ETERNAL UNIVERSITY, BARU SAHIB, RAJGARH, SIRMOUR HIMACHAL PRADESH

Restructured and Revised Syllabi of M.Sc. (Ag.) Entomology as per BSMA Committee Recommendations, Education Division ICAR - New Delhi touching elements of New Education Policy

Syllabi Applicable from Academic Session 2024-25 onwards

Dr. Khem Singh Gill Akal College of Agriculture

Restructured and Revised Syllabi of M.Sc. (Ag.) Entomology as per BSMA Committee Recommendations, Education Division ICAR - New Delhi touching elements of New Education Policy

(i) Course Work	Credits (Minimum requirement)
Major Courses	20
Minor Courses	08
Supporting Courses	06
Common Courses	05
Seminar	01
(ii) Thesis Research	30
Total	70

Note:

As per New Education Policy, the student has the option to exercise his choice for the courses. Hence semester wise syllabus scheme has to be prepared by the Major Advisor / Head of the Department by instructing and guiding the student to fill Programme of Study for Postgraduate Students (PSPS) popularly known as yellow form within two weeks after getting admission / registration

Course Title with Credit Load
M.Sc. (Ag) Entomology

Course Code	Course Title	Credit Hours
ENT 501*	Insect Morphology	3 (2+1)
ENT 502*	Insect Anatomy and Physiology	3 (2+1)
ENT 503*	Insect Taxonomy	3 (1+2)
ENT 504*	Insect Ecology	3 (2+1)
ENT 505*	Biological Control of Insect Pests and Weeds	3 (2+1)
ENT 506*	Toxicology of Insecticides	3 (2+1)
ENT 507	Host Plant Resistance	2 (1+1)
ENT 508*	Concepts of Integrated Pest Management	2 (2+0)
ENT 509*	Pests of Field Crops	3 (2+1)
ENT 510*	Pests of Horticultural and Plantation Crops	3 (2+1)
ENT 511*	Post Harvest Entomology	2 (1+1)
ENT 512	Insect Vectors of Plant Pathogens	2 (1+1)
ENT 513	Principles of Acarology	2 (1+1)
ENT 514	Vertebrate Pest Management	2 (1+1)
ENT 515	Techniques in Plant Protection	1 (0+1)
ENT 516	Apiculture	3 (2+1)
ENT 517	Sericulture	3 (2+1)
ENT 518	Lac Culture	3 (2+1)
ENT 519	Molecular Approaches in Entomology	3 (2+1)
ENT 520	Plant Quarantine, Biosafety and Biosecurity	2 (2+0)
ENT 521	Edible and Therapeutic Insects	2 (1+1)
ENT 522	Medical and Veterinary Entomology	2 (1+1)
ENT 523	Forest Entomology	2 (1+1)
ENT 591	Master's Seminar	1 (0+1)
ENT 599	Master's Research	30 (0+30)

*Compulsory Major Courses

Major courses: From the Discipline in which a student takes admission. Among the listed courses, the core courses compulsorily to be taken may be given *mark

Minor courses: From the subjects closely related to a student's major subject

Supporting courses: The subject not related to the major subject. It could be any subject considered relevant for student's research work (such as Statistical Methods, Design of Experiments, etc.) or necessary for building his/ her overall competence.

Common Courses: The following courses (one credit each) will be offered to all students undergoing Master's degree programme:

Common Courses: 05 credits

PGS 501	Library and Information Services	0+1
PGS 502	Technical Writing and Communications Skills	0+1
PGS 503	Intellectual Property and its Management in Agriculture	1+0
PGS 504	Basic Concepts in Laboratory Techniques	0+1
PGS 505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

SCHEME OF EXAMINATION
(Continuous Assessment and End-Semester Examination)

MARKS DISTRIBUTION FOR DIFFERENT CREDIT HOUR COURSES

CREDITS	THEORY			PRACTICALS		
T+P	Total	Mid- Session	End Term	Total	Mid- Session	End Term
1+0	100	40 (30+10#)	60	-	-	-
2+0	100	40 (30+10#)	60	-	-	-
3+0	100	40 (30+10#)	60	-	-	-
4+0	100	40 (30+10#)	60	-	-	-
5+0	100	40 (30+10#)	60	-	-	-
6+0	100	40 (30+10#)	60	-	-	-
0+1	0	0	0	100	50	50
1+1	50	20 (15+5#)	30	50	-	50
2+1	65	25 (20+5#)	40	35	-	35
3+1	75	30 (25+5#)	45	25	-	25
4+1	80	35 (30+5#)	45	20		20
0+2	0	0	0	100	50	50
1+2	35	15 (10+5#)	20	65	-	65
2+2	50	20 (15+5#)	30	50		50
3+2	60	25 (20+5#)	35	40		40
0+3	0	0	0	100	50	50

#Assignments marks

Course Contents

M.Sc. (Ag.) Entomology

ENT 501

Insect Morphology

Credits: 2 + 1 Mid-Session Exam: 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To acquaint the students with the external morphology of the insect's body and thefunctioning of various body parts.

Theory

Units	Content	Lectures
I	External Morphology: Insect body wall structure, cuticular outgrowths, colouration and special integumentary structures in insects, body tagmata, sclerites and segmentation. Head- Origin, structure and modification; mouthparts, antennae, their types and functioning; tentorium and neck sclerites. Thorax- Areas and sutures of tergum, sternum and pleuron, pterothorax; wings: structure and modifications, venation, wing coupling apparatus and mechanism of flight; legs: structure and modifications. Abdomen- Segmentation and appendages; genitalia and their modifications; embryonic and post-embryonic development.	12
II	Insect sense organs (mechano-, photo- and chemo- receptors); organogenensis at pupal stage; insect defense; chaetotaxy; morphological traits in relation to forensic entomology.	6
III	Types of immature stages in insect orders, morphology of egg, nymph/ larva and pupa, identification of different immature stages of crop pests and stored product insects. Comparative study of life history strategies in hemi-metabola and holometabola, immature stages as ecological and evolutionary adaptations, significance of immature stages for pest management.	10

Practical

1	Preparation of permanent mounts of different body parts and their appendages of taxonomic importance including male and female genitalia;	5
2	Dissection of genitalia. Types of immature stages in insects; their collection, rearing and preservation;	4
3	Identification of immature insects to orders and families, in endopterygote orders, viz., Diptera, Lepidoptera, Hymenoptera and Coleoptera using key;	5

Learning outcome

Students are expected to have a complete understanding of the comparative morphology of the external features of insects that can be utilized in taxonomy, ecology and applied entomology.

Suggested Reading

Chapman RF. 1998. *The Insects: Structure and Function*. Cambridge Univ. Press, Cambridge. Chu HF. 1992. *How to Know Immature Insects*. William Brown Publication, Iowa.
Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.
Evans JW. 2004. *Outlines of Agricultural Entomology*. Asiatic Publ., New Delhi. Gillott C. 1995.

Entomology, 2nd Ed. Plenum Press, New York, London.

Gullan PJ and Cranston PS. 2000. *The Insects, An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Peterson A. 1962. *Larvae of Insects*. Ohio University Press, Ohio.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.

Snodgross RE. 1993. *Principles of Insect Morphology*. Cornell Univ. Press, Ithaca.

Tembhore DB. 2000. *Modern Entomology*, Himalaya Publishing House, Mumbai.

Stehr FW. 1998. *Immature Insects*. Vols. I, II. Kendall Hunt Publication, Iowa.

ENT 502

Insect Anatomy and Physiology

Credits: 2 + 1 Mid-Session Exam: 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To impart knowledge about the anatomy and physiology of insect body systems;nutritional physiology; and their applications in entomology.

Theory

Units	Content	Lectures
I	Scope and importance of insect physiology; physiology of integument, moulting, chemistry of cuticle, biosysthesis of chitin; growth, hormonal control, metamorphosis and diapause; pheromone secretion, transmission, perception and reception.	10
II	Physiology and mechanism of digestion, circulation, respiration, excretion, reproduction, secretion (exocrine and endocrine glands) and nerve impulse transmission in insects.	9
III	Importance of insect nutrition- role of vitamins, proteins, amino acids, carbohydrates, lipids, minerals and other food constituents; extra and intra-cellular microorganisms and their role in physiology; artificial diets.	9

Practical

1	Latest analytical techniques for analysis of free amino acids of haemolymph;	4
2	Determination of chitin in insect cuticle;	3
3	Examination and count of insect haemocytes; preparation and evaluation of variousdiets;	4
4	Consumption, utilization and digestion of natural and artificial diets.	3

Learning outcome

Students are expected to have a thorough understanding of insect growth anddevelopment, physiology of exoskeleton, endoskeleton and different organ systems; action and role of hormones, pheromones, physiology of nutrition and its application.

Suggested Reading

Chapman RF. 1998. *Insects: Structure and Function*. ELBS Ed., London.

Duntson PA. 2004. *The Insects: Structure, Function and Biodiversity*. Kalyani Publishers, New Delhi.

Gullan PJ and Cranston PS. 2000. *The Insects*: *An Outline of Entomology*, 2nd Ed. Blackwell Science, UK.

Kerkut GA and Gilbert LI. 1985. *Comprehensive Insect Physiology, Biochemistry and Pharmacology*. Vols. I-XIII. Pergamon Press, New York.

Patnaik BD. 2002. *Physiology of Insects*. Dominant Publishers, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Vol. 1. *Structure, Physiology and Development.* Chapman and Hall, New York.

Simpson SJ. 2007. *Advances in Insect Physiology*, Vol. 33, Academic Press (Elsevier), London, UK.

