV: Ecology, communication and migration in mammals.

UNIT-V: Effect of some hormones on reproductive functioning of mammals, current topics in mammalogy.

Practical

Identification of different types of mammals especially rodents; factors governing population density; study of rat burrows and their architecture; feeding and exploratory behaviour.

Suggested Readings

Burton M. 1975. *How Mammals Live*. Elsevier-Phaidon.

Davis DE & Golley FB. 1963. *Principles of Mammology*. Reinhold Publ.

Feldhamer GA, Drikamer LC & Vessey SH. 2007. *Mammology: Adaptation, Diversity, Ecology*. JHU Press.

Gunderson HL. 1976. *Mammology*. McGraw Hill.

Martin RE, Pine RH & DeBlase AF. 2000. *Manual of Mammology*. McGraw Hill.

Vaughan 1972. *Mammology*. WB Saunders.

ZOO 509 PRINCIPLES OF ARACHNOLOGY 2+1 SEM -II

Objective

To sensitize the students on arachnids including acarines; how they differ from insects in their morphology and feeding habits.

Theory

UNIT-I: General features and classification of arachnids; categories of arachnids.

UNIT-II: Comparative morphology and anatomy; habitat and feeding habits of arachnids.

UNIT-III: General features, feeding habits of phytophagous, stored product, house dust and soil mites.

UNIT-IV: Molecular, cellular and physiological basis of host-parasite interactions in mites and ticks.

UNIT-V: Role of predatory mites and spiders in integrated pest management programmes; ecology and ethology of acarines and their control methods.

Practical

Collection, extraction, preservation, mounting and study of various arachnids, dissection of spiders and mounting of organs and systems, use of rearing techniques.

Suggested Readings

Channa Basavanna GP. 1981. *Contributions to Acarology in India*. Acarological Soc. Of India.

Chillar BS, Gulati R & Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ.

Evans GO. 1992. *Principles of Acarology*. CABI.

Gerson U & Smiley RL. 1990. *Acarines as Biocontrol Agents*. Chapman & Hall.
Jeppson LR, Keifer HH & Baker EW. 1975. *Mites Injurious to Economic Plants*. Univ. of California Press.

ZOO 601 ADVANCES IN ANIMAL BEHAVIOUR 3+0 SEM - II

Objective

To acquire knowledge about recent aspects of animal behaviour and animal sociality.

Theory

UNIT-I: Animal signals, classical ethological approach, ritualization.
UNIT-II: Types of communication signals, their properties and the behavioural functions including mimicry.
UNIT-III: Optimal tactics of foraging, predation and reproduction; habitat selection, territorialty.
UNIT-IV: Economics of insect sociality, altruism.
UNIT-V: Cyclic behaviour, translocation, biological clock, entrairnnent and resetting; role of exogenous and endogenous factors on rhythmicity.

Suggested Readings

Altman J. 1976. *Organic Foundations of Animal Behaviour*. Hopt Rinehart & Winston.
Chadwick DJ & Ackrill K. 1995. *Circadian Clocks and their Adjustments*. Willey Publ.
Grier JW. 1984. *Biology of Animal Behaviour*. Times/Mosby.
John Alcock 2005. *Animal Behaviour*. Sinauel Assoc.
Krebs JR & Davies NM. 1978. *Behavioural Ecology*. Blackwell.
Peter Marler & William J Hamilton 1966. *Mechanisms of Animal Behaviour*. John Wiley & Sons.

ZOO 602 FUNCTIONS OF ECOSYSTEM 3+0 SEM - II

Objective

Ecosystem is unified entity. Any disturbance in a component means disturbance to the ecosystem as a whole. This course concentrates on the recent trends of disturbances and their effects on ecosystem.

Theory

UNIT-I: Ecosystem, components, primary and secondary production, rates and factors influencing these processes.
UNIT-II: Animal response to different envirornments. Changing envirorunent and responses and strategies of animals.
UNIT-III: Stress ecology, concept and status; stress effects on ecosystem resources, biodiversity and plant reproduction.
UNIT-IV: Habitat and bioresource exploitation, optimal exploitation, concepts and uses.
UNIT-V: Pollution, causes and effects, bioindicators, pollution management.

Suggested Readings

Leveque C. 2003. *Ecology: From Ecosystem to Biosphere*. Science Publ.
Mooney HA & Gordon M. 1983. *Disturbance and Ecosystem*. Springer Verlag.
Nobel BJ & Wright RT. 2000. *Environmental Science: A Way the World Works*. Prentice Hall.
O'Neill P. 1985. *Environmental Chemistry*. George Allen & Unwin.
Polurin N. 1986. *Ecosystem: Theory and Application*. John Wiley & Sons.
Watt KEF. 1968. *Ecology and Resource Management: A Quantitative Approach*. McGraw- Hill.

ZOO 603 ADVANCED ACAROLOGY 2+1 SEM - I

Objective

To educate the students about mites occuring in various habitats, harmful and beneficial mites, their role in different ecosystems, their management practices.

Theory

UNIT-I: Specialized morphological adaptations of ticks and mites; macro and micro environmental factors affecting the distribution of mites in different media.
UNIT-II: Mites and post harvest technology, interrelationship between mites and microorganisms.
UNIT-III: Predator-prey interactions with special reference to biological control of pests; mites as plant pests and vectors.

UNIT-IV: Role of soil mites in edaphic ecosystem; acarines and human health; mites associated with invertebrates and vertebrates.

UNIT-V: Ticks in relation to livestock; recent trends in acarology.

Practical

Collection, preservation and identification of mites upto family; study of life history of some mites.

Suggested Readings

Channa Basavanna GP. 1981. *Contributions to Acarology in India*. Acarological Soc. of India.

Chillar BS, Gulati R & Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ.

Evans GO. 1992. *Principles of Acarology*. CABI.

Gerson U & Smiley RL. 1990. *Acarines as Biocontrol Agents*. Chapman & Hall.

Jeppson LR, Keifer HH & Baker EW. 1975. *Mites Injurious to Economic Plants*. Univ. of California Press.

ZOO 604 ADVANCES IN APIDOLOGY 3+0 SEM - I

Objective

Honeybees and other bees are of high economic importance to man. These have been utilized for bee products and pollination of crops. Recent development of knowledge on their biology is important for their harnessing and use.

Theory

UNIT-I: Evolution of bees and sociality, bee colony.

UNIT-II: Physiology of cast determination, role of hormones, controversies about bee dances.

UNIT-III: Sex determination, honeybee genetics and breeding, semen preservation and insemination.

UNIT-IV: Bee pathogens and their interactions, bee poisoning, pesticides and their mode of action, bee repellents and their function, bee flower interaction-chemical and physiological basis.

UNIT-V: Bee products and their chemical nature and uses.

Suggested Readings

Free JB. 1993. *Insect Pollination of Crops*. Academic Press.

Michener CD. 1974. *The Social Behaviour of the Bees*. Cambridge Univ. Press.

Morse RA & Flottum K. 1990. *ABC & XYZ of Bee Culture*. The AI Root Co.

Morse RA & Nowogrodzki (Ed) 1990. *Honeybee Pests, Predators and Diseases*. 2nd Ed. Cornell Univ. Press.

Rinderer T. 1986. *Bee Genetics and Breeding*. Academic Press.

Sihag RC. 1995. 1997. *Pollination Biology.* Vol. I-III. Rajendra Sci. Publ.

Thomas D Seeley. 1985. *Honeybee Ecology: A Study of Adaptation in Social Life*. Princeton Univ. Press.

ZOO 605 ADVANCES IN VERMICULTURE 3+0 SEM - I

Objective

Earthworms are becoming very important in biodegradation of organic matter, their studies in relation to various biotic and abiotic components and their role in different ecosystems should be clearly understood.

Theory

UNIT-I: Earthworm ecology; interactions with biotic and abiotic components.

UNIT-II: Earthworm population dynamics; feeding preferences and assimilation; efficiency of different earthworm species.

UNIT-III: Earthworms in food chains; diseases, pests, predators and enemies of earthworms.

UNIT-IV: Earthworms as a potential sources of biodegradation, earthworms and soil productivity, waste management and resources recovery.

UNIT-V: Proteins from earthworm biomass, nutritional status of earthworm protein, biohazards of earthworm meal, soil pollutants and earthworms.

UNIT-VI: Vermitech- the science of earthworm biotechnology; international scenario-the Indian perspectives and future trends.

Suggested Readings

Edwards CA & Bater JE. 1977. *Biology of Earthworms*. Chapman & Hall.
Edwards CA. 1998. *Earthworm Ecology*. CRC Press.
Sultan A Ismail 1997. *Vermicology- The Biology of Earthworms*. Orient Longman.

DEPARTMENT OF SOCIOLOGY

Course Title : **Advances in Social Research Methods**

Course No. **Soc 605 (2+1)**

Course Contents

Objectives : To acquaint the students with various advance research techniques and methods.

Theory :

Unit –I : Meaning, objectives, types and significance of social research, Different approaches : positivism, versthen, phenomenology, ethnomethodology and post modern methods.

Unit-II : Fact and theory, hypothesis and its dimensions, features and types of good research design.

Unit-III : Census, sampling, types & its characteristics, criteria for selecting sample procedure and sampling design.

Unit-IV : Primary sources of data collection : questionnaire, interview, interview schedule and observation, secondary sources of data, qualitative and quantitative data processing & analysis and result presentation.

