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AGRICULTURAL CHEMICALS

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
AC 100	INTRODUCTION TO AGROCHEMICALS	3	0
AC 101	BASIC CHEMISTRY-I	3	1
AC 102	BASIC CHEMISTRY-II	3	1
AC 201	SYNTHETIC AGROCHEMICALS FOR INSECT AND MITE MANAGEMENT	3	1
AC 204	SYNTHETIC ORGANIC CHEMISTRY	2	2
AC 208	XENOBIOTIC MOVEMENT, TRANSFORMATION AND METABOLISM	2	2
AC 299	SEMINAR	1	0

II Trimester

AC 103	LABORATORY TECHNIQUES	1	2
AC 202	SYNTHETIC AGROCHEMICALS FOR DISEASE AND NEMATODE MANAGEMENT	3	1
AC 203	SYNTHETIC AGROCHEMICALS FOR WEED MANAGEMENT	3	1
AC 205	SPECTROSCOPIC AND CHROMATOGRAPHIC TECHNIQUES	3	2
AC 206	AGROCHEMICAL FORMULATION	3	2
AC 299	SEMINAR	1	0

III Trimester

AC 104	AGROCHEMICALS: REGULATION, QUALITY CONTROL AND MANAGEMENT	3	0
AC 200	CHEMISTRY OF BIOPESTICIDES	3	1
AC 207	PESTICIDE RESIDUE CHEMISTRY	2	2
AC 209	AGROCHEMICALS AND ENVIRONMENT	2	0
AC 300	RECENT ADVANCES IN AGROCHEMICALS	3	0
AC 299	SEMINAR	1	0

Core Courses :

For M.Sc. : Within the discipline: AC 101, AC 102, AC 103 and AC 104

Agricultural Chemicals

Major Field : **Agricultural Chemicals**

Minor Fields : **Ph.D** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AC 100: INTRODUCTION TO AGRO-CHEMICALS (3L) I

Chronological development , classification, structures, general properties and uses of major conventional, synthetic and natural agrochemicals including plant production chemicals, nitrification inhibitors, chemical hybridizing agents and hydrogels. Formulation, quality control, safety aspects, pesticide poisoning and antidotes. Production, consumption and trade statistics of pesticides. Implications in the environment. General aspects of pest and pesticide management.

AC 101: BASIC CHEMISTRY-I (3L+1P) I

Atomic structure: quantum numbers, and atomic orbitals. Chemical bonding: theories of bonding, molecular orbitals and aromaticity. Organic compounds: nomenclature, isomerism - constitutional, configurational and conformational, chirality, Cohn-Ingold-Prelog rules. Chemistry of terpenoids, alkaloids, flavonoids and heterocyclic compounds, carbohydrates, amino acids, proteins, nucleic acids. Inductive, inductomeric, mesomeric and electromeric effects, acidity and basicity and levelling effects in organic compounds.

AC 102: BASIC CHEMISTRY-II (3L+1P) I

Laws of thermodynamics, kinetic theory of gases and chemical kinetics. Solutions and colligative properties, surface chemistry, chemical and ionic equilibria, electrochemistry, redox reactions. Chemical analysis - principles, classification, volumetric and gravimetric analysis, potentiometric titrations. Electromagnetic spectrum, principles of absorption and emission spectrophotometry.

AC 103: LABORATORY TECHNIQUES (1L+2P) II

Acquaintance with laboratory glassware and apparatus. Precautions in handling toxic chemicals and hazardous reactions. Solvent

purification and drying. Extraction, distillation, crystallization, sublimation, separation methods. Standard solutions.

Functions of common equipments – water and oil pumps, heating and cooling baths, stirrers, rotary evaporators and C, H-Analyzer. Principles of thin layer, paper and column chromatography.

AC 104 : AGROCHEMICALS REGULATION, QUALITY CONTROL AND MANAGEMENT (3L) III

Laws, acts and rules governing registration and regulations of agrochemical production and use. Acts and regulations promoting social security and welfare of workers. EPA, WHO, FAO and national/ international guidelines. Regulatory aspects as per Insecticide Act. Quality-definition and need. Establishment of quality control laboratory, Business Management : motivation, manpower planning, operation research, capital budgeting and marketing.

AC 200 : CHEMISTRY OF BIOPESTICIDES (3L+1P) III

Chemistry of isoprenoids, phenolics and alkaloids. Sources, isolation, characterization, properties and mode of action of important groups of naturally occurring insecticides (pyrethroids, nicotinoids, rotenoids, limonoids, microbial macrolides). Bacillus thuringiensis and nuclear polyhedrosis virus based insecticides and other biopesticides, semiochemicals, insect hormones, insect growth regulators, feeding deterrents and repellents etc. Natural nematicides, fungicides, mollusicides and rodenticides. Agricultural antibiotics, mycotoxins, phytotoxins and bioherbicides. Allelochemicals. Chemical ecology.

AC 201: SYNTHETIC AGROCHEMICALS FOR INSECT AND MITE MANAGEMENT (3L+1P) I

Preparation, properties, uses, structure-activity relationship (QSAR) and mode of action of major groups of insecticides and acaricides (organochlorine, organophosphorus, carbamates, pyrethroids and neonicotinoides). Insecticide synergists. Fumigants and other chemicals for post-harvest storage of agricultural commodities. Anti JH/mimics and other synthetic IGRs.

AC 202: SYNTHETIC AGROCHEMICALS FOR DISEASE AND NEMATODE MANAGEMEMENT (3L+1P) II

Preparation, properties, uses, structure-activity relationships and mode of action of major groups of fungicides. Inorganic : copper, mercury and sulphur compounds. Organometallics: compounds of tin arsenic, mercury etc. Organophosphorus compounds, dithiocarbamates, polyhalogenalkanes, sulfenyl compounds, phenols, quinones, carboxamide, carboximides, azoles and other heterocyclics compounds. Nematicides: halocarbons, organophosphorus compounds, carbamates etc.

AC 203 : SYNTHETIC GROCHEMICALS FOR WEED MANAGEMENT (3L+1P) II

Preparation, properties, uses, structure-activity relationship and mode of action of major groups of herbicides such as phenoxy alkanoic acids, carbamates, substituted phenylureas, triazines, pyridinium compounds, dinitroanilines, sulfonylureas, imidazolinones and phenoxy phenoxy propionicacid (fop) herbicides. Herbicide safeners. Synthetic plant growth regulators.

AC 204 : SYNTHETIC ORGANIC CHEMISTRY (2L+2P) I

Walden inversion, asymmetric synthesis, optical resolution, racemic modification. Reaction mechanisms – substitution, elimination, addition and condensation reactions. Important name reactions and rearrangements. Synthetic reagents and their applications. Protective groups in organic synthesis. Photochemistry, pericyclic reactions and sigma tropic rearrangement.

AC 205: SPECTROSCOPIC AND CHROMATOGRAPHIC TECHNIQUES (3L+2P) II

Principles, instrumentation and application of spectroscopic (UV, IR, NMR, and mass spectrometry) and chromatographic (thin layer, high performance liquid, gas liquid, ion-exchange, gel, flash and supercritical fluid chromatography) techniques. Tandem techniques (GC-MS, LC-MS, GC-MS-IR, MS-MS, LC-NMR, GC-IR) with reference to isolation, purification and structure elucidation.

AC 206: AGROCHEMICAL FORMULATION (3L+2P) II

General aspects: definition, objective, process, product spectrum, classification, formulation codes etc. Solid and liquid formulations : preparation, properties specifications and uses. Formulants : carriers / diluents, surfactants, synergists, safeners, encapsulants, binders, anti-oxidants, stabilizers. Formulant-toxicant interactions. Control release formulations. Pesticide mixtures. Application : devices and quality of deposits. Bio-efficacy : basic considerations, absorption, penetration, translocation and activity.

AC 207: PESTICIDE RESIDUE CHEMISTRY (2L+2P) III

Pesticide residues-concepts and toxicological significance. Experimental design, sampling, principles of extraction and clean up from different substrates. Application of spectrophotometric, chromatographic, ELISA and radiotracer techniques in pesticide residue analysis including analysis of polar and insensitive compounds. Confirmatory techniques. Multiresidue methods. Bound and conjugated residues. Method validation: linearity, accuracy, precision, LOD and LOQ. Interpretation of data and statistical analysis.

AC 208: XENOBIOTIC MOVEMENT, TRANSFORMATION AND METABOLISM (2L+2P) I

Basic principles and scope of biotic and abiotic transformations in air, soil, plant, water, pests and animal systems. Xeniobiotic movement in agro ecosystem. Modelling for predicting xenobiotic fate in the environment.

(Pre-requisite any two courses from AC 201 and AC 203)

AC 209: AGROCHEMICALS AND ENVIRONMENT (2L) III

Adverse effects of pesticides on microflora, fauna and on other non-target organisms. Assessment and management of potential health risks. Decontamination of pesticide residues in/ on agricultural commodities, pesticide decontamination : chemical, physical, photo chemical, microbial and enzymatic techniques. Disposal : physical, chemical and biological methods. Ground water decontamination. Disposal of industrial effluents and other xenobiotics. Guidelines for pesticide disposal in the environment.

AC 300: RECENT ADVANCES IN AGROCHEMICALS (3L) III

Recent advances in pesticide development, formulation, analysis and safety evaluation. New synthetic molecules, their mode of action and metabolism. Innovations in pesticide formulation and delivery systems; role of biotechnology in developing herbicide tolerant and insect resistant transgenic plants. Recent developments in botanicals and biopesticides. Intellectual property rights: concepts, development and needs. Codex Alimentarius Commission and sanitary / phytosanitary issues in relation to food safety. Quality requirements for national (NABL) / international (GLP) accreditations of laboratories.

(Pre-requisites: Any two courses from AC 201 and AC 203)

AC 299: SEMINAR (1L) I/II/III

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AGRICULTURAL ECONOMICS

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
A 14	FUNDAMENTALS OF ECONOMICS AND BUSINESS MANAGEMENT	1	1
AG ECON 101	MICROECONOMICS-I	3	0
AG ECON 120	AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS –I (FARM MANAGEMENT)	2	1
AG ECON 130	ECONOMICS OF MARKETING	2	1
AG ECON 202	MACROECONOMICS-II	3	0
AG ECON 235	AGRICULTURAL PRICE ANALYSIS	2	1
AG ECON 241	AGRICULTURAL FINANCE-II	3	0
AG ECON 251	AGRICULTURAL POLICY	3	0
AG ECON 261	RESEARCH METHODS	1	0
AG ECON 320	AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-IV (AGRICULTURAL PRODUCTION UNDER RISK)	1	1
AG ECON 332	QUANTITATIVE ANALYSIS OF MARKETING PROBLEMS: APPLICATION STUDIES	2	1
AG ECON 341	INSTITUTIONAL AND LEGAL ENVIRONMENT FOR AGRIBUSINESS	2	0
AG ECON 360	AGRICULTURAL PROJECT ANALYSIS	2	1
AG ECON 299	SEMINAR	1	0

II Trimester

AG ECON 102	MACROECONOMICS- I	3	0
AG ECON 110/ AS 260	AGRICULTURAL ECONOMETRICS-I	2	1

AG ECON 150	AGRICULTURAL DEVELOPMENT AND PLANNING	3	0
AG ECON 201	MICROECONOMICS-II	3	0
AG ECON 220	AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-II (PRODUCTION FUNCTION ANALYSIS)	2	1
AG ECON 230	INTERNATIONAL TRADE	3	0
AG ECON 340	STRATEGIC MANAGEMENT FOR AGRIBUSINESS	2	0
AG ECON 342	MANAGEMENT OF R&D AND INNOVATION	2	1
AG ECON 299	SEMINAR	1	0

III Trimester

AG ECON 111	AGRICULTURAL ECONOMETRICS-II	3	0
AG ECON 221	AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-III (LINEAR PROGRAMMING)	2	1
AG ECON 231	FUNDAMENTALS OF BUSINESS MANAGEMENT	3	1
AG ECON 240	AGRICULTURAL FINANCE-I	2	1
AG ECON 250	ECONOMIC DEVELOPMENT	3	0
AG ECON 331	MARKETING MANAGEMENT	3	1
AG ECON 299	SEMINAR	1	0

Core Courses :

For M.Sc: Within the discipline : AG ECON 101, AG ECON 102, AG ECON 110, AG ECON 120, AG ECON 130, AG ECON 150, AG ECON 231, AG ECON 240 and AG ECON 261

Agricultural Economics

Major Fields : **Farm Management and Resource Economics**
Agricultural Marketing and Trade
Agricultural Finance and Project Analysis
Agricultural Development and Policy
Agri-business Management

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

The total minimum credit requirement of course work for M.Sc./Ph.D. in Agricultural Economics is 55/45 including Minor field(s).

DESCRIPTION OF COURSES

A 14: FUNDAMENTALS OF ECONOMICS AND BUSINESS MANAGEMENT (1+1) I

Fundamentals of Economics: Basic microeconomic concepts; theory of demand; elasticity of demand; theory of supply; elasticity of supply, demand and supply projections; concept of national income; nature and scope of farm management; principles of farm management.

Fundamentals of Agribusiness: Agribusiness management defined; basic functions of management; agribusiness environment; essential quantitative techniques for managerial decisions.

Global Issues in Agribusiness: Intellectual property rights in agriculture; tariff and non-tariff barriers to trade; social and legal concerns; protection of traditional knowledge and traditional practices; methods of project analysis; cost-benefit analysis; assessment of impact of technology – total factor productivity and economic surplus approach.

AG ECON 101: MICROECONOMICS-I (3L) I

Theory of consumer behaviour: concepts, utility functions- existence and nature, utility maximization, analytical approaches, limitations and applications; demand theory, ordinary and compensated demand functions-derivations-analytical approaches, limitations and applications; demand theory and elasticity matrix

generation; total price effect, decomposition analysis, direct and cross effects-analytical approaches and applications generalised to n variables.

Extended theory of consumer behaviour: Recent developments in the theory of demand - linear expenditure system, constant elasticity demand function, dynamic versions of demand functions-distributed lag models, Houthakker's and Taylor's dynamic models; utility functions - separable and additive, homogenous and homothetic functions, direct and indirect; theory of revealed preference; composite commodity theorem; consumer's surplus; expected utility with risk.

Basic theory of the firm: concepts, production functions, productivity curves and isoquants derivations - analytical approaches, limitations and applications; optimization behaviour - alternative models, short run and long run cost functions; factor demand derivation; total price effect-substitution effect, output effect and profit maximization effect-decomposition analysis-analytical approaches and applications generalised to n variables; supply and elasticity matrix generation-conceptual framework for agricultural commodities; joint products-concepts and constrained optimisation.

Extended theory of the firm: homogenous production functions; constant elasticity of substitution production functions-concepts, properties, equilibrium analysis and applications; duality in production, production under uncertainty, linear production functions for single and multi-output cases.

Perfect competition, market demand functions, temporal supply functions and externalities, commodity market equilibrium-short run, long run, differential cost conditions; theory of cost and empirical evidence on the shape of cost functions, taxation applications, factor market-supply demand functions, futures market-hedging, risk assumption.

AG ECON 102: MACROECONOMICS-I (3L) II

Concept and measurement: Basic concepts; national income; product; wealth; money price level; employment, unemployment and output in the economy.

Employment Theory: Say's Law; Quantity theory of money, wages, prices, employment and production; classical theory of saving, investment and interest rate.

The simple Keynesian model: consumption function, fiscal policy and Keynesian dynamics. Keynesian and Classical synthesis; Keynesian theory of interest, IS-LM form of the model, classical version of the synthesis.

Input-output model, the concept of full employment, inflationary gap.

The theory of income determination and multiple market economic systems; Multiplier and accelerator analysis; The Walrasian, Keynesian, Fisherian and Samuelsonian systems.

The integration of macroeconomics with monetary analysis in the context of both open and closed economies.

AG ECON 110/AS 260: AGRICULTURAL ECONOMETRICS-I (2L+1P) II

Representation of economic phenomenon, relationship among economic variables, linear and non-linear economic models.

Ordinary least squares methods of estimation of simple and multiple regression models. The BLUE properties of least squares estimates, tests of significance and confidence intervals. Summary statistics- correlation matrix, residual variance, co-efficient of multiple correlation, standard errors of estimated coefficients and their uses, partial correlation and its uses. Maximum likelihood estimation.

Multicollinerarity, principal component analysis, use of dummy variables, Generalised Aitken's least-

squares methods of estimation, Random coefficients models. Heteroscedasticity. Auto-correlation, Durbin-Watson test, error of specification, Estimation from grouped data. Distributed lag model, Use of Dummy Variables, Logit model, Probit Model.

AG ECON 111: AGRICULTURAL ECONOMETRICS-II (3L) III

Mixed estimation: Use of instrumental variables in regression analysis; Errors in variables models. Distributed lag models-alternative specifications-partial adjustment and adaptive expectations model, partial adjustment-cum-adaptive expectations models, Grouping of observations, Grouping of equations. SURE estimates.

Simultaneous equation systems: Basic rationale, identification problems, Single equation methods of estimation-indirect least squares, two stage least squares, and K-class estimators, and limited information, maximum likelihood, three-stage least squares, and full information maximum likelihood; Relative merits of these methods and their small and large sample properties; Recursive models. Pooling cross-section and time series data.

(Pre-requisite: AG ECON 110)

AG ECON 120: AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-I (FARM MANAGEMENT) (2L+1P) I

Farm management and farm business-nature, scope and objectives. Characteristics of farming and requirements of success in farming. Task of management, classification of decisions and the process of decision making in farming. Measurement of management input in farming. Types and systems of farming and factors affecting types of farming.

Basic principles of farm management and farm business - principles of marginal returns, costs substitution in choice of practices, equimarginal returns, combining enterprises and time comparison. Law of comparative advantage.

Farm records and farm accounting. Concept of size of farm and business, Measures of farm efficiency, Methods of evaluating farm assets, outputs and inputs, Methods of computing depreciation, cost concepts.

Elements of Costs- Material cost, Labour cost, Overhead cost, Cost statement, Cost accounting, Cost audit. Cost of production and pricing. Cost-Volume-Profit relationship.

Essentials of farm planning and budgeting, farm surveys, questionnaire preparation and pretesting, data collection and analysis, enterprise budgets, partial and complete budgets and whole farm planning.

Elements of risk and uncertainty in agriculture, measurement of risk and adjustments to risk, Review of farm management research, education and extension in relation to changing needs in India.

AG ECON 130: ECONOMICS OF MARKETING (2L+1P) I

Marketing and price in an exchange economy-concepts of market, demand, supply and price equilibrium. Joint demand for goods and services. Concept of a perfect market. Measures of marketing efficiency.

Spatial dimension of price and production. Price equilibrium in spatially separated markets-two- and multi-region cases. Space and transfer costs; components of transfer costs; distance-cost relationship; transfer cost surface. Alternative modes of transportation; effect of transport network on costs; collection and delivery cost functions. Minimisation of transfer costs.

Markets with spatially dispersed production-the concept of site price. The law of market areas; boundaries between competing markets.

Efficient organisation within market areas -

product assembly, isolated plant sites, competing plants, processing plants and numbers. Elementary theory of location.

Price equilibrium with alternative product forms. Product form choices; product price boundaries; processing costs; short run plant costs; multiple product forms and spatially separated markets.

Temporal market price relationship - time dimension and storage cost; two period demand case; multiperiod demand case; carryover between production periods; spatial and seasonal price models.

Price discrimination among markets - types of price discrimination. The theory of price discrimination. Models of firm behaviour. Price discrimination among markets, product forms, time and space.

AG ECON 150: AGRICULTURAL DEVELOPMENT AND PLANNING (3L) II

Role of agriculture in economic development. Theories of agricultural development. Economics of traditional agriculture. Socio-cultural and institutional constraints in technology transfer. Planning models. Planning for utilization of resources and Indian Five Year Plans. Measures bias and technical change and its implication on agricultural development; indicators of sustainability and their measurements; Forward and backward linkages. Measurement of inter-regional and temporal variations in agricultural growth and equity. Agricultural development in USA, Japan, China and India.

AG ECON 201: MICROECONOMICS-II (3L) II

Monopoly-basic theory, profit maximization-cost function, production function approaches; price discrimination, types of discrimination, monopoly applications - multiple plant/product monopolist, taxation effects, revenue maximising monopolist, monopsony - profit maximisation analysis, monopolistic competition-short run and long run equilibrium analysis, duopoly and oligopoly-quasi-competitive, collusion, Cournot and Stakelberg solutions for homogenous product market; product differentiation, market shares and kinked demand curve solutions for differential products; duopsony and oligopsony-profit maximization analysis, bilateral monopoly-reference, collusion and bargaining solutions, theory of games – two person and zero sum games and mixed strategies.

Theory of distribution: demand/supply/pricing of single and several factors-perfectly and imperfectly competitive markets-monopoly in product market, monopsony in factor market, bilateral monopoly, marginal productivity theory of input returns, distribution and relative factor shares, rent, wages, interest and prices, elasticity of factor substitution, technological progress and income distribution-neoclassical theory, effects of technological progress, pricing of fixed factors, the adding-up and product exhaustion theorems.

Multimarket equilibrium-pure exchange, two commodity exchange, production and exchange: analytical approaches, Walras law, numeraire and money-monetary equilibrium and money in the utility function; Multimarket equilibrium-existence, Brouwer's fixed point theorem; static and dynamic stability analysis, uniqueness, input-output model-output/price/income determination, substitution theorem and decomposability analysis.

(Pre-requisite: AG ECON 101)

AG ECON 202 : MACROECONOMICS-II (3L) I

Introduction to dynamic macroeconomic Models, Inflation and unemployment, supply side tax effects, The use of rational expectations, Business cycle and its alternative equilibrium model, Stability analysis.

Monetary and fiscal policies, Fiscal Policy as an instrument of development, incidence of tax and fiscal policies, policy mix.

Public Borrowing-Internal and external aid, Deficit financing, Development Financing; The international general equilibrium system; Impediments to global efficiency; International macro economic policies, IMF, IBRD,UNCTAD, NIEO. Students desiring to undertake in depth study may be encouraged for group wise visits to international economic institutions.

(Pre-requisite: AG ECON 102)

AG ECON 220: AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS–II (PRODUCTION FUNCTION ANALYSIS) (2L+1P) II

Production concepts. Resource product relationship in agriculture. Important historical background and characteristics of different forms of production functions-linear, quadratic, square-root, Spillman, cubic, semi-log, Cobb-Douglas-optimisation, CES, VES and Leontief. Frontier production function.

Production surfaces, isoquants and isoclines, economic application. Principles of choice and resource allocation. Price and production relationship. Resource combination and cost minimisation, optimisation of inputs use under various resource conditions.

Multiple product relationship. Production possibility curves. Choice between products and resource use. Spatial and temporal allocation of resources.

Returns to scale and farm size. Analysis of factor shares in agriculture and their implications on income distribution.

Dualities between production, cost and profit functions; Derivation of supply and factor demand functions from production and profit functions.

Optimization under risk and uncertainty; optimisation over time.

(Pre-requisite: AG ECON 101)

AG ECON 221: AGRICULTURAL PRODUCTION AND RESOURCE ECONOMICS-III (LINEAR PROGRA-MMING) (2L+1P) III

Problem formulation for programming; preparation of input-output matrix, objective functions and constraint equations. Assumptions of linear programming; basic and non-basic solutions; feasible and infeasible solutions.

Linear Programming: Graphical method; Simplex method; Simplex method and its application for solving agricultural problems; use of artificial factors; problems of degeneracy, inconsistency, infeasible and unbounded solutions. Generalised simplex method; dual simplex method.

Application of linear programming for solving practical problems in farming with the help of following: Variable resource programming; variable price programming; integer programming; recursive programming. Risk programming. MOTAD and its extensions. Theory of games and application of linear programming for solving games problems in farm decision making. Sensitivity analysis. Goal programming and its

application, Multi-objectives programming. Transportation models. Dynamic programming. Inventory and waiting line models: Inventory control – deterministic and probabilistic models. Queuing models. Non-linear programming.

AG ECON 230: INTERNATIONAL TRADE (3L) II

International trade: Basic concepts. The theory of international trade; absolute and comparative advantage; international trade equilibrium.

Supply side analysis: opportunity cost; trade under increasing opportunity costs; factor endowments; trade and factor prices; factor price equalisation.

Demand side analysis: community indifference curves; demand and international trade.

Integration of demand and supply; offer analysis; general equilibrium; equilibrium in product and factor markets.

Application of trade theory; terms of trade; supply and demand shifts; technological change; factor supplies and trade; factor intensities; transport costs; location. Trade with many goods and countries; Leontief paradox; human skills; technological gaps; the product cycle; scale economics.

Trade policy: Protection; tariff and non-tariff measures; trade and market structure; trade liberalisation; factor mobility and movements; role of multinational enterprises.

International finance: institutional money and credit markets; foreign exchange markets.

Balance of payments analysis: funds flow; capital and current account. international adjustment mechanisms; fiscal and monetary adjustments.

The International Monetary System; Bretton Woods to WTO. Recent developments in the international trade system. Implications for developing countries. Trade Blocks.

(Pre-requisite: AG ECON 130)

AG ECON 231: FUNDAMENTALS OF BUSINESS MANAGEMENT (3L+1P) III

Foundations for study of management: Management defined; management as an art and science; technical, human and conceptual requirements for management. Principles of management. Managerial philosophy.

Problem solving and decision-making: Problem recognition and analysis. Managerial decision-making process. Processing of information - quantitative and qualitative.

Planning: Setting objectives; MBO (Management by objectives); Goal setting. Strategic planning. Implementing management plans. Policy formulation.

Organizing: Organizational structure and design. Authority, control and organizational relationships. Responsibility.

Actuating: Actuating human resources; staffing and recruiting. Managerial motivation – theories of motivation. Leadership and related theories. Trait theories. Situational theories. Managerial communication. Appraisal. Compensation. Motivation.

Controlling: Management control. Audits. Operating control of quality and quantity. Budget control.

Sales forecasting, sales budgeting and control.

Common property resources and their management.

AG ECON 235: AGRICULTURAL PRICE ANALYSIS (2L+1P) I

Consumer behaviour. Producer behaviour. Producer and consumer core system. Price determination. Demand for and supply of farm products. Demand for and supply of factor inputs in agriculture. Demand model for durable inputs. Demand for capital and credit. Models for predicting marketed surplus, income growth. Total factor productivity and its sources. Price policy models. Demand supply projections. Food Security. Market integration. Buffer stocks operations; PDS. Futures market.

(Pre-requisite: AG ECON 110)

AG ECON 240: AGRICULTURAL FINANCE-I (2L+1P) III

Definition and scope of agricultural finance. Its relationship with farm management, land economics, principles of economics, psychology and sociology. Growing emphasis on agricultural finance in developing countries. Changing concept of agricultural finance with special reference to India. Introduction to public finance. Agricultural finance as a part of public finance.

Capital in agriculture: Classification of capital - working capital and fixed capital, divisible and indivisible capital, owned and borrowed capital. Sources of capital. Principles of capital investment: average rate of return, pay back, internal rate of return, net present value and capital budgeting.

Meaning and concept of agricultural credit: Capital and credit, credit as a substitute for saving, credit and saving. Classification of farm business credit, production versus consumption credit. Desirable characteristics of a loan. Credit as a tool for economic development. Different methods of charging interest, cost of credit.

Financial accounting system: Balance sheet analysis, its valuation difficulties, income statement, inventory adjustments, percentages and ratios.

Three R's of credit; 3 C's of credit and their relation to 3Rs of credit. Return as a guide in use of credit; marginal analysis; budgeting. Incorporating risk in budgeting. Repayment capacity. Self liquidating loan; non-self liquidating loans. Strengthening repayment capacity. Terms of payment. Different types of risks; risk bearing ability. Increasing owner equity; Stabilising income; Diversification, insurance, flexibility and contracts. Internal cash / asset rationing. Internal credit rationing; External credit rationing.

Legal aspects of credit: Real estate mortgage; Title theory; Chattel mortgages: Livestock, Crop, Commodity, equipment, miscellaneous. Promissory note; sale contract; other credit instruments.

Concept of supervised credit; objectives of supervised credit; procedures, costs and sources of funds for supervised credit; supervised credit and extension agencies.

Agricultural taxation; investment criteria (portfolio analysis).

Brief review of institutional lending procedures in India.

AG ECON 241 : AGRICULTURAL FINANCE-II (3L) I

Evaluation of Agricultural Credit and Policies in India-history of rural financial market, relative importance of various credit institutions. Financial intermediaries, their role and importance in Agricultural Development. Review of various Committee Reports on Rural Credit and Investment-Rural Debt and Investment Surveys, All India Rural Credit Survey Committee report, All India Rural Credit Review Committee report, CRAFICARD report, Khusro Committee Report, Narasimham Committee report.

Cooperative Banking Institutions-Role of cooperatives in financing Agriculture-Social control of credit: Bank natioalisation, Lead Bank schemes, Group lending, Role of commercial banks in financing agriculture, Rural credit review panel report-Multi agency approach. Small farmers development agencies. Role of State Bank of India in financing agriculture. Role of Reserve Bank of India in financing agriculture. Agricultural financing and infrastructure programmes for weaker sections. Credit guarantee scheme-Crop insurance. Agricultural Finance Corporation, Agricultural Refinance Corporation, NABARD-Agricultural taxation, Agricultural subsidies and Indian agriculture.

Role of functioning of International Financial Institutions-World Bank, IMF and Asian Development Bank.

(Pre-requisite: AG ECON 240)

AG ECON 250: ECONOMIC DEVELOPMENT (3L) III

Concepts of economic growth, economics of development and under development: Theories of economic growth-classical, Marxian, Keynesian and neoclassical growth theories; Theories of under development-Low level equilibrium trap, critical

minimum effort, big push; take-off, social and technological dualisms. Models of economic growth-Harrod-Domar, Kaldor, Mahalanobis, Lewis, Fei-Ranis, Input-Output, multisectoral models. The roles of capital accumulation, human capital and technological change in economic development, Strategy of economic development-Balanced vs. Unbalanced growth, choice of technique, investment criteria. Research prioritisation and resource allocation.

(Pre-requisite: AG ECON 150)

AG ECON 251: AGRICULTURAL POLICY (3L) I

Meaning of Agricultural Policy- Criteria for policy-means, ends and conflicts of objectives, a simple model of welfare maximization, agricultural policy for interpersonal and interregional balanced growth. Efficiency and Welfare Impact Assessment, Role of the Centre and the State.

Food Policy- Production, marketing and distribution, evaluation of agricultural price policy in the short run and long run, Agricultural taxation and subsidy, Land policy, Credit Policy.

Agricultural Policy Analysis- Allocation of public funds including research funds and institutional credit among regions and commodities, population-energy policy. Market liberalization policies, infrastructure policies, agricultural labour policies, input policies, technology policy. Critical review of Agricultural Policy.

Food security and nutrient policy analysis- Concepts and definition of poverty, inequality, food security and malnutrition; Poverty, hunger, poverty mapping, gender analysis.

AG ECON 261: RESEARCH METHODS (1L) I

Selection and formulation of agricultural economic research projects. Preparation of scientific reports and thesis.

Sampling; sampling methods-block, area, systematic, simple and stratified random sampling, non-sampling errors, non-response in surveys.

Methods of data collection-interview and non-interview survey, cost accounting method, preparation of interview schedules. Mechanics of analysis-coding, tabulation testing, presentation and interpretation for audience or publication.

Analysis of economic time series components and their interpretation. Growth curves and their estimation. Index numbers, their characteristics and construction of price and quantity index numbers.

(Pre-requisite: AG ECON 110)

AG ECON 320: AGRICULTURAL RODUCTION AND RESOURCE ECONOMICS-IV (AGRICULTURAL PRODUCTION UNDER RISK) (1L+1P) I

Various types of risk in agriculture and their measurement: Decision Theory: Introduction to decision analysis, Concept of probability, subjective probability and its illustration,

estimation of posterior probability in the application of Bayes' Theorem. Selection of optimal action under risk with and without forecast device. Minimax and Maximin Criterion; General Model of Discrete Decision Analysis.

Risk response analysis-Supply response risk, formulation of production function under risk, Optimum input decision under risk.

Risk Programme Model-Linear risk programming model, Portfolio selection or E-V model, Markowitz model, McInnerrey's model, Hazell model, Kataoka model.

AG ECON 331: MARKETING MANAGEMENT (3L+1P) III

Understanding marketing management - Core concepts of marketing. Orientation of agricultural organisations and companies towards the market place. Adoption of marketing management in the agricultural sector. Building customer satisfaction

through quality, service and value. Marketing process. Marketing plan.

Analyzing marketing opportunities: Marketing information system. Marketing decision. Marketing research. Analyzing buyer behavior, industries and competitors.

Researching and selecting target markets: Measuring and forecasting market demand; identifying market segments and selecting target markets. Marketing Mix. Indian marketing environment- the agricultural scene.

Developing marketing strategies: Differentiating and positioning the market offer. PLC (Product life cycle). Designing marketing strategies.

Marketing programs: Managing product lines, brands, packaging. Managing service business and ancillary services. Pricing strategies, decisions and programmes. Marketing channels: Importance, role and selection. Designing communication and promotion programmes. Managing sales force.

Evaluating and controlling market performance: Annual plan control. Profitability control. Efficiency control.