Wigglesworth VB. 1984. *Insect Physiology*. 8th Ed. Chapman and Hall, New York.

ENT 503
Insect Taxonomy

Credits: 1 + 2
Contact Hours: 14 + 56

Mid-Session Exam: 15 (10+5#)
Practical Exam: 65
End-Semester Exam: 20

Aim of the course

To sensitize the students on the theory and practice of classifying organisms (with special reference to animals) and the rules governing the same. To introduce the students tothe classification of insects up to the level of families with hands-on eXperience in identifying the families of insects with an emphasis on the practical aspects.

Theory

Units	Content	Lectures
I	History of insect classification; principles of systematics and its importance. Identification, purpose, methods character matrix, taxonomic keys. Descriptions- subjects of descriptions, characters, nature of characters, analogy *v/s* homology, parallel *v/s* convergent evolution, intraspecific variation in characters, polythetic and polymorphic taxa, seXual dimorphism. Brief evolutionary history of insects- introduction to phylogeny of insects and Classification of Superclass Hexapoda – Classes – Ellipura (Collembola, Protura), Diplura and Insecta- and the Orders contained. International Code of Zoological Nomenclature, Phylocode, its brief explanation and uses. Process of speciation and interbreeding allopatric species. Molecular systemnatics, DNA barcoding, karyological and biochemical approaches in taxonomy. Insect labeling protocols and procedures.	6
II	Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them. Collembola, Protura, Diplura. Class Insecta: Subclass Apterygota – Archaeognatha, Thysanura. Subclass: Pterygota, Division Palaeoptera – Odonata and Ephemeroptera. Division: Neoptera: Subdivision: Orthopteroid and Blattoid Orders (=Oligoneoptera: Plecoptera, Blattodea, Isoptera, Mantodea, Grylloblattodea, Dermaptera, Orthoptera, Phasmatodea, Mantophasmatodea, Embioptera, Zoraptera), Subdivision: Hemipteroid Orders (=Paraneoptera): Psocoptera, Phthiraptera, Thysanoptera and Hemiptera.	4
III	Distinguishing characters, general biology, habits and habitats of insect orders and economically important families contained in them (Continued). Division Neoptera – Subdivision Endopterygota, Section Neuropteroid- Coleopteroid Orders: Strepsiptera, Megaloptera, Raphidioptera, Neuroptera and Coleoptera, Section Panorpoid Orders Mecoptera, Siphonaptera, Diptera, Trichoptera, Lepidoptera, and Section Hymenopteroid Orders: Hymenoptera.	4

Practical

1	Study of Orders of insects and their identification using taxonomic keys;	8
2	Keying out families of insects of different major Orders: Odonata, Orthoptera, Blattodea, Mantodea, Isoptera, Hemiptera, Thysanoptera, Phthiraptera, Neuroptera, Coleoptera, Diptera, Lepidoptera and Hymenoptera;	12
3	Field visits to collect insects of different orders.	8

Learning outcome

- Students are eXpected to know the evolution of arthropods, especially insects and other heXapods, and their hierarchical classification
- Acquire working skills for collecting, mounting, and preserving insects
- Understand the basic concepts of taXonomic hierarchy, identification, taXonomic characters, variations, taXonomic keys and preparation of taXonomic papers
- Identify insects of economic importance up to family levels, taking up the insect orders of agriculture and veterinary importance

Suggested Reading

CSIRO 1990. *The Insects of Australia: A Text Book for Students and Researchers*. 2nd Ed. Vols. I and II, CSIRO. Cornell Univ. Press, Ithaca.

Freeman S and Herron JC. 1998. *Evolutionary Analysis*. Prentice Hall, New Delhi.

Gullan PJ and Cranston PS. 2010. *The Insects: An outline of Entomology*. 4th Ed. Wiley-Blackwell Publications, West SusseX, UK.

Mayr E. 1971. *Principles of Systematic Zoology*. Tata McGraw Hill, New Delhi.

Richards OW and Davies RG. 1977. *Imm's General Text Book of Entomology*. 10th Ed. Chapman and Hall, London.

Ross HH.1974. *Biological Systematics.* Addison Wesley Publ. Company.

Triplehorn CA and Johnson NF. 1998. *Borror and DeLong's Introduction to the Study of Insects.* 7th Ed. Thomson/ Brooks/ Cole, USA/ Australia.

ENT 504
Insect Ecology

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To teach the concepts of ecology, basic principles of distribution and abundance of organisms and their causes. Study life tables, constructing life tables, organization of communities, diversity indices. Train students in sampling methodology, calculation of diversity indices, relating insect population fluctuations to biotic and/or abiotic causes.

Theory

Units	Content	Lectures
I	History and definition. Basic Concepts. Organisation of the Biological world. Plato's Natural Balance *vs* Ecological Dynamics as the modern view. Abundance and diversity of insects, Estimates and Causal factors. Study of abundance and distribution and relation between the two. Basic principles of abiotic factors and their generalised action on insects. Implications for abundance and distribution of organisms including insects- Law of the Minimum, Law of Tolerance, and biocoenosis, Systems approach to ecology.	7
II	Basic concepts of abundance- Model *vs* Real world. Population growth basic models – EXponential *vs* Logistic models. Discrete *vs* Continuous growth models. Concepts of Carrying capacity, Environmental Resistance and Optimal yield. Vital Statistics- Life Tables and their application to insect biology. Survivorship curves. Case studies of insect life tables. Population dynamics- Factors affecting abundance- Environmental factors, dispersal and migration, Seasonality in insects. Classification and mechanisms of achieving different seasonality- Diapause (Quiescence) – aestivation, hibernation.	7
III	Biotic factors- Food as a limiting factor for distribution and abundance, Nutritional Ecology. Food chain- web and ecological succession. Interspecific interactions- Basicfactors governing the interspecific interactions- Classification of interspecific interactions – The argument of cost-benefit ratios. Competition- Lotka-Volterra model, Concept of niche ecological homologues, competitive eXclusion. Evolution of mimicry, colouration, concept of predator satiation; evolution of life history strategies.	7
IV	Community ecology- Concept of guild, Organisation of communities- Hutchinson Ratio, May's *d/w*, Relation between the two and their association with Dyar's Law and Przibram's law. Relative distribution of organisms, Concept of diversity- the Wallacian view. Assessment of diversity. Diversity-stability debate, relevance to pest management. Pest management as applied ecology. Climate change and insect pest/ natural enemy population; ecological engineering.	7

Practical

1	Types of distributions of organisms;	1
2	Methods of sampling insects, estimation of densities of insects and understanding the distribution parameters- Measures of central tendencies, Poisson Distribution, Negative Binomial Distribution;	2

3	Determination of optimal sample size. Learning to fit basic population growth models and testing the goodness of fit;	2
4	Fitting Holling's Disc equation;	1
5	Assessment of prey-predator densities from natural systems and understanding the correlation between the two;	2
6	Assessing and describing niche of some insects of a single guild;	1
7	Calculation of niche breadth, activity breadth and diagrammatic representation of niches of organisms;	1
8	Calculation of diversity indices- Shannon's, Simpson's and Avalanche Index andunderstanding their associations and parameters that affect their values;	2
9	Problem solving in ecology. Field visits to understand different ecosystems and tostudy insect occurrence in these systems.	2

Learning Outcome

- The students are expected to be well versed with the basic concepts of ecology,ecological succession, population ecology, community ecology, nutritional ecology and different insect-ecosystem interactions
- Quantification of insect diversity and abundance, life table analyses, predator- prey and host-parasitoid relations, functional and numerical responses, niche breadth and overlap

Suggested Reading

Begon M, Townsend CR and Harper JL. 2006. *Ecology: From Individuals to Ecosystems*. 4th Ed. Blackwell Publishing, USA/ UK/ Australia.

Chapman JL and Reiss MJ. 2006. *Ecology: Principles and Applications*. 2nd Ed. CambridgeUniv. Press, Cambridge.

Fowler J, Cohen L and Jarvis P. 1998. Practical Statistics for Field Biology. 2nd Ed. John Wiley& Sons, Chichester, West SussexPO19 8SQ, England.

Gotelli NJ and Ellison AM. 2004. *A Primer of Ecological Statistics.* Sinauer Associates, Inc., Sunderland, MA.

Gotelli NJ. 2001. *A Primer of Ecology.* 3rd Ed. Sinauer Associates, Inc., Sunderland, MA Gupta RK. 2004. *Advances in Insect Biodiversity*. Agrobios, Jodhpur.

Krebs CJ. 1998. *Ecological Methodology*. 2nd Ed. Benjamin-Cummings Publ. Co., New York. Krebs CJ. 2001. *Ecology: The Experimental Analysis of Distribution and Abundance.* 5th Ed. Benjamin-Cummings Publ. Co., New York.

Magurran AE. 1988. *Ecological Diversity and its Measurement.* Princeton Univ. Press, Princeton. Price PW. 1997. *Insect Ecology*. 3rd Ed. John Wiley, New York.

Real LA and Brown JH. (Eds). 1991. *Foundations of Ecology: Classic Papers with Commentaries*. University of Chicago Press, Chicago.

Schowalter Timothy D. 2011. *Insect Ecology – An Ecosystem Approach*. 3rd Ed. Academic Press, London, UK/ CA, USA.

Southwood TRE and Henderson PA. 2000. *Ecological Methods.* 3rd Ed. Methuen and Co. Ltd., London.

Speight MR, Hunta MD and Watt AD. 2006. *Ecology of Insects: Concepts and Application*. Elsevier Science Publ., The Netherlands.