Unit-V : Scaling techniques : Bogardus, Likert and Guttman. Descriptive statistics : measures of central tendency & dispersion, use of t test, Z test and Chi square test.

Practical :

Field based survey for collection of social science data for research and use of M.S. Excel and SPSS for statistical analysis of data,

Suggested readings :

1. Bose, P.K. (1995). Research Methodology ICSSR Publications.
2. Allen, Kenneth. (2007). The Social Lens. Sage Pub. Ltd. U.K.
3. Murthy, C. (2011). Research Methodology. Vrinda Publications Ltd.
4. Goode, W.J. and Hatt, P.K. (1981). Methods in Social Research. McGraw Hill Book Co.

5. Singh, A.K., (2012). Test, Measurements and Research Methods in Behavioral Sciences. Bharti Bhawan Publsiher.
6. Kothari, C.R. (1985). Research Methodology; Methods and Techniques. New Delhi, Wiley Eastern Ltd.
7. Young, Pauline, V. (1974). Scientific Social Surveys and Research. Asia Publisher.
8. Moser, C.A. (1990). Survey Methods in Social Investigation. The MacMillan Co. New York.
9. Earl Babbie, (2004). The Practice of Social Research (10th Ed.), Thomson Woodworth.
10. Giddens, A. (1993). New Rules of Sociological Methods, Stanford University Press.
11. Kerlinger, F.N. (1973). Foundation of Behavioural Research, Half Ronehartand Winston, New York.

DEPARTMENT OF SOCIOLOGY

Course Title : Emerging Rural Social Problems

Course No. Soc 513 (2+1)

Course Contents

Objective : To acquaint the students about emerging rural social problems in Indian context.

Theory :

Unit-I : Meaning and types of social problems, social disorganization, importance of study of social problems and role of sociology in tackling social problems.

Unit-II : Anomie (Durkheim), discourse theory (Foucault), differential association (Sutherlant), labeling theory (Becker).

Unit-III : Inequality of caste, class, gender, ethnicity, communalism and problem of minorities.

Unit-IV : Female foeticide, divorce, over population, rural poverty, problems of elderly, drug addiction & alcoholism, unemployment, untouchability and changing family patterns & customs.

Unit-V : Agrarian unrest, suicide, crime, juvenile delinquency, prostitution & AIDS and honour killing.

Practical : Field and institutional visits, preparation of field project for analyzing the emerging problems of rural society, theme based group assignments.

Suggested readings :

1. Ahuja, Ram (2000) : Social Problems in India, New Delhi. Rawat Publications.
2. Desai, A.R. (2006). Rural Sociology in India. Popular Parkashan, Bombay.
3. Beteille, Andre (1974). Social Inequality, New Delhi. OVP.
4. Berman, G.D. (1979). Caste and other Inequalities. Essay in Inequality, Meerut. Molklore Institutions.
5. Srinivas, M.N. (1992). Social change in Modern India. Orient Longman, New Delhi.
6. Ghurye, G.S. (1968). Social Tensions in India. Popular Parkashan, Bombay.

COURSE CURRICULUM FOR MSc & PhD PROGRAMME IN MATHEMATICS

Course Structure

MAJOR COURSES:

COURSE NO	COURSE TITLE	CREDITS	SEM
MATH 511*	Abstract Algebra	3+0	I
MATH 512*	Mathematical Analysis	3+0	I
MATH 513*	Ordinary Differential Equations	2+1	I
MATH 514*	Fluid Dynamics	2+1	I
MATH 515*	Complex Analysis	3+0	II
MATH 516	Integral Equations and Calculus of Variations	2+1	I
MATH 517	Partial Differential Equations	2+1	II
MATH 518	Measure and Integration Theory	3+0	I
MATH 519	Fuzzy Set Theory	3+0	I
MATH 520	Bio-Fluid Dynamics	2+1	I
MATH 521	Topology	3+0	II
MATH 522	Discrete Mathematics	2+0	II
MATH 523	Graph Theory	2+0	II
MATH 524	Functional Analysis	3+0	II
MATH 525	Viscous Fluid Dynamics	2+1	II
MATH 526	Mathematical Modeling	2+0	I
MATH 527	Differential Geometry & Tensors	3+0	I
MATH 528	MATLAB	2+1	II
MATH 529	Operations Research Techniques	2+1	II
MATH 591	Masterôs Seminar	1	I, II
MATH 599	Masterôs Research	10	I, II
MATH 611	Computational Fluid Dynamics	2+1	I
MATH 612	Advanced Complex Analysis	3+0	I
MATH 613**	Mathematical Programming	3+0	II
MATH 614**	Integral Transform and Z-transform	3+0	I
MATH 615	Advanced Abstract Algebra	3+0	II
MATH 616	Special Functions	3+0	I
MATH 617	Information Theory	3+0	I
MATH 618	Advanced Numerical Analysis	3+0	I
MATH 619	System of Differential Equations	2+1	II
MATH 620	Mathematical Foundation of Image Processing	2+1	I
MATH 621	Computational Neuroscience	2+1	II
MATH 622	Algebraic Topology	3+0	I
MATH 691	Doctoral Seminar-I	1	I, II
MATH 692	Doctoral Seminar-II	1	I, II
MATH 699	Doctoral Research	45	I, II

Minimum Credit Requirements:	**M.Sc.**	**Ph.D.**
Major	36	18
Minor	09	08
Supporting	05	05
Seminar	01	02
Research	10	45
Total	**61**	**78**
Non Credit Compulsory Courses	05	05 (If not studied in M.Sc.)

Teaching Program
for
Department of Mathematics
CCS HAU, Hisar

Programmes

M.Sc.	**Mathematics**
Ph.D.	**Mathematics**

M.Sc. (Mathematics)

Field of specialization: Mathematics

***Compulsory courses:** MATH 511, MATH 512, MATH 513, MATH 514, MATH 515

Supporting courses: From subject matter fields (other than minor) relating to area of special interest and research problem.

Minor fields: From subject matter fields relating to area of special interest and research problem or any other as approved by Dean Post Graduate Studies.

Deficiency courses: As recommended by the advisory committee of the student.

Ph. D. (Mathematics)

Fields of specialization: Pure Mathematics, Applied Mathematics

****Compulsory courses:** MATH 613, MATH 614

Supporting courses: From subject matter fields (other than minor) relating to area of special interest and research problem.

Minor fields: From subject matter fields relating to area of special interest and research problem or any other as approved by Dean Post Graduate Studies.

Deficiency courses: As recommended by the advisory committee of the student.

Undergraduate Elective/M.Sc. Supporting/Minor Courses
Postgraduate Courses

MATH 511 ABSTRACT ALGEBRA 3+0 SEM I

Theory

UNIT-I: Conjugates and centralizers in S_n, p-groups, group actions, counting orbits. Sylow subgroups, Sylow theorems, applications of Sylow theorems, description of group of order p2 and pq, survey of groups upto order 15.

UNIT-II: Normal and subnormal series, solvable series, derived series, solvable groups, solvability of S_n-the symmetric group of degree n Ó 2, central series, nilpotent groups and their properties, equivalent conditions for a finite group to be nilpotent, upper and lower central series. composition series, Zassenhaus lemma, Jordan-Holder theorem.

UNIT-III: Modules, cyclic modules, simple and semi-simple modules, Schur lemma, free modules, torsion modules, torsion free modules, torsion part of a module, modules over principal ideal domain and its applications to finitely generated abelian groups.

UNIT-IV: Noetherian and Artinian modules, modules of finite length, noetherian and artinian rings, Hilbert basis theorem. Hom R(R,R), opposite rings, Wedderburn ï Artin theorem, maschk theorem, equivalent statement for left Artinian rings having non-zero nilpotent ideals. Radicals: Jacobson radical, Radical of an Artinian ring.

Suggested Readings

S. Luther and I.B.S. Passi, Algebra, Vol. I-Groups, Vol. III-Modules, Narosa Publishing House (Vol. I ï 2013, Vol. III ï 2013).
Charles Lanski, Concepts in Abstract Algebra, American Mathematical Society, First Indian Edition, 2010.
Vivek Sahai and Vikas Bist, Algebra, Narosa Publishing House, 1999.
D.S. Malik, J.N. Mordenson, and M.K. Sen, Fundamentals of Abstract Algebra, McGraw Hill, International Edition, 1997.
P.B. Bhattacharya, S.K. Jain and S.R. Nagpaul, Basic Abstract Algebra (2nd Edition), Cambridge University Press, Indian Edition, 1997.
C. Musili, Introduction to Rings and Modules, Narosa Publication House, 1994.
N. Jacobson, Basic Algebra, Vol. I & II, W.H Freeman, 1980 (also published by Hindustan Publishing Company).
M. Artin, Algebra, Prentice-Hall of India, 1991.
Ian D. Macdonald, The Theory of Groups, Clarendon Press, 1968.

MATH 512 MATHEMATICAL ANALYSIS 3+0 SEM I

Theory

UNIT-I: Riemann-Stieltjes integral, existence and properties, integration and differentiation, the fundamental theorem of calculus, integration of vector-valued functions, rectifiable curves.

UNIT-II: Sequence and series of functions, pointwise and uniform convergence, Cauchy criterion for uniform convergence, Weirstrass M test, Abel and Dirichlet tests for uniform convergence, uniform convergence and continuity, uniform convergence and differentiation, Weierstrass approximation theorem.