Computer application in marketing management: Market intelligence, its need, analysis and dissemination - Case studies

AG ECON 332: QUANTITATIVE ANALYSIS OF MARKETING PROBLEMS: APPLICATION STUDIES (2L+1P) I

The role of models in marketing; Use of mathematical models.

Allocation models: The assignment problem; the transportation problem; media selection problem; channel selection problem; product line selection problem; blending problem.

Competitive Strategy Models: Blending problems; equipment purchase problems; pricing problems; sequencing problems; brand switching models; market share problems; Personnel management problems.

Waiting line models: Facility planning problems at market yards; service facility problems.

Network models: Problems of new product introduction; Problems of moving markets to new locations; Planning problems of marketing projects like processing development.

Inventory Models; Manpower planning problems; Pipeline storage inventory problems; Buffer stock problems.

AG ECON 340: STRATEGIC MANAGEMENT FOR AGRIBUSINESS (2L+1P) II

Total quality management: TQM and business strategy; economics of quality control; Statistical tools and techniques for quality control.

Introduction to Agmark, BIS, ISI and FPO. GMP/GHH (good manufacturing and hygienic practices), TQC/TQM (total quality control and total quality management), SQC (Statistical Quality Control), product quality monitoring, HACCP (hazard analysis and critical control points), *Codex alimentarius* (international quality standards), ISO standards and certification. Food standards for safety and health. Quality appraisal and auditing systems.

Inputs for Strategic planning: Environmental scanning. Internal scanning. Identification of competitive advantages. SWOT analysis.

Developing Strategies**:** Strategy at different levels and departments in the organization. Strategy formulation. Corporate level strategies. Business level strategies. Price and non-price strategies. Integration strategy. Situational strategy. Evaluation of strategy. Implementation of strategic plans.

Creating and sustaining a strategic organization: Strategic organizations versus others. Inputs and role of people – the prime movers. Importance and role of organizational culture and leadership in creating and maintaining strategic pro-activeness of the organization.

AG ECON 341: INSTITUTIONAL AND LEGAL ENVIRONMENT FOR AGRIBUSINESS (2L) I

Agribusiness Institutions; SWOT analysis; Case studies: Contract farming, Food processing units, NGO, professional support and services.

Manager's functional use of various legal documents like acts, rules, notifications and executive orders; and salient features of commercial and regulatory laws of general interest and laws related to organizational forms.

Increasing concern for ethical standards in business practices, Issues of human rights, environment, consumer protection and fair market practices and their impact on the fortunes of the firm, options available to the manager,

the fundamental need for firms to be proactive, self-disciplined, creative and responsive.

Non-tariff barriers (sanitary, phyto-sanitary) and Tariff barriers (Government support, export subventions); Social and legal concerns; protection of traditional knowledge and traditional practices; Environmental impact and concerns

Market integration. Processing, Marketing and Trade of Agricultural Products.

Risk management and early warning system. Organizing farmers and their participation for policy planning.

AG ECON 342: MANAGEMENT OF R&D AND INNOVATION (2L+1P) II

Technological Innovations and Creativity: Nature, process and importance of technological innovation; R&D and economic Development; Product design, marketing and consumer; Innovation and creativity.

Technology Development and Diffusion: Technology generation, assessment, refinement and diffusion.

Strategic Considerations: R&D as a corporate function; R&D resources; Partnerships in Innovation.

Organisation for R&D and Innovation: Human resource management issues in innovation and R&D; Leadership and R&D Management; Organisation Design and Structure for R&D; R&D Project Management; Measurement, Evaluation and Assessment of R&D.

Assessment of different technological options: Conventional, chemical based, organic farming, GMOs etc. and their impact on food quality, safety, food security, and poverty.

Micro Considerations: Research priority setting; National R&D infrastructure and Institutional Framework; Fiscal and other incentives; Industry, institutions and Government Interface.

Issues in R&D Management: Commercialisation of R&D; Management of Intellectual Property Rights; Financing of R&D projects.

AG ECON 360: AGRICULTURAL PROJECT ANALYSIS (2L+1P) I

Definition of a project, identification and formulation of project, need for project, ex-post and ex-ante appraisal, basic data requirement, discounted cash flow analysis and measure of probability, choice of discount rate, consideration of alternatives, divergence of private and social profits, government action to bring out equality of social and private profits, social objectives and accounting price.

Allocation of scarce resources; land, labour, capital foreign exchange; present and future consumption, optimum use of taxes and subsidy.

Public ownership and planning, relationship between plans and projects selection and investment programme; private sector projects, method of evaluation of private projects, social cost-benefit and switching values, uses and abuses of sensitivity analysis.

Accounting prices for traded and non-traded

goods, marginal social costs and marginal social benefits, financing of projects, scale and fixing of projects, impact of project outputs on production and consumption elsewhere. Shadow wage rates and accounting rate of interest, uncertainty and investment criteria, external effects related to inputs and outputs of the projects, indicators of economic worthiness in project appraisal; period of recovery, capital output ratio, accounting rate of return, benefit cost ratio, internal rate of return, net present value, economic rate of return, comparison of indicators.

AG ECON 299: SEMINAR (1L) I/II/ III

3

AGRICULTURAL ENGINEERING

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
AE 127	OPERATIONS RESEARCH	3	0
AE 128	INSTRUMENTATION AND RESEARCH METHODOLOGY IN AGRICULTURAL ENGINEERING	2	1
AE 131	ENVIRONMENTAL ENGINEERING FOR PLANTS AND ANIMALS	3	0
AE 214	DYNAMICS OF FARM MACHINERY	2	1
AE 216	PRODUCTION TECHNOLOGY	2	1
AE 222	OPEN CHANNEL HYDRAULICS	3	l
AE 223	SOIL MECHANICS	3	l
AE 227	FLUID MECHANICS	3	1
AE 230/ PHT 230	HEAT AND MASS TRANSFER	3	0
AE 232	DESIGN OF STORAGE STRUCTURES	l	l
AE 251/ ES 210	SOIL & WATER CONSERVATION ENGINEERING	3	0
AE 299	SEMINAR	l	0

II Trimester

AE 129	DIMENSIONAL ANALYSIS AND SIMILITUDE	2	0
AE 209	ERGONOMICS	2	1
AE 212	THEORY OF ELASTICITY AND APPLICATION	3	0
AE 213	EXPERIMENTAL STRESS ANALYSIS	2	1

AE 215	SOIL DYNAMICS	2	1
AE 219	ADVANCED FARM POWER	2	l
AE 220	LAND AND WATER MANAGEMENT SYSTEMS DESIGN	3	0
AE 225	ADVANCED HYDROLOGY	3	l
AE 226	FARM DRAINAGE SYSTEMS DESIGN	3	1
AE 229	IRRIGATION SYSTEMS DESIGN	3	1
AE 231/ PHT 231	DRYING AND DEHYDRATION	2	1
AE 233	DESIGN OF PROCESSING PLANTS	3	0
AE 242	FARM STRUCTURES AND ANIMAL HOUSING	2	0
AE 245	NUMERICAL METHODS IN FLUID FLOW AND HEAT TRANSFER	2	1
AE 299	SEMINAR	l	0

III Trimester

A 16	BASIC AGRICULTURAL ENGINEERING	1	1
AE 130/ PHT 130	ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS	2	1
AE 143/ ST 143	SEED PROCESSING	2	1
AE 208/ ES 208	RENEWABLE SOURCES OF ENERGY	2	1
AE 210	ADVANCED STRESS ANALYSIS	3	0
AE 211	THEORY OF VIBRATIONS	3	0
AE 218	ADVANCED FARM MACHINERY DESIGN	2	1
AE 221	GROUNDWATER HYDRAULICS AND DEVELOPMENT TECHNOLOGY	2	l
AE 228	FLOW THROUGH POROUS MEDIA	2	1
AE 234	UNIT OPERATIONS IN AGRICULTURAL PROCESS ENGINEERING	3	0
AE 252	WATERSHED MANAGEMENT	2	1
AE 253	MODELING IN INTEGRATED WATER RESOURCES MANAGEMENT	2	1
AE 299	SEMINAR	l	0

Core Courses :

For M.Sc: Within the discipline: AE 128 and AE 129

Outside the discipline: AS 101, AS 150 and CS 123

Agricultural Engineering

Major Fields: **Farm Power and Equipment**
Soil and Water Conservation Engineering
Agricultural Processing and Structures.

Minor Fields: **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

A 16: BASIC AGRICULTURAL ENGINEERING (IL+IP) III

Scope and application of Agricultural Engineering. Soil and Water Conservation Engineering; important physical properties of soil; soil erosion- types; causes and control; soil conservation structures; irrigation wells; tubewells and pumps; measurement, conveyance and control of irrigation water, sprinkler and drip irrigation. Field drainage; surface and sub surface drainage. Farm Power, sources and scope of mechanization, use of farm engines, power tillers and tractors on the farm, use of electricity on the farm. Farm Machines, selection, utilisation and maintenance of farm machinery, agricultural equipment and machines for seed-bed preparation, seeding, interculture, plant protection, harvesting and threshing, farm machinery standards and quality control, farm workshop tools, simple manufacturing processes and machines. Agricultural Processing and Structures; cleaning, grading, drying, milling, packaging, thermo-chemical treatments, storage and materials handling; livestock housing; greenhouses and other controlled environment structures.

AE 127: OPERATIONS RESEARCH (3L) I

Introduction to methods of operations research, formulation of problem and construction of models, linear programming, solution to linear programming problems, sensitivity analysis, duality in linear programming, net work analysis including flow, shortest route, minimal spanning tree, PERT and CPM, transportation and assignment problems. Sequencing and scheduling, inventory control, replacement models, Markov chains, dynamic programming.

AE 128: INSTRUMENTATION AND RESEARCH METHODOLOGY IN AGRICULTURAL ENGINEERING (2L+1P) I

Elementary concepts of measuring systems. Performance characteristics, Advance techniques

of measurement of force, motion, torque and power, pressure, temperature, flow etc. Signal conditioning and monitoring, Applications in measuring devices. Parameters involved in agricultural engineering research, planning and organising experiments for data acquisition and statistical analysis. Application of digital computers in data acquisition and analysis. Data retrieval and report writing.

AE 129: DIMENSIONAL ANALYSIS AND SIMILITUDE (2L) II

Scope of dimensional analysis, transformation analysis, transformation of units of measurement, dimensional homogeneity, complete sets of dimensionless products, Buckingham's pi theorem, determinants, transformation of dimensionless products, similarity and model testing, dimensional analysis as applied to problems of stress and strain, fluid mechanics, heat transfer and electro-magnetic theory, differential equations and similarity. Application of dimensional analysis to problems of Agricultural Engineering.

AE 130/PHT 130: ENGINEERING PROPERTIES OF BIOLOGICAL MATERIALS (2L+1P) II

Biological materials, uniqueness in relation to other materials; physical characteristics viz. dimensions, density, volume, porosity and surface area; concept of rheology; rheological equations for stress and strain; visco-elastic characteristics of food materials; aerodynamic and hydrodynamic properties; thermal, electrical and optical properties; applications of engineering properties in design and operation of agricultural equipment and systems.

AE 131: ENVIRONMENTAL ENGINEERING FOR PLANTS AND ANIMALS (3L) I

Description of aerial environment near the earth's surface; transport processes in soil; environmental interactions of biological systems and their physical surroundings emphasizing biological response of animals and plants; design of efficient environmental control machines and systems to enhance productivity and health.

AE 143/ST 143: SEED PROCESSING (2L+IP) III

Introduction to seed processing; preparing seed for processing; seed drying; cleaning and grading; seed treatment; seed handling; weighing and bagging; Seed storage; Construction, layout and installation of seed processing plant; Economics of seed processing; management of seed processing plant.

AE 208/ES 208: RENEWABLE SOURCES OF ENERGY (2L+IP) III

General concepts in heat and mass transfer, availability of solar radiation, characteristics of different materials for use in alternate energy devices. Energy use pattern. Solar energy applications; design of solar energy operated systems for heating, cooling, distillation, drying, dehydration, water pumping and power generation for rural applications, photo-voltaic devices, energy storage, utilisation of wind energy for electrical and mechanical power generation, types of wind mills and their characteristics, mechanics of wind mills, design of wind mills. Recycling of agricultural waste. Energy conversion processes of plant materials to fuels. Anaerobic fermentation of biomass. Design of biogas plants for heating, lighting and power generation. Producer gas and its utilisation. Concepts of hybrid and integrated energy conversion systems; energy auditing methods; energy modeling.

AE 209: ERGONOMICS (2L+IP) II

Importance and scope of ergonomics in Indian Agriculture; major human physiological systems and processes; physiological concepts; physiological responses and indices; assessment of work performance; design of tools, equipment, controls and work space; physical environment in relation to human performance and physical well being; its assessment and control.

AE 210: ADVANCED STRESS ANALYSIS (3L) III

Plane stresses, stress-strain relationship, equilibrium and compatibility equations, Airy's function, three dimensional stress analysis, stresses in thick .cylinders, elastic strain energy, theory of failure, shear centre, unsymmetrical bending, curved flexural members, non-circular shafts.

AE 211: THEORY OF VIBRATIONS (3L) III

Analysis of single and multiple degree of freedom system using Newton's law of motion, the energy method, influence coefficient and matrices method. Introduction to transient vibration in a system using Laplace transform and vibration of continuous media.

AE 212: THEORY OF ELASTICITY AND APPLICATION (3L) II

Equations of elasticity in two and three dimensions, two dimensional problem in polar and curvilinear coordinates. Torsion of non-circular shafts, bending of prismatic bars.

AE 213: EXPERIMENTAL STRESS ANALYSIS (2L+1P) II

Experimental stress analysis method in agricultural machine design, electrical resistance in strain gauge rosette, brittle lacquer, photoelastic method and photo-stress, testing techniques

AE 214: DYNAMICS OF FARM MACHINERY (2L+1P) I

Farm machine systems characteristics and evaluation, Analysis of forces, motion and their equilibrium in the elements of farm machines, dynamic balancing and stability of farm machines. Analysis of typical problems in tractor implement systems. Research reviews on design and analysis of farm machines and components.

AE 215: SOIL DYNAMICS (2L+1P) II

Stress-strain relationship in soil, failure pattern, pulverization, effect of speed, energy requirement and model simulations. Relationship of soil parameters to forces acting on tillage tools, design of soil working implements.

AE 216: PRODUCTION TECHNOLOGY (2L+IP) I

Reliability of engineering. product, risk analysis. Workshop planning and layout. Theory of plastic properties and heat treatment of metals. Workshop practices applied in prototype production, common tools, press operations:theory and practice of welding; welding processes; metal cutting and machining process; jigs, fixtures and gauges; casting and die casting processes. Non-traditional methods of machining. Computer aided manufacturing system, CNC, DNC, robotics.

AE 218: ADVANCED FARM MACHINERY DESIGN (2L+1P) III

Principles of design and development of agricultural machines; hydraulic and mechanical power transmission systems; linkages on agricultural machines safety devices on farm equipment, design characteristics and force analysis of various soil working tools; design standards and operation of seed drills and planters; design and operation of machines for chemical plant protection; design of forage, root crops and grain harvesting equipment; design factors and equipment for threshing and winnowing of crops; utilization efficiency and performance of various agricultural machines; introduction to computer simulated designs.

AE 219: ADVANCED FARM POWER (2L+lP) II

Animate and inanimate sources of farm power, farm power use patterns in India and abroad; analysis and testing of internal combustion engines specifically for use in farm tractors, transmission, chassis and stability; traction theory; slippage and sinkage of wheels; tractor tests and test codes; power losses in the tractor; dynamometers and hydraulic equipment; selection of tractors and power tillers

with reference to land holdings; power requirement for various farm operations; utilization and performance of power tillers; pollution by tractors and farm engines; methods to control pollution; manufacturing of tractor and power tillers in India, use of alternate fuels; problems and prospects.

AE 220: LAND AND WATER MANAGEMENT SYSTEMS DESIGN (3L) II

Introduction; review of different models (both deterministic and stochastic) production function; simulation of system response; micro-level optimisation; macro-level optimization; results expected; basic data; case studies.

AE 221: GROUND WATER HYDRAULICS AND DEVELOPMENT TECHNOLOGY (2L+lP) III

Ground water occurrence in India: types of aquifers; geohydrological investigations; basic equations of groundwater flow; groundwater budget; different types of boundary conditions; flow in different types of aquifers; hydraulics of flow towards wells; aquifer tests and modeling; regional groundwater flow; finite difference and finite element methods; groundwater recharge; conjunctive use of groundwater with other sources of water.

AE 222: OPEN CHANNEL HYDRAULICS (3L+lP) I

Open channel flow and its classification: open channels and their properties; energy and momentum principles; critical flow-its computation and analysis; uniform flow and its computation; concepts of boundary layer; surface. roughness; velocity distribution and instability to uniform flow; theory, analysis and methods of computations of gradually varied flow; hydraulic jump; gradually varied and rapidly varied unsteady flow; hydraulic structures for on-farm application and use in energy dissipation and special applications.

AE 223: SOIL MECHANICS (3L+ lP) I

Physical and engineering properties of soil, stress, deformation, shear strength, consolidation, stability and compaction, gradation, moisture content, compaction of soils for earth dams, embankments, piles, foundation and walls theory. Pressure distribution diagram, earth pressure theory, retaining walls, forces acting on earth retaining structures, lateral earth pressure, Coulomb's earth pressure theory, assumptions and deficiencies, active and passive earth pressures, bearing capacity of soils, stability requirements of a foundation, soil rating, soil loading tests, Housel's bearing capacity method, perimeter-area ratio method. Settlement and lateral expansion of soils.

AE 225: ADVANCED HYDROLOGY (3L+lP) II

Mathematical modeling of hydrologic processes-precipitation, infiltration, evapo-transpiration, run-off, soil water balance; probabilistic analysis of rainfall for irrigation scheduling; rainfall-run-off relationships; analysis of hydrographs; watershed modeling; frequency analysis for design of hydrologic systems; time series analysis for hydrologic design and forecasting.

AE 226: FARM DRAINAGE SYSTEMS DESIGN (3L+lP) II

Hydrologic basis for drainage system design; occurrence of floods; analysis of rainfall for drainage system design; analysis of flow into and through soil upto effective root zone depth; drainage and crop production; types of drains; surface drainage systems; sub-surface drains in homogenous isotropic soils and anisotropic .heterogeneous soils; drainage for salinity control; soil dynamics in a sub-surface drained soil; computational analysis for solution of flow and draw-down problems, basics of drainage coefficients and degree of desirable drainage; drainage structures; design, layout and construction of farm drainage systems considering rainfall, topography, soil and crops; gravity-cum-pump drainage systems; drainage using tubewells (vertical

drainage); macro-drainage system considerations in design; outlet considerations, drainage modeling; legislation involved.

AE 227: FLUID MECHANICS (3L+IP) I

Review of fluid properties and definitions; fluids flow concepts and basic equations; kinetics and dynamics of fluid flow; method of describing motion, velocity, acceleration; Euler's equation; stress and deformation components for general cases; fundamental equations derived from principles of mass transfer and conservation of mass, momentum and energy; ideal fluid flow requirements; vortex, irrotational and rotational flow; velocity potential; stream function; flow net; two and three dimensional flow; boundary layer theory; velocity distribution; transition from laminar to turbulent flow; Heleshaw models.

AE 228: FLOW THROUGH POROUS MEDIA (2L+IP) III

Physical and chemical properties for the medium and the fluid; theories of saturated flows; confined and unconfined flow phenomena and analysis; steady and unsteady flow phenomena

and analysis; classical capillary models; parallel, serial and branching types of models; Hogen, Poissenlls, Iberal and Gibb's theories: Venzol's model: diffusion theory; Philip's equation and Muskat models.

AE 229: IRRIGATION SYSTEMS DESIGN (3L+IP) II

Sources of irrigation water availability; hydraulic design of the canal delivery system; traditional concept of crop water requirements and irrigation water demand; design of canal capacities and distribution systems; planning and design of water course network (both surface and underground water distribution systems); concept of equity in water distribution; design and installation of different irrigation structures; farmers' participation in irrigation water management; design of systems for direct pumping from flowing streams, small reservoirs, wells and tubewells; design with constraints of water supply, funds, material and equipment; irrigation scheduling and irrigation efficiencies; principles of irrigation scheduling and water application in relation to soil-plant and climatic parameters; design, construction and layout of different surface water application methods compatible with evaluation of surface water application methods; feasibility of pressurized irrigation system, sprinkler and micro-irrigation systems; types of various systems, their design considerations, design procedures, evaluation of the, systems, layout and uniformity determination; operation and maintenance of the sprinkler and micro-irrigation equipment; design of software part of the sprinkler and micro-irrigation systems; energy consideration, its requirement and optimisation for different agro-climatic conditions; economic analysis of the systems.

AE 230/PHT 230: HEAT AND MASS TRANSFER (3L) I

Modes of heat and mass transfer: uni- and

multi-directional heat conduction; principles of conservation; boundary layer and turbulence: momentum and energy equations; radiative heat transfer; heat and mass transfer analogy; molecular diffusion of fluids; mass transfer operations; absorption; adsorption; extraction-exchange and leaching.

AE 231/PHT 231: DRYING AND DEHYDRATION (2L+lP) II

Kinetics of moisture sorption and desorption, mechanism of moisture transport, theory of drying, drying rate calculation, methods of drying grains, seeds and forage crops, dehydration techniques for different food products, effect of drying and dehydration on physico-chemical compositions.

AE 232: DESIGN OF STORAGE STRUCTURES (lL+lP) I

Storage losses of food materials due to micro-organisms, enzymes, moisture and insects. Treatments of agricultural products for longevity in

storage, equilibrium moisture content, moisture migration, design of fans and aeration ducts, different methods of storage, basic principles in design of grain storage structures, effect of friction, pressure distribution and flow characteristics, salient features in design of cold storage structures.

AE 233: DESIGN OF PROCESSING PLANTS (3L) II

Raw food materials, harvesting, handling and packaging of food materials, unit operations in processing plants, plant layout and its evaluation, salient features of processing plants for cereals, horticultural crops, poultry and meat products, guidelines for design and cost analysis of processing plants.

AE 234: UNIT OPERATIONS IN AGRICULTURAL PROCESS ENGINEERING (3L) III

Size reduction, sorting and grading, threshing, dehusking and milling, principles ofcleaning, aspiration and ventilation, extrusion, materials handling devices and their operational features, packaging machinery and materials.

AE 242: FARM STRUCTURES AND ANIMAL HOUSING (2L) II

Types of farm structures and animal housing, design of farm structures, environmental control in farms, livestock building and storage structures, green house, selection of material and equipment. Cost estimation.

AE 245: NUMERICAL METHODS IN FLUID FLOW AND HEAT TRANSFER (2L+ 1P) II

Review of governing equations and their classifications; discretisation procedures; stability; consistency; convergence; alternative methods; problem formulation; applications for steady state and time dependent problems.

AE 251/ES 210: SOIL & WATER CONSERVATION ENGINEERING (3L) I

Concepts of soil and water conservation; relevance of soil and water conservation in agriculture; productivity loss due to soil erosion; moisture stress and moisture excess. Types of soil erosion; mechanics of water erosion of soil; effect of land preparation and cultivation practices on soil erosion; theories of sediment yield and sediment transport; bed load movement; measurement of sediment yield and sediment transport; effective life of dams and water detention structures; effect of soil erosion on the life of multi-purpose river valley projects; soil erosion loss and fertility; erosion in water conveyance systems; design of channel for erosion control; maximum permissible velocity; hill soil erosion; land slides; mechanics of wind erosion; types of wind erosion and soil movement; wind erosion control measures. Analysis of hydrologic data including rainfall, evapotranspiration; watershed characteristics; overland flow; methods of estimation of runoff; peak rate and time distribution of hydrograph; synthetic hydrograph; infiltration process; hydrologic evaluation of land treatment; flood routing. Erosion control; design of soil conservation structures; farm ponds and temporary storage reservoirs, drop structures; chute spill ways; temporary storage reservoirs; small earth dams; afforestation and associated agronomic practices; the role of river valley projects; soil conservation department, CADA etc. in undertaking soil and water conservation work.

AE 252: WATERSHED MANAGEMENT (2L+IP) III

Degradation of land and water resources (processes and status); impact on environment (flood, drought, productivity loss); land capability classification; land use concepts; soil and water conservation measures; design methods and standards; water harvesting, watershed gauging and instrumentation; hydrological data generation; data reduction; estimation of water yield; runoff peak flow and soil loss of small watersheds; watershed

management; integrated land use planning: impact evaluation and assessment; relevance to agricultural water management; watershed management programs in the country; peoples' participation; research status: methodology and future needs.

AE 253: MODELLING IN INTGEGRATED WATER RESOURCES MANAGEMENT (2L+1P) III

Introduction to modeling, model types, models in soil and water resources; model selection techniques; database requirement, availability, generation and use for model development. Development of conceptual and physecs based models. Use of numerical methods in model development and use of Geographic Information System (GIS) tool. Advantage of model hybridization over individual model types, model calibration, validation and testing for accuracy, consistency and sensitivity. Use of expert system techniques, heuristics in soil and water resources; development of expert watershed systems; use of artificial Neural Networks in modeling.

AE 299: SEMINAR (lL) I/ II / III

4

AGRICULTURAL EXTENSION

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
AG EXT 100	FUNDAMENTALS OF EXTENSION	2	1
AG EXT 131	PSYCHOLOGY OF HUMAN BEHAVIOUR	2	1
AG EXT 201	COMPARATIVE AGRICULTURAL EXTENSION	3	0
AG EXT 211	FUNDAMENTALS OF COMMUNICATION	3	1
AG EXT 213	DIFFUSION AND ADOPTION OF INNOVATIONS	2	1
AG EXT 223	AGRICULTURAL RESEARCH MANAGEMENT	2	1
AG EXT 231	TRAINING FOR HUMAN RESOURCE DEVELOPMENT	2	1
AG EXT 261	HERITAGE OF INDIAN AGRICULTURE	2	1
AG EXT 301	ADVANCES IN AGRICULTURAL EXTENSION	3	1
AG EXT 302	METHODS OF MONITORING AND EVALUATION	2	1
AG EXT 321	ADVANCED MANAGEMENT TECHNIQUES	2	1
AG EXT 333	DEVELOPMENT COMMUNICATION	2	1
AG EXT 299	SEMINAR	1	0

II Trimester

AG EXT 101	PLANNING AND EXECUTION OF EXTENSION PROGRAMMES	3	1
AG EXT 212	EXTENSION METHODS AND COMMUNICATION TECHNOLOGY	3	1
AG EXT 222	ORGANIZATIONAL BEHAVIOUR	2	1
AG EXT 234	ADVANCES IN IMPACT ASSESSMENT TECHNIQUES	2	1
AG EXT 241	DYNAMICS OF PLANNED CHANGE	3	1
AG EXT 251	METHODS OF SOCIAL RESEARCH	3	1

AG EXT 311	VISUAL AND GRAPHIC COMMUNICATION	1	2
AG EXT 299	SEMINAR	1	0

III Trimester

A 15	BASICS OF EXTENSION EDUCATION	1	1
A 18	ON-FARM EDUCATION AND VISITS TO DIFFERENT INSTITUTIONS	0	2
AG EXT 111	PHOTOGRAPHY	2	2
AG EXT 121	FUNDAMENTALS OF RURAL SOCIOLOGY	3	1
AG EXT 214	AGRICULTURAL JOURNALISM	3	1
AG EXT 221	FUNDAMENTALS OF AGRICULTURAL MANAGEMENT	2	1
AG EXT 232	ENTREPRENEURSHIP DEVELOPMENT	2	2
AG EXT 252	TECHNIQUES OF MEASUREMENT IN BEHAVIOURAL SCIENCES	3	1
AG EXT 331	ADVANCES IN TRAINING TECHNOLOGY	2	1
AG EXT 299	SEMINAR	1	0

Agricultural Extension

Major Fields: **Agricultural Extension**

Agricultural Communication

Agricultural Management

Minor Fields: **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

The total minimum credit requirement of course work for M.Sc./Ph.D. in Agricultural Extension is 55 / 45 including Minor field(s).

DESCRIPTION OF COURSES

A 15: BASICS OF EXTENSION EDUCATION (1L+1P) III

Concepts and characteristics of education process, Objectives, Philosophy and Principles of Extension Education. Historical development of Extension Education and Community Development in India. On-going Agricultural Extension Programmes at National level. Basic Principles of teaching-learning process. Extension teaching methods and Audio-visual Aids – preparation and use of posters, charts, flash cards, and flannel graphs. Handling of audio-visual equipment and projectors. Concept of rural sociology, social institutions, exposure to village institutions. rural value systems, culture, norms, process of socialization. Concept and elements of communication. Media of Communication-Mass, group, interpersonal and traditional.

A 18 : ON FARM EDUCATION AND VISITS TO DIFFERENT INSTITUTIONS (2P) III

On Farm Education: Analysis of socio-economic profile of rural families and their farming situations, Determination and prioritization of village problems, Formulation of Objectives, Preparation of action plan, Orientation of IARI TOT and KVK activities, Educational Tour, Visit to different ICAR institutes and SAUs for orientation in agricultural research, education and extension programmes, Visit to IARI Regional Stations, Understanding Agro-ecological situation of the country.

AG EXT 100: FUNDAMENTALS OF EXTENSION (2L+1P) I

Origin and growth of Extension in India and

World; Meanings and aims of Education and their implication to extension education; Concepts, meaning and objectives of extension education-An analysis of various definitions of extension education; Role of extension in agricultural development; Growth of extension as a scientific discipline, profession and its relationship with subject matter fields and allied social sciences; Conceptual and philosophical similarities and differences between extension education and extension work, community development, TOT, distance education, and adult education; andragogy and pedagogy; Principles and theories of adult learning; A brief history of development of Agricultural Extension System (AES) in India; Agricultural Extension and early efforts of community development; Community development programme and National extension Service; approaches of rural development; Agricultural extension service system of Department of agriculture, Analysis of different approaches, systems and models of Extension-Farmers participatory approaches, Farmers' first and Farmer Last model, farming system research and extension; Extension role of SAUs and ICAR institutes; Integrated functioning of teaching, research and extension; national demonstration, operational research projects, Krishi Vigyan Kendra, Lab to Land programmes, NARP and NATP (Institute Village Linkage Programme, technology Assessment and Refinement, Agricultural Technology Management Agency, Agricultural Technology Information Centre,)

AG EXT 101: PLANNING AND EXECUTION OF EXTENSION PROGRAMMES (3L+1P) II

Importance, Principles and Process in Developing sound Extension Programmes; Development Planning; Rural Development, Sustainable development, Self- Help Group Approach to Development. Organizational structure for planning at various levels. Formulation of Five Year Plans in India; Planning for grassroots level activities- Role of Panchayats; Need Assessment, Execution of various Programmes; Project formation and Project Appraisal in terms of social benefit analysis; Project Management Technique-CPM and PERT, Logical Framework Approach (LFA), Programme Evaluation; People's participation in Extension Programmes, Participatory Planning through PRA, Hands-on experience in PRA tools and techniques, Significance and importance of Agricultural and Rural Development Programmes, Different approaches of the Programmes, Critical Analysis of the various Agricultural and Rural Development Programmes including NGO's, Visits to selected extension project areas – DOE, KVKs, SAUs, and ICAR institutes.

AG EXT 111: PHOTOGRAPHY (2L+2P) III

Brief history and Basic Science of Photography; Camera: Evolution, its components, functions and use and accessories, Digital Camera, its difference with conventional film camera; Light: Fundamentals, Lighting techniques, daylight and artificial light, creating different photographic set-ups to suit scientific samples; Lenses: Photographic lenses, Lens aberrations, Resolving power, Type of lenses, their application; Exposure: Light intensity and film speed, Exposure controls, Effect of aperture and shutter speed, Over, correct and under exposures, Exposure meters; Depth of field: Sharpness, Variables controlling Depth of Field, Influence in picture making; Filters: Type of filters, Effects and Filter factor, Application in B/W and Colour Photography; Conventional film photographic process: A brief outline about film types and sizes, a brief outline of processing chemistry and printing. The Picture: Elements of a picture, Photographic composition, Forms Feelings, Balance Cohesion and aesthetics; Electronic imaging: Digital photography, Photographing with Digital Cameras and its controls, capturing digital images using scanners and Digital Image Processing, Controlling brightness and contrast; Controlling tones dodging and burning tools; Colour controls - using hue, saturation and variations; Scanning: scanners, scanning reflective and transparent original, resolution and output, post scanning image controls;

Output: intricacies of printing digital images, leaser printing, inkjet printing and photographic paper printing; Output for on-screen presentations and for web pages; Preparing lecture slides – content limitation and layout; its utility in preparing pre-press pages for research papers and other publications; Applications: In Agriculture, Scientific Photography, Communication, Scientific presentation and Extension work.