Townsend Colin R, Begon Michael and Harper John L. 2008. *Essentials of Ecology*. 3rd Ed. Blackwell Publishing, USA/ UK/ Australia.

Wilson EO, William H and Bossert WH. 1971. *A Primer of Population Biology*. Harvard University, USA.

Wratten SD and Fry GLA. 1980. *Field and Laboratory Exercises in Ecology*. Arnold, London.

ENT 505

Biological Control of Insect Pests and Weeds

Credits: 2 + 1 Mid-Session Exam: 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To train the students with theory and practice of biological control, mass production techniques and field evaluation of various biological control agents like parasitoids, predators and various entomopathogenic microorganisms.

Theory

Units	Content	Lectures
I	History, principles and scope of biological control; important groups of parasitoids, predators and pathogens; principles of classical biological control- importation, augmentation and conservation. History of insect pathology, infection of insects by bacteria, fungi, viruses, protozoa, rickettsiae, spiroplasma and nematodes.	8
II	Biology, adaptation, host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogenic nematodes, viruses, bacteria, fungi, protozoa, etc., their mode of action. Biological control of weeds using insects. Epizootiology, symptomatology and etiology of diseases caused by the above and the factors controlling these. Defense mechanisms in insects against pathogens.	8
III	Mass production of quality bio-control agents- techniques, formulations, economics, field release/ application and evaluation. Development of insectaries, their maintenance.	6
IV	Successful biological control projects, analysis, trends and future possibilities of biological control. Importation of natural enemies- Quarantine regulations, biotechnology in biological control. Semiochemicals in biological control.	6

Practical

1	Identification of common natural enemies of crop pests (parasitoids, predators, microbes) and weed killers;	4
2	Visits to bio-control laboratories to learn rearing and mass production of egg, egg- larval, larval, larval-pupal and pupal parasitoids, common predators, microbes and their laboratory hosts, phytophagous natural enemies of weeds;	5
3	Field collection of parasitoids and predators. Hands-on training in culturing, identification of common insect pathogens. Quality control and registration standards for biocontrol agents.	5

Learning outcome

- Students are expected to have a good understanding of the role of natural enemies in managing pest populations below those causing economic damage
- Learn the techniques for mass production of quality bio-agents and their optimal use in IPM

Suggested Reading

Burges HD and Hussey NW. (Eds). 1971. *Microbial Control of Insects and Mites.* Academic Press, London.

De Bach P. 1964. *Biological Control of Insect Pests and Weeds.* Chapman and Hall, New York. Dhaliwal GS and Arora R. 2001. *Integrated Pest Management: Concepts and Approaches.* Kalyani Publishers, New

Delhi.
Gerson H and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual.* Chapman and Hall, New York.
Huffaker CB and Messenger PS. 1976. *Theory and Practices of Biological Control.* Academic Press, London.
Ignacimuthu SS and Jayaraj S. 2003. *Biological Control of Insect Pests*. PhoeniX Publ., New Delhi. Saxena AB. 2003. *Biological Control of Insect Pests*. Anmol Publ., New Delhi.
Van Driesche and Bellows TS. Jr. 1996. *Biological Control*. Chapman and Hall, New York.

ENT 506
Toxicology of Insecticides

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To orient the students with structure and mode of action of important insecticides belonging to different groups, development of resistance to insecticides by insects, environmental pollution caused by toxic insecticides and their toxicological aspects.

Theory

Units	Content	Lectures
I	Definition and scope of insecticide toxicology; history of chemical control; pesticideuse and pesticide industry in India.	5
II	Classification of insecticides and acaricides based on mode of entry, mode of actionand chemical nature; categorization of insecticides on the basis of toxicity – criteriafor bees, beneficial insects and other insects in general; structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids, tertiary amines, neonicotinoids, oxadiazines, phenyl pyrozoles, insect growth regulators, microbials, botanicals, new promising compounds/ new insecticide molecules; nanopesticides; drawbacks of insecticide abuse.	7
III	Principles of toxicology; evaluation of insecticide toxicity; joint action of insecticides- synergism, potentiation and antagonism; factors affecting toxicity of insecticides; insecticide compatibility, selectivity and phytotoxicity. bioassay definition, objectives, criteria, factors, problems and solutions.	5
IV	Insecticide metabolism; insect-pest resistance to insecticides; mechanisms and types of resistance; insecticide resistance management and pest resurgence.	5
V	Insecticide residues, their significance and environmental implications; procedures of insecticide residue analysis. Insecticide Act, registration procedures, label claim, and quality control of insecticides; safe use of insecticides; diagnosis and treatment of insecticide poisoning.	6

Practical

1	Insecticide formulations and mixtures;	2
2	Laboratory and field evaluation of bio-efficacy of insecticides;	2
3	Bioassay techniques;	1
4	Probit analysis;	1
5	Evaluation of insecticide toxicity;	2
6	Toxicity to beneficial insects;	2
7	Pesticide appliances;	1
8	Working out doses and concentrations of pesticides;	2
9	Procedures of residue analysis.	1

Learning outcome

Students are expected understand the concept of toXicity, bio-efficacy, insecticide formulations, modes of action of insecticides, estimation of insecticide residues and have significant know-how about the functioning of various types of spray equipments.

Suggested Reading

Chattopadhyay SB. 1985. *Principles and Procedures of Plant Protection.* OXford and IBH, New Delhi.

Dodia DA, Petel IS and Petal GM. 2008. *Botanical Pesticides for Pest Management*. Scientific Publisher (India), Jodhpur.

Dovener RA, Mueninghoff JC and Volgar GC. 2002. Pesticides formulation and delivery systems: meeting the challenges of the current crop protection industry. ASTM, USA

Gupta HCL.1999. *Insecticides: Toxicology and Uses.* Agrotech Publ., Udaipur.

Ishaaya I and Degheele (Eds.). 1998. *Insecticides with Novel Modes of Action.* Narosa Publ. House, New Delhi.

Ishaaya I and Degheele D. 1998. *Insecticides with Novel Modes of Action: Mechanism and Application*. Norosa Publishing House, New Delhi.

Krieger RI. 2001. *Handbook of Pesticide Toxicology*. Vol-II. Academic Press. Orlando Florida. Mathews GA. 2002. *Pesticide Application Methods*. 4th Ed. Intercept. UK.

Matsumura F. 1985. *Toxicology of Insecticides.* Plenum Press, New York.

Otto D and Weber B. 1991. *Insecticides: Mechanism of Action and Resistance*. Intercept Ltd., UK.

Pedigo LP and Marlin ER. 2009. *Entomology and Pest Management*, 6th Edition, Pearson Education Inc., Upper Saddle River, New Jersey 07458, U.S.A.

Perry AS, Yamamoto I, Ishaaya I and Perry R. 1998. *Insecticides in Agriculture and Environment.* Narosa Publ. House, New Delhi.

Prakash A and Rao J. 1997. *Botanical Pesticides in Agriculture.* Lewis Publication, New York. Roy NK. 2006. *Chemistry of Pesticides*. Asia Printograph Shahdara Delhi.

ENT 507
Host Plant Resistance

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To orient the students with host plant resistance.

Theory

Units	Content	Lectures
I	History and importance of resistance; principles, classification, components, typesand mechanisms of resistance.	2
II	Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.	2
III	Chemical ecology, tritrophic relations, volatiles and secondary plant substances;basis of resistance. Induced resistance – acquired and induced systemic resistance.	3
IV	Factors affecting plant resistance including biotypes and measures to combat them.	2
V	Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.	3
VI	Role of biotechnology in plant resistance to insects.	2

Practical

1	Screening techniques for measuring resistance;	2
2	Measurement of plant characters and working out their correlations with plantresistance;	3
3	Testing of resistance in important crops;	3
4	Bioassay of plant extracts of susceptible/ resistant varieties;	3
5	Demonstration of antibiosis, tolerance and antixenosis.	3

Learning outcome

Students are expected to acquire a thorough knowledge of the types and basis of mechanisms involved in host plant resistance, screening techniques to measure resistance and insect resistance breeding.

Suggested Reading

Dhaliwal GS and Singh R. (Eds). 2004. *Host Plant Resistance to Insects -Concepts and Applications.* Panima Publ., New Delhi.

Maxwell FG and Jennings PR. (Eds). 1980. *Breeding Plants Resistant to Insects.* John Wiley and Sons, New York.

Painter RH. 1951. *Insect Resistance in Crop Plants*. MacMillan, London. Panda N and Khush GS. 1995. *Plant Resistance to Insects.* CABI, London.

Smith CM. 2005. *Plant Resistance to Arthropods – Molecular and Conventional Approaches.* Springer, Berlin.

ENT 508

Concepts of Integrated Pest Management

Credits: 2 + 0 Mid-session exam: 40 (30+10#)

Contact hours: 28+0 End-semester exam: 60

Aim of the course

To familiarize the students with principles of insect pest management, including concept and philosophy of IPM**.** Train students in computation of ETL and implementing IPM programmes.