UNIT-III: Power series, uniform convergence and uniqueness theorem, Abel theorem, Tauber theorem. Functions of several variables, linear transformations, euclidean space R_n, derivatives in an open subset of R_n, chain rule, partial derivatives, continuously differentiable mapping, Young and Schwarz theorems.

UNIT-IV: Taylor theorem, higher order differentials, explicit and implicit functions, implicit function theorem, inverse function theorem, change of variables, extreme values of explicit functions, stationary values of implicit functions, Lagrange multipliers method, Jacobian and its properties.

Suggested Readings

Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, 1976, International Student Edition.

T. M. Apostol, Mathematical Analysis, Narosa Publishing House, New Delhi, 1974.

H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.

G. De Barra, Measure Theory and Integration, Wiley Eastern Limited, 1981.

R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.

R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.

S.C. Malik and Savita Arora, Mathematical Analysis, New Age International Limited, New Delhi, 2012.

MATH 513 ORDINARY DIFFERENTIAL EQUATIONS 2+1 SEM I

Theory

UNIT-I: Preliminaries, Ů approximate solution, Cauchy-Euler construction of an Ů approximate solution of an initial value problem, equi-continuous family of functions, Ascoli-Arzela Lemma, Cauchy-Peano existence theorem. Lipschitz condition, Picards-Lindelof existence and uniqueness theorem for dy/dt =f(t,y), solution of initial-value problems by Picards method, dependence of solutions on initial Conditions.

UNIT-II: Linear systems, matrix method for homogeneous first order system of linear differential equations, fundamental set of solutions, fundamental matrix of solutions, Wronskian of solutions, basic theory of the homogeneous linear system, Abel-Liouville formula, non-homogeneous linear system. Strum Theory, self-adjoint equations of the second order, Abel formula, Strum Separation theorem, Strum fundamental comparison theorem.

UNIT-III: Nonlinear differential systems, phase plane, path, critical points, autonomous systems, isolated critical points, path approaching a critical point, path entering a critical point, types of critical points- center, saddle points, spiral points, node points, stability of critical points, asymptotically stable points, unstable points, critical points and paths of linear systems, almost linear systems.

UNIT-IV: Nonlinear conservative dynamical system, dependence on a parameter, Liapunov direct method, limit cycles, periodic solutions, Bendixson nonexistence criterion, Poincore- Bendixson theorem(statement only), index of a critical point. Strum-Liouville problems, orthogonality of characteristic functions.

Practical

Problems on initial-value problems by Picards method, dependence of solutions on initial conditions, matrix method for homogeneous first order system of linear differential equations, nonlinear differential systems, nonlinear conservative dynamical system, Strum-Liouville problems.

Suggested Readings

E.A. Coddington and N. Levinson, Theory of ordinary differential equations, Tata McGraw Hill, 2000.

S.L. Ross, Differential equations, John Wiley and Sons Inc., New York, 1984.

W.E. Boyce and R.C. Diprima, Elementary differential equations and boundary value problems, John Wiley and Sons, Inc., New York, 4th edition, 1986.

G.F. Simmon, Differential Equations, Tata McGraw Hill, New Delhi, 1993.

MATH 514 Fluid Dynamics 2+1 SEM I

Theory

UNIT-I: Kinematics - velocity at a point of a fluid. Eulerian and Lagrangian methods. Stream lines, path lines and streak lines. Velocity potential. Irrotational and rotational motions. Vorticity and circulation. Equation of continuity. Boundary surfaces. Acceleration at a point of a fluid. Components of acceleration in cylindrical and spherical polar co-ordiantes.

UNIT-II: Pressure at a point of a moving fluid. Euler equation of motion. Equations of motion in cylindrical and spherical polar co-ordinates. Bernoulli equation. Impulsive motion. Kelvin circulation theorem. Vorticity equation. Energy equation for incompressible flow. Kinetic energy of irrotational flow. Kelvin minimum energy theorem. Kinetic energy of infinite fluid. Uniqueness theorems.

UNIT-III: Axially symmetric flows. Liquid streaming part a fixed sphere. Motion of a sphere through a liquid at rest at infinity. Equation of motion of a sphere. Kinetic energy generated by impulsive motion. Motion of two concentric spheres. Three-dimensional sources, sinks and doublets. Images of sources, sinks and doublets in rigid impermeable infinite plane and in impermeable spherical surface.

UNIT-IV: Two dimensional motion, use of cylindrical polar co-ordinates. Stream function. Axisymmetric flow. Stoke stream function. Stoke stream function of basic flows. Irrotational motion in two-dimensions. Complex velocity potential. Milne-Thomson circle theorem. Two-dimensional sources, sinks, doublets and their images. Blasius theorem.

Practical

Problems on Eulerian and Lagrangian methods, Equation of continuity, Acceleration at a point of a fluid, Euler equation of motion, Energy equation for incompressible flow. Kinetic energy of irrotational flow, Motion of a sphere through a liquid at rest at infinity, Motion of two concentric spheres, Use of cylindrical polar co-ordinates, Irrotational motion in two-dimensions.

Suggested Readings

W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers, Delhi, 1988.

F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985.

OôNeill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.

R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company,
New Delhi, 1976.
G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi,
1994.

MATH 515 Complex Analysis 3+0 SEM II

Theory

UNIT-I: Function of a complex variable, continuity, differentiability, analytic functions and their properties, Cauchy-Riemann equations in cartesian and polar coordinates, power series, radius of convergence, differentiability of sum function of a power series, branches of many valued functions with special reference to argz, logz and z_a.

UNIT-II: Path in a region, contour, complex integration, Cauchy theorem, Cauchy integral formula, extension of Cauchy integral formula for multiple connected domain, Poisson integral formula, higher order derivatives, complex integral as a function of its upper limit, Morera theorem, Cauchy inequality, Liouville theorem, Taylor theorem.

UNIT-III: Zeros of an analytic function, Laurent series, isolated singularities, Cassorati- Weierstrass theorem, limit point of zeros and poles. Maximum modulus principle, Schwarz lemma, meromorphic functions, argument principle, Rouche theorem, fundamental theorem of algebra, inverse function theorem.

UNIT-IV: Calculus of residues, Cauchy residue theorem, evaluation of integrals of the types $\int_0^{2\pi} f(\cos\theta, \sin\theta)d\theta$, $\int_{-\infty}^{\infty} f(x)dx$, $\int_0^{\infty} f(x)\sin mxdx$ and $\int_0^{\infty} f(x)\cos mxdx$, conformal mappings. Space of analytic functions and their completeness, Hurwitz theorem, Montel theorem, Riemann mapping theorem.

Suggested Readings

H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
J.B. Conway, Functions of One Complex Variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 2002.
Liang-Shin Hann & Bernand Epstein, Classical Complex Analysis, Jones and Bartlett
Publishers International, London, 1996.
E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London, 1972.
E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London.
Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company, 2009.
H.S. Kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd,
2011.
Dennis G. Zill and Patrik D. Shanahan, A First Course in Complex Analysis with Applications, John Bartlett Publication, 2nd Edition, 2010.

MATH 516 Integral Equations and Calculus of Variations 2+1 SEM I

Theory

UNIT-I: Linear integral equations, some basic identities, initial value problems reduced to Volterra integral equations, methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series. Laplace transform method for a difference kernel. Solution of a Volterra integral equation of the first kind.

UNIT-II: Boundary value problems reduced to Fredholm integral equations, methods of successive approximation and successive substitution to solve Fredholm equations of second kind, iterated kernels and Neumann series for Fredholm equations. Resolvent kernel as a sum of series. Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels. Approximation of a kernel by a separable kernel, Fredholm Alternative, Non homonogenous Fredholm equations with degenerate kernels.

UNIT-III: Green function, use of method of variation of parameters to construct the Green function for a nonhomogeneous linear second order boundary value problem, basic four properties of the Green function, alternate procedure for construction of the Green function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green function, Hilbert-Schmidt theory for symmetric kernels.

UNIT-IV: Motivating problems of calculus of variations, shortest distance, minimum surface of resolution, Brachistochrone problem, isoperimetric problem, geodesic. Fundamental lemma of calculus of variations, Euler equation for one dependant function and its generalization to 'n' dependant functions and to higher order derivatives. Conditional extremum under geometric constraints and under integral constraints.

Practical

Problems on initial value problems reduced to Volterra integral equations, Laplace transform method for a difference kernel, Fredholm resolvent kernel as a ratio of two series. Fredholm equations with separable kernels, Green function, basic four properties of the Green function, motivating problems of calculus of variations, conditional extremum under geometric constraints and under integral constraints.

Suggested Readings

A.J. Jerri, I*ntroduction to Integral Equations with Applications, A* Wiley-Interscience Publication, 1999.

R.P. Kanwal, L*inear Integral Equations*, Theory and Techniques, Academic Press, New York.

W.V. Lovitt, L*inear Integral Equations*, McGraw Hill, New York.

F.B. Hilderbrand, M*ethods of Applied Mathematics*, Dover Publications.

J.M. Gelfand and S.V. Fomin, C*alculus of Variations*, Prentice Hall, New Jersy,1963.

MATH 517 Partial Differential Equations 2+1 SEM II

Theory

UNIT-I: Method of separation of variables to solve Boundary Value Problems (B.V.P.) associated with one dimensional heat equation, steady state temperature in a rectangular plate, circular disc, semi-infinite plate. The heat equation in semi-

infinite and infinite regions. Solution of three dimensional Laplace equations, heat equations, wave equations in cartesian, cylindrical and spherical coordinates. Method of separation of variables to solve B.V.P. associated with motion of a vibrating string. Solution of wave equation for semi-infinite and infinite strings.