AG EXT 121: FUNDAMENTALS OF RURAL SOCIOLOGY (3L+1P) III

Individual and Society, Rural Sociology, concept, scope; Importance of Rural Sociology in Development Extension Work; Rural Sociology and other social sciences, Basic concepts in sociology – society, social structure, community, social organization, social institution, culture, social change, cultural change, technological change, social system, social processes, social values, norms, folkways, mores, customs, sanctions, studies on social sanctions in Indian villages; Culture – Concept, types, patterns, cultural relativism, cultural integration, developmental activities; Social Institutions in development; Family – concept, functions, types of families, psycho-social relationship in the family, as a factor in rural development, Kin and clan – Definition, characteristics, functions, its relationship with group behaviour, kinship types : Socialisation – concept and its role in personality formation as progressive and non-progressive rural person; Social Stratification – concept, status, role, rank, class structure, change in class system in rural India, class and caste system, origin, characteristics, Differences between class and caste, communication patterns in caste, class and caste factor affecting rural development, Groups – Definition, types of groups; Role play to explore group dynamics, Leadership – concept, types and range of leadership behaviour and principles of leadership in community development work, techniques of identifying leaders. Religious Belief System – Superstitions, rituals, festivals; Belief system and its significance in rural development; Social Structure, social organization and social system, concept, conceptual differences, types of social structure, social structure as a social factor in rural development process, Social control – Different components of social control, its significance in rural development, Social Change – Concept, cultural change, technological change, planned change, concept of diffusion, acculturation, Important theories of social change; Social Processes/Social Interaction – Definition, concept, types, Role play to explore social processes, Competition, Conflict, Co-operation, Accommodation, and Assimilation, and change in social processes due to development programmes.

AG EXT 131: PSYCHOLOGY OF HUMAN BEHAVIOUR (2L+1P) I

Psychology as science, its scope and importance in extension education, perception, nature of perception, laws of perception, selectivity in perception, sensory factors in perception, importance of perception in extension work, Attitude, meaning and characteristics, studying attitudes of farmers in field situations, formation of stereotypes and prejudices, factors in attitude change, Motivation, nature, characteristics and types of motives, techniques of motivating farm people, Emotion, its nature, types of emotional response, theories of emotion, the role of emotion in regulating human behaviour, Psychosocial distress and coping mechanisms in farming situations, Learning, indicators of learning, definition and principles of learning, theories of learning, experiential learning. Defense mechanisms, types and importance, Personality and Individual differences, Personality as a set of traits, personality as the Self, Roger's Self theory, Maslow's Self actualization theory; The concept of Emotional Intelligence; Emotional literacy; Emotional self-awareness; managing emotions; self-motivation; harnessing emotions productively; empathy; reading emotions; Relationship between Intelligence Quotient (IQ) and Emotional Intelligence (EQ); handling relationships; social skills.

AG EXT 201: COMPARATIVE AGRICULTURAL EXTENSION (3L) I

A worldwide history of development of agricultural extension; Agricultural extension System of the following countries with brief history, approaches, organizational structure, linkage with research and extension methods used: Kenya, Zambia, Ethiopia, Tanzania; : China, India, Indonesia, Japan, Republic of Korea, Philippines, and Sri Lanka; Nether Lands, Denmark, and United Kingdom; Brazil and Mexico; USA; : Egypt and Israel; Extension System in SAARC Countries. A comparative Analysis of current status of Agricultural Extension worldwide with regard to methodology, client groups, activities and output, Extension methods used, research -extension linkage, human resources for extension, and investment and expenditure in extension; Performance and impact of extension: Performance of T&V system in selected Asian and African countries, successful extension approaches, brief account of methodology and reasons for success; FAO small farmers development projects : Masagana 99 Programme of Philippines; BIMAS programme of Indonesia; Social laboratory Experience of Philippines; and building self-help groups for extension in Philippines; Farming System Research and Extension, Expert System of Extension and Participatory methods of Sustainable Extension. Experience of UK, Italy and USA in privatized extension services; Problems of Agricultural Extension and Future Needs, Major worldwide and region-wise problems of agricultural extension, Future needs & strategies of extension to meat the goals of agricultural extension

AG EXT 211: FUNDAMENTALS OF COMMUNICATION (3L+1P) I

Meaning and Nature of Communication – why study communication - Why, when and how of communication, Defining Communication – Communication Process – Nature of Communication – Purpose of Communication – Levels of Communication – Language, Words and Meaning – Categorization – Levels and Degree of Abstraction – Benefits of Language – Hidden Meaning – Non-verbal Communication. Communicator, Role of Communicator in Extension Education – Communicator's Behaviour – Communication skills – fidelity of Communication – Communication competence and empathy – Communication effectiveness and credibility – Improving oral and written Communication, Exercises in written and oral communication. Message – Meaning, Dimensions of a Message – Characteristics of a good Message – Message treatment and effectiveness – Distortion of Message – simulation games and exercises. Channels of Communication. Meaning – Dimensions – classification – selection – efficiency – credibility – use. Audience or Receivers, Feed Back – Communication Behaviour, Social Net Work – Homophily – Heterophily. Traditional and Mass Media of Communication, Theories and Models of Communication. Interpersonal – Intrapersonal – Mass Media. Communicating with farmers and farm women in villages; Barriers in Communication. Communication and Social Change. Futuristic shape of Communication Technology.

AG EXT 212: EXTENSION METHODS AND COMMUNICATION TECHNOLOGY (3L+1P) II

Concepts and characteristics of education process, extension teaching and learning, Basic principles and management of learning; Experiential Learning – simulation exercises, Practising an experiential lecturette; Instruction system design and methods, Effective Instructional modes for science; Evaluating teaching effectiveness; Non-directive teaching methods for team effort and creativity; Extension methods; classification, features and methodology, group discussion, Demonstration, Field Day, Exhibition, Individual contact, and campaign; Role of media and audio-visual aids in making extension teaching effective; Communication technology and Media materials : Classification, uses, Media Planning – Essential & Optional characteristics, system approach; principles of selecting effective combinations of extension

teaching methods, media; Media-mix and Multi-media presentation; Principles of production of different projected and non-projected media; Developing low cost A-V aids; Practising farm and home visits, method demonstration; Preparing, pre-testing of audio and video materials and modules; Handling and maintenance of audio-visual equipment and projectors, PC and peripherals, photography, reprography; Cost benefit analysis of communication media, Methodological issues in communication research.

AG EXT 213: DIFFUSION AND ADOPTION OF INNOVATIONS (2L+1P)

Introduction to the field: Concept of diffusion, elements of diffusion, traditions of research on diffusion,, typology of diffusion research, contributions and short comings of diffusion research; The generation of innovations: The innovation development process, tracing the innovation-development process, converting research into practice; The adoption process: The concept and stages, shades of agreement. The neglected element – the need, dynamic nature of stages, covert and overt processes at stages, the innovation-decision process – a critical appraisal of the new formulation; Adopter categories: Innovativeness and adopter categories, adopter categories as ideal types, characteristics of adopter categories, predicting innovativeness, simulation of innovation diffusion; Perceived attributes of innovations and their rate of adoption, Attributes rating of current farm and home practices, Shades of proposals on attributes, factors influencing rate of adoption. The diffusion effect and the concept of over adoption; Opinion leadership and multi-step flow of innovation: Concepts of homophily and heterophily and their influence on flow of innovations, measuring opinion leadership, characteristics of opinion leaders; Monomorphic and polymorphic opinion leadership; Type of innovation – decisions: Optional, collective, authority and contingent innovation decisions; Consequences of innovations: Desirable or undesirable, direct or indirect, anticipated or unanticipated consequences. Content amalysis of recent adoption studies, Field visit to study recently diffused innovations.

AG EXT 214: AGRICULTURAL JOURNALISM (3L+1P) III

Journalism – Concept, Theories scope; Agricultural Journalism as means of mass communication, Its form and role in rural development Opportunities, strengths and limitations; Basics of Writing – News stories, feature articles, magazine articles, farm bulletins and folders; Techniques of collection of materials for news story and feature articles, News collection and interview, Writing for farm magazines and folders, Rewriting; Art of clear writing: Readability and comprehension testing procedures; Photo Journalism; communicating with pictures; Radio and TV Journalism: Techniques of writing scripts for radio and TV; Agricultural Advertisements: Dynamics, types, storyboard, designing aids, Promoting agricultural products in rural areas; Fundamentals of layout and design; Art of page makeup; designing cover page of magazines; Techniques of Editing and proof reading; Interface with editors of journals and magazines, Research in Agricultural Journalism and applications, Printing methods & processes of printing different extension publications, Budgeting for printing jobs. Visits to different printing presses.

AG EXT 221: FUNDAMENTALS OF AGRICULTURAL MANAGEMENT (2L+1P) III

The nature and scope of management with special reference to agricultural institutions. Administration vs. management. Evolution of management thought. Principles, functions and concepts of management. Basic management issues in an extension organization. Planning – guide lines, requirements and techniques. Systems approach to the planning process. Decision making – steps, tools and limitations. Organizing-basic elements of an organization. Concepts of authority and responsibility. Span of management. Signs of a

poor organization. Departmentation – basic factors to be considered for grouping of activities. Service units – placement. Organizational climate. Delegating – meaning, nature, need, principles and limits. Directing – nature, ways of giving good direction. Consultative direction – merits and demerits. Coordinating – principles and steps. Controlling – meaning, importance and methods. Budgeting – purpose, types of budgets. The budgeting process. Auditing – internal and external. On being a professional manager – roles, styles and strategies. Problems of agricultural management in India. Recent advances in management science. Visit to three different organizations – government, public and private sectors.

AG EXT 222: ORGANIZATIONAL BEHAVIOUR (2L+1P) II

Introduction to organizations: Concept and properties of organizations – levels of organizations – organizational goals – formal and informal organizations, Theories of organizations: Nature of organizational theory – various approaches to organizational theory – classical theories – features of Bureaucracy – administrative theory and Scientific management – Neo-classical theories – – the human relations movement – modern theory – Systems approach to study organizations – Contingency or situations approach, Behaviour in organization : Psychological factors in organization-needs and motives – Attitude and values – alienation and work – work motivation – interpersonal communication – organizational communication – leadership behaviour – decision making, problem solving techniques – organizational climate – change proneness and resistance to change, Organizational structure: Concepts and functions of organizational structure – Process in organizing – Departmentation – span of Management – delegation of authority – Centralisation and decentralization – line and staff organization – functional organization – divisonalisation – Project organization – Matrix organization – free form organization – top management structure. Analysis of cases related to organizational process – attitudes and values, motivation, leadership. Study of organizational structure of development departments.

AG EXT 223: AGRICULTURAL RESEARCH MANAGEMENT (2L+1P) I

Agricultural research system in India: history of Agricultural research in India and present system of Agricultural research, role and characteristics of Agricultural research: Role ;of Agricultural Research – kinds of research basic, fundamental – adaptive – explorative – concept and techniques of Farming System Research; concept, philosophy and functions of research management; research, planning and implementation – identification and prioritization of research problems – evaluation of proposals – Ex-Ante or pre-feasibility study – Fund raising for research project, -techniques of project implementation – application pf PERT/CPM – time management techniques, evaluation of research project, communication of research findings – problems in communication and utilization of research findings, principles of research management, - basic principles of formal organization, - concept of organizational structure, - hierarchy – departmentation – span of management – authority, the scientist: role of farm scientist – needs and motives – socialization process – work motivation, group processes, - interpersonal communication and feed back techniques – increasing interpersonal competencies - immaturity, maturity theory – transactional analysis, - collaborative process, - conflict management, - leadership styles, reward system in research organization, characteristics of successful scientists; case study of life and characteristics of selected scientists, factors of scientific productivity. Exercises in prioritization of research problems, evaluation of research problems, formulation of research proposals, exercises in motivation and team building process.

AG EXT 231: TRAINING FOR HUMAN RESOURCE DEVELOPMENT (2L+1P) I

Training and Education – Concept, meaning and

relationship, factors affecting training, Types of training, current trends in training – organizational development approach; Training Process - different phases of training; Experiential learning through simulation games, Conceptual models of training; Training strategy and designs, Training need assessment, characteristics of good training programme, Exercises on developing training design, training curriculum and training programme; Training Methods their importance, uses and limitations – case study, role play, lectures, programmed instruction, group discussion, brain storming, field methods, transactional analysis, business games etc., Training Evaluation and follow up – methods and strategy; Effective management of human resources – performance appraisal, working climate, changing roles etc.; Training structures and facilities available for human resource development. Visit to training institutions for sharing experiences.

AG EXT 232: ENTREPRENEURSHIP DEVELOPMENT (2L+2P) III

Concept and theory of Development, Self Employment; Concept, need, scope and prospects of Entrepreneurship Development; Entrepreneurship in Agriculture, agro-industries, scope, constraints and strategy; Approach and Experiences in Entrepreneurial Development in India and other Developing Countries; Entrepreneurship Development Cycle and process, Training for Entrepreneurship Development; Development of Entrepreneurial Characteristics and Motives, Motivation Theories; Arousal of Motivation, Achievement Motivation Syndrome; Simulation games and exercises for developing entrepreneurial competencies – risk taking, self efficacy, creativity, achievement planning, influencing process, problem solnimg; Entrepreneurship Development among youth and women, Empowerment of women entrepreneurs; Identification of potential entrepreneurs, Business Planning: Need & Scope for Business Plan, Project Designing and Planning: Government Policies & Programmes, Support & Service Organizations, Understanding Market Needs, Identifying Business Opportunities, Product Identification, Market Survey and Demand Analysis; Development of business plan; Project Report preparation, Project Appraisal techniques – economic, financial, technical, and social; Enterprise launching, Planning Resourcing; Enterprise Management, Management skills, Production management, Financial management, Marketing Strategy – pricing, costing, break-even analysis, Accounts and book keeping; Growth, Survival and Sustenance; Studies on Entrepreneurship Development in Agriculture. Visits to enterprises with entrepreneurs, training and development professionals.

AG EXT 234: ADVANCES IN IMPACT ASSESSMENT TECHNIQUES (2L+1P) II

Concepts and processes in impact assessment; Domains of impact assessment- Technical, socio-cultural, economic, institutional, environmental, human, periodic-short and long term; Levels of impact assessment; Approaches in developmental projects; Criteria and indicators: typologies and properties of indicators –goodness and exactness, internal and external validity, specificity, gender sensitiveness, stakeholders' orientation; Impact monitoring- concept, purpose and methods; Designs in impact assessment; Participatory need and stakeholders' perception assessment; Quantitative and qualitative techniques for impact assessment, Social impact analysis; Economic impact analysis-cost-benefit analysis, social-cost benefit analysis, partial budget analysis; Environmental impact analysis; Institutional impact analysis; Sustainability analysis; Stakeholders analysis; Gender analysis; Livelihood analysis; Human impact assessment; Case study; Policy implications of impact assessment Field studies for identification and ranking of criteria / indicators for impact assessment, Development and analysis of cases in impact assessment.

AG EXT 241: DYNAMICS OF PLANNED CHANGE (3L+1P) II

Group Dynamics – Concept, theories and

impact, transactional analysis and interaction analysis – importance in team work and planned change; Prejudice – concept, nature, types and factors affecting prejudice and remedial measures; Group norms and mores; process of group formation and mobilization; Studies on Group Dynamics and Dynamics of Change – group behaviour and patterns of action-dynamics of human interaction, some Indian experiences; Dynamics of change – Concept, types and importance in rural community, people's institutions for development; Typology of change – planned-, indoctrination-, technocratic-, coercive-, emulative-, etc; Theories of change – immanency, functionalism, economic, technological, historical, ideological, evolutionary and Field Theory; Factors affecting change, Stimulants and Barriers to change. Group Discussions to identify stimulants and barriers to changes, Exercises on transactional analysis, interactional analysis and team building, Lab processing of existing cases related to group dynamics, group decisions, and dynamics of change; Role Play; or Psycho-Drama to explore into group dynamics; Exercises on small group interaction i.e., T group and Laboratory training method.

AG EXT 251: METHODS OF SOCIAL RESEARCH (3L+1P) II

Science and Scientific approach-Characteristics of Social research-Problems of objectivity-Science and values-Theory and facts –Different types of social research-Historical-Descriptive-experimental-Elements of Scientific methods:-Selection and formulation of problem, Concept- meaning and its role Hypothesis: Nature, type and its testing Types of variables-constitutive operational definitions of constructs and variables. Measurement: General theory of measurement-postulates of measurement-levels of measurement, types of reliability-Improvement of reliability: Validity: Types of validity-a variance definition of validity-the variance relation of validity and -the variance relation of validity and reliability-factors influencing validity. Methods of observation and data collection:-Interviews and Interview schedules-Projective methods-Content analysis-Observation Sociometric- The semantic differential Case study-Use of documents records-and indices. Principals of analysis and interpretation: Research Report-style manuals-format of research report-the thesis or dissertation. Design of social research**:** Meaning, purpose and principles of research design; experimental and Ex-post-facto approaches, Faulty designs, criteria of research design. General designs of research**:** Different types of basic, experimental designs- Variants of basic experimental designs-Simple randomized subject design- Factorial design. Types of research: Ex-post facto research, Action research methodology- Participatory research. Recent advances in social research methodology, Advances in collection of data, analysis of data etc. Use of computers in social science research; Data treatment by computer, Formulation and conduct of a research including data collection, analysis, report writing and presentation, Critical evaluation of research papers & a thesis and its presentation.

AG EXT 252: TECHNIQUES OF MEASUREMENT IN BEHAVIOURAL SCIENCES (3L+1P) III

Role of measurement in Social Sciences; Levels of measurement; Theory of Scale development; Process and techniques of scale construction; Types of scales in social Research; Scale Construction Methods: Paired Comparison Technique, Equal Appearing Interval, Successive Interval, Summated Rating; Scalogram Analysis; Scale Discrimination Techniques; Q-Sort Technique; Projective and non-projective techniques; Semantic Differential Technique; Meta Analysis; Critical Incident Technique; Content analysis; Sociometry; Utilization of these techniques in Extension Research; Advantages and limitations of these techniques. Using different types of scales and techniques in the field and laboratory situation; Critical study of the scales constructed and used in Extension Education research.

AG EXT 261: HERITAGE OF INDIAN AGRICULTURE (2L) I

Philosophical bases: Nature and Environment – Indian approach to environment: Soil, water, air, plants, animals and forests; Philosophical and spiritual bases; Unity in diversity – Value system of Indian sub-continent Unifying underlying force – trust, co-existence, sharing, linkages, networking, social capital, etc.; Medicinal plants and traditional healing systems: Ayurveda, Siddha, Tribal medicine, Vaids and living traditions; Ancient Indian Climatology: Festivals, rituals and traditions in agriculture; religion and magic in agriculture; Rise and Fall of Civilizations: Values and issues in the collapse of Indus valley civilization and comparative analysis of other civilizations of China, Mesopotamia, India and Egypt. Historical bases- Economic history of Indian agriculture: Commerce and trade during pre-colonial and Colonial period; The case of cotton, linen, indigo and cottage industries; Commodity exchange and trading in agricultural produce across Indian provinces, kingdoms and far-away empires; Indian trade and commerce in South and South-east Asia; Agricultural experimentation and research; Colonial period and history of Indian Council of Agricultural Research; Local governance – Village councils, revenue and land records, Zamindari and Ryatwari systems, Lessons from Gupta and Chola periods. Relevance, concerns and Issues- Agriculture in ancient, mediaeval and Colonial India: Transition, change and shifts (Structural and technological changes); Planning in Indian agriculture – Crop planning: sequencing and patterns, Contingency planning – Famine relief mechanisms and mechanisms for buffering drought; Genetic heritage of Indian agriculture: Plant origins and plant introduction; economic exploitation, genetic bio-diversity and systems of conservation and protection, bio-prospecting and bio-piracy; Indigenous Knowledge systems: subsistence, self-sufficiency and sustainability; Rationale and validation; Sustainable Development: Austerity and contentment in Rural India; Food habits and healthy ways of living; Rethinking nutrition; Philosophical bases of sustainability; Organic Farming in India: Holistic traditions.

AG EXT 301: ADVANCES IN AGRICULTURAL EXTENSION (3L+1P) I

Approaches of Agricultural Extension: A critical analysis of different approaches of agricultural extension, Extension programmes of corporate sector, the concept importance and implications of livelihood extension, Technology Base of Agricultural Extension : Importance and relevance of indigenous knowledge system, identification and documentation of ITK, Integration of ITK system with formation research., Agricultural Knowledge and Information System (AKIS) Concept of Agricultural Knowledge and Information System, Targeting of AKIS, significance of theories of social learning for extension practice; Cyber Extension: Concept of cyber extension, national and international cases on extension projects using ICT and their impacts, Economics of Agricultural extension: National investments in agricultural extension, impacts of agricultural extension, alternative methods of financing agricultural extension, privatization of agricultural extension – scope, limitations and experiences and cases; Implications of GATT agreement for extension services, re-orientation of extension services for agri-business and marketing activities, GOI-NGO collaboration to improve efficiency of extension. Extension and contemporary issues: Extension and issues related to rural poverty, environmental protection of farm and home, bio-diversity, sustainable development, food and nutritional security, recent advances in biotechnology. Analysis of ITK system, cases on integration of ITK and formal research system, Analysis of cases on cyber extension, and privatization of extension.

AG EXT 302: METHODS OF MONITORING AND EVALUATION (2L+1P) I

Definition of Monitoring, Objectives, Major Components of project Monitoring: Project Progress

report: Summary, Progress of physical implementation and financial performance compared to targets, performance of principal inputs and services. Special Diagnostic studies, Project Completion report, Project sustainability. Monitoring Standards: Past quality or performance, the quality of other systems, Desired quality, Professional standards, the quality required, Planning targets and Optimal quality. Usefulness of monitoring: role of project Completion Reports in Monitoring (PCRs): New Approaches to participatory impact Monitoring: Participatory Monitoring: Project Management in Practice. The six steps: Identification of project and activities, Preparation of research proposals, Review of research proposals, Approval of research projects and commitment of resources, Implementation and monitoring of research and Evaluation of completed projects and impact. Evaluation: Theory: Definition of evaluation and related activities. Why evaluation? What has been wrong with our Traditional Evaluation? Difference between research and evaluation. Types of Evaluation: Objective Oriented, Management Oriented; Context Evaluation, Input evaluation, Process Evaluation, Product Evaluation, Consumer oriented evaluation, Expertise Oriented Evaluation, Adversary Oriented Evaluation, Naturalistic and Principal oriented evaluation. Major activities involved in conducting evaluation. Evaluation Standards: Utility Standards, Feasibility Standards, Propriety standards and Accuracy standards. Clarifying the Evaluation Request and Responsibilities. Setting boundaries and analyzing the evaluation context. Identifying and selecting the evaluative questions, criteria and issues. Planning the information collection, analysis and interpretation. Developing management plan for the evaluation. Dealing with political, ethical and interpersonal aspects of evaluation. Reporting and using evaluation information. Meta Evaluation: Evaluation of evaluation.

AG EXT 311: VISUAL AND GRAPHIC COMMUNICATION (1 (1L+2P) II

e of visuals in Communication; Characteristics of visuals, functions of visuals and graphics; Theories of visual perception; Classification of visuals, visual formats, Selection of visuals; Designing message for visuals; Designing & layout of visual elements, balancing; Graphic formats & Devices, typology, Presentation of scientific data, general and exact data; Principles of Production of visuals, low-cost visuals, photographs, reprographic visuals, PC based visuals, and digitized video materials in multi-media production; Designing visuals for print and TV/ video media; Pre-testing and Evaluation of visuals. Preparation of low-cost visuals (projected & non-projected); Designing & Layout of visuals for Charts, posters, headliners etc., Generating computer – aided presentation graphics, scanning of visuals and preparation of visuals.

AG EXT 321: ADVANCED MANAGEMENT TECHNIQUES (2L+1P) I

Forecasting Techniques : Qualitative and judgmental methods, time series analysis, casual forecasting models. Technological forecasting – the Delphi methods, multi-criteria analysis, scenario construction and growth analogy. Choosing the appropriate forecasting techniques for various situations. Management Information System (MIS): Basic concepts, types of information needed at various levels, designs of MIS in an agricultural extension organization. Scope for computerization, system alternatives and evaluation. Implementation, operation and maintenance of the system. Management by Objectives (MBO) : Elements of the MBO system. The process of MBO. Making MBO effective. Evaluation of the MBO system – strengths and weaknesses. Transactional Analysis (TA) : Ego states, transactions, inter relationships, strokes, stamps. Managing Organizational Stress: Sources of stress in an organization, effects of stress, coping mechanisms and managing stress. Team Building Processes: Types of teams. Steps in teamwork, Facilitators and barriers to effective team performance. Building and maintaining relationships, nature of prejudice, tips in reducing inter-

personal conflicts, inter-group conflict revolving techniques. Decision Support Systems (DSSs): Basic information about Artificial Intelligence (AI) and Expert Systems (ESs), their future applications in an extension system. Zero Base Budgeting (ZBB): Concept, purpose, process and application in a typical extension organization. Practical exercises on forecasting techniques, Management Information System (MIS), Management by Objectives (MBO) and Transactional Analysis (TA), Team building processes, skills in coping with organizational stress, exercises on Decision Support Systems (DSSs) and Zero Base Budgeting (ZBB)

AG EXT 331: ADVANCES IN TRAINING TECHNOLOGY (2L+1P) III

Paradigm shift in training-learning scenario, Training Approaches – Experiential learning – laboratory – organizational development (system) approaches; Training Design, Designing an effective training programme, Harmonizing training needs, objectives, content and methods, Designing an effective training session – the semantics involved, Designing experiential training sessions, simulation exercises, and openness in training transactions – managing dilemmas, ambivalence and conflicts and confusion (for both trainers and trainees), Recent Training Techniques for understanding and facilitating team building, group dynamics, motivation and empowerment, laboratory methods: micro-lab, process work, and sensitivity training, Psychological Instruments as training tools: TAT, Inventories, Cases, etc., Participatory Training Techniques: Role Play, Psycho-drama, Coaching, Counseling, etc.; Trainers' Roles and dilemmas, Training Styles Co-Training, Training Effectiveness; Techniques of Agro-ecosystem Analysis, Rapid Rural Appraisal, Participatory Rural Appraisal, Programmed Instruction, and Multimedia Techniques in training. Designing participatory training sessions through simulations and experiential learning, Field sessions of PRA, and Agro-ecosystem analysis.

AG EXT 333: DEVELOPMENT COMMUNICATION (2L+1P) I

Concept and components of development; Theories of development and development communication; Approaches and development of communication media for development communication; Conceptual differences/similarities between development communication and development support communication; Development communicators: characteristics and role demands; Process skills pertaining to process of agricultural development; communication media and technology; Networking mechanisms among various development agencies both at operational level and field level; Experiences generated from application of media for promoting development: case studies; participatory approach to integrated media development in extension and development projects; Developing information support for development communication projects; formulating and conducting development communication projects in India; Conventional mass media and traditional media used in development communication; Determinants of communication effectiveness of development projects. Critical evaluation of communication media and technology in development communication; Developing agricultural communication projects; Visits to mass media organizations engaged in development communication; Formulating communication plans and strategy; Cost benefit analysis of media use in development.

AG EXT 299: SEMINAR (1L) I, II, III

5

AGRICULTURAL PHYSICS

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
AP 100	BASIC CONCEPTS OF PHYSICS - I	4	1
AP 104	ENERGY BASIS IN NATURE	2	0
AP 105	MATHEMATICS IN AGRICULTURE	3	0
AP 110/ SSAC 110	FUNDAMENTALS OF SOIL PHYSICS	3	1
AP 130	FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY	3	1
AP 310	TRANSPORT PROCESSES IN SOILS	3	1
AP 331	SATELLITE AGROMETEOROLOGY	2	1
AP 299	SEMINAR	1	0

II Trimester

AP 101	BASIC CONCEPTS OF PHYSICS - II	3	1
AP 120	PRINCIPLES OF BIOPHYSICS	3	1
AP 140	PRINCIPLES OF REMOTE SENSING	3	1
AP 210	PHYSICS OF SOIL AND WATER CONSERVATION	2	1
AP 211	PHYSICS OF VADOSE ZONE	2	1
AP 230	CROP MICROMETEOROLOGY	2	1
AP 299	SEMINAR	1	0

III Trimester

AP 102	PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE	3	1
AP 103	PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE	3	1
AP 141	GIS AND GPS – PRINCIPLES AND APPLICATIONS	2	1

AP 212	SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH	3	1
AP 240	REMOTE SENSING IN AGRICULTURE	2	1
AP 311	MODELING SOIL PHYSICAL PROCESSES	2	1
AP 330	EVAPOTRANSPIRATION	2	1
AP 299	SEMINAR	1	0

Core Courses :

For M.Sc.: Within the discipline: AP 100, AP 101, AP 105, AP 110, AP 120 and AP 130

Agricultural Physics

Major Field : **Agricultural Physics**

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

AP 100: BASIC CONCEPTS OF PHYSICS - I (4L+P) I

Linear, circular, relative motions, Conservation of mass, energy and momentum, Forces in nature, range of their operation, action at a distance, Gravitational field, potential, Elasticity, stress-strain relations – moduli of elasticity, Hooke's law, molecular and structural basis of strength of materials, Hydrostatic pressure; Surface Tension, Capillary rise, contact angle, Hydrodynamics – laminar and streamline flow, Poiseuille's equation, Stoke's law; Thermometry, Measurement of heat, specific heat, Transfer of heat - conduction, convection and radiation, Change of phase, equation of state, vapour pressure and relative humidity, Laws of thermodynamics, free energy, chemical potential, Kinetic theory of gases, Brownian motion, mean free path; Simple harmonic motion, concepts of phase, phase difference,interference and reflection of sound waves, ultrasonics, applications; Wave theory of light, Huygen's principle, reflection, refraction, diffraction, polarization, interference and scattering of light waves; Electromagnetic theory of light, Geometrical optics, lens aberrations, Resolving power, principles of optical instruments, Illuminated and luminous objects and light sources; luminescence, incandescence, fluorescence, auto-fluorescence, phos-phorescence, bio-luminiscence, Qualitative and quantitative measurement of light, colour, optical spectrometery; Electric charges, potential, field, intensity and strength of electric field, current, Coulomb's law, Dielectrics, capacitance, electrostatic units, Resistance, resistivity, Ohm's law, steady currents in conductors, insulators and semi conductors; Magnetic materials, induced magnetism, Electromagnetism, measurement of magnetic field, geomagnetism, effects of the earth's magnetic field on life, Electromagnetic inductions and applications, Electromagnetic units.

AP 101: BASIC CONCEPTS OF PHYSICS -II (3L+1P) II

Maxwell's theory of electromagnetism, Atomic structure, Avagadro hypothesis and molecules, atomic and molecular weights, atomic sizes, Quantum mechanics: Heisenberg's uncertainty principle, De-Broglie hypothesis, wave function, Eigen state, Schrodinger equation, Spectroscopy: atomic and molecular spectra, Cathode rays; positive rays, Radio activity, alpha-, beta-, and gamma- rays, detection and measurement of radiation, Rutherford's theory of the scattering of alpha particles; X-rays, nature and properties, scattering of X-rays by atoms, Diffraction of X-rays and Bragg's law, characteristic X-ray spectra, Planck's quantum theory of thermal radiation, Quantum theory and Photo-electric effect, elements of special theory of relativity, Atomic Nucleus and its constitution, angular momentum of the nucleus, nuclear transmutation of elements, proton-neutron hypothesis; cosmic rays, elementary particles, natural radioactivity, types of radiations, their interaction with matter and decay; isotopes, isotopic masses and abundances, mass spectrograph and mass spectrometers, stable isotopes, atomic masses, packing fractions and binding energies; Theory of radioactive disintegration, half life and mean life; Mass spectrometer, Nuclear fission, fusion, nuclear reactions, neutron moderation, nuclear energy, atomic power, production of artificial isotopes; Physical principles of Radiation detection, types of radiation detectors, efficiency of detectors, uses of radiation detectors; Elements of radioactive sources, handling, radiation protection and cardinal principles of radiation safety.

AP 102: PRINCIPLES OF PHYSICAL TECHNIQUES IN AGRICULTURE (3L+1P) III

Physical principles of measurement of relationships, direct and indirect measurements, Scale of operation, Laboratory, field and regional scales, Specificity of techniques to characterize objects, Resolution, limitations and relative advantages, Optical Microscope, reflection, polarized microscopes; Colourometric techniques, single and double beam instruments; Reflection, transmission and absorption in relation to the properties of the object, UV and Visible sphectrophotometry, applications; Sensors and transducers, principles of operation of field-based instruments like leaf area meter, canopy analyzer, quantum sensor, spectroradiometer, laser land leveler etc.; Infrared thermometry, principles, emissivity, Infrared spectroscopy, characteristics of agricultural materials; X-rays, crystal structure, applications, clay mineralogy, cotton fibres, small angle scattering; Electron microscopy, electron optics, aberrations, contrast and image formation, specimen preparation techniques, Transmission and scanning electron microscopy, morphological characterization of viruses, macromolecules, clay minerals and other material; Atomic absorption spectroscopy, principle of operation, detection limits and sensitivity; Polarography, applications; Nuclear techniques, Detection and measurement of charged particles, types of detectors, counting systems, radiation monitoring instruments, radiation hazard evaluation and protection, Tracer methodology, Isotopes and their applications in different branches of agriculture, Seed irradiation, gamma chamber and gamma irradiation for genetic variability, Agricultural produce preservation; Mass spectrometer, principle and applications.