Theory

Units	Content	Lectures
I	History, origin, definition and evolution of various terminologies. Importance of resistance, principles, classification, components, types and mechanisms of resistance. National and international level crop protection organizations; insecticide regulatory bodies; synthetic insecticide, bio-pesticide and pheromone registration procedures; label claim of pesticides – the pros and cons.	7
II	Concept and philosophy, ecological principles, economic threshold concept and economic consideration. Insect-host plant relationships; theories and basis of host plant selection in phytophagous insects.	4
III	Tools of pest management and their integration- legislative, quarantine regulations, cultural, physical and mechanical methods; semiochemicals, biotechnological and bio-rational approaches in IPM. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys; political, social and legal implications of IPM; pest risk analysis; pesticide risk analysis; cost- benefit ratios and partial budgeting; case studies of successful IPM programmes. ITK-s in IPM, area-wide IPM and IPM for organic farming; components of ecological engineering with successful examples.	9
IV	Characterization of agro-ecosystems; sampling methods and factors affecting sampling; population estimation methods; crop loss assessment direct losses, indirect losses, potential losses, avoidable losses, unavoidable losses; global and Indian scenario of crop losses. Computation of EIL and ETL; crop modeling; designing and implementing IPM system. Screening techniques; breeding for insect resistance in crop plants; exploitation of wild plant species; gene transfer, successful examples of resistant crop varieties in India and world.	8

Learning outcome

Students are expected to have significant knowledge of IPM concepts, estimationof losses due to insect pests, computation of ETL, EIL and should be able takemanagement decisions.

Suggested Reading

Dhaliwal GS and Arora R. 2003. *Integrated Pest Management – Concepts and Approaches.* Kalyani Publishers, New Delhi.

Horowitz AR and Ishaaya I. 2004. *Insect Pest Management: Field and Protected Crops*. Springer, New Delhi.

Ignacimuthu SS and Jayaraj S. 2007. *Biotechnology and Insect Pest Management*. Elite Publ., New Delhi.

Norris RF, Caswell-Chen EP and Kogan M. 2002. *Concepts in Integrated Pest Management.* Prentice Hall, New Delhi.

Pedigo RL. 2002. *Entomology and Pest Management.* 4th Ed. Prentice Hall, New Delhi. Subramanyam B and Hagstrum DW. 1995. *Integrated Management of Insects in Stored Products.* Marcel Dekker, New York.

ENT 509
Pests of Field Crops

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To familiarize the students about nature of damage and seasonal incidence of pestiferous insects that cause loss to major field crops and their effective management by different methods.

Theory

Units	Content	Lectures
Systematic position, identification, distribution, host-range, bionomics, nature and extent of damage, seasonal abundance and management of insect and mite pests and vectors. Insect pest scenario in relation to climate change.		
I	Polyphagous pests: grasshoppers, locusts, termites, white grubs, hairy caterpillars, and non-insect pests (mites, birds, rodents, snails, slugs, etc.). Insect pests of cereals and millets and their management.	12
II	Insect pests of pulses, tobacco, oilseeds and their management.	8
III	Insect pests of fibre crops, forage crops, sugarcane and their management.	8

Practical

1	Field visits, collection and identification of important pests and their natural enemies;	5
2	Detection and estimation of infestation and losses in different crops;	5
3	Study of life history of important insect pests.	4

Learning outcome

Students are expected to acquire knowledge of insect pests of field crops, theirnature of damage, life history traits and effective management.

Suggested Reading

David, BV and Ramamurthy, VV. 2001. *Elements of Economic Entomology*. Popular Book Depot, Chennai.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essentials of Agricultural Entomology*. Kalyani Publishers, New Delhi.

Dunston AP. 2007. *The Insects: Beneficial and Harmful Aspects*. Kalyani Publishers, New DelhiEvans JW. 2005. *Insect Pests and their Control*. Asiatic Publ., New Delhi.

Nair MRGK. 1986. *Insect and Mites of Crops in India*. ICAR, New Delhi. Prakash I and Mathur RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.

Saxena RC and Srivastava RC. 2007. *Entomology at a Glance*. Agrotech Publ. Academy, Udaipur.

ENT 510

Pests of Horticultural and Plantation Crops

Credits: 2 + 1 Mid-Session Exam: 25 (20+5#)
Contact hours: 28+28 Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To impart knowledge on major pests of horticultural and plantation crops regarding the extent and nature of loss, seasonal history, their integrated management.

Theory

Units	Content	Lectures
	Systematic position, identification, distribution, host range, bionomics and seasonal abundance, nature and extent of damage and management of insect pests of various crops.	
I	Fruit Crops- mango, guava, banana, jack, papaya, pomegranate, litchi, grapes, *ber*, fig, citrus, *aonla*, pineapple, apple, peach and other temperate fruits.	7
II	Vegetable crops- tomato, potato, radish, carrot, beetroot, cole crops, French beans, chow-chow, brinjal, okra, all gourds, drumstick, leafy vegetables, etc.	7
III	Plantation crop- coffee, tea, rubber, coconut, arecanut, cashew, cocoa, etc.; Spices and Condiments- pepper, cardamom, clove, nutmeg, chillies, turmeric, ginger, beetle vine, etc.	7
IV	Ornamental, medicinal and aromatic plants and pests in polyhouses/ protected cultivation.	7

Practical

1	Collection and identification of important pests and their natural enemies on different crops;	7
2	Study of life history of important insect pests and non-insect pests.	7

Learning outcome

Students are expected to acquire knowledge of insect pests of horticultural, medicinal and plantation crops, their nature of damage, life history traits and effective management.

Suggested Reading

Atwal AS and Dhaliwal GS. 2002. *Agricultural Pests of South Asia and their Management.* Kalyani Publishers, New Delhi.

Butani DK and Jotwani MG. 1984. *Insects and Vegetables.* Periodical Expert Book Agency, New Delhi.

Dhaliwal GS, Singh R and Chhillar BS. 2006. *Essential of Agricultural Entomology.* Kalyani Publishers, New Delhi.

Srivastava RP. 1997. *Mango Insect Pest Management.* International Book Distr., Dehra Dun. Verma LR, Verma AK and Goutham DC. 2004. *Pest Management in Horticulture Crops*: *Principles and Practices*. Asiatech Publ., New Delhi.

ENT 511
Post Harvest Entomology

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To focus on requirement and importance of grain and grain storage, to understand the role of stored grain pests and to acquaint with various stored grain pest management techniques for avoiding losses in storage.

Theory

Units	Content	Lectures
I	Introduction, history of storage entomology, concepts of storage entomology and significance of insect pests. Post-harvest losses *in toto vis-à-vis* total production offood grains in India. Scientific and socio-economic factors responsible for grain losses. Concept of seed vault.	3
II	Important pests namely insects, mites, rodents, birds and microorganisms associatedwith stored grain and field conditions including agricultural products; traditional storage structures; association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and eXtent of damage, role of field and cross infestations and natural enemies, type of losses in stored grains and their effect on quality including biochemical changes.	3
III	Ecology of insect pests of stored commodities/ grains with special emphasis on role of moisture, temperature and humidity in safe storage of food grains and commodities. Stored grain deterioration process, physical and biochemical changes and consequences. Grain storage- types of storage structures i.e., traditional, improved and modern storage structures in current usage. Ideal seeds and commodities' storage conditions.	3
IV	Important rodent pests associated with stored grains and their non-chemical and chemical control including fumigation of rat burrows. Role of bird pests and their management. Control of infestation by insect pests, mites and microorganisms. Preventive measures- Hygiene/ sanitation, disinfestations of stores/ receptacles, legal methods. Curative measures- Non-chemical control measures- ecological, mechanical, physical, cultural, biological and engineering. Chemical control-prophylactic and curative- Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Insecticide resistance in stored product pests and its management; recent advances (MAS, PPP, HS) in storage pest management; integrated approaches to stored grain pest management.	5

Practical

1	Collection, identification and familiarization with the stored grains/ seed insect pests and nature of damage caused by them;	2
2	Detection of hidden insect infestation in stored food grains;	2
3	Estimation of uric acid content in infested produce; estimation of losses in stored food grains;	2

4	Determination of moisture content in stored food grains;	2
5	Familiarization of storage structures, demonstration of preventive and curative measures including fumigation techniques;	2
6	Treatment of packing materials and their effect on seed quality;	2
7	Field visits to save grain campaign, central warehouse and FCI warehouses and institutions engaged in research or practice of grain storage like CFTRI, Mysore; IGSMRI, Hapur, etc. (only where logistically feasible).	2

Learning outcome

Students are expected to acquire knowledge of pestiferous insects, mites, rats andbirds affecting stored produce, their nature of damage, life history traits and effective management.
Detection of insect infestation and familiarization with different storage structures.
Learning preventive and curative measures to manage infestation in storagehouses.

Suggesting Reading

Hall DW. 1970. *Handling and Storage of Food Grains in Tropical and Subtropical Areas.* FAO. Agricultural Development Paper No. 90 and FAO, Plant Production and Protection Series No. 19, FAO, Rome.
Jayas DV, White NDG and Muir WE. 1995. *Stored Grain Ecosystem.* Marcel Dekker, New York.
Khader V. 2004. *Textbook on Food Storage and Preservation*. Kalyani Publishers, New Delhi.
Khare BP. 1994. *Stored Grain Pests and Their Management.* Kalyani Publishers, New Delhi.
Subramanyam B and Hagstrum DW. 1995. *Interrelated Management of Insects in Stored Products.* Marcel Dekker, New York.

ENT 512
Insect Vectors of Plant Pathogens

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To teach the students about the different groups of insects that act as vectors of plant pathogens, vector-plant pathogen interaction, and management of vectors for controlling diseases.

Theory

Units	Content	Lectures
I	History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics; mouth parts and feeding processesof important insect vectors. Efficiency of transmission.	3
II	Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors.	3
III	Transmission of plant viruses by aphids, whiteflies, mealy bugs and thrips.	2
IV	Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers.	3
V	Transmission of plant viruses by psyllids, beetles and mites. Epidemiology andmanagement of insect transmitted diseases through vector management.	3

Practical

1	Identification of common vectors of plant pathogens- aphids, leafhoppers, whiteflies,thrips, beetles, nematodes;	3
2	Culturing and handling of vectors; demonstration of virus transmission through vectors- aphids, leafhoppers and whiteflies;	4
3	Vector rearing and maintenance;	3
4	Estimating vector transmission efficiency, studying vector-virus host interaction.	4

Learning outcome

Students are eXpected to be well versed with insect vectors of plant pathogens,acquire knowledge on disease transmission and vector management techniques.