UNIT-II: Partial differential equations: Examples of PDE classification. Transport equation ï initial value problem. Non-homogeneous equations. Laplace equation ï fundamental solution, Mean value formula, properties of harmonic functions, Green function.

UNIT-III: Heat Equation ï fundamental solution, Mean value formula, properties of solutions, energy methods. Wave equation ï solution by spherical means, non-homogeneous equations, energy methods.

UNIT-IV: Non-linear first order PDE ï complete integrals, envelopes, characteristics, Hamilton Jacobi equations (Calculus of variations, Hamilton ODE, Legendre transform, Hopf-Lax formula, weak solutions, uniqueness).

Practical

Solution of three dimensional Laplace equations, heat equations, solution of wave equation for semi-infinite and infinite strings, partial differential equations: examples of PDE classification, non-homogeneous equations, heat equation ï fundamental solution, non-linear first order PDE ï complete integrals.

Suggested Readings

I.N. Sneddon, Elements of Partial Differential Equations, McGraw Hill, New York.

Peter V. Oôeil, Advanced Engineering Mathematics, ITP.

L.C. Evans, Partial Differential Equations: Second Edition (Graduate Studies in Mathematics) 2nd Edition, American Mathematical Society, 2010.

H.F. Weinberger, A First Course in Partial Differential Equations, John Wiley & Sons, 1965.

M.D. Raisinghania, Advanced Differential equations, S. Chand & Co.

MATH 518 Measure and Integration Theory 3+0 SEM I

Theory

UNIT-I: Set functions, intuitive idea of measure, elementary properties of measure, measurable sets and their fundamental properties. Lebesgue measure of a set of real numbers, algebra of measurable sets, Borel set, equivalent formulation of measurable sets in terms of open, closed, F_σ and G_δ sets, non measurable sets.

UNIT-II: Measurable functions and their equivalent formulations, properties of measurable functions, approximation of a measurable function by a sequence of simple functions, measurable functions as nearly continuous functions, Egoroff theorem, Lusin theorem, convergence in measure and F. Riesz theorem, almost uniform convergence.

UNIT-III: Shortcomings of Riemann Integral, Lebesgue Integral of a bounded function over a set of finite measure and its properties. Lebesgue integral as a generalization of Riemann integral, bounded convergence theorem, Lebesgue theorem regarding points of discontinuities of Riemann integrable functions, integral of non-negative functions, Fatou Lemma, monotone convergence theorem, General Lebesgue Integral, Lebesgue convergence theorem.

UNIT-IV: Vitali covering lemma, differentiation of monotonic functions, function of bounded variation and its representation as difference of monotonic functions,

differentiation of indefinite integral, fundamental theorem of calculus, absolutely continuous functions and their properties.

Suggested Readings

Walter Rudin, Principles of Mathematical Analysis (3rd edition) McGraw-Hill, Kogakusha, 1976, International Student Edition.

H.L. Royden, Real Analysis, Macmillan Pub. Co., Inc. 4th Edition, New York, 1993.

P. K. Jain and V. P. Gupta, Lebesgue Measure and Integration, New Age International (P) Limited Published, New Delhi, 1986.

G.De Barra, Measure Theory and Integration, Wiley Eastern Ltd., 1981.

R.R. Goldberg, Methods of Real Analysis, Oxford & IBH Pub. Co. Pvt. Ltd, 1976.

R. G. Bartle, The Elements of Real Analysis, Wiley International Edition, 2011.

MATH 519 Fuzzy Set Theory 3+0 SEM I

Theory

UNIT-I: Definition of fuzzy set, expanding concepts of fuzzy set, standard operations of fuzzy set, fuzzy complement, fuzzy union, fuzzy intersection, other operations in fuzzy Set, T-norms and T- conorms.

UNIT-II: Product Set, definition of relation, characteristics of relation, representation methods of relations, operations on relations, path and connectivity in graph, fundamental properties, equivalence relation, compatibility relation, pre-order relation, order relation, definition and examples of fuzzy relation, fuzzy matrix, operations on fuzzy relation, composition of fuzzy relation, α - cut of fuzzy relation, projection and cylindrical extension, extension by relation, extension principle, extension by fuzzy relation, fuzzy distance between fuzzy Sets.

UNIT-III: Graph and fuzzy graph, fuzzy graph and fuzzy relation, α - cut of fuzzy graph, fuzzy network, reflexive relation, symmetric relation, transitive relation, transitive closure, fuzzy equivalence relation, fuzzy compatibility relation, fuzzy pre-order relation, fuzzy order relation, fuzzy ordinal relation, dissimilitude relation, fuzzy morphism, examples of fuzzy morphism.

UNIT-IV: Interval, fuzzy number, operation of interval, operation of α - cut interval, examples of fuzzy number operation, definition of triangular fuzzy number, operation of triangular fuzzy number, operation of general fuzzy numbers, approximation of triangular fuzzy number, operations of trapezoidal fuzzy number, bell shape fuzzy number.

Suggested Readings

Kwang H. Lee, First Course on Fuzzy Theory and Applications, Springer International Edition, 2005.

H.J. Zimmerman, Fuzzy Set Theory and its Applications, Allied Publishers Ltd., New

Delhi, 1991.

John Yen, Reza Langari, Fuzzy Logic - Intelligence, Control and Information, Pearson Education, 1999.

MATH 520 Bio-Fluid Dynamics 2+1 SEM I

Theory

UNIT-I: Basic concepts of fluid dynamics, viscosity, Reynold transport theorem, rates of change of material integrals, continuity equation, Navier-Stokes equations of motion, simplification of basic equations, Reynolds number of flows, the cardiovascular system, the circulatory system, systemic and pulmonary circulations, the circulation in the heart, diseases related to circulation.

UNIT-II: Blood composition, structure of blood, viscosity of blood, yield stress of blood, blood vessel structure, diseases related to obstruction of blood flow, flow in pipes and ducts, developing and fully developed flow, special characteristics of blood flow, Poiseuille flow and its consequence, applications of Poiseuille law for the study of blood flow.

UNIT-III: Pulsatile flow in circular rigid tube and its quantitative aspects, the pulse wave, Mones- Korteweg expression for wave velocity in an inviscid fluid-filled elastic cylindrical tube and its applications in the cardiovascular system, wave propagation accounting for viscosity and its application to cardiac output determination, blood flow through artery with mild stenosis, expressions for pressure drop across the stenosis and across the whole length of artery, shear stress on stenosis surface.

UNIT-IV: Non-Newtonian fluids and their classification, laminar flow of non-newtonian fluids, power-law model, Herschel-Bulkley model, Casson model, flow in the renal tubule, solutions when radial velocity at the wall decreases (i) linearly with z (ii) exponentially with z, peristaltic flows, peristaltic motion in a channel, characteristic dimensionless parameters, long- wavelength analysis.

Practical

Problems on Navier-Stokes equations of motion, Simplification of basic equations, Reynolds number of flows, Flow in pipes and ducts, Special characteristics of blood flow, Blood flow through artery with mild stenosis, Shear stress on stenosis surface, laminar flow of non-newtonian fluids, power-law model.

Suggested Readings

Jagan N. Mazumdar; Biofluid Mechanics, World Scientific Pub.

J.N. Kapur; Mathematical Models in Biology and Medicine, Affiliated East-West Press Pvt. Ltd.

T.J. Pedley; The Fluid Mechanics of Large Blood Vessels, Cambridge Uni. Press, 1980.

M. Stanley; Transport Phenomenon in Cardiovascular System, 1972.

OôNeill, M.E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.

J. L. Bansal, Viscous Fluid Dynamics, Oxford and IBH Publishing Company, New Delhi, 2000.

MATH 521 Topology 3+0 SEM II

Theory

UNIT-I: Definition and examples of topological spaces, comparison of topologies on a set, intersection and union of topologies on a set, neighbourhoods, interior point and interior of a set , closed set as a complement of an open set , adherent point and limit point of a set, closure of a set, derived set, properties of closure operator, boundary of a set , dense subsets, interior, exterior and boundary operators,

alternative methods of defining a topology in terms of neighbourhood system and Kuratowski closure operator.

UNIT-II: Relative (Induced) topology, base and subbase for a topology, base for neighbourhood system, continuous functions, open and closed functions, homeomorphism, connectedness and its characterization, connected subsets and their properties, continuity and connectedness, components, locally connected spaces.

UNIT-III: Compact spaces and subsets, compactness in terms of finite intersection property, continuity and compact sets, basic properties of compactness, closeness of compact subset and a continuous map from a compact space into a Hausdorff and its consequence, sequentially and countably compact sets, local compactness and one point compatification.

UNIT-IV: First countable, second countable and separable spaces, hereditary and topological property, countability of a collection of disjoint open sets in separable and second countable spaces, Lindelof theorem, T_0, T_1, T_2 (Hausdorff) separation axioms, their characterization and basic properties.

Suggested Readings

C.W.Patty, Foundation of Topology, Jones & Bertlett, 2009.

Fred H. Croom, Principles of Topology, Cengage Learning, 2009.

George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

J. L. Kelly, General Topology, Springer Verlag, New York, 2000.

J. R. Munkres, Toplogy, Pearson Education Asia, 2002.

K. Chandrasekhara Rao, Topology, Narosa Publishing House Delhi,2009.

K.D. Joshi, Introduction to General Topology, Wiley Eastern Ltd, 2006.