AP 103: PHYSICS OF RADIATION INTERACTIONS IN AGRICULTURE (3L+1P) III

Electromagnetic Spectrum, Energy sources and their characteristics, Spectral distribution of radiant energy, Energy content in different radiations, Radiation units, Flux, intensity, emittance, inter conversion of radiometric units, Radiation

principles, Resolution, Geometry considerations, solid angle concept, inter conversion of photometric units; Interaction of radiation with matter, Scattering, Reflection, transmission, absorption, Diffuse and specular radiations, Lambertian surface, Different types of scattering; Photosynthetically active radiation, Einstein, mole, photon units and their inter-conversion; Colour designations; Conversion of optical to thermal and other forms of energy; Thermal radiations, Blackbody radiation, Kirchoff's law, Stefan-Boltzmaan law, Planck's law, Wein's displacement law, Rayleigh-Jean's law, Thermal properties of interacting materials, thermal emissivity, thermal inertia; Microwave radiations, Dielectric constant, Microwave energy dissipation in interacting materials, isotropic and non-isotropic mediums, Microwave transmission, reflection, polarization, Microwave and radio wave heating; Ionizing and non-ionizing radiations, Applications in Agriculture and Biology, Energy balance of land surfaces, energy budget of leaf, energy budget of crop canopy, Radiation interception.

AP 104: ENERGY BASIS IN NATURE (2L) I

Forms and manifestations of energy, Sources of energy, Principles of energy flows, Energy flow in ecosystems, Energy conservation, Inter-conversion of energy forms, Efficiency of energy conversion, Energy balance of systems, Solar Energy and Solar radiation, Solar flares, Solar activity and their influence on terrestrial ecosystems, Energy and atmospheric systems, Energy content of agricultural produce and the calorific value, Evaluation of agricultural operations for their energy efficiency, machine, human and other inputs, Social and economical aspects of Energy.

AP 105: MATHEMATICS IN AGRICULTURE (3L) I

Functions, Limits, Continuity, Linear equations, non-linear equations, Polynomials, infinite series and Taylor series, Vectors, matrices and determinants, Inversion of matrices, Eigen values and Eigen vectors, Orthogonality, Grahm-Schmidt processes, least square problems, Differentiation, Integration, Areas, Partial differential equations, applications, Solutions to differential and integral equations; Systems of coordinates, Cartesian, cylindrical, spherical and polar coordinates, Three dimensional geometry, relative motion of frame of reference; Probability, probability distributions and applications; Curve fitting, regression and correlation, linear and non-linear; Geostatistics, Averaging and scaling methods; Fourier analysis, Numerical approximations, Numerical analysis, Finite element method, Monte Carlo analysis, Stochastic methods, Iterative and optimal techniques.

AP 110/SSAC 110: FUNDAMENTALS OF SOIL PHYSICS (3L+1P) I

Physical characterization of soil, Particle size, soil texture, mechanical analysis, shape and specific surface, Geometry of pore space, porosity and Pore size distribution, Void ratio, relative density and degree of compaction; Consistency of soils, consistency limits, consistency index, consistency and deformation of cohesive soils; Soil strength, measurement of soil strength, methods of testing soil strength; Clay the colloidal component, swelling and shrinkage, Soil structure and aggregation, micro-aggregation, soil conditioners; Geometry of water phase, measurement of soil water, direct and indirect methods, Water content and potential, thermodynamic basis of the potential concept, different components of soil water potential, Soil water characteristic, hysteresis, and available water, Flow of water in soil, Darcy's law, hydraulic conductivity, and water diffusivity, Saturated and unsaturated flow, Methods for saturated and unsaturated hydraulic conductivity measurement, Capillary movement of water, contact angle, Water entry into soil, permeability, redistribution; Field water balance, groundwater drainage, evaporation from bare soil; Gaseous phase, content and composition, renewal of soil air,

measurement of soil aeration, gaseous diffusion; Soil temperature, factors affecting soil temperature, measurement of soil temperature, heat capacity and specific heat, heat flow in soils, thermal conductivity and diffusivity of soil; Soil colour and its measurement.

AP 120: PRINCIPLES OF BIOPHYSICS (3L+1P) II

Introduction and scope of Bio physics, Weak and strong interactions in biological systems and structure and property of water, Physical, chemical and biological origin of life, Structure and function of biological molecules and organization of living matter, Unicellular and multi-cellular life forms, Types of specialized cells and their functions, Cell and cell to cell communication, Structure of plant and animal cells and membranes, Basis for cell membrane voltages, bioelectricity of cell membrane and measurement; Amino acids and peptides, Protein structure; Primary and secondary, Nucleic acids, Mechanism of genetic control, Polysaccharides, Lipids and artificial membranes, Electrophysiology, Nature and identification of Plant and animal Viruses; Bioenergetics - Types of binding forces, Laws of thermodynamics, negative-entropy, and Information theory; Experimental techniques used for the separation and characterization of biomolecules; Transport phenomena in biological systems, Simple, Active and passive transport.

AP 130: FUNDAMENTALS OF METEOROLOGY AND CLIMATOLOGY (3L+1P) I

Sun and earth, seasons, Solar radiation and laws of radiation, Heat balance of the earth and atmosphere, Meteorology and climatology; Instruments for measurement of meteorological elements, Variation of pressure and temperatures with height, Saturation deficit, vapour pressure, psychrometric equation, Potential temperature; Air masses – Types and properties, Pressure gradient; cyclones and anti-cyclonic motions; Clouds and their classification, Precipitation processes, artificial rain making, Thunderstorms and dust storms, haze, mist, fog and dew, Local wind systems; land and sea breeze circulation, Mountain and valley winds, land and sea breeze; Weather charts, Forecasting methods – short, medium and long range forecasting techniques, Recent models used in forecasting and their limitations and impact on Agriculture, Numerical weather prediction, Environmental indicators of weather changes, El Nino and southern oscillations, Weather and Climate, Seasonal distribution of climatological elements over latitudes, Climatic classification: Koppen and Thornthwaite systems, Types of climate: humid and dry climates, Climatic changes and global warming, Agroclimatic indices, Agroclimatic zones; different agroecological zones for India, Climatology of India; Monsoons, rainfall variability, elements of monsoon meteorology; Atmospheric and soil drought, Frequencies of disastrous weather events in different regions.

AP 140: PRINCIPLES OF REMOTE SENSING (3L+1P) II

Introduction, Electromagnetic Radiation, Electromagnetic Spectrum, Interactions with the Atmosphere, Passive versus Active Remote Sensing; Characteristics of Images; Ground based, Air borne and space borne Sensors; Satellite Characteristics, Pixel Size, and Scale, Spectral, Radiometric and Temporal Resolution;

Cameras and Aerial Photography, Multispectral Scanning, Thermal Imaging, Imaging and Non-imaging systems, Geometric Distortion; Weather, Land Observation, Marine and other Observation Satellites, Indian Remote sensing satellites, Data Reception, Spectral signatures and indices; Microwave Remote sensing, principles, Imaging spectrometry, interferometry, Radar Basics, Viewing Geometry and Spatial Resolution, Image distortion, Target interaction, Image Properties, Advanced Applications, Polarimetry and Scatterometry; Airborne versus Space borne Systems; Image Analysis, Visual interpretation, Digital processing, Preprocessing,

Enhancement, Transformations, Classification, Integration; Applications, Agriculture, Forestry, Geology, Hydrology, Land Cover, Mapping, Oceans and Coastal, Oil Spill Detection.

AP 141: GIS AND GPS – PRINCIPLES AND APPLICATIONS (2L+1P) III

Introduction, History, basic concepts, principles, techniques, procedures and terminology of geographic information systems, Geographical Data types/models, Data characteristics and Management, RDBMS, Technical aspects of GIS data collection, linking spatial and non-spatial data, Errors and quality control, data output; Map projections: Basic Geodesy Geiod /Datum/ Ellipsoid, Co-ordinate systems, scale factor, distortions, Classification of map projections, transformations, surveying; Raster based GIS: Spatial referencing, definition and representation, data structure, advantages and disadvantages; Vector based GIS : Definition, concept, data structure, capture and Vector and raster formats, vector to raster and raster to vector conversion, advantages and disadvantages; Principles of graph theory, Topology and Geometry; Spatial Analysis: Statistical analysis, Measurement, Proximity (buffering), overlay analysis, classification, network analysis, Multi-criteria analysis, Site suitability analysis, Nearest neighbour analysis, Thiessen polygon, surface mapping, Interpolation, DEM, Geostatistical analysis, spatial and non-spatial query, Software and hardware requirements of GIS, Interface between GIS and RS, GIS for modeling; Trends in GIS: Web GIS, 3D GIS, Object oriented GIS, Mobile GIS, Knowledge based GIS, data warehousing, data mining, Metadata, Data interoperability, Open GIS consortium, GIS customisation, DSS and SDSS; Applications of GIS: Watershed Development, Disaster management, Terrain analysis, Agriculture, biodiversity, Precision farming, e-governance, Agricultural Research Information system etc.; Basic Concepts of GPS, Space segment, Control segment, User's segment; Working principles of GPS, Measuring distance and timing, Errors in GPS data and correction, Differential GPS, Integration of GPS data with GIS data, use of GPS in remote sensing analysis, Past, present and future status of GPS, Applications of GPS in Agriculture and natural resource management.

AP 210: PHYSICS OF SOIL AND WATER CONSERVATION (2L+1P) II

Degradation of land and environment and role of soil and water conservation. Physics of soil erosion by water, Overland flow, Particle transport by running water effect of climate and hydrology; Rainfall energy, impact of raindrop and soil detachment, Rainfall erosivity indices; Water erosion prediction equation; Soil erodability, soil physical properties affecting erosion, Topography and soil surface cover, Universal soil loss equation, its modification, estimation of soil loss and its prediction, Erosion measurement on watershed basis, Run off estimation methods and prediction using conventional and modern techniques, Types of soil erosion and its control. Wind erosion-wind velocity, initiation and movement of soil particles, Siltation, suspension and surface creep and mechanics involved, Soil physical properties affecting wind erosion, Wind erosion equation and its computation, Control of wind erosion. Water harvesting and recycling; hydrologic assessment, Rainwater management and Storm water harvesting procedures, Surface run off, run off model components, Storage losses, seepage and its controls, Watershed characterization and management, Desertification and its control. Land capability classification, Soil and water conservation problems in different agro-ecological regions and associated with different types of soils; Techniques for soil and water conservation for agricultural and non-agricultural land, gullies, ravines and hilly areas, Soil physical properties in conservation forestry, agroforestry and grasslands.

AP 211: PHYSICS OF VADOSE ZONE (2L+1P) II

Spatial variability of soil physical properties in the field, Vadose Zone characterization, Sub divisions of vadose zone, Soil structural problems of vadose zone and their amelioration and management, Soil quality and soil resilience, Ground water and surface water relationships, Drainage, The physics of infiltration, vertical infiltration, Green-Ampt model, Philip model, homogeneous and layered soil infiltration, horizontal infiltration; Evaporation, Methods of computing contribution of deeper layers, Preferential flow of water; Simultaneous distribution and movement of water and other materials and energy in soil profile; Components of water balance equation, methods of computation, Scaling of soil water phenomena, Temperature and nutrient variations in a homogeneous and layered soil, Energy and nutrient balance of vadose zone, Movement of contaminants to groundwater, Geophysical characterization of vadose zone, Soil productivity and irrigability indices, Dryland salinity process, Irrigation-induced salinity process, Modification of vadose zone for optimal soil physical conditions.

AP 212: SOIL PHYSICAL ENVIRONMENT AND PLANT GROWTH (3L+1P) III

Effect of soil physical properties on plant growth: soil structure, soil strength, mechanical impedance, tillage practices, Soil moisture – plant water relations, available water, newer concepts of water availability, least limiting water range, soil-plant-atmosphere system as a physical continuum, plant uptake of soil moisture, irrigation and water use efficiency, evaporation, transpiration and evapotranspiration, dynamics of water in the soil-plant-atmosphere continuum; Root growth – germination and seedling emergence, hydraulic properties of roots, characterization of root growth parameters, water balance of the root zone, soil physical properties and root growth, flow of water to roots, Xylem hydraulics; Soil Temperature – effect of soil temperature on plant growth, soil temperature management, thermal regimes, mulching; Radiation – Heat budget and energy balance in the field, radiation use efficiency, control of diffuse radiation, radiation exchange in the field, exchange of heat and vapour to the atmosphere; Aeration – critical oxygen concentration and factors affecting; Water balance – field water balance and water use efficiency, consumptive use; Nutrition – nutrient uptake and use by plants, managing soil physical condition for improved plant nutrition, Integrated nutrient management in relation to soil physical condition; Modelling - Interactions of soil, management and climatic factors on plant growth, development of sustainability indices.

AP 230 : CROP MICROMETEOROLOGY (2L+1P) II

Micro, meso and macro climates and their importance, Atmosphere near the ground – bare soil and crop surfaces, momentum transfer, exchange coefficient, Richardson number and Reynold's analogy, Boundary layer, frictional effects, eddy diffusion, forced and free convection; Temperature, wind, vapor pressure

and carbon dioxide profiles in crops, Roughness and zero plane displacement, Modification of microclimate due to cultural practices; Instruments and measuring techniques in micrometeorology, Canopy and leaf temperatures and their biological effects, Thermal time, heat use efficiency and their application in field crops, Application of thermal time to pest and disease assessment and forecasting, Effect of weather on growth, development and yield of crops, Crop-weather relationships, Crop growth models.

AP 240: REMOTE SENSING IN AGRICULTURE (2L+1P) III

Scope of remote sensing in Agriculture, sensors and platforms, data availability for agricultural remote sensing, Interaction of EM radiation with soil components, Differentiation and identification of soils and soil resource mapping by remote sensing, Interaction of EM radiation with plant

components and crop canopies, Spectral indices and hyper-spectral bands, crop mapping, vegetation dynamics, Crop stress evaluation and differentiation, Infra red thermometry, Crop growth monitoring models and yield forecasting, Retrieval of crop biophysical parameters – LAI, Biomass; Land cover and land planning with reference to different agro eco-regions, Land degradation process and their evaluation by remote sensing; Role of remote sensing in water resource development and management, Ground water resources, identification of potential zones, Generation of different thematic maps for integrated watershed management, Vegetation types and their mapping, Shifting cultivation; Utility of SAR data for agricultural purposes, salinity mapping, soil moisture mapping, Flood assessment, and management by remote sensing; Precision farming principles - VRT, Modern techniques and machines.

(Pre-requisite: AP 140)

AP 310: TRANSPORT PROCESSES IN SOILS (3L+1P) I

Theory of transport in soil, generalized approaches based on continuum mechanics and thermodynamics of irreversible processes, motion in tube with laminar flow, scales and effective parameters, homogeneous porous medium, Water – Stationary flow of water, water flow in saturated soil, Darcy's law, Laplace equation, solutions to Laplace equation, Euler's theorem, water flow in unsaturated soil, parameterisation of unsaturated hydraulic conductivity, hydraulic functions for typical soil textures, equation for transient flow of water, dynamics of water flow, stationary water flux, diffusivity, Boltzmann transformation and a wetting front, methods of measuring saturated and unsaturated hydraulic parameters; Nutrients and salts – Physical processes of the movement of solutes, diffusion, mass flow, convection, root interception, convective dispersive equation (CDE), miscible and immiscible displacement, hypothetical and experimental breakthrough curves, dynamics of solute transport, solutions and applicability of CDE, methods of determination of dispersion and diffusion coefficients, solute transport during infiltration; Heat – Measurement of thermal diffusivity and conductivity, ground heat flux and soil temperature, determination of heat flux in soil, flow of water by heat action; Air – gas movement and exchange, gaseous diffusion equations for soil and air, methods of measuring gaseous diffusion coefficient, steady state and transient state gaseous diffusion, Oxygen diffusion rate; Contaminants – sorption, degradation and fate of agrochemicals in soil, chemicals with linear, nonlinear and kinetic interactions of stable and unstable chemicals, numerical solutions.

(Pre-requisite: AP 110)

AP 311: MODELING SOIL PHYSICAL PROCESSES (2L+1P) III

Mathematical tools, Gaussian random variables, density and distribution functions, central limit theorem, generalized functions, Infinite series of orthogonal functions, Fourier series, Bessel functions, Modeling Potential and limitations, modeling physical systems, conservation equation, flux law, dynamics, systems at equilibrium, Numerical approximations, finite differences, finite elements, finite difference model of steady, saturated and unsteady unsaturated flow, applicability of numerical approximations, numerical simulations, stationary flow and infiltration in homogeneous and heterogeneous soil, Mathematical models for miscible displacement, solution for dispersion equation, mathematical dispersion models, analytical solutions for ion transport, Modeling water uptake by roots under water and salinity stresses, Modeling water erosion, soil erosion, Modeling nutrient and contaminant dynamics, Interconnectivity of different models.

(Pre-requisite: AP 105 and AP 110)

AP 330: EVAPOTRANSPIRATION (2L+1P) III

Radiation and its interaction with crop environment and radiation use efficiency, Energy balance, its components and their estimation in crop canopy, Theories of evapotranspiration – concept of evaporation, potential and actual evapotranspiration, Estimation of potential evapotranspiration using different approaches – empirical, aerodynamic, radiation, Bowen ratio, combination and eddy correlation techniques, Thornthwaite's climatic water balance, Measurement of evapotranspiration using various types of lysimeters, Water use efficiency, irrigation scheduling and yield functions.

(Pre-requisite: AP 130)

AP 331: SATELLITE AGROMETEOROLOGY (2L+1P) I

Scope and importance of agrometeorology from space, Types of Meteorologcal satellites – Geostationary and Polar orbiting, International Satellite systems and their payloads – NOAA, LANDSAT, SPOT, TERRA and AQUA, DMSP, METEOSAT, GOES, TRMM etc., National satellite systems and their payloads – INSAT, IRS, MEGHA-TROPIQUES, RISAT etc., Satellite sensor equipment and satellite data products available for agrometeorology, Retrieval of cloud type and structure in Visible and Infrared regions, Estimation of rainfall by Visible, Infrared and Passive and Active microwave techniques, Retrieval of land surface emissivity and temperature – single channel and split window algorithms, Components of surface radiation balance – global radiation, surface albedo and outgoing long wave radiation, Estimation of latent heat flux, sensible heat and roughness parameter, Retrieval of Surface soil moisture, Retrieval of crop biophysical parameters from meteorological satellite data by empirical, semi-empirical and physical techniques, Crop phenology and dynamics, Crop growth monitoring and Early warning systems, Drought monitoring, assessment and management, Modeling net primary productivity of agroecosystems, Agroecological zoning using remote sensing and GIS.

(Pre-requisite: AP 130)

AP 299: SEMINAR (1L) I/II/ III

6

AGRICULTURAL STATISTICS

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
AS 101	ELEMENTARY STATISTICAL METHODS	2	1
AS 150	MATHEMATICAL METHODS	4	0
AS 160	PROBABILITY THEORY	2	0
AS 161	STATISTICAL METHODS-I	2	1
AS 167	APPLIED MULTIVARIATE ANALYSIS	2	1
AS 168	ECONOMETRICS	2	1
AS 169	PLANNING OF SURVEYS / EXPERIMENTS	2	1
AS 200	DESIGN OF EXPERIMENTS-II	1	1
AS 201	SAMPLING TECHNIQUES – II	1	1
AS 202	STATISTICAL GENETICS – II	1	1
AS 203	REGRESSION ANALYSIS	1	1
AS 204	LINEAR MODELS	2	0
AS 206	OPTIMIZATION TECHNIQUES	1	1
AS 299	SEMINAR	1	0

II Trimester

AS 102	ELEMENTARY DESIGN OF EXPERIMENTS	2	1
AS 151	MATHEMATICAL METHODS IN STATISTICS	4	0
AS 162	STATISTICAL METHODS – II	2	1
AS 165	SAMPLING TECHNIQUES – I	3	1
AS 170	STATISTICAL MODELLING	2	1
AS 171	BIOINFORMATICS– I	3	1
AS 205	ADVANCED STATISTICAL INFERENCE	1	1

AS 207	STOCHASTIC PROCESSES	3	0
AS 301	ADVANCED DESIGN OF EXPERIMENTS-I	2	1
AS 303	ADVANCED SAMPLE SURVEYS-I	2	1
AS 305	ADVANCED STATISTICAL GENETICS-I	2	1
AS 299	SEMINAR	1	0

III Trimester

AS 103	ELEMENTARY SAMPLING & NON-PARAMETRIC METHODS	2	1
AS 163	STATISTICAL INFERENCE	4	1
AS 164	DESIGN OF EXPERIMENTS-I	3	1
AS 166	STATISTICAL GENETICS-I	3	1
AS 208	BIOINFORMATICS-II	2	1
AS 302	ADVANCED DESIGN OF EXPERIMENTS-II	2	1
AS 304	ADVANCED SAMPLE SURVEY-II	2	1
AS 306	ADVANCED STATISTICAL GENETICS-II	2	1
AS 307	FORECASTING TECHNIQUES	1	1
AS 308	BAYESIAN INFERENCE IN SURVEY SAMPLING	1	1
AS 370	RECENT ADVANCES IN THE FIELD OF SPECIALIZATION I / II / III	1	0
AS 299	SEMINAR	1	0

Core Courses :

For M.Sc.: Within the discipline: AS 160, AS 161, AS 162, AS 163, AS 164, AS 165, AS 166 and AS 167.

Agricultural Statistics

Major Field : **Agricultural Statistics**

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

The total minimum credit requirement of course work for M.Sc./Ph.D. in Agricultural Statistics is 55/45 including Minor field(s).

DESCRIPTION OF COURSES

AS 101: ELEMENTARY STATISTICAL METHODS (2L+1P) I

Classification, tabulation and graphical representation of data. Descriptive statistics. Theory of probability. Random variable and mathematical expectation. Probability distributions: Binomial, Poisson, negative binomial, normal distributions and their applications. Concept of sampling distribution: t, chi-square and F distributions. Tests of significance based on normal, t, chi-square and F distributions. 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. Coefficient of determination. Polynomial regression models and their fitting. Selection of variables, validation of models. Introduction to multivariate analytical tools-cluster analysis, discriminant function, principal component analysis.

AS 102: ELEMENTARY DESIGN OF EXPERIMENTS (2L+1P) II

Basic principles of design of experiments. Uniformity trials. Analysis of variance. Completely randomised design, Randomised block design (RBD), Latin square design (LSD), Balanced incomplete block design, Lattice design - concepts, randomisation procedure, analysis and interpretation of results. Analysis of covariance. Missing plot technique and its application to RBD, LSD. Factorial experiments (symmetrical as well as asymmetrical). Confounding in factorial experiments - application in 2^5 and 3^3 factorial experiments. Factorial experiments with control treatment. Groups of experiments. Split plot and Strip plot designs. Change-over design. Sampling in field experiments.

Transformation of data. Response surfaces. Experiments with mixture.

AS 103: ELEMENTARY SAMPLING AND NON-PARAMETRIC METHODS (2L+1P) III

Concept of sampling, sampling vs complete enumeration, simple random sampling, inverse sampling, stratified sampling, cluster sampling, systematic sampling, multistage sampling. Ratio method of estimation. Non-sampling errors. Concept and levels of measurement. Non-parametric tests - sign test, Wilcoxon test, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

AS 150: MATHEMATICAL METHODS (4L) I

Matrix Algebra: Basic terminology, linear independence and dependence of vectors. Row and column spaces, Echelon form. Determinants, rank and inverse of matrices. System of linear equations. Special matrices – idempotent, symmetric, orthogonal. Eigenvalues and eigen vectors.

Calculus: Limit and continuity, differentiation of functions, successive differentiation, partial differentiation, mean value theorems, Taylor and Maclaurin's series. Application of derivatives, L'hospital's rule. Integration of rational, irrational and trigonometric functions. Application of integration.

Differential equation: Differential equations of first order, linear differential equations of higher order with constant coefficient.

Numerical Analysis: Simple interpolation, Divided differences, Numerical differentiation and integration.

Linear Programming: Formulation and graphical solution, simplex method, duality, transportation and assignment problem.

AS 151: MATHEMATICAL METHODS IN STATISTICS (4L) II

Linear Algebra: Group, ring, field and vector spaces, Sub-spaces, basis, Gram Schmidt's orthogonalisation, Galois field - Fermat's theorem and primitive elements. Linear transformations.

Real Analysis: Convergence and divergence of infinite series, use of comparison tests - D'Alembert's Ratio - test, Cauchy's n^{th} root test, Raabe's test, Kummer's test, Gauss test. Absolute and conditional convergence. Riemann integration, concept of Lebesgue integration, power series, Fourier, Laplace and Laplace -Steiltjes' transformation, multiple integrals.

Matrix Algebra: Unitary, Similar, Hadamard, Circulant, Helmert's matrices. Kronecker and Hadamard product of matrices. Sub-matrices and partitioned matrices, Permutation matrices, Full rank factorization, Equations having many solutions, Generalized inverses, Moore-Penrose inverse, Applications of g-inverse. Spectral decomposition of matrices, Differentiation and integration of matrices, Quadratic forms.

Graph theory: Concepts and applications. Fuzzy set theory.

AS 160: PROBABILITY THEORY (2L) I

Elements of measure theory. Probability - classical and frequency definitions, Axiomatic approach, laws of probability, conditional probability. Bayes theorem. Random variable - discrete and continuous. Probability mass and probability density functions, distribution function, Mathematical expectation and its laws. Probability generating, moment generating and characteristic functions. Inversion and Uniqueness theorems for characteristic functions. Markov's, Chebychev's and Kolmogorov's inequalities. Modes of stochastic convergence. Weak and strong laws of large numbers, Central limit theorems. Concepts of stochastic processes. Random walk, Markov chains.

AS 161: STATISTICAL METHODS - I (2L+1P) I

Descriptive statistics- exploratory data analysis techniques. Random variable. Discrete probability distributions: Uniform, Bernoulli, binomial, Poisson, negative - binomial, geometric, hypergeometric, multinomial. Continuous probability distributions: rectangular, exponential, Cauchy, normal, gamma, beta, Weibull, lognormal, logistic, Pareto. Exact sampling distributions. Central t, χ^2 and F distributions. Bivariate normal distribution - conditional and marginal. Correlation, rank correlation, correlation ratio, intra-class correlation. Regression analysis, partial and multiple correlation and regression.

AS 162: STATISTICAL METHODS - II (2L+1P) II

Sampling distribution of correlation coefficient, regression coefficient, correlation ratio, intra class correlation coefficient. Non-central t, χ^2 and F distributions. Distribution of quadratic forms. Cochran's theorem. Tests for normality. Large sample tests. Tests of significance based on t, χ^2 and F distributions. Truncated and compound distributions. Fitting of orthogonal polynomials. Pearsonian curves. Categorical data analysis-loglinear models, Association between attributes. Distributions of order statistics. Variance stabilizing transformations.

(Pre requisite: AS 161)

AS 163: STATISTICAL INFERENCE (4L+1P) III

Point estimation, Properties of estimators: Unbiasedness, consistency, efficiency and sufficiency. Frechet-Cramer-Rao inequality, Rao-Blackwell theorem, completeness and bounded completeness, Basu's theorem. Methods of estimation - Maximum likelihood, least squares, minimum χ^2, minimum distance, moments, maximum entropy. Testing of hypothesis: Neyman-Pearson lemma, power function, uniformly most powerful tests and their constructions, unbiased tests, likelihood ratio tests. Confidence-interval estimation. Sequential analysis, Sequential probability ratio test. Elements of Decision theory and Bayesian inference. Non-parametric tests: run, sign, rank, median, Wilcoxon-Mann-Whitney, Kruskal-Wallis, Friedmann two - way ANOVA by ranks.

(Pre-requisite: AS 162)

AS 164: DESIGN OF EXPERIMENTS - I (3L+1P) III

Basic principles of design of experiments, uniformity trials - shape and size of plots and blocks. Elements of linear estimation. Analysis of variance and covariance. Completely randomized, Randomised block and Latin square designs. Mutually orthogonal latin squares. Missing plot techniques. Balanced incomplete block (BIB) designs - General properties and analysis with and without recovery of information. Construction of BIB designs, Youden square designs, Lattice designs. Change-over designs. Groups of experiments. Factorial experiments, Confounding in symmetrical factorial (2^n and 3^n series) experiments, Split plot and Strip-plot designs.

AS 165: SAMPLING TECHNIQUES - I (3L+1P) II

Probability sampling. Simple random sampling, estimation of proportions, confidence-interval, determination of sample size, inverse sampling. Sampling with varying probabilities with replacement. Stratified sampling, ratio, difference and regression estimators, cluster sampling, multi-stage sampling with equal probability. Systematic sampling, double sampling, successive sampling. Non-sampling errors - sources and classification, non-response survey techniques, imputation methods, measurement errors, repeated measurement techniques, interpenetrating sub-sampling.

AS 166: STATISTICAL GENETICS - I (3L+1P) III

Physical basis of inheritance. Analysis of segregation, detection and estimation of linkage for qualitative characters. Amount of information about linkage, Combined estimation, Disturbed segregation. Gene and genotypic frequencies, Random mating and Hardy-Weinberg law, Application and extension of the equilibrium law, Fisher's fundamental theorem of natural selection. Disequilibrium due to linkage for two pairs of genes, sex-linked genes, forces affecting gene frequency-selection, mutation and migration, equilibrium between forces in large populations, polymorphism. Polygenic system for quantitative characters, concepts of breeding value and dominance deviation. Genetic variance and its partitioning, 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. Restricted selection index, Inbreeding and cross-breeding, Changes in mean and variance.

AS 167: APPLIED MULTIVARIATE ANALYSIS (2L+1P) I

Multivariate normal distribution, marginal and conditional distribution, Wishart distribution, Hotelling's T^2 and Mahalanobis' D^2 statistics, Test of hypothesis on means, Multivariate analysis of variance and covariance, Cluster analysis, Classification by linear discriminant function, Canonical correlations, Principal components, Factor analysis.

(Pre-requisites: AS 160, AS 161 and AS 162)

AS 168: ECONOMETRICS (2L+1P) I

Study of single equation linear regression models: Maximum likelihood and ordinary least-squares methods of estimation, Statistical inference in linear regression, Estimation subject to linear restrictions, Use of dummy variables, Multicollinearity. Generalized least-squares method of estimation, Seemingly Unrelated Regression Equations, Heteroscedasticity, Auto-correlation, Distributed lag models.

Elements of time-series analysis-measurement of secular trend, seasonal fluctuations, cyclical fluctuations, periodogram analysis, harmonic analysis, serial correlation and correlogram. Index numbers – their characteristics and construction. Index numbers of wholesale and consumer prices.

AS 169: PLANNING OF SURVEYS / EXPERIMENTS (2L+1P) I

Agricultural statistical system in India, Organisation of agricultural and livestock census, Nature of surveys - adhoc or repetitive, methods of data collection, problem of sampling frame, choice of sampling design, Agricultural surveys - some case studies, Crop estimation surveys, Statistics of livestock and livestock products, fisheries statistics, Land use statistics, Prices of agricultural commodities, Crop forecasting, Role of different organisations engaged in data collection in India, Sources of agricultural statistics.

Planning and designing of experiments, Preparation of layout plans and field visits related to applications of designs. Sampling in field experiments, Experiments on cultivators' fields. Long-term and rotational experiments. Intercropping and agroforestry experiments.

(Pre-requisites: AS 164, AS 165; or AS 102, AS 103)

AS 170: STATISTICAL MODELLING (2L+1P) II

Empirical and mechanistic models. Nonlinear growth models like monomolecular, logistic, Gompertz, Richards. Applications in agriculture and fisheries. Formulation of nonlinear statistical model.

Estimation of parameters using iterative procedures like Taylor's , Steepest descent, Levenberg - Marquardt's. Choice of initial values. Examination of residuals and adequacy of a model. Fitting of nonlinear statistical models using nonlinear estimation procedures and software packages.

Compartmental modelling - First and second order input-output systems, Dynamics of a multivariable system. Applications in plant growth and animal physiology. Two-species systems. Lotka-Volterra, Leslie-Gower and Holling-Tanner non-linear prey-predator models. Volterra's principle and its applications. Gause competition model. Multi-species modelling.

(Pre-requisite: AS 150)

AS 171: BIO INFORMATICS – I (3L+1P) II

Basic Biology: Proteins and enzymes, genes, gene structures, gene expression and regulation, Molecular tools, nucleotides, nucleic acids, Markers, bioenergetics.

Structural and functional genomics: Organization and structure of genomes, genome mapping, assembling of physical maps, strategies and techniques for genome sequencing and analysis.

Computing techniques: Languages useful for browsing biological databases on web; Computer networks – Internet, World wide web, Web browsers – EMBnet, NCBI; Databases pertaining to Nucleic acid sequences, protein sequences, Genome and Proteome; Searching sequence databases, Structural databases.

Statistical Techniques: MANOVA, Cluster analysis, Discriminant analysis, Principal component analysis, Principal coordinate analysis, Multidimensional scaling; Multiple regression analysis; Likelihood approach in estimation and testing; Resampling techniques – Bootstrapping and Jack-knifing; Markov Models.

Tools for Bioinformatics: DNA Sequence Analysis – Features of DNA sequence analysis, Approaches to EST analysis; Pairwise alignment techniques: Comparing two sequences, PAM and BLOSUM, Global alignment (The Needleman and Wunsch algorithm), Local Alignment (The Smith-Waterman algorithm), Dynamic programming, Pairwise database searching; Sequence analysis– BLAST and other related tools, Different methods of Multiple sequence alignment, Searching databases with multiple alignments; Alignment Scores, Design and Analysis of microarray experiments.