Suggested Reading

Basu AN. 1995. *Bemisia tabaci* (Gennadius) – *Crop Pest and Principal Whitefly Vector of Plant Viruses.* OXford and IBH, New Delhi.

Harris KF and Maramarosh K. (Eds.). 1980. *Vectors of Plant Pathogens*. Academic Press, London.

Maramorosch K and Harris KF. (Eds.). 1979. *Leafhopper Vectors and Plant Disease Agents*. Academic Press, London.

Youdeovei A and Service MW. 1983. *Pest and Vector Management in the Tropics*. EnglishLanguage Books Series, Longman, London.

ENT 513
Principles of Acarology

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To acquaint the students with external morphology of different groups of mites, train in identification of commonly occurring families of plant associated mites, provide information about important mite pests of crops and their management.

Theory

Units	Content	Lectures
I	History of Acarology; importance of mites as a group; habitat, collection and preservation of mites. Soil arthropods and their classification, habitats and their identification.	4
II	Introduction to morphology and biology of mites and ticks. Broad classification-major orders and important families of Acari including diagnostic characteristics. Estimation of populations; sampling and extraction methods for soil arthropods.	4
III	Economic importance, seasonal occurrence, nature of damage, host range of mite pests of different crops, mite pests in polyhouses, mite pests of stored products and honeybees. Management of mites using acaricides, phytoseiid predators, fungal pathogens, etc. Culturing of phytophagous, parasitic and predatory mites. Mode of action of acaricides, resistance of mites and ticks to acaricides, its management.	6

Practical

1	Collection of mites from plants, soil and animals;	3
2	Extraction of mites from soil, plants and stored products;	2
3	Preparation of mounting media and slide mounts;	2
4	External morphology of mites;	2
5	Identification of mites up to family level using keys;	3
6	Studying different rearing techniques for mites.	2

Learning outcome

Students are expected to identify mites up to family level.
Acquire knowledge of mite pests of cultivated crops, their nature of damage, lifehistory traits and effective management.

Suggested Reading

Anderson JM and Ingram JSI. 1993. *Tropical Soil Biology and Fertility: A Handbook of Methods.* CABI, London.
Chhillar BS, Gulati R and Bhatnagar P. 2007. *Agricultural Acarology*. Daya Publ. House, New Delhi.
Dindal DL. 1990. *Soil Biology Guide*. A Wiley-InterScience Publ., John Wiley and Sons, NewYork.
Gerson U and Smiley RL. 1990. *Acarine Biocontrol Agents – An Illustrated Key and Manual*. Chapman and Hall, NewYork.
Gupta SK. 1985. *Handbook of Plant Mites of India.* Zoological Survey of India, Calcutta. Gwilyn O and Evans GO. 1998. *Principles of Acarology*. CABI, London.

Jeppson LR, Keifer HH and Baker EW. 1975. *Mites Injurious to Economic Plants*. University of California Press, Berkeley.
Krantz GW. 1970. *A Manual of Acarology.* Oregon State Univ. Book Stores, Corvallis, Oregon. Pankhurst C, Dube B and Gupta, V. 1997. *Biological Indicators of Soil Health.* CSIRO, Australia. Qiang Zhiang Z. 2003. *Mites of Green Houses- Identification, Biology and Control*. CABI, London. Sadana GL. 1997. *False Spider Mites Infesting Crops in India.* Kalyani Publishers House, New Delhi.
Walter DE and Proctor HC. 1999. *Mites- Ecology, Evolution and Behaviou*r. CABI, London. Veeresh GK and Rajagopal D. 1988. *Applied Soil Biology and Ecology*. Oxford and IBH Publ., New Delhi.

ENT 514
Vertebrate Pest Management

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To impart knowledge on vertebrate pests like birds, rodents, mammals and othersof different crops, their biology, damage they cause and management strategies.

Theory

Units	Content	Lectures
I	Introduction to vertebrate pests of different crops; biology of vertebrate pests suchas rodents, birds and other mammals.	2
II	Bio-ecology of birds of agricultural importance, patterns of pest damage and assessment, roosting and nesting systems in birds; management of pestiferous birds; conservation of predatory birds.	3
III	Bio-ecology of rodents of agricultural importance, patterns of pest damage and assessment, burrowing pattern and habitat of rodents; management of pestiferous rodents.	3
IV	Bio-ecology of higher vertebrates of agricultural importance, patterns of damage and assessment, their habitat; management of pestiferous vertebrates.	3
V	Management strategies- physical (trapping, acoustics and visual), chemical (poisons,repellents, fumigants and anticoagulants), biological (predators, parasites), cropping practices, alteration of habitats, diversion baiting and other eco-friendly methods – Operational practices- baiting, equipments and educative programmes.	3

Practical

1	Identification of important rodents, birds and other vertebrate pests of agriculture, food preference and hoarding;	7
2	Social behaviour, damage assessment, field survey, population estimation, management strategies: preventive and curative methods.	7

Learning outcome

Students are expected to be well versed with vertebrate pest diversity, their nature of damage, life history traits, behaviour and effective management.

Suggested Reading

Ali S. 1965. *The Book of Indian Birds*. The Bombay Natural History Society, Bombay. Fitzwater WD and Prakash I. 1989. *Handbook of Vertebrate Pest Control.* ICAR, New Delhi. Prakash I and Ghosh PK. 1997. *Rodents in Indian Agriculture*. Vol. I. State of Art Scientific Publ., Jodhpur.
Prakash I and Ghosh RP. 1987. *Management of Rodent Pests.* ICAR, New Delhi.
Prater SH. 1971. *The Book of Indian Animals*. The Bombay Natural History Society, Bombay. Rahman A. 2020. *Protective and Productive Entomology* Narendra Publishing House, New Delhi

ENT 515

Techniques in Plant Protection

Credits: 0 + 1 Mid-Session Exam: 50

Contact Hours: 0 + 28 End Semester Exam: 50

Aim of the course

To acquaint the students with appropriate use of plant protection equipments andtechniques related to microscopy, computation, pest forecasting, etc.

Practical

1	Pest control equipments, principles, operation, maintenance, selection, and application of pesticides;	2
2	Release of bio-control agents;	1
3	Seed dressing, soaking, root-dip treatment, dusting, spraying, and pesticide application through irrigation water;	2
4	Application of drones in plant protection;	1
5	Soil sterilization, solarization, deep ploughing, flooding, techniques to check thespread of pests through seed, bulbs, corms, cuttings and cut flowers;	2
6	Uses of light, transmission and scanning electron microscopy;	1
7	Protein isolation from the pest and host plant and its quantification using spectrophotometer and molecular weight determination using SDS/ PAGE;	2
8	Use of tissue culture techniques in plant protection;	1
9	Computer application for predicting/ forecasting pest attack and identification.	2

Learning outcome

Students are expected to have a good knowledge of different plant protectionequipments and techniques related to pest forecasting.

Suggested Reading

Alford DV. 1999. *A Textbook of Agricultural Entomology*. Blackwell Science, London. Crampton JM and Eggleston P. 1992. *Insect Molecular Science.* Academic Press, London.

ENT 516
Apiculture

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To impart knowledge about the honey bees, and their behaviour and activities; bee husbandry, bee multiplication, bee enemies and diseases and their management; hive products, apitherapy; and managed bee pollination of crops

Theory

Units	Content	Lectures
I	Historical development of apiculture at global level and in India; Classification of bees; global distribution of genus *Apis* and races; Morphology and anatomy of honey bee; Honey bee biology, ecology, adaptations; Honey bee behaviour – nest founding, comb construction, brood care, defense, other in-house and foraging activities; Bee pheromones; Honey bee communication.	5
II	Commercial beekeeping as an enterprise; Design and use of bee hives; Apicultural equipment; Seasonal bee husbandry; Honey bee nutrition and artificial diets; Absconding, swarming, drifting – causes and management; Curbing drone rearing; Laying worker menace – causes, signs and management.	5
III	Bee genetics; Principles and procedures of bee breeding; Screening of honey bee colonies; Techniques in mass queen bee rearing; Mating nuclei and their establishment; Selective mating; Queen bee management; Bee packages.	4
IV	Ectoparasitic and endoparasitic bee mites – biology, ecology, nature and symptoms of damage, management tactics; Wax moths, wasps and ants – biology, ecology, nature and symptoms of damage, management tactics; Predatory birds, their damage potential and management tactics; Pesticide poisoning to honey bees, signs and protection; Protocols in evaluation of pesticide toxicity to honey bees.	5
V	Honey – composition, properties, crystallization, post-harvest handling and processing; Honey quality standards and assessment; Apicultural diversification – potential and profitability; Production/ collection of bee pollen, propolis, royal jelly, bee venom and bees wax and their post-harvest handling; Apitherapy; Value addition of hive products; Development of apiculture project.	5
VI	Non-*Apis* pollinators, their augmentation and conservation; Role of bee pollinators in augmenting crop productivity; Managed bee pollination of crops.	4

Practical

1	Morphological characteristics of honey bee;	1
2	Mouthparts; digestive, respiratory and reproductive adaptations in different castes of honey bees;	2
3	Recording of colony performance;	1
4	Seasonal bee husbandry practices;	1

5	Swarming, queenlessness, swarming, laying workers menaces, etc. and their remedies;	1
6	Innovative techniques in mass queen bee rearing; selection and breeding of honeybees;	2
7	Instrumental insemination; formulation of artificial diets and their feeding;	1
8	Production technologies for various hive products;	1
9	Bee enemies and diseases and their management;	1
10	Recording pollination efficiency;	1
11	Application of various models for determining pollination requirement of crop;	1
12	Developing a beekeeping project.	1

Learning outcome

Students are expected to have a comprehensive knowledge of bee biology, physiology and bee keeping/ apiculture. With practical training it is expected that students develop entrepreneurial skills for apiculture.