MATH 522 Discrete Mathematics 2+0 SEM II

Theory

UNIT-I: recurrence relations and generating functions, some number sequences, linear homogeneous recurrence relations, non-homogeneous recurrence relations, generating functions, recurrences and generating functions, exponential generating functions.

UNIT-II: statements symbolic representation and tautologies, quantifiers, predicates and validity, prepositional logic, lattices as partially ordered sets, their properties, lattices as algebraic systems, sub lattices, direct products and homomorphism, some special lattices e.g. complete, complemented and distributive Lattices.

UNIT-III: Boolean algebras as lattices, various boolean identities, the switching algebra. example, sub algebras, direct products and homomorphism, joint-irreducible elements, atoms and minterms, boolean forms and their equivalence, minterm boolean forms, sum of products, cononical forms, minimization of boolean functions, applications of boolean algebra to switching Theory (using AND, OR and NOT gates), the Karnaugh method.

UNIT-IV: Finite state machines and their transition table diagrams, equivalence of finite state, machines, reduced machines, homomorphism, finite automata, acceptors, nondeterministic, finite automata and equivalence of its power to that of

deterministic finite automata, moore and mealy machines. Grammars and language: phrase-structure grammars, requiting rules, derivation, sentential forms, language generated by a grammar, regular, context -free and context sensitive grammars and languages, regular sets, regular expressions and the pumping Lemma.

Suggested Readings

Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition.

Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics, Schaum Outline Series, McGraw-Hill Book Co, New York.

John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition.

J.P. Tremblay, R. Manohar, ñDiscrete mathematical structures with applications to computer scienceò, Tata-McGraw Hill Education Pvt.Ltd.

J.E. Hopcraft and J.D.Ullman, Introduction to Automata Theory, Langauages and Computation, Narosa Publishing House.

M. K. Das, Discrete Mathematical Structures for Computer Scientists and Engineers, Narosa Publishing House.

C. L. Liu and D.P.Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

MATH 523 Graph Theory 2+0 SEM II

Theory

UNIT-I: definition and types of graphs, walks, paths and circuits, connected and disconnected graphs, applications of graphs, operations on graphs, graph representation, isomorphism of graphs.

UNIT-II: Eulerian and Hamiltonian paths, shortest path in a weighted graph, the travelling sales person problem, planar graphs, detection of planarity and Kuratowski theorem, graph colouring.

UNIT-III: Directed graphs, trees, tree terminology, rooted labeled trees, prefix code, binary search tree, tree traversal.

UNIT-IV: spanning trees and cut sets, minimum spanning trees, Kruskal algorithm, prim algorithm, decision trees, sorting methods.

Suggested Reading

Narsingh Deo, Graph Theory with Applications to Engineering and Computer Science, Prentice ï Hall of India Pvt. Ltd, 2004.

F. Harary: Graph Theory, Addition Wesley, 1969.

G. Chartrand and P. Zhang. Introduction to Graph Theory, Tata McGraw-Hill, 2006.

Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill, Fourth Edition, 1999.

Seymour Lipschutz and Marc Lipson, Theory and Problems of Discrete Mathematics,

Schaum Outline Series, McGraw-Hill Book Co, New York, 2007.

John A. Dossey, Otto, Spence and Vanden K. Eynden, Discrete Mathematics, Pearson, Fifth Edition, 2005.

C. L. Liu and D.P.Mohapatra, Elements of Discrete Mathematics- A Computer Oriented Approach, Tata McGraw-Hill, Fourth Edition.

MATH 524 Functional Analysis 3+0 SEM II

Theory

UNIT-I: Normed linear spaces, metric on normed linear spaces, completion of a normed space, Banach spaces, subspace of a Banach space, Holder and Minkowski inequality, completeness of quotient spaces of normed linear spaces, completeness of lp, L^P, R^n, C^n and C[a,b], incomplete normed spaces.

UNIT-II: Finite dimensional normed linear spaces and subspaces, bounded linear transformation, equivalent formulation of continuity, spaces of bounded linear transformations, continuous linear functional, conjugate spaces. Hahn-Banach extension theorem (Real and Complex form).

UNIT-III: Riesz representation theorem for bounded linear functional on L^P and C[a,b], second conjugate spaces, reflexive space, uniform boundedness principle and its consequences, open mapping theorem and its application, projections, closed graph theorem.

UNIT-IV: Equivalent norms, weak and strong convergence, their equivalence in finite dimensional spaces, weak sequential compactness, solvability of linear equations in Banach spaces, compact operator and its relation with continuous operator, compactness of linear transformation on a finite dimensional space, properties of compact operators, compactness of the limit of the sequence of compact operators.

Suggested Readings

H.L. Royden, Real Analysis, MacMillan Publishing Co., Inc., New York, 4th Edition, 1993.

E. Kreyszig, Introductory Functional Analysis with Applications, John Wiley.

George F. Simmons, Introduction to Topology and Modern Analysis, McGraw-Hill Book Company, 1963.

A. H. Siddiqi, Khalil Ahmad and P. Manchanda, Introduction to Functional Analysis
with Applications, Anamaya Publishers, New Delhi-2006.

K.C. Rao, Functional Analysis, Narosa Publishing House, Second edition.

MATH 525 Viscous Fluid Dynamics 2+1 SEM II

Theory

UNIT-I: Vorticity in two dimensions, circular and rectilinear vortices, vortex doublet, images, motion due to vortices, single and double infinite rows of vortices, Karman vortex street, wave motion in a gas, speed of sound in a gas, equation of motion of a gas, subsonic, sonic and supersonic flows, isentropic gas flow, flow through a nozzle.

UNIT-II: Stress components in a real fluid, relation between cartesian components of stress, translational motion of fluid element, rates of strain, transformation of rates of strains, relation between stresses and rates of strain, the co-efficient of viscosity and laminar flow, Newtonian and non-Newtonian fluids, Navier-Stoke equations of motion, equations of motion in cylindrical and spherical polar co-ordinates, equation of energy, diffusion of vorticity, energy dissipation due to viscosity, equation of state.

UNIT-III: Plane poiseuille and couette flows between two parallel plates, theory of lubrication, hagen poiseuille flow, steady flow between co-axial circular cylinders

and concentric rotating cylinders, flow through tubes of uniform elliptic and equilateral triangular cross-section, unsteady flow over a flat plate, steady flow past a fixed sphere, flow in convergent and divergent chennals.

UNIT-IV: Dynamical similarity, inspection analysis, non-dimensional numbers, dimensional analysis, Buckingham π-theorem and its application, physical importance of nondimensional parameters, Prandtl boundary layer, boundary layer equation in two-dimensions, the boundary layer on a flat plate (Blasius solution), characteristic boundary layer parameters, Karman integral conditions, Karman-Pohlhausen method.

Practical

Problems on circular and rectilinear vortices, speed of sound in a gas, equation of motion of a gas, transformation of rates of strains, Newtonian and non-Newtonian fluids, Navier-Stoke equations of motion, steady flow between co-axial circular cylinders and concentric rotating cylinders, unsteady flow over a flat plate, non-dimensional numbers, physical importance of non-dimensional parameters.

Suggested Readings

W.H. Besaint and A.S. Ramasey, A Treatise on Hydromechanics, Part II, CBS Publishers,Delhi, 1988.

F. Chorlton, Text Book of Fluid Dynamics, C.B.S. Publishers, Delhi, 1985

OôNeill, M.E. and Chorlton, F., Ideal and Incompressible Fluid Dynamics, Ellis Horwood Limited, 1986.

OôNeill, M.E. and Chorlton, F., Viscous and Compressible Fluid Dynamics, Ellis Horwood Limited, 1989.

S.W. Yuan, Foundations of Fluid Mechanics, Prentice Hall of India Private Limited, New Delhi, 1976.

H. Schlichting, Boundary-Layer Theory, McGraw Hill Book Company, New York, 1979.

R.K. Rathy, An Introduction to Fluid Dynamics, Oxford and IBH Publishing Company,New Delhi, 1976.

G.K. Batchelor, An Introduction to Fluid Mechanics, Foundation Books, New Delhi, 1994.

MATH 526 Mathematical Modelling 2+0 SEM I

Theory

UNIT-I: Introduction and the technique of mathematical modeling, classification and characteristics of mathematical models, mathematical modeling through algebra, finding the radius of the earth, motion of planets, motions of satellites, linear and non-linear growth and decay models, population growth models. effects of immigration and emigration on population size, decrease of temperature, diffusion, change of price of a commodity, logistic law of population growth, a simple compartment model, diffusion of glucose or a medicine in the blood stream.

UNIT-II: Mathematical modelling of epidemics, a simple epidemics model, a susceptible ï infected - susceptible (SIS) model, SIS model with constant number of carriers, simple epidemic model with carriers, model with removal, model with removal and immigration, mathematical modelling in economics, Domar macro model, Domar first debt model, Domar second debt model, Samuelson investment model, stability of market equilibrium, mathematical modelling in medicine, arms

race and battles: a model for diabetes mellitus, Richardson model for arms race, Lamechester combat model.

UNIT-III: Mathematical modelling through partial differential equations: mass-balance equations, momentum-balance equations, variational principles, probability generating function, modelling for traffic on a highway.

UNITï IV: Stochastic models of population growth, need for stochastic models, linear birth-death immigration- emigration processes, linear birth-death process, linear birth-death immigration process, linear birth-death-emigration process, non-linear birth-death process.

Suggested Reading

J.N. Kapur, Mathematical Modeling, New Age International Limited.