AS 200: DESIGN OF EXPERIMENTS - II (1L+1P) I

Partially balanced incomplete block designs with two associate classes - properties, analysis and construction. Multiple comparison procedures. Fractional replication of symmetrical factorials. Asymmetrical factorials - construction and analysis of balanced confounded designs. Response surface designs, second order rotatable designs.

(Pre-requisite: AS 164)

AS 201: SAMPLING TECHNIQUES - II (1L+1P) I

Sampling with varying probabilities without replacement, Horvitz – Thompson estimator, Ordered and unordered estimators, Sampling strategies: Midzuno-Sen, Rao-Hartley-Cochran. πPS Sampling: Procedures such as Brewer, Durbin and Sampford, etc. Super population concept - comparison of various sampling strategies. Imperfect frames, Post – stratified estimator, multiple frames. Randomized response techniques.

(Pre-requisite: AS 165)

AS 202: STATISTICAL GENETICS-II (1L+1P) I

Genetic load, Random genetic drift, Effect of finite population size, Theory of path co-efficients. Regular system of inbreeding. Effect of inbreeding on quantitative characters, Multiple allelism in continuous variation, Sex-linked genes,

Maternal effects - estimation of their contribution. Variance component approach and linear regression approach for the analysis of GE interactions. Measurement of stability and adaptability for genotypes. Concepts of general and specific combining ability. Diallel and partial diallel crosses - construction and analysis.

(Pre-requisite: AS 166)

AS 203: REGRESSION ANALYSIS (1L+1P) I

Regression diagnostics - non-normal errors, non-constant error variances, non-independent observations, influential observations (outliers), non-linearity of the model, multi-collinearity in the data. Remedial measures - regression under non-normal errors, transformation of data, generalized least-squares, robust regression, ridge regression, Regression using principal components. Model over-fitting, model under-fitting, selection of variables, adequacy and validation of models. Use of dummy variables, regression with ordinal data. Introduction to non-parametric regression.

AS 204: LINEAR MODELS (2L) I

General Gauss Markoff set up , Gauss-Markoff's theorem, Theory of linear estimation, Test of hypothesis in linear models. Special cases of one and two way classifications (including disproportionate cell frequencies and interaction, cross and nested classifications). Analysis of covariance, variance components models, estimation of variance components from unbalanced data. Unified theory of least-squares, MINQUE, MIVQUE. Mixed models.

AS 205: ADVANCED STATISTICAL INFERENCE (1L+1P) II

Robust estimation and robust tests. Asymptotic techniques, Bayesian inference. Estimation of density function, Conditional inference, Detection and handling of outliers in statistical data. Loglinear models, saturated models, hierarchical models, Analysis of multi - dimensional contingency tables.

AS 206: OPTIMIZATION TECHNIQUES (1L+1P) I

Classical and numerical methods of optimization - Constrained optimization, Lagrange multipliers, Direct search methods, Gradient methods. Linear programming techniques - Simplex method, Karmarkar's algorithm, Duality and Sensitivity analysis, Non-linear programming, Kuhn-Tucker sufficient conditions, Elements of multiple objective programming, Dynamic Programming, Optimal control theory - Pontryagin's maximum principle, Time-optimal control problems.

AS 207: STOCHASTIC PROCESSES (3L) II

Basics of stochastic processes. Random walk models. Markov chains and their applications. Discrete branching processes. Markov processes in continuous time: Poisson process, Random - variable technique. Birth and death processes like pure birth process, linear birth and death process, immigration-birth-death process. Elements of queuing processes - queues in series, queuing networks. Applications of queuing theory. Epidemic processes: Simple deterministic and stochastic epidemic model. General epidemic models - Kermack and McKendrick's threshold theorem. Recurrent epidemics. Chain binomial models. Diffusion processes. Diffusion limit of a random walk and discrete branching process. Forward and backward Kolmogorov diffusion equations and their applications.

AS 208: BIOINFORMATICS-II (2L+1P) III

Genomic databases and analysis of high-throughput data sets, sequence annotation, ESTs, SNPs. BLAST and related sequence comparison methods.

Bayesian techniques and use of Gibbs Sampling, EM algorithm and other statistical methods to discover common motifs in biosequences. Multiple alignment and database search using motif models, ClustalW and others. Concepts in phylogeny.

Gene prediction based on codons, Decision trees, Classificatory analysis, Neural Networks, Genetic algorithms, Pattern recognition, Hidden Markov models. Computational analysis of protein sequence, structure and function.

Expression profiling by microarray/gene chip, proteomics etc., Multiple alignment of protein sequences, Modelling and prediction of structure of proteins, Designer proteins, Drug designing. Advanced topics in design and Analysis of DNA microarray experiments.

(Pre-requisite: AS 171)

AS 301: ADVANCED DESIGN OF EXPERIMENTS-I (2L+1P) II

General properties and analysis of block designs. Balancing criteria. m-associate PBIB designs and their association schemes including lattice designs - properties and construction. Properties and construction of mutually orthogonal Latin squares, Designs for two - way elimination of heterogeneity including lattice square designs. Designs for test treatment – control(s) comparisons, Nested designs, Mating designs. Optimality criteria and optimality of designs, robustness of designs. Diagnostics in design of experiments.

AS 302: ADVANCED DESIGN OF EXPERIMENTS-II (2L+1P) III

Balanced factorial experiments - characterisation and analysis (symmetrical and asymmetrical factorials). Factorial experiments with extra treatment(s). Orthogonal and balanced arrays, Fractional replication, Regular and irregular fractions. 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.

AS 303: ADVANCED SAMPLE SURVEYS-I (2L+1P) II

Design effect. Number of strata and optimum stratification. Controlled selection. Two way stratification, collapsed strata. Unbiased ratio and regression type estimators, multivariate ratio and regression methods of estimation. Systematic sampling in two dimensions. Multi-stage sampling with unequal probabilities. Self weighting designs. Integration of surveys - Lahiri and Keyfitz's procedures. Variance estimation in complex surveys. Taylor's series linearisation, balanced repeated replication, Jackknife and bootstrap methods. Use of softwares for survey data analysis.

AS 304: ADVANCED SAMPLE SURVEYS-II (2L+1P) 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. 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.

AS 305: ADVANCED STATISTICAL GENETICS-I (2L+1P) II

Hardy-Weinberg law with multiple allelic systems, auto-tetraploids and self-sterility alleles. Complex cases of selection with two or more loci. Different approaches to study inbreeding process, methods of path co-efficient, probability and generation matrix. Fisher's 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.

AS 306: ADVANCED STATISTICAL GENETICS -II (2L+1P) 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 - problems relating to computational aspects of genetic variance components, parameter estimation in variance component models for binary response data. 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. Survival analysis and concept of censored observation in animal breeding. Phylogeny and analysis of molecular variance.

AS 307: FORECASTING TECHNIQUES (1L+1P) III

Forecasting techniques with special reference to agriculture. Forecast based on time series data – exponential smoothing, Box - Jenkins approach and non-linear models. Forecast models using weather parameters crop-weather relationships and their use in yield forecast. Forecast using plant characters, forecast surveys, between-year models (regression model, Markov chain probability model and group method of data handling) and within-year models. Agro-meteorological models - climatic water balance model and crop yield assessment. Forewarning of crop pests and diseases. Applications of remote sensing techniques in forecasting. Use of ANN in forecasting.

AS 308: BAYESIAN INFERENCE IN SURVEY SAMPLING (1L+1P) III

Super population models in sample surveys, Stochastic parameter models, Bayes' linear predictor, Bayesian models with multi-stage sampling. Measurement error and small area estimation, Time series approach in survey sampling. Dynamic Bayesian prediction, Kalman filter, Empirical and Hierarchical Bayes predictors, Robust linear prediction, Bayesian robustness.

AS 370: RECENT ADVANCES IN THE FIELD OF SPECIALISATION (1L) I/ II/III

Recent advances in the field of specialisation-sample surveys/design of experiments/statistical genetics/statistical modelling, etc. will be covered by various speakers from the Institute as well as from outside the Institute in the form of seminar talks.

AS 299: SEMINAR (1L) I/II/III

7

AGRONOMY

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
A 2	PRACTICES OF CROP PRODUCTION-I	0	2
A 7	PRINCIPLES OF *KHARIF* CROP PRODUCTION	1	0
AG 201	PRINCIPLES OF CROP PRODUCTION	3	1
AG 203	SOIL FERTILITY AND ITS MANAGEMENT	3	1
AG 206	AGRONOMY OF CEREAL CROPS	3	1
AG 211	MANAGEMENT OF PROBLEM SOILS	3	1
AG 213	FARMING SYSTEMS	3	1
AG 303	RESOURCE MANAGEMENT IN CROPPING SYSTEMS	3	1
AG 299	SEMINAR	1	0

II Trimester

A 1	PRINCIPLES OF *RABI* CROP PRODUCTION	1	0
A 8	PRACTICES OF CROP PRODUCTION-II	0	2
AG 202	PRINCIPLES AND PRACTICES OF WEED MANAGEMENT	3	1
AG 205	PRINCIPLES AND PRACTICES OF IRRIGATION AND DRAINAGE	3	1
AG 207	AGRONOMY OF PULSE AND OILSEED CROPS	3	1
AG 208	AGRONOMY OF COMMERCIAL CROPS	3	1
AG 214	EXPERIMENTAL TECHNIQUES IN AGRONOMY	2	2
AG 301	ADVANCES IN RICE AND WHEAT AGRONOMY	3	1
AG 299	SEMINAR	1	0

III Trimester

A 17	PRACTICES OF CROP PRODUCTION-III	0	2
AG 204	DRYLAND AGRONOMY	3	1
AG 209	AGRONOMY OF FODDER AND PASTURE CROPS	3	1

AG 210	CROP ECOLOGY AND AGROMETEOROLOGY	3	1
AG 212	SEED AGRONOMY	2	1
AG 215	MODERN CONCEPTS IN AGRONOMY	3	1
AG 302	ADVANCES IN PULSE AND OILSEED AGRONOMY	3	1
AG 299	SEMINAR	1	0

Core Courses :

For M.Sc.: Within the discipline : AG 201, AG 202, AG 203, AG 204 and AG 205

Outside the discipline: AS 101 and AS 102

Agronomy

Major Field : **Crop Husbandry**
Resource Management

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

A 1: PRINCIPLES OF *RABI* CROP PRODUCTION (1L) II

Important *rabi* crops of India. Plants in relation to environment. Soil-water-plant relationship. Scheduling and methods of irrigation. Moisture conservation techniques. Agronomic practices for cultivation of *rabi* crops including wheat, barley, chickpea, lentil, field peas, potato, mustard, sunflower, safflower and sugarcane.

A 2: PRACTICES OF CROP PRODUCTION-I (2P) I

Field preparation for different *rabi* crops. Fertilizer calculations according to crops. Counting of seeds of *rabi* crops for test weight. Identification of seeds of *rabi* crops. Soil sampling for moisture determination. Determination of field capacity and permanent wilting point. Sowing methods of different *rabi* crops including mustard, potato, *rabi* vegetables, chickpea, lentil, peas, oats, barley, wheat, fenugreek. Biometric observations on these crops.

A 7: PRINCIPLES OF *KHARIF* CROP PRODUCTION (1L) I

Important *kharif* crops of India. Plants in relation to environment. Soil fertility management in *kharif* crops. Tillage in crop production. Weeds and their control. Concept of cropping and farming systems. Agronomic practices for cultivation of *kharif* crops including rice, maize, sorghum, pearlmillet, greengram, blackgram, pigeonpea, cowpea, soybean and cotton.

A 8: PRACTICES OF CROP PRODUCTION-II (2P) II

Field preparation and selection of crops for summer season crops. Identification of seeds of summer season crops. Sowing methods of summer season crops like sunflower, mungbean, cowpea, blackgram, maize (for cobs), jowar (for fodder) etc. Identification of weeds in *rabi* and zaid season crops. Studies on yield attributes of *rabi* crops.

Harvesting of *rabi* crops. Recording of data on yield of *rabi* crops.

A 17: PRACTICES OF CROP PRODUCTION-III (2P) III

Importance of summer ploughing. Field preparation and selection of crops for *kharif* season. Identification of seeds of *kharif* season crops including rice, maize, sorghum, bajra, greengram, blackgram, pigeonpea, cowpea, soybean, cotton and vegetables. Soil sampling for moisture determination. Seed-bed or nursery-bed preparation of *kharif* crops. Sowing/transplanting of *kharif* crops. Identification of weeds of *kharif* season crops. Irrigation application to *kharif* crops. Herbicide, insecticide, pesticide application to rice and other crops. Interculture operations. Top dressing of fertilizers. Harvesting of *kharif* crops. Recording of data on growth and yield of *kharif* crops.

AG 201: PRINCIPLES OF CROP PRODUCTION (3L+1P) I

Historical aspects of crop production. Modern concepts pertaining to tillage and tillage operations, fallowing vs. intensive cropping, yield potential of crops and their relationship to fertility status of soil. Methodological interpretation of fertilizer experiments, crop plants in relation to environment, space per plant in relation to competition within the crop, competition between component crop plants in a mixed crop and between crops and weeds. Optimum plant population in relation to soil fertility, solar radiation and available moisture regimes. Advanced treatment of principles involved in growth analysis, quantitative agrobiological principles and their validity, Mitscherlich yield equation, its interpretation and applicability, concept of inverse yield-nitrogen law, maximisation of crop yields and the apparent limitations. Economics of crop production, law of diminishing returns in crop production.

AG 202: PRINCIPLES AND PRACTICES OF WEED MANAGEMENT (3L+1P) II

Weeds and their characteristics. Dissemination of weeds and its prevention. Weed biology and ecology. Methods of weed management – cultural, biological and chemical. Classification of herbicides and selectivity. Chemistry and mode of action of common herbicides. Herbicide formulations and mixtures. Herbicide resistance, residues in soils and crops, environmental problems and their management. Integrated weed management in major crops. Weed management in non-cropped areas. Aquatic and parasitic weed control. Application of biotechnology in weed management. Herbicide resistant crops (genetically modified crops).

AG 203: SOIL FERTILITY AND ITS MANAGEMENT (3L+1P) I

Soil fertility problems, essentials of plant growth, soil fertility in relation to physical and chemical characteristics. Plant nutrients, their availability, field management and diagnostic techniques. Nutritional needs of crops, lime and sulphur application. Soil organic matter and organic manures in relation to crop production, activities of soil organisms affecting crop productivity, contribution of green manures, crop rotations and soil fertility. Development of fertilizer use in general and of nitrogenous and phosphatic fertilizers in particular. Fundamentals and methods of application, new fertilizer materials and principles of their evaluation. Summary of important fertilizer trials including long-term experiments. Use of fertilizers in multiple cropping systems. Principles underlying the purchase of fertilizer, economics of fertilizer use, crop production under fertilizer constraints. Fertilizer management in relation to water availability. Site-specific nutrient management. Concept of soil quality, organic farming, and heavy metal contamination and phytoremediation.

AG 204: DRYLAND AGRONOMY (3L+1P) III

Definition and delineation of farming areas, drought resistance in crops, mechanisms for drought tolerance and crop adaptability to drought situations. Drought tolerant crops and crop varieties, plant ideotypes or dryland areas, shoot and root growth characteristics. Soil moisture conservation and utilization, moisture retention and availability concepts, infiltration and ion movement. Water absorption by plant under stress conditions. Controlling evaporation and transpiration losses, mulches and their kinds, effectiveness and economics, antitranspirants and light reflectants. Water harvesting, concept, techniques and practices. Agrotechniques, cropping patterns, fertilizer use, weed control and other management practices for dryland agriculture.

AG 205: PRINCIPLES AND PRACTICES OF IRRIGATION AND DRAINAGE (3L+1P) II

Role of water in plant development and crop production. Place of irrigation in the world and Indian agriculture. Soil and water relations, water movement in soils. Management of soil moisture stress and plant growth. Quality of irrigation water. Scheduling of irrigation, measurement of water, methods of water application. Implements for irrigated farming. Consumptive use of water, methods of determining irrigation requirements, irrigation requirement of important farm crops. Cropping patterns and cultural practices in relation to water supplies. Development of new irrigation projects in India. Drainage-concept and classification. Control of excess water through field drainage with special emphasis on crop production and soil salinity. Interrelationship of drainage with cropping patterns and types of farming.

AG 206: AGRONOMY OF CEREAL CROPS (3L+1P) I

Introduction, origin, history, production trends, adaptability, classification, description and varietal improvement, climate and soil requirements, cultural practices, nutrient requirements, weed management, water management, crop protection, harvesting and threshing in respect to rice, maize, sorghum, pearlmillet, wheat and barley. Produce quality – its components and factors affecting it, handling and processing of the produce.

AG 207: AGRONOMY OF PULSE AND OILSEED CROPS (3L+1P) II

Introduction, origin, history, production trends, adaptability, classification, description and varietal improvement, climate and soil requirements, cultural practices, fertilizer and other nutritional requirements, weed management, water management, crop protection, harvesting and threshing, utilization including industrial by-products in respect of major pulse and oilseed crops. Place of pulse and oilseed crops in multiple, relay and intercropping systems. Role of grain legumes in building soil fertility and moisture conservation.

AG 208: AGRONOMY OF COMMERCIAL CROPS (3L+1P) II

Introduction, origin, history, production, trends, distribution, classification, description and varietal improvement, adaptability, climate, soil, water and nutrient requirements, weed management and crop protection in respect of sugarcane, potato, tobacco, chillies, cotton and jute. Produce quality – its components and factors affecting it, handling and processing of the produce, industrial uses etc.

AG 209: AGRONOMY OF FODDER AND PASTURE CROPS (3L+1P) III

Introduction, origin, history, distribution, classification, climate, soil, water and nutrient requirement of important fodder and pasture crops. Natural grasslands of India. Technology of fodder production, preservation of fodder crops i.e. techniques and principles involved, crop suitability and quality of end products. Establishment of pastures and their management with special reference to weed control and fertilization including micronutrients important to animals, defoliation and its effects, regeneration of infested pastures.

AG 210: CROP ECOLOGY AND AGROMETEOROLOGY (3L+1P) III

Crop ecology and ecosystem concept. Energy flow in an ecosystem. Ecological importance in crop production. Historical aspects of meteorology and climatology. Weather variables - their measurement and relationships with crop plants. Weather hazards and their mitigation. Weather and crop productivity. Crop growth indices – thermal/photothermal units. Agroclimatic classification. Agroclimatic zone of India. Factors determining crop distribution. Geographic distribution of crop plants, their growth and development. Physiological limits of crop yield and variability in relation to the ecological optimum adaptation.

AG 211: MANAGEMENT OF PROBLEM SOILS (3L+1P) I

Problem soils- classification and distribution. Nature and properties of saline, alkali and acidic soils. Plant responses to soil reaction, extent of damage to crops, salt tolerance of the crops. Management and improvement of saline, alkali and acidic soils. Excess soil water conditions - sources and occurrences. Rainfall analysis and water balance. Effect of excess soil water on crop growth. Management of excess soil water, water fluctuation and side movements, lowering of water table for successful crop production. Degraded soils and their rehabilitation.

AG 212: SEED AGRONOMY (2L+1P) III

Importance and classification of seed. Principles and practices of seed production in field crops. Selection of site, land requirement, isolation distance, suitable agronomic practices *i.e.* nutrient management, insect-pests, disease and weed management, roguing, field inspection, harvesting and threshing etc. for seed production of major field crops. Concept and role of genetic purity in seed production. Seed quality concepts and relation of agronomic practices and environment on seed yield and quality. Seed quality control system and organizations, seed certification and procedure. Seed act - its provisions, rules and regulations. Seed processing, storage and testing. Seed size vis-à-vis field emergence, growth and seed yield of field crops.

AG 213: FARMING SYSTEMS (3L+1P) I

Farming systems - importance, definition, objectives, principles, classification, scope and limitations. Farming systems research - procedures and methodologies. On-farm research - rationale, objectives and organization. Steps in on-farm adaptive research-design and conduct of on-farm trials. Statistical analysis, modified stability analysis, risk analysis and recommendation domain. Agricultural systems diversification, alternate land use systems, advances in farming systems research. Case studies, economic analysis of different integrated farming systems. Integration of different farming systems/ enterprises, linkages and collaborations. Farming systems and system simulation - utility of FS models, FSR by using linear programming models, use of Multiple Criteria Analysis for Decision Making (MCDM) techniques for resource allocation. Development of whole farm model. Extrapolation of experimental results for varying farm constraints and resource availability.

AG 214: EXPERIMENTAL TECHNIQUES IN AGRONOMY (2L+2P) II

Historical aspects of field experimentation. Principles and practices of field experimentation (selection of experimental field, layout of experiment, no. of treatments/replications, application of treatments, plot size etc.). Recording of data (before laying out the experiment, during crop growth and after the harvest; sampling, border effects etc.). Statistical analysis of data from agronomic experiments, pooling of data over years/ seasons/sites, contrast analysis, missing plot technique; confounding, covariance analysis. Correlation and regression analysis. Transformation

of data. Interactions in factorial experiments – their evaluation and interpretation. Interpretation of data from weed control, fertilizer, irrigation and intercropping trials. Evaluation of direct, residual and cumulative effects of treatments in cropping systems. Energetics and econometrics. Economic analysis of experimental data, determination of economic optimum dose, gross and net returns.

AG 215: MODERN CONCEPTS IN AGRONOMY (3L+1P) III

Emerging problems in Indian agriculture. Environmental concerns related to intensive use of agricultural inputs. Sustainable agriculture - need, scope, practices and economic evaluation. Organic farming - importance, history, scope, principles and practices, and limitations. Role of agro-biodiversity in sustainable food production. Crop diversification for improved food and nutritional security. Modern approaches for improving resource use efficiency in agriculture. Current status and opportunities for adoption of precision farming in India. Principles and practices of conservation tillage and watershed management. Contract farming - concept, scope, partnerships, types, characteristics, management and administration, problems and advantages for farmers/ sponsors. Concept, characteristics, types, scope and limitations of protected agriculture in India. Plant nutrition - challenges and tasks ahead. Crop modeling, information technology and WTO issues in agriculture.

ADVANCED COURSES

AG 301: ADVANCES IN RICE AND WHEAT AGRONOMY (3L+1P) II

Rice-wheat cropping system - role in food security, productivity trends, constraints and solutions. Rice ecosystems, constraints of production in different rice cultures. Nutrient transformation in submerged and upland rice soil. Innovative approaches for improving nutrient use efficiency, integrated nutrient management in rice-wheat cropping system. Agronomic management in problematic soils. Recent advances in research in rice and wheat crop production. Emerging weeds, insects and diseases problems and their control. Physiological aspects of yield formation, approaches for breaking of yield barrier and role of Agronomy.

AG 302: ADVANCES IN PULSE AND OILSEED AGRONOMY (3L+1P) III

Causes of low yields and strategies for improving productivity of pulses and oilseeds. Significance of legumes/oilseeds in cropping systems. Pulses/ oilseeds in non-traditional areas, yield stability in rainfed/dry areas. New approaches for improving productivity. Nodulation, biological N_2 fixation, quantification of N economy in legume-based cropping. Intercropping systems and current transfer of N. Sources of P and S, use of biofertilizers and micronutrients. Flower drop and growth regulators in pulses/ oilseeds.

AG 303: RESOURCE MANAGEMENT IN CROPPING SYSTEMS (3L+1P) I

Fertilizer materials available in India, their production and consumption. Choice of fertilizers in relation to soil-crop ecosystems. Importance of secondary and micronutrients, deficiency symptoms and remedial measures for optimizing crop production. Integrated nutrient management in major cropping systems.

Environmental aspects of fertilizer use. Soil and land survey for soil irrigability classification. Agricultural land development for irrigated agriculture. Water management in important crops and cropping systems under different soil and agroclimatic conditions. Optimization of available water resources. Watershed management. Tillage practices for improved soil health. Integrated weed management and allelopathy in relation to cropping systems.

AG 299: SEMINAR (IL)I/II/III

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BIOCHEMISTRY

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
BIO 100	BASIC BIOCHEMISTRY	4	1
BIO 101	NUTRITIONAL BIOCHEMISTRY	3	1
BIO 200/ MBB 200	NUCLEIC ACIDS	2	2
BIO 202/ MBB 202	GENETIC ENGINEERING-PRINCIPLES AND METHODS	3	2
BIO 299	SEMINAR	1	0

II Trimester

BIO 103	PLANT BIOCHEMISTRY	3	1
BIO 201/ MBB 201	PROTEIN BIOSYNTHESIS	3	1
BIO 205	INTERMEDIARY METABOLISM	3	0
BIO 206	BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES	3	0
BIO 207	INORGANIC NITROGEN METABOLISM	3	1
BIO 299	SEMINAR	1	0

III Trimester

BIO 104	TECHNIQUES IN BIOCHEMISTRY	2	2
BIO 203/ MBB 203	GENE REGULATION	3	0
BIO 204/ MBB 204	ENZYMOLOGY	3	1
BIO 208	INTRODUCTION TO BIOMEMBRANE	3	0
BIO 299	SEMINAR	1	0

Core Courses

For M.Sc. Within the discipline: BIO 100, BIO 101, BIO 103, BIO 104, BIO 205 and BIO 207

Biochemistry

Major Fields: **Biochemistry**
Nutrition

Minor Fields: **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

BIO 100: BASIC BIOCHEMISTRY (4L+1P) I

Scope and importance of Biochemistry; Chemical foundation of Biochemistry; Water; Buffers; Cell organelles. Chemistry and physico-chemical properties of amino acids; proteins; lipids; carbohydrates and nucleic acids. Concept of free energy in biological reactions, chemical equilibrium and energy production in the cell. Enzymes and coenzymes; Hormones; Basic concepts of fat and carbohydrate metabolism; DNA replication; transcription and translation.

BIO 101: NUTRITIONAL BIOCHEMISTRY (3L+1P) I

Fundamentals of human nutrition; concept of balance diet; calorific value of foods, energy requirement, expenditure and basal metabolic rate; Biochemical composition and utilization of carbohydrates, proteins and fats; Dietary requirements of carbohydrates proteins and fats; Nutritional significance of dietary minerals; Biochemical function and specific deficiency diseases associated with vitamins; Protein –energy malnutrition; Antinutritional factors; Role of diet and nutrition in the prevention and treatment of diseases. Antioxidants; Food allergy; Biochemical changes during processing and storage of food grains, fruits and vegetables; Food additives and Contaminants.

BIO 103: PLANT BIOCHEMISTRY (3L+IP) II

Plant cell organelles; Photosynthesis in higher plants and bacteria. Chemistry of light energy utilization; Plant pigments; Light and dark reactions, C_3/C_4 pathway and crassulacean acid metabolism. Regulation of Rubisco in crop plants. Photophosphorylation and photorespiration; Biosynthesis of membrane and storage lipids; Protein folding, stability, degradation and their post-translational modifications; Role of oligosaccharides and polysaccharides in cellular metabolism; Biosynthesis and degradation of nucleic acids. Phenolics and isoprenoid metabolism. Metabolism

of cyanogenic glycosides and glucosinolates; Alkaloids; Plant hormones; Storage proteins.

BIO 104: TECHNIQUES IN BIOCHEMISTRY (2L+2P) III

Preparation and purification of cell organelles; Assay of enzymes; Amino acid and nitrogen analysis; Spectrophotometry; Spectroflurometry and mass spectrometry; Chromatographic techniques; TLC, ion-exchange, gel filtration, affinity, GLC and HPLC. Electrophoretic techniques – PAGE, SDS-PAGE, Isoelectric focusing and agarose gel electrophoresis. Ultracentrifugation. Use of radioisotopes in biology. Immunochemical techniques. PCR.

BIO 200/MBB 200: NUCLEIC ACIDS (2L+2P) I

History of nucleic acids; DNA as genetic material; Chemistry of nucleic acids; Chromatin structure and function; Structure and conformation of DNA and RNAs; DNA topoisomerases, nucleases, endonucleases and related enzymes; DNA sequencing; Biosynthesis of nitrogenous bases, nucleotides and their regulation.

BIO 201/MBB 201: PROTEIN BIOSYNTHESIS (3L+1P) II

Genetic code; Structure, function of mRNA and tRNA; Ribosome structure and function; Organization and regulation of mRNA, tRNA, rRNA genes and ribosomal proteins; Aminoacyl tRNA synthetases; Mechanistic of protein biosynthesis in prokaryotes and eukaryotes; Protein synthesis inhibitors; Post-translational modifications and their significance; Protein trafficking.

BIO 202/MBB 202: GENETIC ENGINEERING – PRINCIPLES AND METHODS (3L+2P) I

Introduction and historical perspectives; DNA cloning strategies; Characteristics of vectors; DNA sequencing and analysis; Restriction enzymes; Methods of gene isolation: construction and screening of genomic and cDNA libraries; PCR; Site directed mutagenesis; Plant transformation and analysis; Methods of gene silencing; Potential application of genetic engineering in agriculture.

BIO 203/MBB 203: GENE REGULATION (3L) III

Prokaryotic genome organization and gene clustering, operon concept, positive and negative regulation of gene expression; Eukaryotic gene regulation: fundamentals and complexity, transcriptional and post-transcriptional gene regulation; RNA editing; RNA-interference; Signal transduction and gene regulation in plant development and stress responses.

BIO 204/MBB 204: ENZYMOLOGY (3L+1P) III

Enzymes, structure and conformation; Classification, assay, isolation, purification and characterization; Specificity, mechanism of action, steady state and pre-steady state kinetics; Active site mapping, regulation of enzyme activity; Immobilized enzymes and their application; Enzyme engineering.

BIO 205: INTERMEDIARY METABOLISM (3L) II

Intermediary metabolism of carbohydrates and its regulation; Bioenergetics; Electron transfer and oxidative phosphorylation; Mechanism of oxidative phosphorylation. Lipid metabolism - degradation and biosynthesis of fatty acids, sterol biosynthesis, metabolic regulation. Amino acid metabolism-general reactions, degradation and biosynthesis of amino acids. Sulphur metabolism. Metabolism of nucleic acids - degradation and biosynthesis of purines and pyrimidines. Metabolic pathway engineering.

BIO 206: BIOCHEMISTRY OF BIOTIC AND ABIOTIC STRESSES (3L) II

Plant - pathogen interaction and disease development; Changes in metabolism, cell wall composition and vascular transport in diseased plants; Molecular mechanisms of fungal and

bacterial infections in plants; Plant defence responses, antimicrobial and antifungal molecules; Discovery and classification of viruses; Genome organization and physico-chemical properties of viruses; Multiplication stratetgies of viruses; Plant viruses; Host-virus interactions; Pathogen derived resistance; Hypersensitive response; Systemic and acquired resistance; Viriods; Antipathogenic principles; Biochemical basis of water, salt and temperature stresses; Role of heavy metals, air and water pollutants; Interaction between biotic and abiotic stresses; Molecular strategies for imparting tolerance against biotic and abiotic stresses.

BIO 207: INORGANIC NITROGEN METABOLISM (3L+1P) II

Biochemistry of nitrogen cycle. Biological nitrogen fixation; Structure, function and regulation of nitrogenase; Structure, function and regulation of *nif* genes in *Klebsiella pneumoniae*; Biochemical basis of legume-*Rhizobium* symbiosis; Genes involved in symbiosis. Different types of hydrogenases and role of uptake hydrogenase in N_2-fixation; Chemoautotrophy in *rhizobia*. Biochemistry of ferredoxin and other non-haem iron proteins. Biochemistry of nitrate assimilation and mechanism of its regulation; GS/GOGAT and GDH pathways; Ureides and amides as nitrogen transport compounds. Biochemistry of denitrification process and phosphorylation in denitrifying bacteria. Path of carbon assimilation in nitrifying bacteria.

BIO 208: INTRODUCTION TO BIOMEMBRANE (3L) III

Biomembranes, chemical, physico-chemical and structural aspects; Different models, animal, plant and bacterial membranes; Membranes of cellular organelles. Transport across membranes and energy transduction; Proton pumps-ATP-driven, light driven, electron driven. Role of membranes in synthesis and oxidative phosphorylation; Signal transduction. Structure and function of membrane lipids; Positional and fatty acid specificity of lipolytic enzymes.