Suggested Reading

Abrol DP and Sharma D. 2009. *Honey Bee Mites and Their Management.* Kalyani Publishers, New Delhi, India.

Abrol DP. 2009. *Honey bee Diseases and Their Management.* Kalyani Publishers, New Delhi, India.

Abrol DP. 2010. *Beekeeping: A Compressive Guide to Bees and Beekeeping*. Scientific Publishers, India.

Abrol DP. 2010. *Bees and Beekeeping in India*. Kalyani Publishers, New Delhi, India.

Abrol DP. 2012. *Pollination Biology: Biodiversity Conservation and Agricultural Production.* Springer.

Atwal AS. 2001. *World of Honey Bees.* Kalyani Publishers, New Delhi- Ludhiana, India. Atwal AS. 2000. *Essentials of Beekeeping and Pollination*. Kalyani Publishers, New Delhi-Ludhiana, India.

Bailey L and Ball BV. 1991. *Honey Bee Pathology*. Academic Press, London.

Crane Eva and Walker Penelope. 1983. *The Impact of Pest Management on Bees and Pollination.* Tropical Development and Research and Institute, London.

Free JB. 1987. *Pheromones of Social Bees.* Chapman and Hall, London.

Gatoria GS, Gupta JK, Thakur RK and Singh Jaspal. 2011. *Mass Multiplication of Honey Bee Colonies.* ICAR, New Delhi, India.

Grahm Joe M. 1992. *Hive and the Honey Bee.* Dadant & Sons, Hamilton, Illinois, USA. Grout RA. 1975. *Hive and the Honey Bee.* Dadant & Sons, Hamilton, Illinois, USA. Holm E. 1995. *Queen Rearing Genetics and Breeding of Honey Bees.* Gedved, Denmark.

Laidlaw HH Jr and Eckert JE. 1962. *Queen Rearing*. Berkeley, University of California Press. Laidlaw HH. 1979. *Contemporary Queen Rearing.* Dadant & Sons, Hamilton, Illinois, USA. Mishra RC. 2002. *Perspectives in Indian Apiculture*. Agro-Botanica, Jodhpur, India.

Mishra RC. 1995. *Honey Bees and their Management in India.* I.C.A.R., New Delhi, India.

Morse AA. 1978. *Honey Bee Pests, Predators and Diseases*. Cornell University Press, Ithaca and London.

Rahman, A. 2017. *Apiculture in India*, ICAR, New Delhi

Ribbands CR. 1953. *The Behaviour and Social Life of Honey Bees.* Bee Research Association Ltd., London, UK.

Rinderer TE. 1986. *Bee Genetics and Breeding.* Academic Press, Orlando.

Sardar Singh. 1962. *Beekeeping in India*. I.C.A.R., New Delhi, India (Reprint: 1982). Seeley TD. 1985. *Honey Bee Ecology*. Princeton University Press, 216 pp.

Snodgrass RE. 1925. *Anatomy and Physiology of the Honey Bee*. Mc Graw Hill Book Co., New York & London.

Snodgrass RE. 1956. *Anatomy of the Honey Bee*. Comstock Publishing Associates, Cornell Univ. Press, Ithaca, New York.

ENT 517
Sericulture

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the Course

To familiarize the students with entrepreneurial opportunities in entomology, sericulture in particular, and providing information on silk worm rearing, production and management.

Theory

Units	Content	Lectures
I	History of Sericulture, importance, organizations involved in sericulture activities, silkworm types, distribution, area and silk production.	5
II	Mulberry species, ecological requirements, cultivation, improved varieties, propagation methods, sapling production, planting and pruning techniques; pest and diseases, management strategies; intercropping, water and weed management. Food plants of eri silkworm, castor cultivation, intercultural operations, nutrient and water management; method of harvest; host plants of Tasar, nursery and cultivation, selection of seed, soaking and heap making, pruning techniques. Food plants of Muga silkworm, Som and Soalu propagation methods; nursery techniques; intercultural operations and weed management.	7
III	Silkworm origin – classification based on voltinism, moultinism, geographical distribution and genetic nature – pure races –multivoltine and bivoltine races –cross breeds – bivoltine hybrids –Races and hybrids of mulberry, eri, tasar and muga silkworm- Morphology and biology of silkworm, sex limited characters; anatomy of digestive and eXcretory systems of larva; structure and function of silk glands.	6
IV	Rearing house, types, disinfection, room and bed disinfectants; egg incubation methods, Chawki rearing, feeding, cleaning and spacing; rearing of late age worms, feeding, cleaning, spacing and moulting care; mountages, cocoon harvesting and marketing; pests and diseases of silkworms and their management.	5
V	Post cocoon technology, stifling, cocoon cooking, brushing, reeling, re-reeling, bleaching, degumming, dyeing, printing and weaving, different reeling machines; value addition in sericulture; economics of sericulture.	5

Practical

1	Morphology of mulberry plants;	1
2	Identification of popular mulberry genotypes;	1
3	Nursery bed and main field preparation;	1
4	Planting methods;	1
5	Identification of nutrient deficiency symptoms;	1
6	Identification of weeds;	1

7	Pruning and harvesting methods;	1
8	Identification of pests and diseases of mulberry–*Terminalia arjuna, Terminalia tomentosa,* Som and Soalu- Nursery and pruning techniques – Intercultural operations;	2
9	Morphology of silkworm – Identification of races – Dissection of mouth parts andsilk glands – Disinfection techniques – rearing facilities – silkworm rearing – feeding, cleaning and spacing – Identification of pests and diseases of mulberry silkworm – hyperparasitoids and mass multiplication techniques – silkworm eggproduction technology –Tasar, Eri and muga silkworms – rearing methods–pests and diseases of non-mulberry silkworms – Visit to grainage, cocoon market and silk reeling centre – Economics of silkworm rearing.	5

Learning outcome

Students taking up sericulture are eXpected to have a thorough knowledge of silkworm morphology, races, biology, and all the practices of rearing for silk production.

They should be well versed with the pests and diseases of silkworm and their management.

With practical training it is eXpected that students develop entrepreneurial skills for sericulture or link up with industries to sell cocoons for silk production or guide farmers engaged in silk worm rearing/ sericulture.

Suggested Reading

Dandin SB and K Giridhar. 2014. Hand book of Sericulture Technologies. Central Silk Board, Bangalore, 423p.

Govindaiah G, VP, Sharma DD, Rajadurai S and Nishita V Naik. 2005. A teXt book on mulberry crop protection. Central Silk Board, Bangalore.450 p.

Jolly MS, Sen SK, Sonwalkar TN and Prasad GK. 1980. Non–mulberry Silks. FAO Agicultural Services Bulletin 29. Food and Agriculture Organization of the United Nations, Rome, 178 p.

Mahadevappa D, Halliyal VG, Shankar DG and Ravindra Bhandiwad. 2000. Mulberry Silk Reeling Technology. OXford and IBH Publishing Co. Pvt. Ltd, New Delhi. 234 p.

Mohanty PK. 2003. Tropical wild cocoons of India. Daya Publications, Tri Nagar, New Delhi, 197 p.

Nataraju B, Sathyaprasad K, Manjunath D and Kumar A. 2005. Silkworm crop protection. CSB, Bangalore. 412 pp.

Rangaswami G, Narasimhanna MN, Kasiviswanathan K, Sastry CR and Jolly MS. 1976. Food Plants of non-mulberry silkworms. In: *Mulberry cultivation*. FAO Agricultural Services Bulletin. Vol.1, Chapter-13. Rome, Italy. 96 p.

Tribhuvan Singh and Saratchandra B. 2004. Principles and Techniques of silkworm seed production. Discovery publishing House, New Delhi, 360 pp.

E-resources

www.silkwormgenomics.org; www.silkboard.com; ww.silkgermplasm.com; www.csrtimys.res.in

ENT 518
Lac Culture

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To familiarize the students with entrepreneurial opportunities in entomology with an emphasis on lac culture in particular. To provide information on lac insectrearing, production and management.

Theory

Units	Content	Lectures
I	History of lac production; importance, potential of lac production in India; organizations involved in lac production activities; strains of lac insects and lac crops – distribution, area and production of different strains of lac.	5
II	Steps and operation of lac production; lac host plant species, ecological requirements, their cultivation; seasons of host plants, harvest time of host plants, rearing seasons; grouping of host trees, pruning methods, timing; lac host plant pests and diseases; management strategies.	5
III	Basic morphology and taXonomy of lac insect, strains of lac insect and their characteristics; composition of lac; biology of lac insect, species diversity and distribution.	5
IV	Introduction, lac insect-host plant interaction; selection of brood lac, local practices, improved alternatives, coupe system; propagation of lac insects: natural self inoculation, artificial inoculation; inoculation process and duration; removal of phunki, harvesting of lac, immature harvesting, mature harvesting and time of harvesting. Predators and parasitoids of lac insect, hyperparasites, diseases and their management.	6
V	Lac production stages; factors affecting yield and quality of shellac. Pure stock of host plants (kusum, palas, ber, pigeonpea, semialata); alternative method; technology of brood preserving. Host-specific technologies – cultivation on specific host plants; integration of lac cultivation with agro-forestry and horticulture; socio-economic potential of lac; eXport-import of lac/ lac products; marketing of lac and its products. Lac processing and value addition; entrepreneurship development.	7

Practical

1	Lac host cultivation and lac production practices; Equipments for lac production;	2
2	Conventional and advanced methods; Coupe system of lac production;	2
3	Cultivation of suitable host plants; Pruning of host trees;	1
4	Herbarium of host plants; Strains of lac insects;	1
5	Brood lac selection and treatment for pest management; Slide preparation of adult and immature stages;	2
6	Inoculation of host tree; Identification of natural enemies of lac insect and their management;	2

7	Molecular characterization of lac insect where possible; Harvesting;	1
8	Process of manufacture of seed lac, shell lac from stick lac; Grading of seed lac and shellac;	2
9	Marketing of lac products and by products.	1

Learning outcome

The students are eXpected to have good knowledge of lac host trees and theirmaintenance for lac production.