J.N. Kapur, Mathematical Models in Biology and Medicine, Affiliated East-West Press (P) Ltd.

Mathematical Models in the Social, Management and Life Sciences, D.N. Burghes and A.D. Wood, John Wiley & Sons.

Mathematical Modeling, J.G. Andrews & R.R Mclone, Butterworths (Pub.) Inc.

MATH 527 Differential Geometry & Tensors 3+0 SEM I

Theory

UNIT-I: Transformations, covariant and contravariant tensors, multiplication and contraction of tensors. The Quotient law, Fundamental tensors, associated tensors.

UNIT-II: Christoffel symbols, Geodesic, covariant and differentiation, curvature, Ricei and Einstein tensors, the two fundamental forms, spherical indicatrix.

UNIT-III: Curvilinear co-ordinates on a surface, lines of curvature, asymptotic lines, the equations of gauss and codazzi, Geodesic and Geodesic Parallels.

UNIT-IV: Definition of manifolds, sub-manifolds, charts and Atlases, connections, parallelism of vectors.

Suggested Readings

R.J.T. Bell, Elementary Treatise on Co-ordinate geometry of three dimensions, Macmillan India Ltd., 1994.

Barry Spain, Tensor Calculus, Radha Publ. House , Calcutta, 1988.

J.A. Thorpe, Introduction to Differential Geometry, Springer-Verlog, 2013.

Weatherbum, Reimanian Geometry and Tensor Calculus, Cambridge Uni. Press, 2008.

MATH 528 MATLAB 2+1 SEM II

Theory

UNIT-I: Introduction to MATLAB Programming: Basics of MATLAB programming, anatomy of a program, variables and assignments, data types, operators, working with complex numbers, mathematical operations, functions for input and output, good programming style. Introduction to vectors in Matlab: defining a vector, accessing elements within a vector, basic operations on vectors.

UNIT-II: Strings, string functions, cell array, creating cell array. Introduction to matrices in Matlab: defining matrices, matrix functions, matrix operations. Vector functions Loops: for loops, while loops, branching (conditional statements) - if

statement, if else statement, else if statement, executable files, subroutines, built in functions and user defined functions, function handles, function handles in m-files, inline functions.

UNIT-III: Linear Algebra: solving a linear system, finding eigen values and eigenvectors, polynomial curve fitting on fly, curve fitting with polynomial functions, least squares curve fitting, general nonlinear fits, interpolation, data analysis and statistics, numerical integration. Ordinary Differential Equations: a first order linear ODE, a second order nonlinear ODE, Ode23 versus ode45, nonlinear algebraic equations, roots of polynomials.

UNIT-IV: Data files: saving and recalling data, saving a session as text, C style read/write, graphs and plots- basic 2-D plots, overlay plots, specialized 2-D plots, 3-D plots, interpolated surface plots, using subplots for multiple graphs, saving and printing graphs, mesh, contour, contourf, using built-in algorithms: optimization and numerical integration (areas), root finding.

Practical

Practical problems on mathematical operations, functions for input and output, good programming style, basic operations on vectors, matrix functions, matrix operations, vector functions loops: for loops, while loops, finding eigen values and eigenvectors, data analysis and statistics, numerical integration, ordinary differential equations, using built-in algorithms: optimization and numerical integration (areas), root finding.

Suggested Readings

Amos Gilat, MATLAB An Introduction With Applications 5ed, Publisher: Wiley.

C. F. Van Loan and K.-Y. D. Fan., Insight through Computing: A Matlab Introduction
to Computational Science and Engineering, SIAM Publication, 2009.

Y.Kirani Singh, B.B. Chaudhari, MATLAB Programming, PHI Learning, 2007.

Krister Ahlersten, An Introduction to Matlab, Bookboon.com.

Rudra Pratap, Getting Started with MATLAB, Oxford University Press.

MATH 529 Operations Research Techniques 2+1 SEM II

Theory

UNIT-I: Operations Research: origin, definition and scope. Linear Programming: formulation and solution of linear programming problems by graphical and simplex methods, big - M and two-phase methods, degeneracy, duality in linear programming.

UNIT-II: Transportation Problems: basic feasible solutions, optimum solution by stepping stone and modified distribution methods, unbalanced and degenerate problems, transhipment problem. Assignment problems: Hungarian method, unbalanced problem, case of maximization, travelling salesman and crew assignment problems.

UNIT-III: Concepts of stochastic processes, poisson process, birth-death process. Queuing models: basic components of a queuing system, steady-state solution of Markovian queuing models with single and multiple servers (M/M/1, M/M/C, M/M/1/k, M/M/C/k).

UNIT-IV: Inventory control models: economic order quantity (EOQ) model with uniform demand, EOQ when shortages are allowed, EOQ with uniform replenishment, inventory control with price breaks.

Game Theory: two person zero sum game, game with saddle points, the rule of dominance, algebric, graphical and linear programming methods for solving mixed strategy games.

Practical

Problems on solution of linear programming problems by graphical and simplex methods, transportation problems, assignment problems, queuing models, inventory control models, game Theory.

Suggested Readings

H.A. Taha, Operation Research-An introducton, Printice Hall of India.

P.K. Gupta and D.S. Hira, Operations Research, S. Chand & Co.

S.D. Sharma, Operation Research, Kedar Nath Ram Nath Publications.

J.K. Sharma, Mathematical Model in Operation Research, Tata McGraw Hill.

MATH 611 Computational Fluid Dynamics 2+1 SEM I

Theory

UNIT-I: Basic equations of fluid dynamics, analytic aspects of partial differential equations classification, boundary conditions, maximum principles, boundary layer theory, finite difference and finite volume discretizations, vertex-centred discretization, cell centred discretization., upwind discretization, nonuniform grids in one dimension.

UNIT-II: Finite volume discretization of the stationary convection-diffusion equation in one dimension, schemes of positive types, defect correction, non-stationary convection diffusion equation, stability definitions, the discrete maximum principle, incompressible Navier-Stokes equations, boundary conditions, spatial discretization on collocated and on staggered grids, temporal discretization on staggered grid and on collocated grid.

UNIT-III: Iterative methods, stationary methods, Krylov subspace methods, multigrade methods, fast poisson solvers, iterative methods for incompressible Navier-Stokes equations, shallow-water equations ï one and two dimensional cases, Godunov order barrier theorem.

UNIT-IV: Linear schemes, scalar conservation laws, euler equation in one space dimensionï analytic aspects, approximate Riemann solver of Roe, Osher scheme, flux splitting scheme, numerical stability, Jameson ï Schmidt ï Turkel scheme, higher order schemes.

Practical

Problems on analytic aspects of partial differential equations classification, finite difference and finite volume discretizations, non-stationary convection diffusion equation, incompressible Navier-Stokes equations, iterative methods, Euler equation in one space dimension, numerical stability.

Suggested Readings

P. Wesseling, Principles of Computational Fluid Dynamics, Springer Verlag, 2000.
J.F. Wendt, J.D. Anderson, G. Degrez and E. Dick, Computational Fluid Dynamics : An Introduction, Springer-Verlag, 1996.
J.D. Anderson, Computational Fluid Dynamics: The basics with applications, McGraw-Hill, 1995.
K. Muralidher, Computational Fluid Flow and Heat Transfer, Narosa Pub. House.
T.J. Chung, Computational Fluid Dynamics, Cambridge Uni. Press.
J.N. Reddy, An introduction to the Finite Element Methods,McGraw Hill International Edition, 1985.

MATH 612 Advanced Complex Analysis 3+0 SEM I

Theory

UNIT-I: Integral Functions, factorization of an integral function, Weierstrass factorisation theorem, factorization of sine function, gamma function and its properties, Stirling formula, integral version of gamma function, Riemann Zeta function, Riemann functional equation, Runge theorem, Mittag-Leffler theorem.

Unitï II: Analytic Continuation, natural boundary, uniqueness of direct analytic continuation, uniqueness of analytic continuation along a curve, power series method of analytic continuation, Schwarz reflection principle, Germofan analytic function, Monodromy theorem and its consequences, harmonic functions on a disk, Poisson kernel, the Dirichlet problem for aunitdisc.

Unit-III: Harnack inequality, Harnack theorem, Dirichlet region, Green function, canonical product, Jensen formula, Poisson-Jensen formula, Hadamard three circles theorem, growth and order of an entire function, an estimate of number of zeros, exponent of Convergence, Borel theorem, Hadamard factorization theorem.

Unit-IV: The range of an analytic function, Bloch theorem, Schottky theorem, Little Picard theorem, Montel Caratheodory theorem, Great Picard theorem, univalent functions, Bieberbach conjecture (statement only) and the ñ1/4 theoremò.

Suggested Readings

H.A. Priestly, Introduction to Complex Analysis, Clarendon Press, Oxford, 1990.
S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House, 2011.
J.B. Conway, Functions of one Complex variable, Springer-Verlag, International student-Edition, Narosa Publishing House, 2002.
Liang-shin Hann & Bernand Epstein, Classical Complex Analysis, Jones and Bartlett
Publishers International, London, 1996.
E.T. Copson, An Introduction to the Theory of Functions of a Complex Variable, Oxford University Press, London.
E.C. Titchmarsh, The Theory of Functions, Oxford University Press, London.