BIO 299: SEMINAR (1L) I/II/III

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COMPUTER APPLICATION

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
CA 100	INTRODUCTION TO COMPUTER APPLICATION	1	1
CA 111	COMPUTER ORGANIZATION AND ARCHITECTURE	3	0
CA 112	FUNDAMENTALS OF COMPUTER PROGRAMMING IN C	2	1
CA 114	MATHEMATICAL FOUNDATIONS IN COMPUTER APPLICATION	4	0
CA 211	COMPILER CONSTRUCTION	2	1
CA 212	COMPUTER GRAPHICS	2	1
CA 213	ARTIFICIAL INTELLIGENCE	2	1
CA 214	INTERNET TECHNOLOGIES AND APPLICATIONS	2	1
CA 215	SOFTWARE ENGINEERING	2	0
CA 299	SEMINAR	1	0

II Trimester

CA 101	COMPUTER FUNDAMENTALS AND PROGRAMMING	3	1
CA 121	OBJECT ORIENTED PROGRAMMING AND DESIGN	2	1
CA 122	OPERATING SYSTEM	2	1
CA 123	NUMERICAL ANALYSIS	2	1
CA 124	SYSTEM ANALYSIS AND DESIGN	2	1
CA 221	DATA WAREHOUSING AND DATA MINING	2	1
CA 222	MULTIMEDIA AND APPLICATIONS	1	1
CA 223	MANAGEMENT INFORMATION SYSTEM	2	1
CA 224	GIS AND REMOTE SENSING TECHNIQUES	2	1
CA 225	DATA ANALYSIS IN AGRICULTURE	1	2
CA 299	SEMINAR	1	0

III Trimester

CA 131	DATA BASE MANAGEMENT SYSTEM	2	2
CA 132	DATA STRUCTURES AND ALGORITHMS	2	1
CA 134	MODELING AND SIMULATION	2	1
CA 135	COMPUTER NETWORKS	2	1
CA 299	SEMINAR	1	0

Core Courses :

For M.Sc.: Within the discipline: CA 111, CA 112, CA 121, CA 122, CA 124, CA 131, CA 132, CA 135, CA 211 and CA 225

Computer Application

Major Field : **Computer Application**

Minor Fields: **M.Sc**. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own major field.

The total minimum credit requirements of course work for M.Sc. Computer Application is 55 including Minor field (s)

DESCRIPTION OF COURSES

CA 100: INTRODUCTION TO COMPUTER APPLICATION (1L+1P) I

Overview of computers; Computer organization; Software - System software and Application software; Networking; Internet services.

CA 101: COMPUTER FUNDAMENTALS AND PROGRAMMING (3L+1P) II

Computer Fundamentals - Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, character representation: ASCII, EBCDIC. Functional units of computer, I/O devices, primary and secondary memories. Programming Fundamentals - Algorithm development, techniques of problem solving, flowcharting, stepwise refinement; Representation of integer, character, real, data types; constants and variables; Arithmetic expressions, assignment statement, logical expression; Sequencing, alteration and iteration; Arrays, string processing; Sub-programs, recursion, files and pointers; Structured programming concepts; Top down Design, development of efficient programs; Program correctness; Debugging and testing of programs.

CA 111: COMPUTER ORGANIZATION AND ARCHITECTURE (3L) I

Number systems; Boolean algebra - minimization of Boolean function using Karnaugh Map; Logic Gates, Combinational circuits – multiplexer, demultiplexer, encoder, decoder; Sequential circuits: Flip-flops, Half and Full adder, Shift register, Counters; Organization of CPU, Control Unit- Instruction and Execution cycle in CPU, Register Organization, The Instruction Cycle, Instruction Pipelining; Memory organisation - Internal memory: Semiconductor Main Memory (RAM, ROM, EPROM), Cache Memory, Advanced DRAM Organization; External Memory - Magnetic Disks, RAID, Optical Memory, Magnetic Tape;

Basic structure of computer hardware and system software - Addressing methods and machine programme sequencing; Input-output organisations - accessing I/O devices - direct memory access (DMA) – interrupts; Introduction to microprocessors – CISC and RISC Architecture, Study of functional units of microprocessors.

CA 112: FUNDAMENTALS OF COMPUTER PROGRAMMING IN C (2L+1P) I

Computer algorithms; Over view of C; Structure of program, Data types, Constants, Variables, Expression, Operators; Basic input/ output and library functions; Control structures; Arrays; Pointers, Structure and union, Pointer to functions, Function returning pointers; Dynamic memory allocation; File management; Graphics.

CA 114: MATHEMATICAL FOUNDATIONS IN COMPUTER APPLICATION (4L) I

Matrix algebra: Basic operations on matrices, Rank and inverse of matrices, System of linear equations, Characteristic roots and equations, Eigen values and eigen vectors; Basic Differentiation, Integration and Differential Equations; Vector algebra: Double and Triple Product of vectors; Coordinate geometry: circles and conic sections; Three dimensional geometry: point, straight line, plane and sphere; Sets: Set theory, subsets, operations on sets, set cardinality and counting; Functions: Bijective functions, pigeon-hole principle, Boolean functions, permutation functions, Boolean algebra, recursion relations; Number Theory: Binary arithmetic, exponentiation, induction, sequences, Fibonacci sequence, big-oh notation, GCD, Euclidean algorithm, partially ordered sets, congruence and equivalence relation, encryption scheme, linear homogenous recurrence relations with constant coefficients; Graph Theory: Graphs, trees, LAN, Eulerian cycles, Hamiltonian cycles, graph coloring, graph algorithms; Mathematical Logic: Propositional calculus, proposition, logic connectives and compound statements, conjunction, disjunction, truth tables, duality, tautologies and fallacies; Turing Machine: DFA, NFA.

CA 121: OBJECT ORIENTED PROGRAMMING AND DESIGN (2L+1P) II

Procedural abstraction, command and functional procedures; Data encapsulation - concepts of modules and interfaces; Data abstraction and types; Introduction to object orientation; History and evolution of object oriented languages; Object oriented programming in C++ - Abstract data types, classes, objects, object/message paradigm, overloading, dynamic binding, parametric polymorphism, Inheritance: class and object inheritance, inheritance and dynamic binding, multiple inheritance; Object oriented software design; Generic and reusable classes.

(Pre-requisite: CA 112)

CA 122: OPERATING SYSTEM (2L+1P) II

Operating system overview: operating system as an extended machine and resource manager; Operating system classifications; Operating system modes and system calls; Operating system architecture; Process model, Process synchronization, Concurrent processes, Process scheduling criterion and algorithms; Problem of mutual exclusion; Deadlock and prevention; Race conditions; Semaphores; Monitors; Process allocation; Memory management; Multi-programming with fixed and variable number of tasks; Continuous allocation; Paging, Demand paging, Page fault; Virtual memory; Fragmentation; Segmented memory management, Shared segments; Segmented and demand paged management, Overlays and swapping, Thrashing; Multi processor system, Master slave scheduling; Homogeneous scheduling; Device management system; Dedicated share and virtual devices; Spooling channels; Multiplexer and selector, control units; Traffic controllers and device handlers; Information management memory techniques; Input-Output file protection; Distributed operating system (Course to be taught in accordance to the Unix Operating System).

(Pre-requisite: CA 111)

CA 123: NUMERICAL ANALYSIS (2L+1P) II

Introduction to complex variables; Basic concepts: Floating point number system, Implication of finite precision, Rounding off errors; Interpolation: Polynomial interpolation, Inverse interpolation, Spline interpolation; Numerical integration: Trapezoidal rule, Simpson's 1/3rd and 3/8th rules; Ordinary differential equations: Runge-Kutta methods, Predictor - corrector methods; Linear system of equations: Gaussian's elimination, Operation counts, Implementation including pivoting and scaling, Direct factorization methods, Iterative techniques and their analysis; Linear Difference equations; Non-linear equations : Bisection, Newton Raphson, false positions, Secant methods, Iterative methods; Inverse of Matrices; Computation of eigen values and eigen vectors: Error estimates, the power methods – Jaccobi and Householder Method; Exposure to mathematical software packages.

CA 124: SYSTEM ANALYSIS AND DESIGN (2L+1P) II

Effective communication in systems analysis: Tools of the system analyst, problem definition, classification, data collection and analysis; Systems planning and alternative, feasibility and proposal: User and management involvement, planning alternatives, design considerations, systems feasibility, selection of a system plan, the system proposal; System Cost Determination: System costs and System benefits, Comparative cost analysis. Data processing costs; A Structured Approach to system design: Structured top-down design, data administration and data dictionaries; Audible systems, Logical design requirements, Form requirement and design. Project Management and control: Development of standards, project control, Gantt charts, PERT and CPM; System conversion and Implementation: Planning consideration, conversion methods, system follow up and quality assurance of the new system.

CA 131: DATA BASE MANAGEMENT SYSTEM (2L+2P) III

Database system - Operational Data, Characteristics of database approach, architecture; Overview of DBMS; Data associations - Entities, Attributes and Associations, Relationship among Entities, Representation of Associations and Relationship, Data Model classification, Entity Relationship model; Relational Data Structure-Relations, Domains and Attributes, Relational Algebra and Operations, Retrieval Operations; Relational Database Design - Anomalies in a Database, Normalization Theory, and Normal forms; Query processing; Distributed Databases-concepts, architecture, design; Structured Query Language (SQL) - Data Definition Language (DDL), Data Manipulation Language (DML), PL/SQL - Stored procedure, Database triggers; Relational Data Base Management Package.

(Pre-requisite: CA 101 or CA 112)

CA 132: DATA STRUCTURES AND ALGORITHMS (2L+1P) III

Representation of character, string and their manipulation; Linear list structure; Stacks; Queues; Heaps; Sorting algorithms; Searching algorithms; Representation and processing of linear linked lists; Multiple linked structures; Sparse arrays; Tree Structures: Representation of tree structures and different tree traversal algorithms; Graph and geometric algorithms.

(Pre-requisite: CA 112)

CA 134: MODELING AND SIMULATION (2L+1P) III

Uses and purposes of simulation; Classification of models; Generation and testing of random numbers, Simulation of stochastic events and processes, Design of simulation experiments, Analysis of data generated by simulation experiments, Discrete event simulation; Verification and validation of simulation models,

Simulation languages, Simulation of agricultural problems and systems.

(Pre-requisites: CA 101 or CA 112, AS 101 or AS 161)

CA 135: COMPUTER NETWORKS (2L+1P) III

The importance of Networking, Types of Networking, Network Topology, Transmission Media, Data communication: Concepts of data, signal, channel, bandwidth, bit-rate and baud-rate; Maximum data-rate of channel; Analog and digital communications, asynchronous and synchronous transmission; Network adapters card, Multiplexer (FDM, TDM, STDM), Hub, Repeater. Network References Models: Layered architecture, protocol hierarchies, interface and services; ISO-OSI references model, TCP/IP reference model; Datalink layer function and protocols: Framing, error-control, flow control; sliding window protocol; HDLC, SLIP and PPP protocol; Network layer - routing algorithms, congestion control algorithms; Internetworking: bridges and gateway; Transport layer - connection management, addressing; Flow control and buffering, multiplexing; Session layer – RPC; Presentation layer - abstract syntax notation; Application layer - File Transfer Protocol (FTP), Telnet, Simple Mail Transfer Protocol(SMTP); World Wide Web(WWW) - Wide Area Indexed Servers (WAIS), WAP; Network Security; Data compression and cryptography.

(Pre-requisite: CA 111)

CA 211: COMPILER CONSTRUCTION (2L+1P) I

Introduction to Compiler, Compilation Process, Compiler Structure; Programming Language Grammars, Elements of a Formal Language Grammar, Derivation, Reduction & Syntax Trees, Ambiguity Regular Grammar & Regular Expression – Context Free Grammar; Introduction to Finite Automata, Deterministic Finite Automata, Non-deterministic Finite Automata; Scanning & Parsing Techniques – The Scanner, Regular Grammar and FSA, Top Down Parsing, Parsing Algorithm, Top Down Parsing Without Backtracking, Predictive Parsers, Bottom Up Parsing, Parsing, LR Parsers, Shift Reduce Parsing ; Symbol Table Organization, Memory Allocation – Static & Dynamic Memory Allocation, Compilation Control Transfer, Procedure Calls, Conditional Execution, Iteration Control Construct; Lexical Syntax Errors, Semantic, Major Issues In Optimization, Optimizing, Transformations, Local Optimization, Program Flow Analysis, Global Optimization.

(Pre-requisite: CA 114)

CA 212: COMPUTER GRAPHICS (2L+1P) I

Introduction, Application of Graphics, Elements of Graphics Workstation, Graphics I/P Devices; Development of computer graphics: Basic graphics system and standards; Raster scan and random scan graphics; Continual refresh and storages displays; Display processors and character generators; Colour display techniques; Frame buffer and bit operations, Concepts in raster graphics; Points, Lines and Curves; Scan conversion; Line-drawing algorithms; Circle and ellipse generation; Polygon filling; Conic-section generation; Antialiasing; Two-dimensional viewing: Basic transformations; Co-ordinate systems; Windowing and clipping; Segments; Interactive picture-construction techniques; Interactive input/ output devices.; Three-dimensional concepts: 3-D representations and transformations; 3-D viewing; Algorithm for 3-D volumes, Spline curves and surfaces; Fractals; Quadtree and Octree data structures; Hidden line and surface rendering and animation.

(Pre-requisite: CA 112)

CA 213 : ARTIFICIAL INTELLIGENCE (2L+1P) I

Introduction to Artificial Intelligence (AI); Scope of AI: Games, theorem proving, natural language processing, robotics, expert system; Knowledge: General concept of knowledge, Knowledge based system, Representation of

knowledge, Knowledge organization and manipulation, Acquisition of knowledge; Symbolic approach: Syntax and Semantics for Prepositional Logic (PL) and First order predicates logic (FOPL), Properties of well formed formulas (wffs), Conversion to clausal form, Inference rules, Resolution principle, Non deductive inference methods; Search and Control strategies: Blind search, Breadth- first search, Depth – First search, Hill climbing method, Best – First search, Branch and Bound search; Learning: Concept of learning, learning automation, genetic algorithms, learning by induction; Expert System: Introduction to expert system, Characteristics features of expert system, Applications, Importance of Expert system, Rule based system architecture.

(Pre-requisite: CA 132)

CA 214: INTERNET TECHNOLOGIES AND APPLICATIONS (2L+1P) I

Survey of contemporary Internet Technologies - Role, use and implementation of current tools; Application Layer Services and protocols - Domain name services, network management protocol, electronic mail and file transfer protocol; World Wide Web – Web pages, Web Sites, Web Servers; Intranet and Extranet Concepts; Web Application Architectures; Hyper Text Markup Language (HTML); Building static and dynamic web pages; Scripting Languages - Client side and server side scripting; Interaction with database.

(Pre-requisites: CA 121, CA 131 and CA 135)

CA 215: SOFTWARE ENGINEERING (2L) I

Software engineering definition; Software Development: Phases, Process models, Project structure, Project team structure, Role of Metrics, Measurement, Software quality factors. Planning and Software Project: Requirement Analysis, Cost Estimation, Project Scheduling, Quality Assurance Plan, and Project Monitoring Plans. System Design: Design Objectives, Design Principles, Design Tools, and Techniques, Prototyping Structured Programming Coding: Programming practices, Verification, Monitoring and Control. Testing: Testing Fundamentals, Functional Testing, Structural Testing, Test Plan activities, Unit testing, Integration Testing. Reliability: Concept of Software Reliability, Reliability Models, Limitations of Reliability Models, Software Maintenance.

(Pre-requisite: CA 124)

CA 221: DATA WAREHOUSING AND DATA MINING (2L+1P) II

Concepts and principles of data warehousing; Data warehousing architecture; System process and process architecture; Data warehousing design; Database schema; Partitioning strategy; Aggregations; Data marts; Meta data management; Data warehouse process; Query Management; Data warehouse security; Backup and recovery; Capacity planning; Testing the warehouse. Introduction to data mining; Neural networks; Fuzzy logic; Visualization techniques; Decision trees; Association rules; Statistical and clustering models.

(Pre-requisite: CA 131 and AS 161)

CA 222: MULTIMEDIA AND APPLICATIONS (1L+1P) II

Introduction to Multimedia Technology - Computers, communications and entertainment; Framework for multimedia systems; M/M devices, presentation devices and the user interface, M/M presentation and authoring; Digital representation of sound and transmission; Brief survey of speech recognition and generation; Digital video and image compression; JPEG image compression standard; MPEG motion video compression; DVD technology, Time based media representation and delivery; M/M software environment; Limitation of workstation operating systems; M/M systems services; OS support for continuous media applications; Media stream

protocol; M/M file system and information representation; Data models for M/M and Hypermedia information.

(Pre-requisite: CA 111)

CA 223: MANAGEMENT INFORMATION SYSTEM (2L+1P) II

Basic management principles; Objectives of MIS; System concepts of MIS; Planning, design and implementation of MIS; Decision making with MIS; Data information and communication of MIS; Information systems in agriculture; Development of a MIS; Accounting and Financial management; Project management-project scheduling CPM and PERT.

(Pre-requisite: CA 124)

CA 224: GIS AND REMOTE SENSING TECHNIQUES (2L+1P) II

Introduction to Geographical Information System; Introduction- maps and spatial information, components of a GIS; GIS Internals - data representation- raster and vector data structures and analysis techniques; Digital Elevation Models; Data input, verification, storage and output; Spatial modelling- manual and automatic digitizing process; Data errors in GIS; Classification methods-multivariate analysis and classification; Spatial interpolation; Current and potential uses of GIS in agricultural planning; Software components used in GIS; GIS in India.

Physics of remote sensing, atmospheric effects and remote sensing sensors; Spectral signatures of earth surface features, spectral characteristics of vegetation, soil and water; Data acquisition system, satellite image acquisition; Data collections: pre-processing and data storage; Visual and digital image interpretation; Digital image processing.

(Pre-requisite: AS 101 or AS 161)

CA 225: DATA ANALYSIS IN AGRICULTURE (1L+2P) II

Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data; Fitting and testing the goodness of fit of probability distributions; Testing of hypothesis; t-test, Chi-square test and F-test; Concept of analysis of variance and covariance of data for one-way and multi-classified experiments; Analyzing crossed and nested classified designs; Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression; Multivariate Analysis Techniques: Principal component analysis, Factor analysis, Canonical Correlation Analysis, Cluster Analysis, Discriminent function; Analysis of time series data etc.

(Pre-requisites: CA 101 or CA 112, AS 101 or AS 161)

CA 299: SEMINAR (1L) I /II /III

10

ENTOMOLOGY

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
A 5	MAJOR PESTS OF CROPS AND THEIR MANAGEMENT	1	2
ENT 100	INSECT BIODIVERSITY	2	1
ENT 101	INSECT MORPHOLOGY	2	1
ENT 102	PEST MANAGEMENT IN FIELD AND HORTICULTURAL CROPS – I	2	1
ENT 103	INSECT PEST MANAGEMENT	3	0
ENT 105	PRINCIPLES OF BIOLOGICAL CONTROL	2	1
ENT 107	PRINCIPLES OF INSECT PHYSIOLOGY	2	1
ENT 206	INSECT BIOCHEMISTRY	2	1
ENT 299	SEMINAR	1	0

II Trimester

ENT 106	PRINCIPLES OF INSECT ECOLOGY	2	1
ENT 108	PRINCIPLES OF INSECT TOXICOLOGY	2	1
ENT 200	INSECT BIOSYSTEMATICS	2	1
ENT 202	ADVANCES IN BIOLOGICAL CONTROL	2	1
ENT 203	PEST MANAGEMENT IN FIELD AND HORTICULTURAL CROPS – II	2	1
ENT 301	ADVANCES IN INSECT PHYSIOLOGY	2	1
ENT 299	SEMINAR	1	0

III Trimester

ENT 104	PESTS OF STORED PRODUCTS AND THEIR MANAGEMENT	2	1
ENT 201	INSECT PATHOLOGY	2	1
ENT 204	INSECT NUTRITION AND HOST PLANT RESISTANCE	2	1

ENT 205	ADVANCES IN INSECT TOXICOLOGY	2	1
ENT 300	BIOCHEMISTRY OF INSECTICIDE ACTION	2	1
ENT 302	RECENT TRENDS IN ENTOMOLOGY	2	1
ENT 299	SEMINAR	1	0

Core Courses :

For M.Sc.: Within the discipline: ENT 100, ENT 101, ENT 105, ENT 106, ENT 107 and ENT 108

Outside the discipline: AS 101

Entomology

Major Fields: **Insect Biosystematics**
Insect Pest Management (Ecology and Biological Control)
Insect Toxicology
Insect Physiology

Minor Fields: **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

A 5: MAJOR PESTS OF CROPS AND THEIR MANAGEMENT (lL+2P) I

History of entomology; position of insects in animal kingdom; distinguishing characters of insects and mites and their damage; major insect pests of field crops, vegetables and fruits and their management, stored grain pests and their management, non-insect pests and insect pollinators, principles of insect control and pest control appliances.

ENT 100: INSECT BIODIVERSITY (2L+IP) I

Introduction to class Insecta and its position in phylum Arthropoda; history of insect classification; phylogeny, evolution and nomenclature; diversity of insect and mite fauna in various ecosystem; importance of biodiversity in relation to agriculture and environment; methods of collecting, preserving and studying insects and their immature stages; classificationof insects up to orders and identification of agriculturally important groups.

ENT 101: INSECT MORPHOLOGY (2L+1P) I

Insect dominance, structural perfections and developmental characteristics; growth laws and theories in entomology; integument, its structure, functions; head, its origin, segmentation, sclerites, sutures; types of antennae; mouth parts and their modifications; sensilla on various appendages; tentorium; neck and its sclerites; thorax, its sclerites and modifications; wing venation, articulation and wing coupling; legs and their modifications; abdomen, its sclerites, appendages and external genitalia; embryology and development.

ENT 102: PEST MANAGEMENT IN FIELD AND HORTICULTURAL CROPS - I (2L+1P) I

Nomenclature, bionomics, distribution, incidence and succession of insects and mite pests of major kharif crops: Cereals and millets, rice, maize, sorghum and millets, Pulses: Pigeon pea and mungbean, Oilseeds: Soybean, castor, sunflower and groundnut, Other crops like cotton, sugarcane, tobacco and tuber crops;Tropical fruits: Mango, sapota, banana and guava, Vegetables: Brinjal, okra, chilies and cucurbits. Weak spots in the life-cycle of the pests; economic damage and management strategies.

ENT 103: INSECT PEST MANAGEMENT (3L) I

History and concepts; ecological and socio-economic aspects; economic injury level, economic threshold level; dimensions of insect plant interactions and advances in varietal resistance to crop pests; biological, chemical, legal, cultural, genetic and other management tactics and their integration; sampling and measuring for economic levels of damage, analysis and modelling; biotype development; importance of biosystematics in pest diagnostics; bio-pesticides and toxicology in pest management; habitat management; wide area management of epidemics of crop pests; case studies on pests of national importance and their management strategies.

ENT 104: PESTS OF STORED PRODUCTS AND THEIR MANAGEMENT (2L+1P) III

Bionomics and management of pests of stored products including fungi, mites, rodents and other non insect pests; principles and methods of safe storage, detection methods; estimation of losses; improved storage structures, ware houses, grain storage facilities and their management; fumigation with conventional and inert gases, vacuum fumigation; insect trapping devices used in storage, use of plastics in storage; sanitary and phytosanitary considerations.

ENT 105: PRINCIPLES OF BIOLOGICAL CONTROL (2L+ 1P) I

The philosophy, scope, history and importance of biological control; theoretical and empirical basis of biological control; parasitism and predatism, phases of parasitism; important parasitic and predatory groups of insects and biocontrol agents; ecological basis of classical and applied biological control; methods of colonization, recovery and evaluation; introduction, culture, establishment and management of natural enemy populations; biological control of weeds.

ENT 106: PRINCIPLES OF INSECT ECOLOGY (2L+1P) II

History of ecology and its basic concept; habitat and niche, food chain; ecological succession; theories of Hopkins, phase, biotic etc., ecological and biological indicators; population dynamics; natural balance; biotic potential and environmental resistance; factors affecting insect distribution in space and time; biotic and climatic control; diapause, hibernation, aestivation, migration and dispersal; tropism and kinesis; social life and thermo regulation; sampling techniques; life table; population models and forecasting concept; global warming.

ENT 107: PRINCIPLES OF INSECT PHYSIOLOGY (2L+1P) I

Scope and importance of insect anatomy and physiology; comparative anatomy and physiology of digestive, excretory, respiratory, circulatory, nervous, endocrine and reproductive systems in Lepidoptera, Coleoptera, Hemiptera, Diptera, Orthoptera and Hymenoptera; general physiology of digestion, absorption and excretion. Cuticle as a protective body layer in terrestrial insects. Effect of radiations on insects, sterile male techniques, use of radio-isotopes in physiological studies.

ENT 108: PRINCIPLES OF INSECT TOXICOLOGY (2L+1P) II

Measurement of potency and susceptibility; factors affecting toxicity of insecticides; bio-efficacy; biological and physical properties of conventional insecticides; laboratory evaluation of insecticides; bioassay techniques and their importance; formulations types, uses and advances; insect growth regulators and chitin inhibitors; plant protection appliances; symptoms of insecticide poisoning and their antidotes; restricting / phasing out of harmful insecticides. Insecticides Act; BIS standards.

ENT 200: INSECT BIOSYSTEMATICS (2L+1P) II

Principles and application of zoological nomenclature; palaeontology and phylogeny; species concept and speciation; taxonomic publications; identification keys; description of new taxa; taxonomic characters; numerical taxonomy; cladistics and phenetics; molecular systematics; taxonomic collections and curation; current trends in insect classification; institutions of importance in biosystematics; status of biosystematics in India.

ENT 201: INSECT PATHOLOGY (2L+1P) III

Introduction, history, definitions and techniques in insect pathology; classification, diagnostics and symptoms caused by insect pathogens- protozoa, bacteria, rickettsiae, fungi, viruses and nematodes; factors affecting epizootology / enzootology of insect diseases and field efficacy; mass production of insect pathogens; bioassay and field evaluation; mammalian toxicity and safety of insect pathogens; commercial production and formulations; application and precautions; diseases of beneficial insects; molecular biology of insect pathogens.

ENT 202: ADVANCES IN BIOLOGICAL CONTROL (2L+1P) II

Immature stages of parasitoids and predators; host- natural enemy interactions; mass production; chemical ecology; development of improved bio-control agents; species / strain differentiation in insect natural enemies using molecular techniques; experimental techniques for the evaluation of natural enemies; case studies on - biological control of important insect pests and weeds through introduction, importation, augmentation and conservation of natural enemies; guidelines for export and import of bio-control agents; international standards for testing side effects of pesticides on natural enemies.

ENT 203: PEST MANAGEMENT IN FIELD AND HORTICULTURAL CROPS – II (2L+1P) II

Nomenclature, bionomics, distribution, incidence and succession of insect and mite pests of major rabi crops: Cereals: Wheat, barley and oats; Pulses: Chickpea, pea and lentil; Oilseeds: Mustard, safflower and linseed; Vegetables: Cole crops, tomato, onion and potato; Subtropical fruits: Citrus and grapes. Weak spots in the life cycle of the pests; economic damage and management strategies.

ENT 204: INSECT NUTRITION AND HOST-PLANT RESISTANCE (2L+1P) III

Importance of insect nutrition; nutrition of phytophagous insects, entomophagous insects; role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals in insect nutrition; growth factors; extra and intra cellular micro organisms and their transmission, location and physiology; importance of host plant resistance, history, dimensions of insect plant interactions; mechanisms of resistance; role of secondary plant metabolites in host selection, genetics of resistance; chemoreception; phagostimulants; deterrents; allelopathy; breeding crops for resistance; insect resistance in major field crops; conventional and molecular methods of investigating resistance; components of a programme for plant resistance to insects; factors affecting expression or permanence of resistance. Insect host-plant relationships, mechanisms of host selection, various concepts.

ENT 205: ADVANCES IN INSECT TOXICOLOGY (2L +1P) III

Pesticide industry in India- commercial aspects; effect of insecticides on insect at population level; insecticide resistance; detection, monitoring and management; synergism, antagonism and potentiation; ecotoxicology and biomagnification; botanical insecticides, synthetic pyrethroids and novel group of insecticides; pesticide residues in commodities and their decontamination; "Codex Alimentarious" considerations.

ENT 206: INSECT BIOCHEMISTRY (2L+ 1P) I

Metabolic specialisations in insects in relation to carbohydrates, lipids, amino acids and proteins; role of trehalose and glycogen in energy production; insect lipids and their metabolism during flight, diapause and reproduction; biochemistry of tyrosine, tryptophan and proline metabolism in insects; biosynthesis , mode of action and metabolism of insect juvenile hormones and ecdysones; pheromone biosynthesis and regulation of release; insect neuropeptides with special emphasis on PTTH, adipokinetic hormone, proctolin and bursicon; insect specific proteins.

ENT 300: BIOCHEMISTRY OF INSECTICIDE ACTION (2L+ 1P) III

Biochemical and biophysical targets in the nervous systems of insects and non target organism; molecular targets in the neuroendocrine, integument, gut and respiratory systems; Structure – activity relationships and mode of action of insecticides at the molecular level especially of carbamates, organo phosphates, nicotinoids, pyrethroids and recently introduced compounds; basic aspects of insecticide metabolizing enzymes. Metabolism of insecticides in insects and non-target organisms; molecular basis of insecticide selectivity.

ENT 301: ADVANCES IN INSECT PHYSIOLOGY (2L+ 1P) II

Advances in physiology of various systems; adaptation of insects to various ecosystems; special emphasis on the physiology of neuro-endocrine, reproductive, respiratory and muscular systems; role of hormones in metamorphosis, development and reproduction. Chemistry of cuticle- pre and post metamorphic changes; ultrastructure of nerve and glial cells, cuticle, trachea, muscle fibres, epidermis and midgut cells; sensory physiology; chemical communication in insects; pheromones in insect behaviour; exocrine and accessory glands; acoustic communication; photoperiodism; diapause; immunity; insect clocks; insect venoms; migration and dispersal, polymorphism in insects and its endocrine regulation.

ENT 302: RECENT TRENDS IN ENTOMOLOGY (3L) III

Current topics in biosystematics, molecular and numerical approaches; DNA barcodes and biological names register; insect biodiversity and prospects for gene transformation. Chemical ecology of agriculturally important insect pests; tri-trophic interactions; recombinant insect viruses in insect control; insect behavioural and morphological defences against parasitoids. Ecological side effects of biological control. *Bt* crystal proteins and their mode of action; *Cry* genes in developing insect resistant transgenic crops; advances in insecticide evaluation; ion channels as targets for insecticides-cholinergic, octopamine and GABA receptors. Recent advances in reproductive biology and endocrinology of insects; reproductive parasitism and role of *Wolbachia;* transgenic insects; insect tissue culture; recent developments in sterile insect release programmes; insect gut protease and amylase inhibitors and lectins-their role in transgenic technology. Computer aided decision making and modelling; system approach in agro-ecosystem; remote sensing; perception of sound and light by insect – their applications.

ENT 299: SEMINAR (1L) I/II/ III

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ENVIRONMENTAL SCIENCES

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
ES 100	INTRODUCTION TO ENVIRONMENTAL SCIENCES	3	0
ES 101	ANALYSIS OF AGROECOSYSTEMS	3	0
ES 103	ENVIRONMENTAL POLLUTION	3	0
ES 201	CROP GEOGRAPHY AND ECOLOGY	3	0
ES 202/ SSAC 202	INSTRUMENTAL METHODS OF ANALYSIS	2	1
ES 206/ PP 203	STRESS PHYSIOLOGY	2	1
ES 210/ AE 251	SOIL AND WATER CONSERVATION ENGINEERING	3	0
ES 301	BIODIVERSITY	2	0
ES 299	SEMINAR	1	0

II Trimester

ES 104 / PP 104	GLOBAL CLIMATE CHANGE	2	1
ES 105/ PATH 105	NON-PARASITIC AND PHANEROGAMIC DISEASES OF PLANTS	1	1
ES 203	MICROBIAL ECOLOGY	3	1
ES 204	ENVIRONMENTAL IMPACT ASSESSMENT	3	0
ES 205	WASTE MANAGEMENT	2	1
ES 211	SOIL AND WATER POLLUTION	2	1
ES 303	AGROFORESTRY	2	0
ES 304	ADVANCED ENVIRONMENTAL MONITORING TECHNIQUES	2	2

ES 299	SEMINAR	1	0

III Trimester

ES 102/ AP 102	AGRIELECTRONICS AND INSTRUMENTATION	1	2
ES 106	ENVIRONMENTAL CHEMISTRY	2	2
ES 107	ENVIRONMENTAL MICROBIOLOGY	2	1
ES 207	AIR POLLUTION	2	1
ES 208/ AE 208	RENEWABLE SOURCES OF ENERGY	2	1
ES 209	PERSISTENT ORGANIC POLLUTANTS	2	0
ES 212	BIOFUELS FOR ENVIRONMENTAL PROTECTION	2	0
ES 302	SIMULATION OF ECOLOGICAL PROCESSES	2	1
ES 299	SEMINAR	1	0

Core Courses :

For M.Sc.: Within the discipline: ES 100, ES 103, ES 106, ES 107 and ES 202

Environmental Sciences

Major Field : **Environmental Sciences**

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

ES 100: INTRODUCTION TO ENVIRONMENTAL SCIENCES (3L) I

Definitions and concepts in environmental Sciences; components of environment atmosphere, hydrosphere, pedosphere, biosphere and their interactions; energy flow in ecosystems; ecosystems of the world; biogeographic regions; biological building blocks; nutrients and nutrient cycling in different eco-systems; climate and its impact on agriculture; agroclimatic regions, soils and cropping patterns of India and agricultural productivity, biotic and abiotic interactions, plant diseases and pests; soil-plant-atmospheric interactions; agriculture and environmental pollution; greenhouse gases and global climatic changes; environmental issues.

ES 101: ANALYSIS OF AGROECOSYSTEMS (3L) I

Agro-ecosystems, ecological and social attributes, interactions among chemical, physical, biological and socio-economic components of agro-ecosystems, trophic systems in agriculture, nutrients cycling, carrying capacity, community concepts, competition, biodiversity, characteristics and functions of agro-environmental resources (soil, water, climatic factors, living organisms, farm chemicals, rural infrastructure), energy movements, biogeochemical cycles, integrated management of agro-ecosystems, adaptation, assessment of the impact of environmental variation on agro-ecosystems, options for sustainable development.

ES 102 /AP 102: AGRIELECTRONICS AND INSTRUMENTATION (lL+2P) III

Survey of the basic parameters required for quantitative agriculture and biology, possibility of measuring such parameters by suitable electrical/ electronic gadgets. Introduction to electrical and electronic circuit elements;

principle of circuit theory; fabrication of circuits to measure specific parameters needed in agricultural research; calibration and evaluation of the gadgets

with reference to commercial gadgets. (During this course students will be econouraged to fabricate some electrical/ electronic gadgets of their own interest to feel self-reliant. Time is no limitation, students can work in the laboratory during evening hours or on holidays)

ES 103: ENVIRONMENTAL POLLUTION (3L) I

Definition and source of pollution; Different types of pollution -Air, water and soil, pollution and their sources and effects on biosphere; fuel and atmospheric pollutants; sources and diffusion of $S0_2$, CO, CO_2, CFC, CH_4, NO in atmosphere, particulates and heavy metals in air; sampling and analysis technique type and sources of water pollution; waste water and its treatments; nitrate, heavy metals and pesticide residues in surface and sub- surface waters; sample and analysis techniques. Sources of soil pollution; nature of pollution and their harmful effects; solid wastes and their disposal; use of land for waste treatment and disposal; use of land for waste treatment and disposal; inter-relationship of crop and animal production systems, air, water and soil pollution in different ecosystems. Environmental quality indices and standards.

ES 104 / PP 104: GLOBAL CLIMATE CHANGE (2L+IP) II

Definition and concepts of climate change, climate variability, greenhouse effect, history and evidences of climate change, causes of climate change with emphasis to agriculture, monitoring of greenhouse gases, scenarios of climate change, rising carbon dioxide concentration and its impact on agroecosystem, carbon dioxide enrichment technology and research for crop plants. GCMs, impacts on various agro ecosystems, methodology for impact assessment, adaptations of climate change, mitigation of climate change, carbon sequestration. International conventions and global initiatives.

ES 105/ PATH 105: NON-PARASITIC AND PHANEROGAMIC DISEASES OF PLANTS (lL+IP) III

Historical review, interaction of biotic and abiotic stresses, effect of air pollution and acid rain, frost damage, diseases due to unfavourable temperature and soil moisture, nutritional deficiency disorders, methods of determining deficiencies in crops, injury due to pesticides/herbicides, diseases due to phanerogamic parasites.

ES 106: ENVIRONMENTAL CHEMISTRY (2L+2P) III

Introduction, concept and scope of environmental chemistry, natural cycles of the environment such as hydrological, oxygen, nitrogen, phosphate and sulphur, chemical and photochemical reactions in the atmosphere, photolytic and radiolytic scavangers and their transformations, chloro fluoro carbons and ODSs, chemical toxicology in the environment, PAN, classification and nature of environmental pollutants and analytical techniques for detection of major pollutants. Mechanism of organic reactions, fate of organic molecules in the atmosphere, reactive intermediates and isomerism. Acid base theory, concept of pH and redox reactions involving pollutants in soil. Chemistry of metals and non metals with reference to agricultural production.

ES 107: ENVIRONMENTAL MICROBIOLOGY (2L+1P) III

Environmental determinants governing the existence of microbes in the terrestrial, aquatic and extreme environments; Aerobiology of agricultural pathogens; Microbial communities and ecosystems (Population Dynamics); Land use strategies and microbial diversity – Spatial distribution; Microbial communities biotic and abiotic interactions in sustainable agriculture, Bioindicators – their relevance and utility; Measurement of Microbial activity in environmental samples; Microbial transpsort and bioaugmentatin; Microorganisms and organic pollutants; Biodegradation, Bioremediation; Scale up

processes for bioremediation; Microorganisms and metal pollutants; Emerging Technologies in environmental microbiology and its application; Bioreporters, Biosensors, and Microprobes; Micobial Fuel Cell; Environmental Risk assessment of GMOs; IPRs.

ES 201: CROP GEOGRAPHY AND ECOLOGY (3L) I

Scope, factors (physical and social) determining crop distribution, classification of climate, bioclimate zones, physiological limits of crop yield and variability in relation to the ecological optimum adaptation, humidity provinces, photo and thermoperiodism, geographic distribution of crop plant, growth and development, relationship of developmental physiology, manipulation of developmental physiology of crops.

ES 202 / SSAC 202: INSTRUMENTAL METHODS OF ANALYSIS (21+ IP) I

Basic principles, Electrometric equipment-EC; Spectroscopic Methods- Visible, UV, IR, Flame emission, Atomic absorption ICP, Mass Spectrometry, NMR, Chromatographic Techniques -column, TLC, GLC, HPLC, ion- chromatograph; Computer aided analysis -autoanalyser, Kjeltec; X-ray diffraction and Thermal Analysis; maintenance of equipments.

ES 203: MICROBIAL ECOLOGY (3L+ IP) II

Soil Environment; Soil Organisms -Bacteria, Fungi, Actinomycetes, Algae, Protozoa, Viruses;

The Community and its development; Microbial Community, dispersal, colonisation, succession and the climax; Nutrition tolerance range, Geography and Microenvironment of micro-organisms, natural selection; Interspecific relationships-homeostasis, commensalism, Protocooperation, symbiosis, competition, amensalism Parasitism Predation; Microbiology of the rhizosphere; phyllosphere and water bodies, Effect of microorganisms on animals and plants; Environmental influences on micro-organisms- Effect of temperature, aeration, moisture, osmotic pressure, pH, energy source, etc.; Microbial transformations The carbon cycle, The Nitrogen cycle, transformation of phosphorus, sulphur, iron and other related transformations; microbial degradation of pesticides; Mycorrhizal links with plants; their functioning and ecological significance; Ecology of microbial corrosion Microbial plasticity -relevance to microbial ecology; Modelling in microbial ecology.

ES 204: ENVIRONMENTAL IMPACT ASSESSMENT (3L) II

EIA- introduction, methodologies; Monitoring tools for EIA, surveys, spatial databases, experiments, models, GIS, remote sensing, decision support systems; EIA of physical, chemical, biological, socio-economic factors; integrated impact assessment; policy; legislative implications; case studies for various sectors.

ES 205: WASTE MANAGEMENT (2L+IP) II

Introduction; liquid, solid and gaseous wastes; Sources and their generation; physical, chemical and biological properties of wastes; Waste disposal; Impact on environment-air water and soil pollution, Waste processing technologies- physical, chemical and biological methods; Hazardous wastes, their characterization, collection and disposal methods, Agricultural and industrial wastes, their management and utilization; Resource recovery and recycling for energy; Case studies in India and abroad, Waste management laws.

ES 206/PP 203: STRESS PHYSIOLOGY (2L+IP) I

Problems of water, temperature, salt, water logging and pollution stresses, internationally and nationally. Drought: magnitude, frequency and severity, impact on agriculture and society, response of wild population and crops to drought. Drought resistance in crops: various mechanisms: some case studies, molecular and genetic basis of drought resistance, breeding for drought resistance. Salt stress- alkalinity and salinity, morphological,

physiological and biochemical responses to various salts, mechanism of resistance to salt and selection through tissue culture, breeding for salt resistance. Temperature and crop productivity: tolerance to heat and frost. Growth metabolic processes and tolerance to water logging. Pollution and crop productivity: pollution indicators. Genetic engineering for various stresses. Light stress (cloudy days)- a problem for kharif crop.

ES 207: AIR POLLUTION (2L+IP) III

Composition of clean Atmospheric air, classification of major air pollutants, Sources and nature of air pollutants; Air pollution climatology; Inter relationship between meteorology and air pollution; Influence of topography on transport and diffusion of pollutants; photochemical smog; sulphur compounds and London Type Smog, Monitoring techniques $S0_2$, CO, NOX, SPM, CH_4, etc. Effect of air pollutants on vegetation, animal and man; global effects of air pollution; acid rain and air pollution laws, impact of air pollution on agriculture.

ES 208/AE 208: RENEWABLE SOURCES OF ENERGY (2L+IP) III

Concepts of Energy: definition units, form , conservation of energy, Fossil fuels: coal, petroleum, natural gas, L.P.G., wood; smokeless chullahs, power generation and environmental pollution caused by Thermal, hydroelectric, nuclear Power plants, Energy consumption pattern in urban and rural sector. Solar Energy: Solar radiation, concepts of heat and mass transfer, Design of solar thermal systems, and applications in heating, cooling, distillation, drying, dehydration etc. Design of solar photovoltaic systems, power generation for rural electrification, water pumping, solar ponds. Wind Energy: Wind pattern of different regions of India. Wind energy for mechanical and electrical power generation. Types of wind mills, Geothermal and Tidal Energy. Biogas : Biogas from animal and agricultural wastes, Designs and types of biogas plants, utilization of biogas for heating, cooking, lighting and power generation. Characteristics of Biogas slurry and its utilization. Liquid fuels from petro- crops. Energy plantation crops. Integrated Rural Energy programme: Recycling of agro-industrial wastes for fuel and manure. Concept of producer gas, characterization of fuel material for producer gas. Designs and types of gasifiers. Animal draft power and its efficient utilization in rural sector.

ES 209: PERSISTENT ORGANIC POLLUTANTS (2L) III

Persistent organic pollutants (POPs) in the environment with reference polynuclear aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCBs), dioxins, oxiranes, volatile organic compounds (VOCs) and pesticides; toxic build up of POPs in soil micro flora and fauna; physical chemical and biological techniques for their disposal and decontamination; ground water contamination; dynamics of POPs in atmosphere, legislation and regulations and international treaties to control POPs in the environment.

ES 210 / AE 251: SOIL AND WATER CONSERVATION ENGINEERING (3L) I

Concepts of soil and water conservation; relevance of soil and water conservation in agriculture; productivity loss due to soil erosion; moisture stress and moisture excess. Types of soil erosion; mechanics of water erosion of soil; effect of land preparation and cultivation practices on soil erosion; theories of sediment yield and sediment transport; bed load movement measurement of sediment yield and sediment transport; effective life of dams and water detention structures; effect of soil erosion on the life of multi-purpose river valley projects; soil erosion loss and fertility; erosion in water conveyance systems; design of channel for erosion control; tractive force theory; maximum permissible velocity; hill soil erosion; land slides; mechanics of wind erosion; types of wind erosion

and soil movement; wind erosion control measures. Analysis of hydrologic data including rainfall, evapotranspiration; watershed characteristics; overland flow; methods of estimation of runoff; peak rate and time distribution of hydrograph; synthetic hydrograph; infiltration process; hydrologic evaluation of land treatment; flood routine.

Erosion control; design of soil conservation structures; farm ponds and temporary storage reservoirs, drop structures; chute spill ways; temporary storage reservoirs; small earth dams; afforestation and associated agronomic practices; the role of soil water conservation work river valley projects; soil conservation department, CADA etc.

ES 211: SOIL AND WATER POLLUTION (2L+IP) I

Characteristics of soil pollution; major soil problems e.g. erosion, salinity, sodicity water logging and loss of fertility. Chemical degradation; toxic metals and their impact on crop growth. Desertification. Land fill sites and ground water pollution. Physical, chemical and biological characteristics of water resources; Estuaries, rivers, streams, lakes, reservoirs and ground water. Types and sources of water pollution. Pollution impact of modern trends in agriculture, transport of pesticides, metals and nutrients from land to water. Agricultural runoff model. Characteristics of domestic, municipal and industrial effluents, merits and demerits of their utilization in agriculture.

ES 212: BIOFUELS FOR ENVIRONMENTAL PROTECTION (2L) II

Introduction to Bio-fuels and energy scenario of India, Bio-diesel crops of India. Agronomic management for maximizing yields of bio-diesel crops. Carbon sequestration potential of energy plantations In vitro technology and vegetative propagation of bio-fuel crops, Environmental and economic cost-benefit assessment of bio-diesel crops, Phytochemistry of various bio-fuel crops, conversion processes of fatty oil into bio-diesel. Potential of alcohol production from agri-residues, starch and sugar based crops, Biophysical technologies for energy production from biomass, Hydrogen fuel production from biomass its limitations and advantages. Production of Biogas from farm municipal and industrial wastes.

ES 301: BIODIVERSITY (2L) I

Biodiversity -and overview, Biodiversity, change in time and space, Biogeography and major biomass systematics; Systematics and Biodiversity, Taxonomic Nomenclature, centres of origin, species concept and diversity, origin evolution and classification of biological diversity, lower and higher plants diversity, genetic resources, exploration and collection; plant introductions, migration and utilization; threatened and endangered species; Principles of preservation and conservation of Biological diversity In Situ and Ex Situ National and Global bidiversiity conservation measures; National and International institutions associated with conservation. Biodiversity conservation legislations, biodiversity and economics. Biodiversity in the Indian centre of origin, crops and wild relatives. Global environmental changes and Biodiversity.

ES 302: SIMULATION OF ECOLOGICAL PROCESSES (2L+ 1P) III

Fundamentals of dynamic simulation, systems, models and simulation, descriptive and explanatory models, modelling techniques steps, states, rates and driving variables, feedbacks and relational diagrams, numerical integration, introduction to FST language, Modelling crop-environment, interaction, soil health, crop-pest interactions, introduction to a simple crop ecological model, applications of simulation modelling in environmental impact assessment, data requirements, limitations.

ES 303: AGROFORESTRY (2L) II

Natural resources and environment management through ecosystem approach; biotic and abiotic components of ecosystem and their linkages; land use systems; agroforestry options for sustainable land use; agroforestry models for various land use systems; relationships between agro forestry, farm forestry and social forestry; biological productivity in intercropping systems; economics of agroforestry system; agroforestry research in agricultural research system; designs for agroforestry experiments; environmental education as a tool for sustainable agroforestry.

ES 304: ADVANCED ENVIRONMENTAL MONITORING TECHNIQUES (2L+2P) II

Design of environment quality monitoring programs; monitoring methods, their strength / weakness; In-situ / Ex-situ monitoring techniques for physical (sediment yield, runoff) & chemical (chemical erosion, -salinization/sodification, heavy metal contamination) degradation of soil / water resources at field / catchment scales; Application of spectro-photometric / chromatographic / microscopic and molecular techniques for monitoring inorganic and organic pollutants, pesticide residues, green house gases, microbial biomasss/ diversity / community structure & phylogeny; Spatio-temporal environmental resource / degradation mapping with remote sensing tools/ techniques ; Use of GIS, GPS & DSS systems. Integration of multi-source & multi scale data; Computer intelligent processing technologies for analyzing environmental data.

ES 299: SEMINAR (1 L) I *I* II *I* III

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GENETICS

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
GEN 100	ELEMENTS OF GENETICS	3	2
GEN 110	PRINCIPLES OF CYTOGENETICS	3	2
GEN 130	INTRODUCTION TO BIOINFORMATICS	3	1
GEN 201	QUANTITATIVE GENETICS	4	1
GEN 210	BREEDING FIELD CROPS-I	2	1
GEN 241	FUNDAMENTAL CONCEPTS OF PLANT BREEDING	3	2
GEN 301	DEVELOPMENTAL GENETICS	3	0
GEN 299	SEMINAR	1	0

II Trimester

A 10	ELEMENTS OF GENETICS AND PLANT BREEDING	2	1
GEN 120	ELEMENTS OF PLANT BREEDING	3	2
GEN 200	DEVELOPMENT OF GENE CONCEPT	4	0
GEN 208	GENETIC CONTROL OF PLANT REPRODUCTION	2	1
GEN 211	BREEDING FIELD CROPS-II	2	1
GEN 212	DIVERSITY ANALYSIS	2	1
GEN 220	CROP CYTOGENETICS	2	1
GEN 243	CONCEPTS IN HETEROSIS BREEDING	2	1
GEN 302	MOLECULAR CYTOGENETICS	3	0
GEN 299	SEMINAR	1	0

III Trimester

GEN 140	INTELLECTUAL PROPERTY RIGHTS	2	0
GEN 204	MUTAGENESIS	3	2
GEN 206	PLANT GENE EXPRESSION AND REGULATION	3	0

GEN 207	BREEDING FOR STRESS RESISTANCE	3	0
GEN 231	BREEDING FOR CROP QUALITY	2	2
GEN 237	APPLIED CYTOGENETICS	3	1
GEN 242	ADVANCES IN PLANT BREEDING	3	0
GEN 303	TOPICS IN POPULATION GENETICS	2	1
GEN 304	INNOVATIVE APPROACHES IN PLANT BREEDING	2	0
GEN 299	SEMINAR	1	0

Core Courses :

For M.Sc. : Within the discipline: GEN 100, GEN 110 and GEN 120

Genetics

Major Fields : **Genetics**
Plant Breeding

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

A 10: ELEMENTS OF GENETICS AND PLANT BREEDING (2L+1P) II

History of Genetics and Plant Breeding. Cell and cell division. Mendelism. Linkage and recombination. Polyploidy and mutation. Role of genetics in crop improvement. Modes of reproduction. Breeding methods for self-pollinated, cross-pollinated and asexually reproducing crops. Male sterility and incompatibility. Heterosis and hybrid development. Breeding for biotic and abiotic stresses. Variety development and seed production.

GEN 100: ELEMENTS OF GENETICS (3L+2P) I

Introduction: Scope of the course, History of Genetics. Model genetic organisms; genome constancy; C-value paradox. Genetic material: composition, structure, biological significance and replication. Mendelian principles: segregation, Mendel's experiments. Probability and statistical testing, determination of family size in experiments; Independent assortment. Dominance relations and multiple alleles. Gene interaction. Environmental influence on gene expression. Sex linkage, chromosomal theory of inheritance. Linkage and recombination; detection of linkage, linkage groups, four strand crossing over. Gene mapping; two point and three point crosses, F2 data, tetrad analysis. Recombination and mapping in bacteria, viruses and humans; use of molecular markers. Concept of gene and allele, genetic fine structure; mobile genetic elements. Function of genetic material: transcription and translation. Gene regulation in prokaryotes; Gene mutation; induction, detection, mechanisms. Chromosomal aberrations. Variations in chromosome number. Extra-nuclear inheritance. Quantitative inheritance: multiple factors. Population genetics: gene frequency, Hardy-Weinberg equilibrium, changes in gene frequencies. Eukaryotes, Transposable elements & genome evolution.

GEN 110: PRINCIPLES OF CYTOGENETICS (3L+2P) I

History of Cytogenetics. Chromosomes:

chromosomal basis of inheritance, prokaryotic and eukaryotic chromosomes, mitotic and meiotic chromosomes, karyotype analysis, chromosome banding pattern and fine structure; Different forms of chromosomes and their functional significance. Lampbrush chromosomes, Polytene chromosomes, B chromosomes and sex-chromosomes. Cell division: mitotic cell cycle, chromosome cycle and chromosome movements; behaviour of chromosomes during meiosis, sexual and asexual reproduction, consequences and significance, mechanisms and theories of crossing over, cytological basis and role of synaptonemal complex. Structural variation in chromosomes: nature, cytogenetical consequences and their uses-deficiencies, duplications, inversions and interchanges. Numerical, variation in chromosomes: sources and consequences; euploidy and aneuploidy and applied research. Synthesis of natural and new polyploids, haplontic-diplontic barriers and means to overcome them. Chromosomes and trends of organic evolution.

GEN 120: ELEMENTS OF PLANT BREEDING (3L+2P) II

Introduction to plant breeding, historical aspects and genetic basis, Models of reproduction and pollination control- Male sterility and self-incompatibility-methods of plant breeding in self-pollinated and cross-pollinated crops. Hybridization: choice of parents, handling of hybrid material, pedigree selection, bulk method, back cross and other methods; Synthetic and composite populations, Mutation and polyploidy, Biotechnology in plant improvement. Mechanism of varietal release. Seed production, certification and maintenance. Plant Breeder's rights, Germplasm accessions-their utility in initiating breeding programmes through examples in crops. Recurrent Selection.

GEN 130: INTRODUCTION TO BIOINFORMATICS (3L+1P) I

What is Bioinformatics and Agri-informatics? History and development of concept; overview of topics-protein and DNA sequences; sequences databases , sequence retrieval, analysis programs, methods of sequence comparisons; sequence alignment, local alignment, multiple alignment, evolutionary relationship study, database searches, prediction of sequence of protein and its structure, genome databases. Introduction to BTIS, CGIAR, GRIN, CYMMYT, IRRI, information systems and their use in crop improvement. Collection and storage of sequences in the laboratory**:** DNA sequencing; genomic sequencing; cDNA libraries and sequencing cDNA; processing and submission of sequences; computer storage; sequence formats-Gen Bank, EMBL, NCBI, Stanford University, etc.; data storage, using ENTREZ. Database searching for similar sequences**:** Introduction –sequence similarity search; DNA vs. protein search; significance; overview of methods; Perl and Bioperl. Alignment of sequences**:** Pairwise and multiple sequence alignment; Global and Local alignment; significance; overview of methods- principles.

Phylogenetic prediction**:** Phylogeny and sequence variations; concept of evolutionary trees; methods in phylogen-maximum parsimony,distance methods, maximum likelihood, reliability of prediction. Gene prediction**:** Gene structure and characteristics; ORF; methods for microbial and Eukaryotic gene predictions, Internet resources. Genome analysis**:** Genome structure and organization-Prokaryotes and Eukaryotes; sequence assembly and gene identification; methods-comparative genomics, proteomics; synteny, functional genomics. Plant Germplasm/ Varietal information Systems: Familiarization to various international and national plant germplasm systems, pedigree information systems and its use in prediction of heterosis. Use of RDBMS for building up database and retrieval system.

GEN 140: INTELLECTUAL PROPERTY RIGHTS (2L) III

Definitions , Protection of plant varieties and farmers' rights authority and registry. Registration of plant varieties and essentially derived varieties. Duration and effect of registration and benefit sharing, Surrender and revocation of certificate and rectification and correction of register,Farmers' rights, Compulsory license, Plant varieties protection appellate tribunal, Finance, accounts and audit, Infringement, offences, penalties and procedure.

GEN 200: DEVELOPMENT OF GENE CONCEPT (4L) II

Pre-Mendelian concepts of physical basis of heredity. Gene concept in classical genetics. Intragenic complementation and recombination in lower and higher organisms. Fine structure of gene. Complex loci, split genes, mobile genetic elements, assembled genes, overlapping genes, nested genes, genes within genes. Genetic control of metabolism, gene protein relationship. Nature of genetic material and its replication. Transfer of genetic information: transcription and translation. General and specific nature of the genetic code, analysis of code dictionary, mutation suppression. Gene expression and regulation. Synthesis of gene. Implications of gene manipulation.

GEN 201: QUANTITATIVE GENETICS (4L+1P) I

Early thoughts on quantitative inheritance. Mendelian principles-gene, genotypic frequencies: Probability laws-expectations-fixed and random effects models; Genetics distributions. Partitioning of main effects and variances-general concepts of gene action-single gene and multigene models-genetical parameters and their estimation. Heritability and components of gene action. Inbreeding and covariance between relatives. Linkage-epistasis-components of epistasis, their estimation; Mating systems-diallel, north Carolina and line X tester designs. Combining ability-variances of gca and sca in mating systems. Various measures of genetic divergence. Heterosis-complex mating system, gene action, maintenance and utility of genetic variation variation in relation to some crops-self, cross and often cross pollinated. Concepts of population and their improvement, multilines and varietal blends. Recent advances in quantitative genetics and basis of breeding for productivity, illustrated through examples from crops.

GEN 204: MUTAGENESIS (3L+2P) III

History of experimental mutagenesis. Nature of mutations. Spontaneous mutations: mode of induction. Physical mutagens: properties and effect of ionizing radiations, RBE and LET, direct and indirect effects. Chemical mutagens; nature of chemical reactions, mode of action and classification of various chemical groups; transposons as mutagens. Repair of mutagenic damage. Genetic sieves in mutation induction. Screening techniques and selection procedures of induced mutations; test systems. Biological and environmental parameters influencing mutagenic efficiency. Application methodology of mutagens and modification of their action. Specificity of mutation induction and directed mutagenesis; targeted gene replacement; gene silencing. Somaclonal variation. Mutation breeding in plants, animals and micro organisms-scope and achievements. Use of mutagens as carcinostatic agents. Environmental mutagenesis-bacteria, mammalian cell cultures, Drosophila; transgenics as environmental mutagen monitors. Comparative assessment of various types of mutations.

GEN 206: PLANT GENE EXPRESSION AND REGULATION (3L) III

Gene regulation-introduction; purposes; strategies in prokaryotes and eukaryotes; Levels of gene control; Coordinate genetic regulation (case studies-anthocyanin and zein gene families in maize); Tissue specificity-genetic and molecular basis; Influence of transposons on plant gene expression; Light regulated gene expression

(*Arabidopsis* and maize as model systems); Imprinting of genes and genomes and paramutation; Transgene expression and gene silencing mechanism; Regulatory genes-horizontal and vertical homology; cloning-transposon tagging; Regulatory genes as visible markers for transformation; reporter systems to study gene expression,Combinatorial gene control. Eukaryotic transcriptional control; Translational and post-translational regulation; RNA; Signal transduction; Stress-induced gene expression; Gene Haps and Enhancer Haps.

GEN 207: BREEDING FOR STRESS RESISTANCE (3L) III

Nomenclature and classification of stresses. Nature and importance of viral, bacterial, fungal and other diseases, insect pests. Genetic, physiological and molecular mechanisms of disease and insect pest resistance. Host-parasite interaction-variation in pathogen and host, factors affecting host reactions, gene-for-gene concept, implications and significance in plant breeding. Identification of pathogen variation, multipathotype testing, gene postulation using infection type data.

Creation of artificial epiphytotics, screening techniques for breeding materials, sources of resistance, shuttle breeding, stability of resistance, gene deployment over time and space-resistance. Concepts of varietal blends, mixtures and multilines for disease resistance. Marker aided selection. Introgression of genes from the wild relatives of crop plants, pyramiding of resistance genes, elimination of linkage drag. Transgenics in the management of biotic stresses. Use of Bt toxins, protease inhibitors, electins, chitinases and glucanases for insect pest management, Importance and crop specificity of stresses due to temperature, drought, salinity, alkalinity, Aluminium toxicity, water logging and excessive rains. Genetic and physiological mechanisms governing abiotic stress resistance. Breeding procedures for abiotic stress resistance in selected and important crop plants. Achievements in breeding crop plants for abiotic stress resistance.

GEN 208: GENETIC CONTROL OF PLANT REPRODUCTION (2L+1P) II

Fertilization process and its analysis. Genetics and molecular biology of male and female gametes; *in vivo* and *in vitro* fertilization mechanism-applications for crop improvement; Anther and ovule development. Pre- and post fertilization barriers in wide crosses- Principles and techniques to overcome sterility barriers; Male sterility-types and mechanisms, methods of generating male sterility in crop plants. Anther specific genes and their utility in developing male sterility; Pollination mechanisms and their evolution; self incompatibility-cellular, genetic and molecular basis; S gene-structure and function (case studies; Tomato, Brassica, Tobacco); applications; Haploid parthenogenesis-induction and uses; Overview and future prospects.

GEN 210: BREEDING FIELD CROPS-I (2L+1P) I

History, description, classification and origin. Cytology. Floral biology and crossing techniques. Genetics of quantitative and qualitative traits. Germplasm resources. Breeding approaches. Breeding objectives. Seed production and seed certification. *Kharif* crops (Rice, Maize, Millets, Sorghum, Pulses, Oilseeds, Cotton and Sugarcane).

GEN 211: BREEDING FIELD CROPS-II (2L+1P) II

History, description, classification and origin. Cytology. Floral biology and crossing techniques. Genetics of quantitative and qualitative traits. Germplasm resources. Breeding approaches. Breeding objectives. Seed production and seed certification. *Rabi* crops (Wheat, Pulses, Oilseeds)

GEN 212 : DIVERSITY ANALYSIS (2L+1P) II

Introduction to diversity analysis**:** The meaning of diversity, history and development of concept, overview of topics, importance and use of biodiversity in agriculture.

Assessment of diversity: Morphological, biochemical and molecular. Evolution and Diversity: Phylogenetics, concept of evolutionary trees, methods in phylogeny-maximum, parsimony, distance methods, maximum likelihood, reliability of prediction.

Statistical techniques for measuring diversity and marker data analysis: Measures of quantitative and qualitative variability, diversity indices; and methods for marker data analysis. Statistical techniques for clustering: Introduction to various distance/proximity measures, data transformation and choice of scales, hierarchical and non-hierarchical cluster analysis, algorithms for forming clusters/ dendograms, exposure to various statistical softwares. Spatial diversity analysis. diversity analysis and use of DIVA-GIS for

GEN 220: CROP CYTOGENETICS (2L+1P) II

Scope of cytogenetics in crop improvement. Genome analysis; use of conventional and modern techniques- morphological, cytological, genetical, biochemical and molecular tools. Species concept: theories of evolution, isolation mechanisms and criteria for defining species, major crop plants of India, their distribution and centres of diversity; Role of cytogenetical factors in the evolution of major crops like wheat, rice, maize, sugarcane, Brassica, cotton, jute, tobacco, potato, tomato, pulse crops, forage crops and cucurbits.

GEN 231: BREEDING FOR CROP QUALITY (2L+2P) III

Importance of quality in crop breeding; use of related species and allied genera in quality improvement; wheat quality-chemical composition, cooking, nutritional, rheological, baking properties and fractional aspects; gluten quality as molecular subunits, end product uses-case histories; rice quality-chemical composition, aroma, amylase, GT, gel consistency, length:width ratio, elongation ratio, cooking quality; maize quality-properties of corn starch, high quality protein, speciality corns, food uses of regular and speciality corn, kernel mutants and their uses in breeding for quality; pulses quality-breeding for protein quality, amelioration of toxic properties; brassica-breeding for 0-0 brassicas, low erucic acid and glucosinolates and high linoleic acid. Genetics and breeding for high oil content; cotton-fibre quality. Recent development in manipulating crop quality.

GEN 237: APPLIED CYTOGENETICS (3L+1P) III

Application of cytogenetical methods for plant improvement. Location and mapping of genes on chromosomes: Deficiency method. Interchange-genetic consequence, identification of chromosomes involved, all arms marker method, linked marker method. Inversions for location of genes. Trisomics- different types, production, breeding behaviour and location of genes. Monosomics-methods of production, intervarietal substitutions, allelic and non-allelic interactions. Telocentric method of mapping. Relative efficiency of different methods. Application for crop improvement: Duplications-Production and use. Multiple interchange- use in producing inbreds, transfer of genes. Balanced tertiary trisomics-use in hybrid seed production. Polyploid methods: Use of auto-polyploids. Haploidy-methods of production and use. Gene transfer by distant hybridization: scope and limitation, methods to overcome barriers- tissue culture. Allopolyploids-synthesis of new crop species and varieties, Alien chromosome addition and substitutions. Chromosomal control of meiotic pairing and induced transfer of alien genetic variation.

GEN 241: FUNDAMENTAL CONCEPTS OF PLANT BREEDING (3L+2P) I

Variability phenotypic, genetic and environmental. Concepts of quantitative traits and Mendalian genetics pleiotropy, linkage epistasis-

illustrations from cereals. Pulses and oilseed crops. Heritability-additive and dominance variances-combining ability-gca, sca effects and variances in terms of cov (relatives) and additive, dominance variances. Mating designs examples from crops to illustrate inferences drawn for plant breeding decisions. Multiple and convergent crosses. Genetic diversity. Heterosis-relationship between heterosis, genetic diversity and combining ability through case histories. Simple concepts of selection-various selection methods through specific examples from various crops. Response and its actual estimation. Multi-trait selection-asymmetry of response. G x E interactions- various methods of their estimation with illustrative examples from crop plants. Threshold characters-selection indices and path coefficient analysis. Polyploidy and distant hybridization and their role in plant breeding, Inbreeding and cross breeding: changes of mean and variance and applications.

GEN 242: ADVANCES IN PLANT BREEDING (3L) I

Crop domestication as a long term selection experiment, Long –term selection in plants, Population size and long term selection, Gene interaction and selection, Mutational variation and long term selection response, Population-and quantitative genetic models of selection limits, Long term selection with known quantitative trait loci; Long term selection for oil and protein, Physiological changes accompanying long term selection, Mutational variation and long term selection response, Marker-assisted selection. Modern approaches to crop breeding including improvement for quality and resistance attributes. Genotype x environment interaction- adaptation, stability methods of evaluation, Gene pyramiding for multi-trait incorporation.

GEN 243: CONCEPTS IN HETEROSIS BREEDING (2L+1P) II

Introduction-historical aspects: Pre-and and post-Mendelian ideas about heterosis. Development of concepts-evolutionary, biometrical, genetic, molecular, biochemical, and physiological. Role of genetic diversity. Fixation, exploitation of heterosis using different systems such as male sterility, self-incompatibility and apomixis in rice, cotton, maize, bajra, sorghum, oilseeds, pigeon pea and forage crops. Role of biotechnology in heterosis breeding.

GEN 301: DEVELOPMENTAL GENETICS (3L) I

Early ideas on development. Development and differentiation. Origin of cell heterogeneity in early development. Determination and pluripotentiality. Constancy of the genome. Cytoplasmic regulation of gene expression during development. Genome organisation. Gene interacions in development. The organisation of development: genetic mosaics; genetic studies of determination, fate mapping; trans-determination; Homeotic genes in plants and animals- applications. Models of pattern formation and morphogens. Heterochrony in plants and animals. Programmed cell death-significance in development and evolution. Hormonal control of development. Spatial and temporal regulation of gene expression during development and differentiation, Nucleo- cytoplasmic interactions; Sex determination in plants; Transposons and development, clonal analysis in plants and animals; Seed development and apomixis.

GEN 302: MOLECULAR CYTOGENETICS (3L) II

Genome analysis-significance and uses; chromosome banding-basis, techniques and applications. Modern methods of genome analysis-chromosome painting (GISH, FISH), genomic southern hybridization, repeated nucleotide sequences and simple sequence repeats (SSR), flow cytometry and chromosome sorting, immunocytochemistry, micro-spectrophotometry, microdissection, microinjection, microcloning, chromosome-based cloning. Cell cycle analysis and

control mechanisms; molecular machinery for cell division; molecular analysis of meiosis and recombination. Ultra-structure of chromosomes. Artificial chromosomes-synthesis and applications. Moelcular cytotgenetics and evolutionary patterns; analysis of A-, B-genome and plasmon. Future prospects.

GEN 303: TOPICS IN POPULATION GENETICS (2L+1P) III

Hardy-weinberg Law-dynamics of gene frequency under selection, migration, genetic drift, Subdivision-selection in niches; Linkage-fitness; two and multi-gene systems-polymorphisms, inbreeding; Path coefficient, correlation between relatives; Mixed mating systems, genetic load, co-adapted gene complexes, homeostasis, adaptive organisation of gene pools. Introgression, case studies to illustrate various concepts of population genetics.

GEN 304: INNOVATIVE APPROACHES IN PLANT BREEDING (2L) III

Introduction, Markers: morphological, isozymes, DNA markers (RFLP, RAPD, AFLP, SSR). Construction of linkage map; use of mapping populations (F2, RILs, NILs, back cross, doubled haploids)-applications, advantages, constraints. Applications of molecular markers-fingerprinting, molecular markers and phylogenetic relationships. Tagging agronomically important traits. Assessing heterotic performance; Marker assisted selection (MAS)-oligogenic traits, MAS for QTLs. Gene pyramiding using molecular markers. Transgenic plants-applications of transgenic technology, molecular farming, antisense RNA technology-examples from published literature (crop quality, herbicide resistance, insect resistance, disease resistance, viral resistance)-organelle transformation; stability of transgenes. Biosafety issues of transgenics. Somatic hybridization-applications and constraints. Somaclonal variation in crop improvement-overview and future prospects, Plant genetic resources- characterization and utilization. Breeding for biotic stress resistance, abiotic stress tolerance and nutritional quality. Apomixis and its utilization.

GEN 299: SEMINAR (1L) I/II/III

13

HORTICULTURE

TRIMESTER-WISE DISTRIBUTION OF COURSES

I Trimester

		L	P
A 3	PRINCIPLES OF HORTICULTURAL CROPS	2	1
HORT 100	BASIC HORTICULTURE	3	2
HORT 101	FRUIT PRODUCTION-I	3	1
HORT 142	PRINCIPLES OF VEGETABLE PRODUCTION	4	1
HORT 143	NUTRITIONAL REQUIREMENT OF HORTICULTURAL CROPS	3	1
HORT 152	FUNDAMENTALS OF FLORICULTURE	3	2
HORT 201	FUNDAMENTALS OF FRUIT PRODUCTION	4	1
HORT 241	PRINCIPLES OF VEGETABLE BREEDING	4	1
HORT 253	LANDSCAPE GARDENING	3	2
HORT 310	EXPORT ORIENTED HORTICULTURE	3	1
HORT 299	SEMINAR	1	0

II Trimester

HORT 102	FRUIT PRODUCTION-II	3	1
HORT 103	SYSTEMATIC POMOLOGY	3	1
HORT 153	BREEDING OF ORNAMENTAL PLANTS	3	1
HORT 203	BREEDING OF FRUIT CROPS	4	1
HORT 204	PLANT PROPAGATION	2	2
HORT 243/ ST 243	PRINCIPLES AND TECHNIQUES OF VEGETABLE SEED PRODUCTION	4	1
HORT 245	WINTER VEGETABLES	3	1
HORT 256	PROTECTED CULTIVATION OF HORTICULTURAL CROPS	3	1
HORT 303	BREEDING OF CROSS-POLLINATED VEGETABLE CROPS	3	1
HORT 305	COMMERCIAL FLORICULTURE	3	1

HORT 299	SEMINAR	1	0

III Trimester

HORT 211/ PP 211	GROWTH AND DEVELOPMENT	3	2
HORT 244	SUMMER VEGETABLES	3	1
HORT 246	PRODUCTION OF UNUSUAL EXOTIC VEGETABLES	2	1
HORT 252	VALUE ADDITION IN ORNAMENTAL CROPS	1	1
HORT 254	INDOOR PLANTS	3	1
HORT 302	BREEDING OF SELF- POLLINATED VEGETABLE CROPS	3	1
HORT 306	PLANT TISSUE CULTURE IN THE IMPROVEMENT OF HORTICULTURAL CROPS	2	1
HORT 309	ADVANCED BREEDING OF ORNAMENTAL CROPS	3	1
HORT 299	SEMINAR	1	0

Core Courses :

For M.Sc.: 1. Within the discipline: HORT 100

2. Outside the discipline: PHT 255
3. Majoring in Pomology: HORT 101, HORT 201 and HORT 204
4. Majoring in Olericulture: HORT 142, HORT 244 and HORT 245
5. Majoring in Floriculture: HORT 152, HORT 153 and HORT 253

Horticulture

Major Fields: **Pomology**
Olericulture
Floriculture

Minor Fields : **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

A 3: PRINCIPLES OF HORTICULTURAL CROPS (2L+1P) I

Layout and establishment of orchards, kitchen and flower gardens; growing plants in pots; vegetable growing, climatic, soil and cultural requirements of major horticultural crops, crop rotation, application of manures and fertilizers and weed control, methods of propagation and seed production.

HORT 100: BASIC HORTICULTURE (3L+2P) I

Layout of orchards with different methods, their establishment, maintenance and care; principles of planting, training and pruning; propagation, manuring and fertilization; irrigation and plant protection measures; nutritive value of fruits and vegetables, main causes of spoilage of fruits and vegetables and their control measures; principal methods of preservation; commercial fruit and vegetable products; processing equipment; fruit products order; vegetable cultivation in India, types of vegetable growing; cultural practices for important vegetable crops; importance, scope and principles of floriculture and landscaping; different styles and designs of garden; their features and maintenance; landscaping of public places including their plan and planting material.

HORT 101: FRUIT PRODUCTION -I (3L+1P) I

Origin, history, soil, climate, cultivars, propagation, nutrition, orchard management, important pests and diseases connected with the cultivation of major tropical, sub-tropical and temperate fruits such as mango, banana, citrus, grape, papaya, guava, apple, pear, peach, plum, almond, cherry, walnut and berry fruits like black and blue berry etc.

HORT 102: FRUIT PRODUCTION -II (3L+1P) II

Cultivation of some minor fruit crops, namely *ber*, pineapple, sapota, litchi, pomegranate, date, *phalsa*, jackfruit, custard apple, loquat, mangosteen, *bael*, fig, *aonla,* mulberry, *jamun*, carambola, *karonda*, cashew, avocado, passion fruit, persimmon, strawberry, wood apple, *kaer, lasoda* etc.

HORT 103: SYSTEMATIC POMOLOGY (3L+1P) II

Nomenclature including International Code of Nomenclature for cultivated plants; identification, plant keys, registration, description and classification of mango, banana, grape, citrus, guava, *ber*, *aonla*, papaya, apple, pear, peach, plum, almond, sapota, cashewnut, pomegranate and datepalm.

HORT 142: PRINCIPLES OF VEGETABLE PRODUCTION (4L+1P) I

Importance of vegetables; area and production in India; types of vegetable growing; classification of vegetables; soil and climate factors; heat units and chilling requirements; cultural practices; principles governing vegetable production under glass and plastic houses; nutrients essential for plant growth; manures, chemical fertilizers and their response; irrigation and water requirements; crop rotation, crop succession, inter- and mixed-cropping; different pests, diseases and their control measures; role of plant growth substances; harvesting, grading, storage and marketing; vegetable seed production and its storage; vegetable processing; export of vegetables.

HORT 143: NUTRITIONAL REQUIREMENT OF HORTICULTURAL CROPS (3L+1P) I

Factors affecting nutrition; nutrient uptake and their removal from soil; nutrient requirements of major fruits and vegetables, methods and techniques for evaluating the requirement of macro-and micro-elements, role of different macro-and micro-nutrients, their deficiency and toxicity disorders, corrective measures to overcome deficiency and toxicity disorders; soil and foliar application of nutrients in major horticultural crops.

HORT 152: FUNDAMENTALS OF FLORICULTURE (3L+2P) I

Importance and scope of floriculture; history and development of gardens; garden styles and designs; features of gardens; uses and cultivation of ornamental trees, shrubs, climbers, bulbous plants and flowering annuals; cacti and succulents, ferns, palms and foliage plants; turf culture; factors governing growth and flowering of ornamental plants including exploitation of photo-periodism; physiological disorders; layout and management of nursery of ornamental plants; propagation methods and structures; greenhouse plants, their uses, cultivation and maintenance; principles of training, pruning, bending, pinching and disbudding; principles of soil less culture and protected cultivation; fundamental of post harvest technology of important flower crops; factors governing the post harvest life of cut flowers; principles like precooling, pulsing, bud opening, storage; flower senescence; cutting, grading, packaging and marketing of cut flower crops.

HORT 153: BREEDING OF ORNAMENTAL PLANTS (3L+1P) II

Origin, evolution and distribution; genetic resources and conservation; floral and pollen biology, cytology and cyto-genetics of important flower crops; role of introduction and selection in domestication of wild plants; breeding systems; methods of breeding suited to seed and vegetatively propagated plants; role of polyploidy and mutations in the evolution of new varieties; role of heterosis and its exploitation; production of F1 hybrids and utilization of male sterility and self incompatibility; breeding for biotic and abiotic stresses; inheritance of quantitative and qualitative traits and variation in flower characters like fragrance, flower forms (doubleness) and colour; genetic improvement in crops like roses, chrysanthemum, gladiolus, carnation, orchids, anthurium, tuberose, jasmine, marigold, petunia,

antirrhinum, gypsophila, pansy, phlox, stocks, zinnia, sweet pea, dahlia, lilies, amaryllis, bougainvillea, hibiscus *etc.*

HORT 201: FUNDAMENTALS OF FRUIT PRODUCTION (4L+1P) I

Soil and climatic adaptation; winter injury in relation to specific fruits; occurrence of frost and protection against frost; water requirement of fruit crops, intake and utilisation of water; response of fruit plants to varying conditions of soil moisture and humidity and pathological conditions associated with excess and deficiency of moisture; soil management practices; manures and manuring; systems of cultivation, intercrops, cover crops and mulching; growth and fruiting habits; principles, severity, methods and season of pruning with special reference to major fruits; training methods; unfruitfulness associated with internal and external factors; factors concerned with development of fruit, fruit setting as an orchard problem; alternate or irregular bearing; fruit thinning and fruit drop; harvesting; pre-cooling, grading, packing and transport; marketing and local market surveys.

HORT 203: BREEDING OF FRUIT CROPS (4L+1P) II

Importance, problems and prospects in improvement of fruit crops; origin and centres of diversity, causes of variation; breeding systems - incompatibility, apomixis, pathenocarpy, sterility, dichogamy *etc.*, pollinizers, methods of crop improvement - introduction, clonal selection, hybridization, mutation and polyploidy; innovative approaches like embryo rescue, protoplast fusion, genetic engineering; production of seedless fruits; early evaluation techniques; breeding objectives, methods of improvement, inheritance of economic traits, breeding for biotic and abiotic stresses and achievement in important fruit crops like mango, banana, citrus, grape, papaya, apple, peach, pear, almond *etc.*; rootstock breeding; use of marker technology; germplasm conservation; nomenclature, registration, patent and rules for release of fruit varieties.

HORT 204: PLANT PROPAGATION (2L+2P) II

Fundamental principles, propagation by seed, cutting, layering and grafting; reciprocal influence of stock and scion; stock-scion incompatibility; rootstocks for fruit crops; use of plant regulators in propagation; techniques of propagation and equipment.

HORT 211/PP 211: GROWTH AND DEVELOPMENT (3L+2P) III

Defining growth and development; physical and physiological aspects of growth, germination, juvenility, root and leaf differentiation, flowering, fruit set and development, fruit maturity and ripening, abscission, senescence of horticultural crops; factors influencing flowering, plant growth regulators and their effects on physiological processes, seed and bud dormancy, fruit thinning, fruit drop, sex expression and induction of parthenocarpy; plastochrom, water relations, stress physiology in relation to drought, temperature and salts.

HORT 241: PRINCIPLES OF VEGETABLE BREEDING (4L+1P) I

Importance, history and evolutionary aspects of vegetable breeding; genetic architecture; techniques of selfing and crossing; breeding systems and methods; breeding through selection, hybridization, heterosis breeding, male sterility, self-incompatibility; sex forms as simplified technique of hybrid seed production; resistance breeding - for disease, insect and nematode, multiple disease resistance in vegetable crops; mutation breeding; polyploidy breeding; interspecific hybridization; breeding procedures for asexually propagated vegetable crops; biotechnological tools in vegetable breeding and breeding to suit protected environment.

HORT 243/ST 243: PRINCIPLES AND TECHNIQUES OF VEGETABLE SEED PRODUCTION (4L+1P) II

Importance and present status of vegetable seed industry; intellectual property rights and

their implications; seed morphology and development in vegetable seeds; raising of crops for vegetable seed production; environmental factors related to flowering/bolting in vegetable crops; pollination systems and breeding techniques related to vegetable seed production in different crops; isolation distance; roguing; selection procedures and criteria for seed production; hybrid seeds.

HORT 244: SUMMER VEGETABLES (3L+1P) III

Origin, distribution and botanical relationship; general morphology and taxonomy; standard varieties and F1 hybrids, their evaluation and characteristics; basic principles of production, effect of environmental factors on the growth and yield; seed production, insect pests and diseases and their control measures; nutritive value and uses of summer vegetables.

HORT 245 : WINTER VEGETABLES (3L+1P) II

Origin, distribution and botanical relationship; morphology and taxonomy; principles in growing of these crops; environmental factors associated with growth and production; standard varieties and F1 hybrids, seed production techniques, pests and diseases, nutritive value and uses.

HORT 246: PRODUCTION OF UNUSUAL EXOTIC VEGETABLES (2L+1P) III

Importance and scope of growing unusual exotic vegetables; origin, distribution, general morphology, taxonomy, climate and soil requirement, production technology, varieties, seed production and management of insect-pests and diseases in artichoke, asparagus, baby corn, broccoli, Brussels sprout, Chinese cabbage, cherry tomato, celery, endive, leek, lettuce, parsley, parsnip, rhubarb, Swiss chard, gherkin and winter bean.

HORT 252: VALUE ADDITION IN ORNAMENTAL CROPS (1L+1P) III

Importance and opportunities of value addition in floriculture; dry flower making including pot pourries, their uses and trade; extraction technology, uses, sources and trade in essential oils; aromatherapy; pigment and natural dyes extraction technology, sources, uses and trade; pharmaceutical and neutraceutical compounds from flower crops; petal embedded hand made paper making and uses; preparation of products like *gulkand,* rose water, *gulrohan*, *attar*, *pankhuri*; floral craft including bouquets, garlands, flower arrangements *etc*.; tinting (artificial colouring) of flower crops.

HORT 253: LANDSCAPE GARDENING (3L+2P) I

Principles of landscaping and interior-scaping; natural and man made forms and features; bio-aesthetic planning of parks, urban areas, industrial area, golf courses, traffic islands and highways; developing computer added designs (CAD); analysis of various types of sites and their landscape treatments; organization of spaces; visual aspects of plan arrangement namely, view, vista and axis; history of gardens in India; types and styles of gardens; analysis of problems and application of landscape principles for various types of houses, educational institutions, religious places, industrial sites, country sides, farm complexes, embassies, hotels and other buildings, tourist complexes, picnic spots, camping grounds and archaeological as well as other monuments; landscaping of terrace and roof gardens and multi storey buildings; landscaping of various categories of roads; master-plans of cities in relation to open spaces, parks and other recreational areas.

HORT 254: INDOOR PLANTS (3L+1P) III

Introduction, importance and use; environmental factors affecting growth of indoor plants like light, temperature, humidity and air; watering, plant care and maintenance; properties of soil in relation to foliage plants; growing media, substrate, potting media; containers, nutrition and fertilization; description of important flowering and foliage indoor plants; cacti and succulents; propagation of indoor plants; plug and pot plant

production; diseases and insect-pests of indoor plants; growth regulation in indoor plants; interior-scaping principles and factors; flower arrangement with fresh and dry flowers; special gardens like dish, terrarium, hanging baskets, window boxes, miniature gardens, vertical garden *etc.*

HORT 256: PROTECTED CULTIVATION OF HORTICULTURAL CROPS (3L+1P) II

Objectives, importance and scope of protected cultivation of vegetables, fruits and ornamental plants; principles and structures used in protected cultivation including hotbed, cold frame, polyhouse, low tunnel *etc.*; effect of temperature, light, humidity and CO2 on growth, flowering and production; hi-tech nursery raising technology of vegetables and flowers and propagation of fruit crops; selection of crops and varieties, production technology and economics of production of high value vegetables like tomato, cucumber, capsicum, melons, summer squash, ornamental crops like rose, chrysanthemum, carnation, gerbera, lilium, orchids, anthuriums and fruit crops like strawberry and raspberry; micro-irrigation, fertigation and soil-less culture; manipulation of conditions for staggering production; problems associated with growing of horticultural crops in greenhouse and their remedies; use of greenhouse for seed production; growth regulators for manipulation of growth and flowering in ornamentals; post-harvest management of greenhouse grown commodities.

HORT 302: BREEDING OF SELF-POLLINATED VEGETABLE CROPS (3L+1P) III

Origin, distribution, cytogenetics and improvement of solanaceous crops, leguminous crops, okra, potato, lettuce and fenugreek.

HORT 303: BREEDING OF CROSS-POLLINATED VEGETABLE CROPS (3L+1P) II

Origin, distribution, cytogenetics and improvement of cole crops, cucurbitaceous crops, bulb crops, root crops, amaranth and Indian spinach.

HORT 305: COMMERCIAL ORICULTURE (3L+1P) II

Scope and importance of commercial floriculture in India; production technology including integrated nutrient, water, weed, insect and disease management of ornamental plants like rose, marigold, chrysanthemum, orchid, carnation, gerbera, gladiolus, jasmine, dahlia, tuberose, China aster and crossandra under open field conditions for domestic markets; commercial seed production in open field conditions; post harvest technology of loose and cut flowers; value addition in flower crops including dry flowers, essential oils, pigments *etc.*

HORT 306: PLANT TISSUE CULTURE IN THE IMPROVEMENT OF HORTI-CULTURAL CROPS (2L+1P) III

Basic principles of plant tissue-culture in horticulture; morphogenetic potential of higher plant, limitations, economics, suitable crops, methodologies for propagation; immediate and commercial application of plants tissue culture with major emphasis on ornamental, fruit and vegetable crops; virus elimination, protoplast culture and fusion, organogenesis and cell modification by DNA uptake including *Agrobacterium* mediated transformation, generation and selection of variants, cryobiology.

HORT 309: ADVANCED BREEDING OF ORNAMENTAL CROPS (3L+1P) III

Role of biotechnology in improvement of flower crops including *in vitro* mutagenesis, somaclonal variation, transformation, somatic hybridization, anther and ovule culture and somatic embryogenesis; bio safety of transgenics; marker assisted selection; molecular characterization; breeding for biotic and abiotic stresses using biotechnological means; IPR and DUS testing for floricultural crops; biosynthetic pathways of pigment, fragrances and senescence; flower form; bioinformatics - principles and applications; advances in important ornamental crops through biotechnology.

HORT 310: EXPORT ORIENTED HORTICULTURE (3L+1P) I

India's position and potentiality in world trade; export promotion zones in India; scope, produce specification and quality standards for export of fruits *viz.*, mango, grape, litchi, pomegranate, walnut, cashewnut *etc.*, vegetables *viz.*, onion, chilli, okra, bittergourd, gherkin *etc.*, flowers *viz.*, rose, carnation, chrysanthemum, gerbera, speciality flowers *etc.*, cut green and foliage plants, processed and value added products, seed and planting material; hi-tech nurseries, post harvest management for export including packaging and cool chain; HACCP, Codex alimentarius, ISO certification; WTO and its implications, sanitary and phyto-sanitary measures; implications of PVP.

HORT 299: SEMINAR (1L) I/II/III

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MICROBIOLOGY

TRIMESTERW-ISE DISTRIBUTION OF COURSES

I Trimester

		L	P
MB 100	MICROBIOLOGY-I	5	0
MB 101	SOIL MICROBIOLOGY-I	3	2
MB 102	MORPHOLOGY AND ECOLOGY OF ALGAE	3	1
MB 103	TECHNIQUES IN MICROBIOLOGY	0	3
MB 301	IMMUNOLOGY-IMMUNODIAGNOSTICS IN AGRICULTURE	2	2
MB 299	SEMINAR	1	0

II Trimester

MB 200	MICROBIOLOGY OF FOOD	3	2
MB 202	SOIL MICROBIOLOGY - II	3	1
MB 204	PHYSIOLOGY OF ALGAE	3	1
MB 206	BACTERIAL PHYSIOLOGY-I	3	1
MB 300	MICROBIAL GENETICS	3	1
MB 299	SEMINAR	1	0

III Trimester

MB 201	MICROBIOLOGY OF MILK AND WATER	2	1
MB 203	SOIL MICROBIOLOGY-III	2	2
MB 205	INDUSTRIAL MICROBIOLOGY	4	1
MB 207	BACTERIAL PHYSIOLOGY-II	2	1
MB 208	ALGAE IN AGRICULTURE AND INDUSTRY	3	0
MB 209	BIOFERTILIZER TECHNOLOGY	1	2
MB 299	SEMINAR	1	0

Core Courses :

For M.Sc. : Within the discipline : MB 100 and MB 103
Outside the discipline : BIO 100

Microbiology

Major Fields : **Soil Microbiology**
Algology
Applied Microbiology

Minor Field: **Ph.D.** student shall take two minors (9 credits of course work in each) from any of the other fields outside his/her own.

M.Sc. student shall take one minor (9 credits of course work) from any of the other fields outside his/her own.

DESCRIPTION OF COURSES

MB 100: MICROBIOLOGY-I (5L) I

History, development and scope of Microbiology, Prokaryotic and eukaryotic cell, classification, characteristics and importance of major groups of micoorganisms: Protozoa, Algae, Fungi, Bacteria, Actinomycetes, Viruses, Viroids, Bacteriophages, Cyanophages, Rickettsia, Prions. Nutritional and other requirements for microbial growth. Control of Microorganisms: Physical, chemical including antibiotics, Ionization. Role of microbes in : Diseases, Soil, Food, Industry, Environment, Mining and Pharmaceuticals. Morphological and internal structures and their functions in : Eubacteria, Archaebacteria, Cyanobacteria, Virus, Bacteriophage/Cyanophage, Mycoplasma, Rickettsia.

MB 101: SOIL MICROBIOLOGY-I (3L+2P) I

Soil Microorganisms - Ecology, Major groups, direct and indirect methods of studying soil micoorganisms and their activities. Carbon cycle, Decomposition of organic matter, Humus formation, Biosynthesis and Biodegradation of polysaccharides in soil, Nitrogen cycle-Ammonification, Nitrification, Denitrification, non-symbiotic and symbiotic nitrogen fixation through bacteria.

MB 102: MORPHOLOGY AND ECOLOGY OF ALGAE (3L+1P) I

Algae, Historical developments in classification of algae, Range of thallus organization in algae with special reference to green and blue green algae, Asexual and Sexual reproduction in Algae, Development in sexual reproduction of green, brown and red algae. Life cycles of algae. Cell organization and Cell structures (Heterocyst, akinetes, spores, necridia). Evolutionary trends as evidences by living and fossil algae, algal associations.

Physical and chemical characteristics of the algal habitats ranging from hot water springs to snow. Effect of the habitat on algal distribution. Ecological groups of terrestrial, fresh water and

marine habitats and adaptations. Different aspects of limnology. Seasonal succession and growth, energy flow and nutrient cycling, algal contribution to the sediments, eutrophication and pollution. Symbiosis, parasitism and grazing.

MB 103: TECHNIQUES IN MICROBIOLOGY (3P) I

Laboratory rules, tools, equipments and general requirements of a Microbiology laboratory. Microscopy and microscopic examination of living microorganisms- Examination of wet mount, hanging drop technique, slide culture technique. Counting of microbial cells, bacteria, algae, counting of fungal spores (VAM). Enumeration of bacteria by plate count, turbidometric method. Staining methods - Gram staining, Acid-fast staining, bacterial spore staining, capsule staining, flagella staining, staining of algal filaments and spores, staining of VA-mycorrhizal fungi. Sterilisation methods - moist heat, dry heat, filtration, radiation. Preparation of culture media-liquid medium, solid medium. Isolation techniques-soil microorganisms, bacteria, fungi actinomycetes, algae, mycoplasma, anaerobic bacteria. Pure culture techniques. Biochemical tests - hydrolysis of starch, cellulase production, degradation of pectins, hydrolysis of gelatin, casein, urease test, H_2S production, utilisation of carbohydrates, and their catabolism, litmus milk test, IMVIC-test, Production of indole, methyl red and VP test, citrate utilisation, catalase test. Bioassay techniques-antibiotics sensitivity of bacteria. Preliminary serological methods.

MB 200: MICROBIOLOGY OF FOOD (3L+2P) II

Food and their composition: Food as substrate for microorganisms; bacteria important in food microbiology; microflora of meat, fish, eggs, fruits, vegetables, juices, bread and pastry, canned foods. Methods of food production, food spoilages, fermented foods (sauerkraut, pickle, tempeh, tofu). Bacterial toxins in food, food-borne diseases.

MB 201: MICROBIOLOGY OF MILK AND WATER (2L+1P) III

Microbiology of milk, fermented milk products, cheese, pasteurisation, milk spoilage, microbiological methods for examination of milk and milk products; Microbiology of water, sources and types of water, procedures for water purification, sewage treatment; water pollution; biological oxygen demand: nuisance bacteria in water, water-borne diseases.

MB 202: SOIL MICROBIOLOGY-II (3L+1P II

Sulphur metabolism in water and soil; transformation of phosphorus in soil, transformation of iron, transformation of other elements, Mn, Zn, Cu, etc. soil as an ecological system, parasitism, amensalism, commensalism, Proto-co-operation, symbiosis and plant microbial interaction, Biodegradation of wastes and pollutants.

MB 203: SOIL MICROBIOLOGY-III (3L+1P) III

Rhizosphere microorganisms, Phyllosphere microorganisms, plant growth promoting Rhizobacteria, Mycorrhizal associations, Environmental effects on microorganisms - rhizosphere, phyllosphere and soil. Trilogy of plant-microbe microbe-interactions.

MB 204: PHYSIOLOGY OF ALGAE (3L+1P) II

Growth and synchrony, factors regulating algal growth, trophic classification, macro-and micronutrients, respiration and energy yielding processes. Photosynthesis: algal pigments, biosynthesis of chlorophyll, carotenoid and phycobilins and chromatic adapation, arrangement and structure of thylakoids, light reactions, dark reactions photorespiration. Algal nitrogen fixation, nitrogenase enzyme, its nature and properties, heteocyst, its structure and function, nitrogen fixation in non-heterocystous BGA, *nif* gene

organization in cyanobacteria, assimilation of combined nitrogen, protein synthesis and alternative pathways, Energy yielding processes, glycolysis, kreb's cycle, electron transport chain and phosphorylation, fermentation alternate pathways. Adapative responses of algae to stress, toxin production.

MB 205: INDUSTRIAL MICROBIOLOGY (4L+1P) III

Theory and principles of industrial fermentation, fermentor design, different type of fermentor used in industrial fermentation. Microbial culture selection, strain development, the formation and extraction of fermentation product, C&N sources used for industrial fermentation, primary and secondary metabolites, ethanol, beer, wine and cider fermentation. Enzyme production - rennet, cellulase, amylase etc. Immobilisation of enzyme. Amino acid production-glycine, glutamic acid production. Biomass production-microbial insecticide, single cell protein production for use as food and feed. Ergot alkaloid fermentation. Organic acid and related compounds (citric, gluconic, fumaric, kojic acid). Vinegar production, Vitamin and related compounds (carotenoid, vitamin B12, riboflavin, giberellin). Antibiotic production.

MB 206: BACTERIAL PHYSIOLOGY-I (3L+1P) II

Microbial growth, reproduction; Synchronous and continuous culture. Metabolism: (Energy-yielding biochemical processes). Major energy yielding sources for microorganisms - chemical energy and energy transfer, Energy transfer between exergonic and endergonic chemical reactions, Heterotrophic generation of ATP by microorganisms. Substrate level phosphorylation, oxidative phosphorylation, Oxidation reactions, Electron transport systems. Oxidative pathwasys, Krebs' and Glycolytic cycles, fermentation pathways. Regeneration of NAD, fermentation and respiration. Autotrophic generation of ATP: chemolithotrophy, photosynthesis. Non-sulphur bacteria, purple bacteria and green bacteria. Energy requiring biochemical processes. Energy utilisation for biosynthetic processes. Biosynthesis of nitrogenous compounds: proteins and nucleic acids, Biosynthesis of carbohydrates, Biosynthesis of cell wall peptidoglycan, CO_2 fixation by ribulose 1,5 diphosphates, Algal and Bacterial photosynthesis. Energy uitlisation for processes other than biosynthesis. Transport of nutrients into cells.

MB 207: BACTERIAL PHYSIOLOGY-II (2L+1P) III

Biochemistry of nitrogen cycle in nature: Physiology and biochemistry of nitrogen fixing microorganisms. Enzymes involved in biological nitrogen fixation and sources of reducing power. Biochemistry of ferredoxin and other non-haemiron proteins. Biochemical basis of symbiosis. Enzymes involved in the oxidation of ammonia to nitrate. Phosphorylation involved in denitrification. Biochemistry of nitrate assimilation. Biochemistry of hydrogenase enzyme and role in nitrogen fixation. Protein breakdown by microorganisms, deamination, transamination. Pesticides, types, resistance to microbes and metabolism.

MB 208: ALGAE IN AGRICULTURE AND INDUSTRY (3L) III

Role of algae in fertility and productivity of soil: nitrogen contributions, production of growth promoting substances; P-solubilisation, soil physico-chemical properties, reclamation of problem soils. Use of algae as food and feed-*Spirulina, Chlorella, Scenedesmus, Dunaliella, Porphyridium.* Role of algae in aquatic environment - sewage treatment, bioindicators of pollution, metal detoxification. Algae in industry-production of vitamins and fine chemicals, phycocolloids, pigments, glycerol, ammonia and amino acids, antibiotics, enzymes, hydrocarbons, hydrogen as energy, fatty acids, therapeutic uses of algae.

MB 209: BIOFERTILIZER TECHNOLOGY (1L+2P) III

Strains selection of bacteria and cyanobacteria specially for crops, purity test, bulk production (small scale and commercial scale), raw material, structures and man-power required for *Rhizobium,* BGA, *Azotobacter, Azospirillum,* phosphate solubilising inoculants and VAM. Techniques of composting and vermi-compost, purity test.

MB 300: MICROBIAL GENETICS (3L+1P) II

Principles of microbial genetics, basic procedures and terminology, establishment of crosses, selection and classifications of variations, and cis-trans complementation, Genome organization in bacteria, viruses and cyanobacteria, Genetic analysis in bacteria, actinomycetes and cyanobacteria: Gene transfer transformation, conjugation, transduction and methods of gene mapping, extra-chromosomal genetic elements and their inheritance. Genetic analysis of bacteriophages and cyanophages, Comparison of genetic mechanisms in bacteria, algae, yeast and fungi, Gene, genetic code, gene regulation and expression, Genetic engineering :Recombinant DNA, Mechanisms of recombination, Sequencing of nucleic acid and application of genetic engineering in agriculture and industry.

MB 301: IMMUNOLOGY-IMMUNODIAGNOSTICS IN AGRICULTURE (2L+2P) I

Historical developments: Innate Nonspecific immunity, Internal and external, physical & chemical barriers. Non-innate (specific) immunity: cells and organs of immune system, Functions of humeral. Antigens: Humeral immune response- generation, regulation and tolerance. Immunoglobulin and structure. Antigen-antibody interactions. Complement system. Hybrodoma and monoclonal antibody, principle and practices. Organisation and expression of immunoglobulingenes. Experimental systems: Experimental animal models, cell culture system, recombinant DNA technology, Analysis of DNA regulatory sequences, antibody gene transfer in mammalian and plant cells, vaccines.

MB 299: SEMINAR (1L) I/II/III