It is expected that they should perfect the most suitable techniques for lac producton with a good knowledge about diseases and natural enemies of the lac insect.

With practical training it is eXpected that students are able to guide landless labourers, who bring stick lac as forest produce.

Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Sharma KK and Ramani S. 2010. *Recent advances in lac culture*. ICAR-IINRG, Ranchi.

ENT 519
Molecular Approaches in Entomology

Credits: 2 + 1
Contact hours: 28+28

Mid-Session Exam: 25 (20+5#)
Practical Exam : 35
End-Semester Exam: 40

Aim of the course

To acquaint students the latest techniques used in molecular biology.

Theory

Units	Content	Lectures
I	Introduction to molecular biology, techniques used in molecular biology.	4
II	DNA recombinant technology, identification of genes/ nucleotide sequences for traits of interest, techniques of interest in plants and microbes.	5
III	Genes of interest in entomological research- marker genes for seX identification, peptides and neuropeptides, JH esterase, St toXins and venoms, chitinase, Plant-derived enzyme inhibitors, protease inhibitors, trypsin inhibitors, á-amylase inhibitors, lectins, terepenes and terpenoids; genes of non-plant origin, *Bacillus thuringiensis* endotoXins, mode of action of cry genes, classification and properties, synthetic Bt toXin genes, Other toXin genes, genes derived from entomophagous viruses, transgenic plants for pest resistance.	7
IV	Genetically engineered microbes and parasitoids in biological control-Genetic engineering in baculoviruses and fungal biocontrol agents for greater efficacy against insect pests. Effects of transgenic plants on pest biology and development, resistance management strategies in transgenic crops, molecular mechanism of insecticide resistance.	6
V	Genetic-based methods for agricultural insect pest management-insect pest management through sterile insect technique and relase of insects carrying a dominant lethal gene. Methods and application of insect trangenesis, transgenics in silkworm and honeybees. Molecular tools for taXonomy and phylogeny of insect- pests, DNA-based diagnostics. Nano technology and its application.	6

Practical

1	Isolation of DNA/ RNA;	3
2	Agarose gel electrophoresis of DNA, quantification of DNA by spectrophotometirc and agarose gel analysis, PCR amplification of mitochondrial cytochrome oxidase subunit I gene (cox1) and 16S rRNA gene, cloning of PCR amplicons in standard plasmid vectors for sequencing, confirmation of the insert, miniprep of recombinant plasmid DNA, BLAST analysis and multiple sequence alignment of the sequencewith sequences already available in GenBank;	8
3	Isolation of host plant proteins, SDS-PAGE of the isolated proteins.	3

Learning outcome

The students are eXpected to be well versed with the basic techniques used in molecular biology.

Suggested Reading

Bhattacharya TK, Kumar P and Sharma A. 2007. *Animal Biotechnology*. 1st Ed., Kalyani Publication, New Delhi.

Hagedon HH, Hilderbrand JG, Kidwell MG and Law JH. 1990. *Molecular Insect Science*. Plenum Press, New York.

Hoy MA. 2003. *Insect Molecular Genetics: An Introduction to Principles and Applications*. 2nd Ed. Academic Press, New York.

Oakeshott J and Whitten MA. 1994. *Molecular Approaches to Fundamental and Applied Entomology*. Springer Verlag.

Rechcigl JE and Rechcigl NA. 1998. *Biological and Biotechnological Control of Insect Pests.* Lewis Publ., North Carolina.

Roy U and Saxena V. 2007. *A Hand Book of Genetic Engineering*. 1st Ed., Kalyani Publishers, New Delhi.

Singh BD. 2008. *Biotechnology (Expanding Horizons)*. Kalyani Publishers, New Delhi. Singh P. 2007. *Introductory to Biotechnology*. 2nd Ed. Kalyani Publishers, New Delhi.

ENT 520

Plant Quarantine, Bio-safety and Bio-security

Credits: 2 + 0 Mid-session exam: 40 (30+10#)

Contact hours: 28+0 End-semester exam: 60

Aim of the course

To acquaint the learners about the principles and the role of Plant Quarantine in containment of pests and diseases, plant quarantine regulations and set-up. Also, to facilitate students to have a good understanding of the aspects of biosafety andbiosecurity.

Theory

Units	Content	Lectures
I	Definition of pest, pesticides and transgenics as per Govt. notification; relative importance; quarantine – domestic and international. Quarantine restrictions inthe movement of agricultural produce, seeds and planting material; case historiesof eXotic pests/ diseases and their status.	6
II	Plant protection organization in India. Acts related to registration of pesticides and transgenics. Insecticide regulatory bodies, synthetic insecticides, bio-pesticides and pheromone registration procdures. History of quarantine legislations, PQ Order 2003. Environmental Acts, Industrial registration; APEDA, Import and EXport of bio-control agents.	6
III	Identification of pest/ disease free areas; contamination of food with toxigens, microorganisms and their elimination; Symptomatic diagnosis and other techniquesto detect pest/ pathogen infestations; VHT and other safer techniques of disinfestation/ salvaging of infected material.	6
IV	WTO regulations; non-tariff barriers; pest risk analysis, good laboratory practices for pesticide laboratories; pesticide industry; sanitary and phytosanitary measures. Global Positioning System (GPS) and Geographic Information System (GIS) for plant biosecurity, pest/ disease and epidemic management, strategies for combating risks and costs associated with agroterrorism event, mitigation planning, integrated approach for biosecurity. Biosafety, policies and regulatory mechanism, Cartagena Protocol on Biosafety and its implications, issues related to release of genetically modified crops.	10

Learning outcome

Students offering this course are eXpected to have a good knowledge of the rules and regulations of Plant Quarantine, WTO regulations, GAP, Sanitary and Phytosanitary measures.

Suggested Reading

Rajeev K and Mukherjee RC. 1996. *Role of Plant Quarantine in IPM*. Aditya Books.

Rhower GG. 1991. Regulatory Plant Pest Management. In: *Handbook of Pest Management in Agriculture*. 2nd Ed. Vol. II. (Ed. David Pimental), CRC Press.

Shukla A and Veda OP. 2007. *Introduction to Plant Quarantine*. Samay Prakashan, New Delhi.

ENT 521
Edible and Therapeutic Insects

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To create awareness and acquaint students about the contribution that insects make to ecosystems, diets, food security and livelihoods in developed and developing countries.

Theory

Units	Content	Lectures
I	Edible and therapeutic insects: the concept, definition, and importance.	2
II	History and origin of insects as food, feed and medication; important insect speciesand insect products consumed.	2
III	Edible insect ecology, conservation and management of edible insect resources;environmental opportunities of insect rearing.	2
IV	Nutritional composition and role of insects in food security.	2
V	Insect farming: the concept, definitions, and rearing techniques.	2
VI	Processing edible insects for food and feed.	2
VII	Food safety and preservation, edible insects for livelihood security.	2

Practical

1	Survey and identification of edible and therapeutic insect species;	2
2	Collection and preservation of edible and therapeutic insect specimens;	3
3	Rearing techniques of edible insect species;	3
4	Harvesting techniques of edible insects from natural environment;	3
5	Analysis of proximate elemental composition, antioxidant and anti-nutritionalproperties and microbial aspects of preservation.	3

Learning outcome

Students are eXpected to be aware of insects for edible and therapeutic use; theirnutritional composition. Should know the techniques of farming and processing insects for human and animal consumption.

Suggested Reading

Halloran A, Flore R, Vantomme P and Roos N 2018. Edible insects in sustainable food systems. Van Huis A, Itterbeeck JK, Klunder H, Mertens E, Halloran A, Muir G and Vantomme. 2013. Edible insects: future prospects for food and feed security. Food and Agricultural Organization of the United Nations, Rome.

ENT 522
Medical and Veterinary Entomology

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To study the major insect, mite, and tick vectors of disease to man and animals. Students will learn to identify and understand the life cycles, morphology, andbehavior of mosquitoes, ticks, mites, lice, fleas, and other disease vectors.