Mark J. Ablowitz and A.S. Fokas, Complex Variables : Introduction and Applications, Cambridge University Press, South Asian Edition, 1998.
Ruel V. Churchill and James Ward Brown, Complex Variables and Applications, McGraw-Hill Publishing Company.
H.S. kasana, Complex Variable Theory and Applications, PHI Learning Private Ltd, 2011.

MATH 613 Mathematical Programming 3+0 SEM II

Theory

UNIT-I: Separating and supporting hyperplane theorems, revised simplex method for linear programming problem (LPP), Bounded variable problem, convex function.

UNIT-II: Integer programming, Gomoryôs algorithm for the all integer programming problem, Branch and bound technique, quadratic forms, Lagrangeôs function and multiplier.

UNIT-III: Non-linear programming problem (NLPP) and its fundamental ingredients, necessary and sufficient conditions for saddle points, Kuhn-Tucker theorem, convex separable programming algorithm, Kuhn-Tucker conditions for optimization for NLPP.

UNIT-IV: Quadratic programming, Wolfôs method, Bealeôs method, duality in quadratic programming, dynamic programming, principle of optimality due to Bellman, solution of a LPP by dynamic programming.

Suggested Readings

Kanti Swaroop, P.K. Gupta and manmohan, Operation Research, Sultan Chand & Sons., New Delhi, 2007.
S.D. Sharma, Operations Research, Kedar Nath Ram Nath and co., Meerut, 2005.
F. S. Hiller and G. J. Lieberman, Introduction to Operation Research Concepts and Cases (9^{th} Edition), Tata McGraw Hill, 2010.
Hamdy A. Taha, Operation Research, An Introduction (9^{th} edition), Prentice-Hall, 2010.
G. Hadley, Linear Programming, Narosa Publishing House, New Delhi, 2002.

MATH 614 Integral Transforms and Z-Transforms 3+0 SEM I

Theory

UNIT-I: Laplace transform, inverse I.T. and their applications in solving differential equations, system of differential equations, Integral equation, intgro differential equations and their applications to Boundary value Problem.

UNIT-II: Fourier integral formula, Fourier sine and cosine integrals, complex form of Fourier integrals, Fourier transform and there inversion formula and problems, Fourier Sine and cosine transform and there inversion formula and problems, Fourier Sine and cosine transform and there inversion, finite Fourier sine and cosine transform. Fourier transform of derivative, use of F.T. to some B.V. problem.

UNIT-III: Henkel transform and its inversion formulation, Hankel transformation of the derivative of a function, finite Hankel transform, Mellin transform, Properties of Mellin transform, Mellin transformation of derivative of a function M.T of integrals, convolution theorem for Mellin transform.

UNIT-IV: Z-transform: definition, properties, initial value theorem and final value theorem methods of finding Z-transform, inverse Z-transform, application of Z-transform to difference, differential equation.

Suggested Readings

Lokenath Debnath, Integral Transforms and Their Applications, CRC Press, 1995.
A. N. Srivastava and Mohammad Ahmad, Integral Transforms and Fourier Series, Alpha Science.
Allan Pinkus, Fourier Series and Integral Transforms, Cambridge University Press, 1997.

MATH 615 Advanced Abstract Algebra 3+0 SEM II

Theory

UNIT-I: Characteristic of a ring with unity, prime fields Z/pZ and Q, characterization of prime fields, field extensions, degree of an extension, algebraic and transcendental elements, simple field extensions, minimal polynomial of an algebraic element, conjugate elements, algebraic extensions, finitely generated algebraic extensions, algebraic closure and algebraically closed fields, splitting fields.

UNIT-II: Finite fields, Frobenious automorphism of a finite field, roots of unity, cyclotomic polynomials and their irreducibility over Q, normal extensions, finite normal extensions as splitting fields, separable elements, separable polynomials and separable extensions, theorem of primitive element, perfect fields.

UNIT-III: Galois extensions, Galois group of an extension, Dedekind lemma, fundamental theorem of Galois theory, Frobenius automorphism of a finite field, Kleinôs 4-group and diheadral group, Galois groups of polynomials, fundamental theorem of algebra, radicals extensions, Galois radical extensions, cyclic extensions. solvability of polynomials by radicals over Q, symmetric functions and elementary symmetric functions, construction with ruler and compass only.

UNIT-IV: Similar linear transformations, invariant subspaces of vector spaces, reduction of a linear transformation to triangular form, nilpotent transformations, index of nilpotency of a nilpotent transformation, cyclic subspace with respect to a nilpotent transformation, uniqueness of the invariants of a nilpotent transformation, primary decomposition theorem, Jordan blocks and Jordan canonical forms, cyclic module relative to a linear transformation, rational canonicals form of a linear transformation and its elementary divisior, uniqueness of the elementary divisior.

Suggested Readings

I.N. Herstein, Topics in Algebra (Wiley Eastern Ltd.)
P.B. Bhattacharya, S.K. Jain & S.R. Nagpal, Basic Abstract Algebra (Cambridge University Press 1995)
Vivek Sahai and Vikas Bist, Algebra (Narosa publication House)
Surjit Singh and Quazi Zameeruddin, Modern Algebra (Vikas Publishing House 1990)
Patrick Morandi, Field and Galois Theory (Springer 1996)

MATH 616 Special Functions 3+0 SEM I

Theory

UNIT-I: Beta and Gamma Functions: definition and evaluation, Dirichlets integral, the order symbols 0 and O, orthogonal set of functions, inner product of two functions, norm, orthonormal set of functions, Gram-schmidth orthonormaliation method, generalized Fourier series, Strum-Liouville problem, eigen values of the Strum Liouvilie problem, evaluation of eigen values and eigen functions of the Strum-Liouvilla problem.

UNIT-II: Hyper geometric and generalized hyper geometric functions: definition. hypergemetrics series, particular cases of hy-pergeometric series, different forms of hypergemietric function, solution of the hyergeometric equation, linear relations between the solutions of the hypergeometic function, Kummerôs theorem, Gaussôs theorem, Vandermonndeôs Theorem, differentiation of hypergeometric functions.

UNIT-III: Legendreôs polynomials and function: definition of $P_n(x)$, general solution of Legendreôs equation, recurrence relations for $P_n(x)$, Beltramiôs result, Christofis expansion, Christoffels Summation Formula, Rodrigueôs Formula, trigonometric series for $P_n(x)$, generating function, expansion of f(x) in Legendreôs Polynomials.

UNIT-IV: Besselôs Function: general solution, recurrence formula, generates function, simple problems on the functions $P_n(x)$. Hermite polynomials: orthogonal property, recurrence relations. Laguerre Polynomials: Definition, Generating function other forms, orthogonality evaluation of first few polynomials, recurrence formulae.

Suggested Readings

Diego Dominici, Special Functions and Orthogonal Polynomials, American Mathematical Society, 2008.

N. N. Lebedev, Special Functions & Their Applications, Dover books on Mathematics, Courier Corporation, 1972.

MATH 617 Information Theory 3+0 SEM I

Theory

UNIT-I: Measure of information ï axioms for a measure of uncertainty, the shannon entropy and its properties, joint and conditional entropies, trans-information and its properties, axiomatic characterization of the Shannon entropy due to Shannon and Fadeev.

UNIT-II: Noiseless coding - Ingredients of noiseless coding problem, uniquely decipherable codes, necessary and sufficient condition for the existence of instantaneous codes, construction of optimal codes.

UNIT-III: Discrete memoryless channel - classification of channels, information processed by a channel, calculation of channel capacity, decoding schemes, the ideal observer, the fundamental theorem of information theory.

UNIT-IV: Continuous channels - the time-discrete Gaussian channel, uncertainty of an absolutely continuous random variable, the converse to the coding theorem for time-discrete Gaussian channel, the time-continuous Gaussian channel, band-limited channels.

Suggested Readings

R. Ash, Information Theory, Interscience Publishers, New York, 1965.

F.M. Reza, An Introduction to Information Theory, MacGraw-Hill Book Company Inc., 1961.
J. Aczela dn Z. Daroczy, On Measures of Information and their Characterizations, Academic Press, New York.

MATH 618 Advanced Numerical Analysis 3+0 SEM I

Theory

UNIT-I: Iterative methods: theory of iteration method, acceleration of the convergence, Chebyshev method, Mulerôs method, methods for multiple and complex roots, Newton-Raphson method for simultaneous equations, convergence of iteration process in the case of several unknowns.

UNIT-II: Solution of polynomial equations: polynomial equation, real and complex roots, synthetic division, the Birge-Vieta, Bairstow and Graeffeôs root squaring method. System of simultaneous equations (linear): Direct method, method of determinant, Gauss-Jordan, LU factorizations- Doolitteôs, Croutôs and Choleskyôs, partition method, method of successive approximate-conjugate gradient and relaxation methods.

UNIT-III: Eigen vale problems: basic properties of eigen values and eigen vector, power methods, method for finding all eigen values of a matrix, Jacobi, Givensôand Rutishauser method, complex eigen values.

UNIT-IV: Numerical solution of ordinary differential equations: Taylor series method, Picard method, Runge-Kutta methods upto fourth order, multistep method (predictor-corrector strategies), stability analysis- single and multistep methods.

Suggesting Readings

V. Rajaraman, Computer Oriented numerical Methos, PHI, 1993.
S. S. Sastry, Introduction Methods of Numerical Analysis, PHI, 1979.
B. Bradie, A Friendly Introduction to Numerical Analysis, Pearson Education, India, 2007
C.F. Gerald, P.O Wheately, Applied Numerical Analysis, Addison-Wesley, 1998.
S.D. Conte, C de Boor, Elementary Numerical Analysis, McGraw-Hill, 1980.

MATH 619 System of Differential Equations 2+1 SEM II

Theory

UNIT-I: Linear differential systems: definitions and notations, linear homogeneous systems, existence and uniqueness theorem, fundamental matrix, adjoint systems, reduction to smaller homogeneous systems. Non-homogeneous linear systems: variation of constants, linear systems with constant coefficients, linear systems with periodic coefficients, Floquet theory.

UNIT-II: System of differential equations, differential equation of order n and its equivalent system of differential equations, existence theorem for solution of system of differential equations, dependence of solutions on initial conditions and parameters, preliminaries, continuity and differentiability, maximal and minimal solutions, upper and lower solutions, differential inequalities.

UNIT-III: Autonomous systems: the phase plane, paths and critical points, types of critical points; node, center, saddle point, spiral point, stability of critical points.

Critical points and paths of linear systems: basic theorems and their applications, critical points and paths of quasilinear systems.

UNIT-IV: Stability Analysis: asymptotic behaviour of linear system, generalized Gronwallôs inequality, formal approach of stability analysis, phase portrait analysis, stability of solution of system of equations with constant coefficients, linear equation with constant coefficients, Liapunov stability, stability of quasi linear systems.

Limit cycles and periodic solutions: limit cycle, existence and non-existence of limit cycles, Benedixsonôs non-existence theorem, Half-path or Semiorbit, Limit set, Poincare-Benedixson theorem.

Practical

Problems on linear differential systems, non-homogeneous linear systems, system of differential equations, maximal and minimal solutions, differential inequalities, autonomous systems, critical points and paths of linear systems, stability analysis, limit cycles and periodic solutions.

Suggested Readings

E.A. Coddington and N. Levinson, *Theory of Ordinary Differential Equations*, Tata McGraw- Hill , 2000.

S.L. Ross, *Differential Equations*, John Wiley & Sons,

S.G. Deo, V. Lakshmikantham and V. Raghavendra, *Textbook of Ordinary Differential Equations*, Tata McGraw-Hill , 2006.

Mohan C Joshi, *Ordinary Differential Equations, Modern Perspective*, Narosa Publishing House, 2006.

MATH 620 Mathematical Foundation of Image Processing 2+1 SEM I

Theory

UNIT-I: Image**:** The origins of digital image processing, classification of images, examples of fields that use digital image processing, elements of digital image processing systems, image sampling and quantization, some basic relationships like neighbours, connectivity, distance measures between pixels translation, scaling, rotation and perspective projection of image, reading, displaying, writing images using software. Data classes, image types using software based simulation.

UNIT- II: Operations on Images**:** Converting between data classes and image types, some basic gray level transformations histogram processing, enhancement using arithmetic and logic operations combining spatial enhancement methods basics of spatial filters, smoothening and sharpening spatial filters intensity transformation function, histogram processing and function plotting using software.

UNIT ï III: Transforms on Images: Introduction to Fourier transform and the frequency domain. Computing and visualizing image in frequency domain, Smoothing Frequency Domain Filters, Sharpening Frequency Domain Filters, Homomorphism Filtering. Mathematical decomposition on images. Wavelet transform on images.

UNIT- IV: Image restoration: A model of the image degradation / restoration process, noise models restoration in the presence of noise only spatial filtering, periodic noise reduction by frequency domain filtering linear position-invariant degradations estimation of degradation function, inverse filtering wiener filtering, geometric mean filter geometric transformations, image compression: coding

interpixel and psycho visual redundancy image compression models compression standards, image segmentation: detection of discontinuities edge linking and boundary detection thresholding, object recognition: patterns and pattern classes decision-theoretic methods structural methods.

Practical

Coding of pixels translation, scaling, rotation and perspective projection of image, reading, displaying, writing images using software, smoothening and sharpening, histogram processing and function plotting using software, filtering of images, degrading and restoration of images, boundary and object detection in image.

Suggested Readings:

Jain A. K., *Fundamentals of Digital Image Processing*, 1 edition. Englewood Cliffs, NJ: Pearson, 1988.

Lim J. S., *Two-Dimensional Signal and Image Processing*, 1 edition. Englewood Cliffs, N.J: Prentice Hall PTR, 1989.

Gonzalez R. C., Woods R. E., and Eddins S. L., *Digital Image Processing Using Matlab*, 1st edition. New Delhi: Dorling Kindersley Pvt Ltd, 2006.

Gonzalez, *Digital Image Processing*, 4th ed. Upper Saddle River, N.J.: Pearson, 2018.

Gong S., Liu C., Ji Y., Zhong B., Li Y., and Dong H., *Advanced Image and Video Processing Using MATLAB*. Springer International Publishing, 2019.

MATH 621 Computational Neuroscience 2+1 SEM II

Theory

UNIT-I: Dynamical System: Preliminaries from linear algebra, Bases and subspaces, Planer linear systems and its classification, eigenvalues and eigenvector, solving linear systems, phase portraits for planer system, trace-determinant plane, dynamical classification.

UNIT- II: Nonlinear systems: Dynamic systems, the existence and uniqueness theorem, continuous dependence of solutions, the variational equation, Equilibrium in non-linear systems and some illustrative examples, nonlinear sinks and sources, saddles, stability, bifurcation, null clines, Software based simulation.

UNITï III: Neuron: Elements of Neuronal systems, the ideal spiking neuron, spike trains, synapses, postsynaptic potentials, firing threshold and action potential, a phenomenological neuron model, The problem of neuronal coding, rate code as spike count, spike density, population activity, spike code as time-to-first-spike, phase, correlations and synchrony, stimulation reconstruction and reverse correlation. Nernst potential, reversal Potential.

UNIT-IV: Single Neuron Modeling: Hodgkin-Huxley model, definition and dynamics and its software based simulation. Effect of various Ion channels, Sodium channel, potassium channel, low-threshold Calcium channel and its dynamics. Feedback: inhibitory and excitatory synapses. Two-dimensional Neuron models and their software based simulation.

Practical

Problems on eigen values and eigenvector, system of linear equations, stability of critical points of non-linear systems, neuronal coding, coding of Hodgkin-Huxley model, single neuron dynamics modelling.

Suggested Readings:

Gerstner W. and Kistler W. M., *Spiking Neuron Models: Single Neurons, Populations, Plasticity*, 1 edition. Cambridge University Press, 2002.

Feng J., *Computational Neuroscience: A Comprehensive Approach*. CRC Press, 2003.

Dayan P., Sejnowski T. J., and Poggio T. A., *Theoretical Neuroscience – Computational and Mathematical Modeling of Neural Systems*, Revised ed. edition. Cambridge, Mass.: MIT Press, 2005.

Perko L., *Differential Equations and Dynamical Systems*, 3rd edition. New York: Springer, 2006.

Lynch S., *Dynamical Systems with Applications using Mathematica®*, 2007 edition. Boston, Mass: Birkhäuser, 2007.

Trappenberg T., *Fundamentals of Computational Neuroscience*, 2 edition. OUP Oxford, 2009.

Hirsch M. W., Smale S., and Devaney R. L., *Differential Equations, Dynamical Systems, and an Introduction to Chaos*, 3 edition. Waltham, MA: Academic Press, 2012.

Robertson K., Ed., *Computational Neuroscience*. Larsen and Keller Education, 2017.

Miller P., Sejnowski T. J., and Poggio T. A., *An Introductory Course in Computational Neuroscience*, 1 edition. Cambridge, Masachusetts: MIT Press, 2018.

MATH 622 Algebraic Topology 3 + 0 SEM I

Theory

UNIT-I: Mainfolds: Identification (quotient) spaces and identification (quotient) maps; topology n-manifolds including surfaces, Sn, RPn, CPn. and lens spaces. Triangulated manifolds: Representation of triangulated, closed 2-manifolds as connected sums of tori of projective planes.

UNIT- II: Fundamental group, functoriality, retract, deformation retract; Van Kampenôs Theorem, classification of surfaces by abelianizing the fundamental group, covering spaces, path lifting, homotopy lifting, uniqueness of lifts, general lifting theorem for maps.

UNIT- III: Covering transformations, regular covers, correspondence between subgroups of the fundamental group and covering spaces, computing the fundamental group of the circle, RPn, lens spaces via covering spaces.

UNIT- IV: Simplicial homology: Homology groups, functionality, topological invariance, Mayer-Vietoris sequence; applications, including Euler characteristic, classification of closed trangulated surfaces via gomology and via Euler characteristic and orient ability; degree of a map between oriented manifolds, Lefschetz number, Brouwer Fixed Point Theorem.

Suggested Readings:

A Hatcher. Algebraic Topology, Cambridge University Press, 2002.
R C Kirby and L C Siebenmann. Foundational Essays on Topological Manifolds, Smoothings, and Triangulations. Annals of Math Studies 88. Princeton University Press, 1977.
J P May. A Concise Course in Algebraic Topology. University of Chicago Press, 1999.
G E Bredon. Topology and Geometry. Springer GTM 139, 1993.

MATH 591	**MASTER'S SEMINAR**	**1**	**SEM I, II**
MATH 599	**MASTER'S RESEARCH**	**10**	**SEM I, II**
MATH 691	**DOCTORAL SEMINAR-I**	**1**	**SEM I, II**
MATH 692	**DOCTORAL SEMINAR-II**	**1**	**SEM I, II**
MATH 699	**DOCTORAL RESEARCH**	**45**	**SEM I, II**