Theory

Units	Content	Lectures
I	Introduction to medical, veterinary and forensic entomology; Classification of Arthropod-borne diseases; Hematophagy, disease transmission and epidemiology; flies (Diptera) of medical and veterinary Importance; moth flies: Leishmaniasis and Bartonellosis; biting midges (Ceratapogonidae).	4
II	Mosquito taXonomy, biology, and behavior; mosquito viruses: EEE, VEE, SLE, yellow fever,mosquito surveillance; malaria; horse flies, deer flies: EIA, anaplasmosis; muscid flies; Myiasis (Muscoidea); myiasis and louse flies; black flies of medical and veterinary Importance; filariasis: mansonellosis, onchocerciasis.	4
III	Lice of medical and veterinary importance; rickettsial diseases: epidemic typhus, etc.; mites: rickettsial pox; mites and acariasis: mange, scabies, chiggers; spiders and scorpions; fleas (Siphonaptera) of medical and veterinary importance; plague and murine typhus.	3
IV	Ticks of medical and veterinary importance; lyme disease, rocky mountain spotted fever, tularemia; true bugs (Hemiptera): kissing bugs and bedbugs; chagas disease; tsetse flies; Lepidoptera and Hymenoptera of medical and veterinary importance.	3

Practical

1	Identification of arthropod Classes, Orders and Families of medical and veterinary importance;	4
2	Collection, segregation, curing insect and arachnid specimens, their preservation;	4
3	Management of insect and mite pests of medical and veterinary importance;	3
4	Study of some practical aspects in forensic entomology.	3

Learning outcome

Students are expected to identify the arthropods of medical and veterinary importance; identify the diseases transmitted by these arthropod vectors and suggest management options.

Suggested Reading

David BV and Ramamurthy VV. 2011. *Elements of Economic Entomology*, 6th Edition, Namrutha Publications, Chennai.

Gullan PJ and Cranston PS. 2010. *The Insects: An Outline of Entomology*. 4th Edition, Wiley-Blackwell, West SusseX, UK & New Jersey, US.

Mullen G and Durden L. 2018. *Medical and Veterinary Entomology*, 3rd Edition, Academic Press.

ENT 523
Forest Entomology

Credits: 1 + 1
Contact Hours: 14 + 28

Mid-Session Exam: 20 (15+5#)
Practical Exam: 50
End-Semester Exam: 30

Aim of the course

To promote a more global theoretical understanding of pest population dynamics and the causes of forest insect outbreaks: covering pests of both natural forests and plantations, the diversity of tropical forest insects, their ecological functions, the concept of pests and the incidence of pests in natural forests, plantations andstored timber.

Theory

Units	Content	Lectures
I	Introduction to forestry in the tropics, tropical forests: characteristics and types of tropical forests, management of tropical forests and the problems in their management; plantation forestry: beginnings, eXpansion and current status.	2
II	History of tropical forest entomology, diversity of forest insects: structural and functional diversity – the feeding guilds, concept of pests, ecology of insects in forest environment, concept and functioning of ecosystem, role of insects in ecosystem processes of tropical forests: insects as primary consumers, secondary and tertiary consumers, as decomposers, as food, pollinators and other ecological interactions.	3
III	Insect pests in natural forests, general pest incidence, pest outbreaks: Lepidoptera, Coleoptera, Hemiptera, and Hymenoptera; insect pests in plantations, nursery pests, sapling pests, pests of older plantations and their impact; insect pests of stored timber, categories of wood destroying insects and their damage: termitesand beetles.	3
IV	Population dynamics, characteristics of population growth, factors affection population growth, principles governing population dynamics, types and causes of forest insect outbreaks; general issues in forest entomology: enemies' hypothesis, resource concentration hypothesis, pest evolution hypothesis; pest problems in plantations of indigenous *vs* eXotic species; pest problems in monocultures *vs* miXed plantations.	3
V	Management of tropical forest insect pests, historical development and present status of tropical forest pest management, overview of pest management options: preventive measures, remedial measures; unique features of forest pest management;constraints to forest pest management in the tropics; guidelines for the practice of forest pest management in the tropics.	3

Practical

1	Collection, identification and preservation of important insect pest specimens offorest plants and some damage material;	3
2	Detection of insect infestation and assessment of losses due to insect pests;	3
3	Habitat management for vertebrate and insects pests;	3
4	Fire control methods and devices;	2
5	Familiarization with the meteorological and plant protection equipment, application	3

	of pesticides and bio-control agents in the management of insect pests in nurseries and plantations.	

Learning outcome

Students are expected to acquire knowledge of insect pests of forest nurseries, forests and plantations, their nature of damage, life history traits and effective management.

Likewise, students are expected to have a thorough knowledge of pestiferous insects of stored timber, hide and other forest produce.

Suggested Reading

Jha LK and Sen Sarna PK. 1994. *Forest Entomology*. Ashish Publishing House, Delhi.

Nair KSS. 2007. *Tropical Forest Insect Pests: Ecology, Impact, and Management*, Cambridge University Press, Edinburgh/ New York.

Stebbings EP. 1977. *Indian Forest Insects*. JK Jain Brothers.

PGS 501
LIBRARY AND INFORMATION SERVICES

Credits: 0+1 Mid-session exam : 50
Contact hours: 28 End-semester exam : 50

Objective: To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources, to carry out literature survey, to formulate information search strategies, and to use modern tools (Internet, OPAC, search engines etc.) of information search.

Sr. No	Practical Description	No. of Practicals
1.	Introduction to library and its services; Role of libraries in education, research and technology transfer;	1
2.	Classification systems and organization of library;	3
3.	Sources of information- Primary Sources, Secondary Sources and Tertiary Sources;	1
4.	Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.);	2
5.	Tracing information from reference sources;	1
6.	Literature survey; Citation techniques/Preparation of bibliography;	1
7.	Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services;	2
8.	Use of Internet including search engines and its resources; e-resources access methods	3

Suggested Readings

Singh, Ajay Pratap, 2013. Information Communication and Society. New Delhi: EssEss Publishers.
Kumar Krishan, 2013. Reference Service. 5th Rev ed. New Delhi: Vikas.
Dhiman, Anil Kumar, 2005. Information and Reference Sources and Service. New Delhi: EssEss.
Ranganathan, S.R.1989. Reference Service. 2nd Rev. ed. Banglore: Sharda Endowment for Library Science.
Mukjerjee, A.K. 1971. Reference Work and its Tools. 2nd ed. Calcutta: World Press.
Sinha, Pradeep K. 2007. Computer Fundamentals. 4th ed. Delhi: BPB Publications.
#Assignments mark

PGS 502
TECHNICAL WRITING AND COMMUNICATION SKILLS

Credits: 0+1 Mid-session exam : 50
Contact Hours: 28 End-semester exam : 50

Objective: To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).

Sr. No	Practical Description	No. of Practicals
1.	Technical Writing- Various forms of scientific writings- thesis, technical papers, reviews, manuals, etc; Various parts of thesis and research communications (title page, authorship contents page, preface,.	2
2.	Technical Writing- Introduction, review of literature, material and methods, experimental results and discussion);	2
3.	Technical Writing- Writing of abstracts, summaries, précis, citations etc.; commonly used abbreviations in the theses and research communications; illustrations, photographs and drawings with suitable captions;	2
4.	Technical Writing- pagination, numbering of tables and illustrations; Writing of numbers and dates in scientific write-ups;	1
5.	Technical Writing- Editing and proof-reading; Writing of a review article.	1
6.	Communication Skills -Grammar (Tenses, parts of speech, clauses, punctuation marks);	1
7.	Communication Skills -Error analysis (Common errors);	1
8.	Communication Skills -Concord; Collocation; Phonetic symbols and transcription;	1
9.	Communication Skills -Accentual pattern: Weak forms in connected speech:	1
10.	Communication Skills -Participation in group discussion: Facing an interview;	1
11.	Communication Skills -presentation of scientific papers.	1

Suggested Readings

Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.
Collins' Cobuild English Dictionary. 1995. Harper Collins.
Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. Holt, Rinehart & Winston.
Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.
James HS. 1994. Handbook for Technical Writing. NTC Business Books.
Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.
Mohan K. 2005. Speaking English Effectively. MacMillan India.
Richard WS. 1969. Technical Writing. Barnes & Noble.
Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. Abhishek. Sethi J &
Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.
Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.

PGS 503
INTELLECTUAL PROPERTY AND ITS MANAGEMENT IN AGRICULTURE

Credits: 1 + 0 | Mid-session exam: 40 (30+10#)
Contact hours: 14+0 | End-semester exam: 60

Objective: The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Units	Contents	Lectures
I	Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement;	3
II	Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and bio-diversity protection	4
III	Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity	4
IV	International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.	3

Suggested Readings

Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.
Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.
The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000;
Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

PGS 504
BASIC CONCEPTS IN LABORATORY TECHNIQUES

Credits: 0+1 Mid-session Practical: 50
Contact hours: 0+28 End-semester Practical: 50

Objective:
To acquaint the students on the basics of commonly used techniques in laboratory.

Sr. No	Practical Description	No. of Practicals
1.	Safety measures while in Lab; Handling of chemical substances;	1
2.	Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;	1
3.	Washing, drying and sterilization of glassware;	1
4.	Drying of solvents/chemicals.	1
5.	Weighing and preparation of solutions of different strengths and their dilution;	1
6.	Handling techniques of solutions;	1
7.	Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids;	1
8.	Neutralisation of acid and bases;	1
9.	Preparation of buffers of different strengths and pH values.	1
10.	Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;	1
11.	Electric wiring and earthing.	1
12.	Preparation of media and methods of sterilization;	1
13.	Seed viability testing, testing of pollen viability;	1
14.	Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy	1

Reference Books
Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co

PGS 505
AGRICULTURAL RESEARCH, RESEARCH ETHICS AND RURAL DEVELOPMENT PROGRAMMES

Credits: 1 + 0 | Mid-session exam : 40 (30+10#)
Contact hours: 14+0 | End-semester exam: 60

Objective: The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.

Theory

Units	Contents	Lectures
I	History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International	3
II	Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.	3
III	Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics. Concept and connotations of rural development, rural development policies and strategies.	4
IV	Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/ Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.	4

Suggested Readings

Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.
Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ.