

Department of Renewable Energy Engineering

College of Technology & Engineering, MPUAT, Udaipur- 313 001

Semester-wise Scheme for Post Graduate Program in Renewable Energy Engineering, w.e.f. 2022-23

Details of P.G. Programme courses offered for the award of M. Tech. (Ag.) Renewable Energy Engineering Degree

Course Title	Course No.	Credit	Semester			
			I	II	III	IV
Core Courses						
Total 12 credits; two courses in the first semester (6 credits) and one course each in the second and third semester (3 credits each) to be evaluated externally.						
Solar Thermal Energy Conversion Technologies	REE 511	3(2+1)	3	-	-	-
Biomass Energy Conversion Technologies	REE 512	3(2+1)	3	-	-	-
Biogas Technology and Mechanism	REE 521	3(2+1)	-	3	-	-
Renewable Energy Technologies	REE 531	3(2+1)	-	-	3	-
Major Courses						
Total 8 credits; one course in first, second semester & third each						
Energy, Ecology & Environment	REE 513	3(3+0)	3	-	-	-
Energy Generation from Agricultural Waste and Byproducts	REE 514	3 (2+1)	3			
Agro-Energy Audit and Management	REE 515	3(2+1)	3	-	-	-
Wind Energy Conversion and Utilization	REE 522	3(3+0)	-	3	-	-
Energy Management in Food Processing Industries	REE 523	2(1+1)	-	2	-	-
Design and Analysis of Renewable Energy Conversion Systems	REE 524	3(2+1)	-	3	-	-
Alternate Fuels & Applications	REE 535	2 (2+0)	-	-	2	-
Solar Photovoltaic System Design and Analysis	REE 536	2 (1+1)	-	-	2	-
Minor & Supporting Courses: Total of 14 credits; two courses in the first and second semester (one supporting and one minor in each) and one course of minor the in third semester.						
Statistical Methods for Research Work (supporting Course)	AST 511	3(2+1)	3	-	-	-
Application of Engineering Properties in Food Processing	PFE 513	3(2+1)	3	-	-	-
Storage Engineering and Handling of Agricultural Produce	PFE 514	3(2+1)	3	-	-	-
Thermal Environmental Engineering for Agricultural Processing	PFE515	3(2+1)	3	-	-	-
Agri Project Planning and Management	PFE 516	3(2+1)	3			
Farm Structures and Environmental Control	PFE 517	3(2+1)	3	-	-	-
Dairy Product Processing	PFE 522	3(2+1)	-	3	-	-
Food Processing Technologies	PFE 523	3(2+1)	-	3	-	-
Seed Process Engineering	PFE 524	3(2+1)	-	3	-	-
Design of Aquacultural Structures	PFE 525	3(2+1)		3		
Processing of Meat Poultry and Fish	PFE 526	3(2+1)	-	3	-	-
Food Package Engineering	PFE 527	2(1+1)	-	2	-	-
Food Quality and Safety	PFE 528	2(1+1)	-	2	-	-
Food Processing Equipment and Plant Design	PFE 532	2(1+1)	-	-	2	-
Food Processing Entrepreneurship and Start-up	PFE 533	2(1+1)	-	-	2	-
Instrumentation and Sensors in Food Processing	PFE 534	2(1+1)	-	-	2	-
Design of Tractors Systems	FMP 513	3 (2+1)	3			
Machinery for Precision Agriculture	FMP 524	3(2+1)	-	3	-	-
Computer-Aided Design of Machinery	FMP 532	2(0+2)	-	-	2	-
Machinery for Horticulture and Protected Agriculture	FMP 534	2(2+0)	-	-	2	-
Big Data Analytics	CSE 528	2(1+1)	-	2	-	-
Artificial Intelligence	CSE 529	2(1+1)	-	2	-	-
Finite Element Methods	BS 511	3(2+1)	3	-	-	-
Numerical Methods for Engineers	BS 521	3(2+1)	-	3	-	-
Mechatronics and Robotics in Agriculture	ME 529	2(2+0)	-	2	-	-

Any other course(s) of another department other than course(s) from the major can be taken as per recommendations of the student's advisory committee.						
Others (Common Compulsory Courses)						
Total 5 credits						
Library and Information Services	PGS 511	1(0+1)	1	-	-	-
Intellectual Property and its management in Agriculture	PGS 512	1(1+0)	1	-	-	-
Technical Writing and Communications Skills	PGS 521	1(0+1)	-	1	-	-
Basic Concepts in Laboratory Techniques	PGS 522	1(0+1)	-	1	-	-
Agricultural Research, Research Ethics and Rural Development Programmes	PGS 523	1(1+0)	-	-	1	-
Seminar (0+1)	REE 591	1	-	1	-	-
Research (Thesis) Thesis minimum duration 2 semesters	REE 599	30	-	-	-	30
Total credits to be offered		70	17	17	6	30

*For Master Programme, Thesis minimum duration 2 semesters.

COURSE SUMMARY (M. Tech)

Courses	No. of Courses					Credit Hours
	Semester					
	I	II	III	IV	Total	
Core	2 (6)	1 (3)	1 (3)	-	4 (12)	12
Major (Optional)	1 (3)	1 (3)	1 (2)	-	3 (8)	8
Minor	1 (3)	2 (5)	-	-	3 (8)	8
Supporting	1 (3)	1 (3)	-		2 (6)	6
Seminar	-	1 (1)	-	-	1 (1)	1
Research (Thesis)	-	-	-	1	1 (30)	30 (Graded as satisfactory/ Non-satisfactory)
Compulsory Courses	2 (2)	2 (2)	1 (1)	-	5 (5)	5
Total	7 (17)	8 (17)	3 (6)	1	20	70

RENEWABLE ENERGY ENGINEERING

COURSE CONTENT

SOLAR THERMAL ENERGY CONVERSION TECHNOLOGIES

REE 511
3(2+1)

Credit

Course Outcome:

The student is able to understand the detailed knowledge about working and design of various solar thermal devices able to design different solar thermal devices.

Syllabus:

Characteristics of solar radiation: Attenuation, absorption, scattering, and air mass. Solar earth geometry.

Solar flux and weather data. Solar radiation data and estimation: Radiation estimation models and applications. Heat and mass transfer in solar energy utilization: Gray surface, sky radiation, radiation heat transfer coefficient, reflectivity, transitivity, transmittance absorption product. Selective surfaces and materials.

Solar thermal energy collectors (track and untrack): Heat capacity effect, time constant measurement, design and efficiency calculations, F chart method utility.

Techno-economic feasibility of solar thermal energy applications: Cooking, air heating for drying, steam generation, space heating and cooling, refrigeration, architecture, absorption cooling, thermal power generation.

Practicals:

1. Measurement of Solar radiation
2. Estimation of solar energy by model applications
3. Design of solar energy collectors
4. Study of materials used in solar system
5. Energy balance in solar energy collectors
6. Efficiency calculation of collectors

Suggested Readings:

1. Kalogirou S A 2013. *Solar Energy Engineering*. Academic Press, Cambridge,Massachusetts.
2. Duffie J A and Beckman W A 2006. *Solar Thermal Engineering Process*. John Wiley & Sons, New Jersey.
3. Hsien J S 2014. *Solar Energy*. Prentice Hall Inc., New Jersey.
4. Garg H P 1990. *Advances in Solar Energy Technology*. Springer Publishing Company, Dordrecht, Netherland.
5. Sukhatme S P and Nayak J 2008. *Solar Energy: Principles of Thermal Collection and Storage*. Tata McGraw-Hill Publishing Company Limited, New Delhi, India.
6. Bansal N K, Kleeman M K and Meliss M 1990. *Renewable Energy Sources and Conversion Technologies*. Tata McGraw-Hill Pub. Co. Ltd., Delhi.
7. Kishore V V N 2008. *Renewable Energy Engineering and Technology–A Knowledge Compendium*. TERI Press, New Delhi, India.
8. Pai B R and Ramaprasad M S 1991. *Power Generation through Renewable Sources of Energy*. Tata McGraw-Hill Pub. Co., New Delhi.

BIOMASS ENERGY CONVERSION TECHNOLOGIES

REE 512

Credit 3(2+1)

Course Outcome:

The students are enable to extract the energy from biomass and acquainted the skill to knowhow to choose the suitable biomass fuels for different industrial applications with the design and economics of the system.

Syllabus:

Biomass characterization: Types and resources, sustainability issues, assessment tools and methodologies, biomass fuel characterization, Biomass supply chain concept. Direct use of biomass: Size reduction, baling, pelletization, briquetting technologies.

Biochemical conversion of biomass: Feedstock, process design, operation, optimized process parameters, and utilization for biogas and bioethanol production.

Biomass combustion: Stoichiometric air requirement, the chemistry of combustion, design of combustion system, combustion zones, flame structure, stability, emissions. Co-firing of biomass.

Thermo-chemical conversion of biomass: Feedstock, chemistry, reactor design, operation, optimized process parameters, and utilization for gasification, carbonization, torrefaction, and pyrolysis.

Cogeneration technologies: Cycles, topping, bottoming, selection, problems, applications. Waste heat recovery: Estimation, systems, design, and application.

Practicals:

1. Characterization of biomass
2. Design of bio-reactors
3. Determination of techno-economic feasibility of biochemical conversion process.
4. Performance evaluation of combustion gadgets
5. Performance evaluation of gasifiers
6. Performance evaluation of pyrolytic converters
7. Design of waste heat recovery system

Suggested Readings:

1. Vimal O P 1984. *Energy from Biomass*. Agricole Publishing Academy, New Delhi.
2. Twidell J W and Weir A D 2006. *Renewable Energy Sources*. E & F N Spon Ltd., New York.
3. Chaturvedi P 1995. *BioEnergy Resources: Planning, Production, and Utilization*. Concept Pub. Co., New Delhi.
4. Chakravorty A 1985. *Biogas Technology & other Alternative Technologies*. Oxford & IBH Publication Ltd., Delhi.
5. Goswami D Y 1986. *Alternative Energy in Agriculture*. Vol. II (Ed), CRC, Press Inc. Florida, USA.
6. Stout B A 1984. *Biomass Energy Profiles*. FAO Agril. Services Bulletin No.54., Elsevier Science Publishers Ltd., England.

BIOGAS TECHNOLOGY AND MECHANISM

REE 521

Credit 3(2+1)

Course Outcome:

Students are able to design, select, estimate, and analyzed the biogas technology, and chemical and physical conditions and get acquainted with various biogas appliances.

Syllabus:

Biogas Technology: Potential and status, chemistry, physical conditions, and utilization of alternate feedstock materials.

Types of reactors: Single phase, two-phase processes. High rate biomethanation process, selection of model and size, construction technique, and material requirement. The design concept of night soil, kitchen waste, and solid-state cold condition biogas plants.

Biogas distribution and utilization: Properties and uses of biogas, design of gas distribution system. Biogas utilization devices: Biogas scrubbing and compressing, dual-fuel engines and their limitations, generation of power. Testing of biogas appliances.

Effluent: Handling of effluent biogas plant, effluent treatment, and management, BDS applications, and enrichment. Cost and financial viability of biogas plants. Repair and maintenance of biogas plants.

Practical:

1. Design of biogas plant for solid and liquid wastes
2. Cost estimation of different biogas plants: KVIC, Janta, Deenbandhu, type
3. Analysis of biogas
4. Experiment on purification of biogas
5. Performance evaluation of biogas appliances
6. Testing of biogas burner for heat transfer, thermal and cooking efficiency
7. Analysis of Bio-digested slurry
8. Study on use of biogas spent slurry
9. Study and analysis of Carbon credits.

Suggested Readings:

1. Khandelwal K C and Mahdi S S 1986. *Biogas Technology*. A Practical Hand Book, Vol-I, Tata McGraw-Hill Pub. Co. Ltd., New Delhi.
2. Chawala O P 1986. *Advances in Biogas Technology*. ICAR, New Delhi.
3. Rohlich G A, Walbot V, Connar L J, Golueke C G, Hinesly T D, Jones P H, Lapp H M, Loehr R C, Luei Hing C, Pfeffer J T, Prakasam T B S and Brown N L 1977. *Methane Generation from Human Animals and Agril Wastes*. National Academy of Sciences, Washington.
4. Abbasi S A and Nipanay P C 1993. *Modeling and Simulation of Biogas System Economies*. Ashish Pub. House, New Delhi.
5. Mittal KM 1996. *Biogas Systems: Principles and Applications*. New Age international (P) Ltd. New Delhi.
7. Tasneem A, Tauseef S M and Abbasi S A 2012. *Biogas Energy*. Springer Publications, Springer Science and Business Media, New York, USA.
8. Van B A 1981. *Chinese Biogas Manual*. Intermediate Technology Publications, London.

RENEWABLE ENERGY TECHNOLOGIES

REE 531

Credit 3(2+1)

Course Outcome:

The students is acquainted with the skill to understand technical aspects and principles of renewable energy characteristics of the resource base (solar radiation, wind energy, bioenergy, etc.) In a further step an economic analysis of supply technologies.

Syllabus:

Solar Energy: Heat transfer, estimation and physical conversion, Instruments for measurement. Energy collection and analysis: FPC, ETC, concentrating collectors. Solar energy application: Direct and indirect. Solar photovoltaic technology: Conversion, Systems components, integrations, and applications.

Energy from biomass and wastes: Production, distribution, characterization, treatments, recycling. Biomass conversion technologies: Thermo-chemical, bio-chemical, and agrochemical technology. Raw materials, process parameters, end products, and utilization.

Wind energy: Resource estimation, technologies, performance curves, power, and torque characteristics. Airfoils and rotors: Windmill parameters, wind farm design, and considerations.

Alternate Energy Technologies: Ocean Thermal Energy Conversion, Geothermal, Tidal, Hydro. Energy conversion systems: Resources, systems integrations, and analysis, applications. Energy storage: Types, materials, characteristics, and application.

Practical:

1. Analysis of solar collectors
2. Solar Photovoltaic cell characteristics, analysis of SPV systems
3. Characterization of biomass
4. Design and benefit analysis of energy systems
5. Design and efficiency testing of wind energy conversion devices

Suggested Readings:

1. Culp A W 1991. *Principles of Energy Conversion*. McGraw-Hill Pub. Co Inc., NewYork.
2. Odum H T and Odum E C 1976. *Energy Basis for Man and Nature*. McGraw-Hill Pub.Co. Inc., New York.
3. Garg H P and Prakash J 1976. *Solar Energy, Fundamentals and Applications*. TataMcGraw-Hill Pub. Co. Inc., New Delhi.
4. Sukhatme S P 1997. *Solar Energy, Principles of Thermal Collection and Storage*. Tata McGraw-Hill. Pub. Co. Ltd., New Delhi.
5. Duffie J A and Beckman W A 1991. *Solar Engineering of Thermal Processes*. JohnWiley, New York.
6. Twidell J W and Weir A D 1986. *Renewable Energy Sources*. E & FN Spon Ltd.,London.
7. Rai GD 2001. *Non-Conventional Energy Sources*. Khanna Publishers, Delhi.

ENERGY, ECOLOGY, AND ENVIRONMENT

REE 513

Credit 3(3+0)

Course Outcome:

Students will be able to understand the relationship between the carbon cycle, energy policies, energy use and economic growth, and factors affecting the environment.

Syllabus:

Global carbon cycle. Carbon reservoirs flow and human interventions. Global warming and climate change. Energy-efficient technology: Efficiency hierarchy, energy-dependent activities, energy policies, the linkage between energy use and economic growth and environment.

Ecosystem: Kinds, transfection, components of the ecosystem, ecosystem development of evaluation, a major ecosystem of the world, physical environment, and metrology.

Climate change: Impact and models. Energy for sustainable development: Development indices, pillars, subsystems, principles, and dimensions. Low carbon technologies: Energy efficiency projects, carbon trading.

Environment, Environmental degradation: Thermal and chemical pollution, primary and secondary pollutant, air pollution, water pollution, nuclear energy hazard, radioactive hazards, mining hazards, land use, oil spills, and gas leaks.

Global environmental changes: United Nations Framework Convention on Climate Change (UNFCCC), Kyoto protocol and clean development mechanism: Overview, administration, participation, institutions, procedures, project design, and formulation.

Suggested Readings:

1. Essam E and Hinnami EI 1991. *Environmental Impact of Production and Use of Energy*. Tycooly Press Ltd., Dublin.
2. Thomdike E H 1978. *Energy and Environment: A Premier for Scientists and Engineers*. Adson, Wesley Pub. Co., Boston, US.
3. Canter L C 1979. *Environmental Impact Assessment*. McGraw Hill Pub. Co., New York.
4. Wilson R and Jones W J 1974. *Energy, Ecology and the Environment*. Academic Press Inc., Cambridge, Massachusetts, US.
5. Mathur A N, Rathore N S and Vijay V K 1995. *Environmental Awareness*, Himanshu Pub., Udaipur.
6. Dessler A 2011. *Introduction to Modern Climate Change*. Cambridge University Press, Cambridge, England.
7. Coley D 2008. *Energy and Climate Change*. John Wiley & Sons, Ltd., New Jersey.
8. Fowler J M 1984. *Energy and the Environment, Second Edition*. McGraw-Hill, New York.
9. Puppy H G. *Energy and Environment, Mankind and Energy Needs*. Elsevier Pub. Co., New York.
10. Kaushika N D and Kaushik K 2004. *Energy, Ecology, and Environment: A Technological Approach*. Capital Publishing, New Delhi.
11. Rathore N S and Kurchania A K 2001. *Climatic Changes and their Remedial Measures*. Shubhi Publications, Gurgaon.

ENERGY GENERATION FROM AGRICULTURAL WASTE AND BYPRODUCTS

REE 514

Credit 3(2+1)

Course Outcome:

The student will be able to understand the estimation, characterization, storage, and handling of agricultural wastes and by-products to generate energy.

Syllabus:

By-Products: Generation, estimation, and utilization. Agricultural and agro-industrial by-products/wastes: Properties, characterization, on-site handling, storage, and processing. Concept, scope, and maintenance of waste management and effluent treatment

Waste as fuel: Utilization pattern, pretreatments, secondary treatments, mechanism, construction, efficiency, and suitability.

Utilization of agro-based industrial wastes for paper production, production of particleboard, fertilizer through vermicomposting, and fuel.

Thermochemical and biochemical conversion of agricultural waste and byproducts: Densification, combustion, gasification, extraction, pyrolysis, carbonization, torrefaction, liquefaction, anaerobic digestion, and fermentation process.

Practical:

1. Estimation of agricultural waste by remote sensing and field Method
2. Characterization of agricultural waste and by-products
3. Determination of moisture content of biomass
4. Determination of Volatile solids
5. Determination of Fixed carbon content of biomass
6. Determination of ash content of biomass
7. Estimation of calorific value of biomass
8. Estimation of calorific value of biogas
9. Estimation of calorific value of producer gas
10. Determination of Lignin Cellulose Hemicellulose in Biomass
11. Production of fuel from agricultural wastes and by-products,
12. Production of Biogas, Producer gas, and Biodiesel from Agriculturalwaste
13. Techno-economic feasibility of waste to fuel systems

Suggested Readings:

1. Anonymous 1984. *Manure Production and Characteristics*. ASAE Standards, America.
2. Luh BS 1991. *Rice: Production and Utilization*. AVI Publ. Company, Inc. Westport, Connecticut.
3. Chahal DS 1991. *Food, Feed, and Fuel from Biomass*. Oxford & IBH, New Delhi.
4. David C Wilson. 1981. *Waste Management, Planning, Evaluation, Technologies*. Clarendon Press, Oxford, England, UK.
5. Klass D L and George E H 1981. *Fuels from Biomass and Wastes*. Ann. Arbor. Science Publ., New York.
6. Srivastava P K, Maheswari R C and Ohja T P 1995. *Biomass Briquetting and Utilization*. Jain Bros. Publications, New Delhi.

AGRO ENERGY AUDIT AND MANAGEMENT

REE 515

Credit 3(2+1)

Course Outcome: Students will learn detailed energy audits, energy balance techniques, energy management strategies, energy conservation planning, and practices in the agriculture production system.

Syllabus:

Energy resources on the farm: Conventional and non-conventional forms of energy and their use. Heat equivalents and energy coefficients for different agricultural inputs and products. The pattern of energy consumption and their constraints in the production of agriculture.

Direct and indirect energy, an energy audit of production agriculture, rural living, and scope of conservation.

Energy requirement in different agro-based industries: Energy analysis, energy ratio, and specific energy value. Identification of energy-efficient machinery systems: energy losses and their management.

Energy analysis techniques and methods: Energy balance, output and input ratio, resource utilization, conservation of energy sources. Energy conservation planning and practices.

Practical:

1. Study of energy audit techniques.
2. Energy use patterns and management strategies in various agro-industries.
3. Assessment of overall energy consumption, production, and cost in selected agro-industries.
4. Estimation of energy requirement in different agricultural production systems.
5. Study of energy input/output ratio of the different agricultural production systems.

Suggested Readings:

1. Kennedy W J Jr. and Turner W C 1984. *Energy Management*. Prentice-Hall, Upper Saddle River, New Jersey.
2. Pimental D 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press, Florida.
3. Fluck R C and Baird C D 1984. *Agricultural Energetics*. AVI Publ. Company, Inc. Westport, Connecticut.
4. Rai GD 1998. *Nonconventional Sources of Energy*. Khanna Publ., New Delhi.
5. Twindal J W and Wier A D 1986. *Renewable Energy Sources*. E & F.N. Spon Ltd., New York.
6. Verma SR, Mittal J P and Singh S 1994. *Energy Management and Conservation in Agricultural Production and Food Processing*. USG Publ. & Distr., Ludhiana.
7. Singh C P 1978. *Energy Requirement of Important Farm Operations for Existing Cropping System in Punjab*. PAU, Ludhiana.

WIND ENERGY CONVERSION AND UTILIZATION

REE 522

Credit 3(3+0)

Course Outcome:

The students will acquire knowledge regarding the mechanism of wind energy and different types of wind machines available to harness wind power and also be able to design a wind turbine for irrigation as well as for power generation.

Syllabus:

Wind mapping and assessment: Wind energy potential, nature of wind, Weibull and Rayleigh analysis, instruments, history, the taxonomy of windmills, wind power laws.

Wind turbine aerodynamics: Momentum theories, basic aerodynamics, airfoils, and their characteristics. Horizontal Axis Wind Turbine (HAWT): Blade element theory, wake analysis. Vertical Axis Wind Turbine (VAWT): Aerodynamics, rotor design, power regulation, yaw system.

Selection of site. Mechanical and electrical applications. Wind farms: Interfacing, maintenance. Management of power generated by windmill: Instruments and controls. Stand-alone and grid-connected systems. Wind energy storage. Wheeling and banking. Cost economics. Testing and certification procedures.

Wind turbine loads: Aerodynamic loads in steady operation, wind turbulence, static. Wind energy control system (WECS). Synchronous and asynchronous generators. Annual Energy Output (AEO). Testing of WECS.

Practical:

1. Visit to meteorological observatory
2. Wind velocity mapping and curve analysis
3. Wind energy instruments and resource assessment
4. Design of windmills
5. Water pumping windmills
6. Performance evaluation of wind aero-generator
7. Study of Wind turbine loads

Suggested Readings:

1. Lysen EH 1983. *Introduction to Wind Energy*. Consultancy Services Wind Energy Developing Countries, Netherlands.
2. Cheremisinov NP 1978. *Fundamental of Wind Energy*: ANN ARBOR SCIENCE, Pub.Inc. Michigan.
3. More HG and Maheshwari R C *Wind Energy Utilization in India*, Technical Bulletin No. CIAE/82/38, CIAE, Bhopal.
4. Eldridge F R 1980. *Wind Machines*. Van Nostrand Reinhold Co., New York.
5. Lipman N H, Muggrove P J and Pontin GW 1982. *Wind Energy for the Eighties*. Peter Peregrinus Ltd. Stevenage, New York.
6. Powar A G and Mohod A G 2010. *Wind Energy Technologies*. Jain Publication, New Delhi.
7. Manwell J F, McGowan J G and Rogers A L 2012. *Wind Energy Explained—Theory Design and Application*. John Wiley and Sons, New Jersey.

ENERGY MANAGEMENT IN FOOD PROCESSING INDUSTRIES

REE 523

Credit 2(1+1)

Course Outcome:

Students' capability to understand energy sources, analyze energy requirement in food processing operations and economize it in food industries.

Syllabus:

Energy forms and units, energy perspective, norms and scenarios, energy auditing, data collection, and analysis for energy conservation in food processing industries.

Sources of energy, its audit, and management in various operational units of the agro-processing units, passive heating, passive cooling, sun drying, and use of solar energy, biomass energy, and other non-conventional energy sources in agro-processing industries.

Reuse and calculation of used steam, hot water, chimney gases, and cascading of energy sources. Energy accounting methods, measurement of energy, design of computer-based energy management systems, and the economics of energy use.

Practical:

1. Study of energy use pattern in rice mill
2. Study of energy use pattern in sugar mill
3. Study of energy use pattern in dal mill
4. Study of energy use pattern in oil mill
5. Study of energy use pattern in cotton-ginning unit
6. Study of energy use pattern in a milk plant
7. Energy management strategies in rice mill
8. Energy management strategies in sugar mill
9. Energy management strategies in oil mill
10. Energy management strategies in a milk plant
11. Identification of energy-efficient processing machines
12. Assessment of overall energy consumption, production, and its cost in food processing plants
13. Visit to the related food processing industry

Suggested Readings:

1. Pimental D 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press.
2. Rai GD 1998. *Non-conventional Sources of Energy*. Khanna Publisher.
3. Twindal J W and Wier A D 1986. *Renewable Energy Sources*. E & F. N. Spon Ltd.
4. Verma SR, Mittal J P and Singh S 1994. *Energy Management and Conservation in Agricultural Production and Food Processing*. USG Publisher and Distributors, Ludhiana.

DESIGN AND ANALYSIS OF RENEWABLE ENERGY CONVERSION SYSTEMS**REE 524****Credit 3(2+1)****Course Outcome:**

Students will be able to design of various energy conversion systems, standards, and test codes of renewable energy systems and their performance analysis.

Syllabus:

Energy cycle of the earth. Estimation and assessment of renewable energy sources: Water flow and storage, ocean currents and tides, biomass energy, solar energy, wind energy, and other renewable energy sources.

Thermodynamics of renewable energy conversion: Energy and exergy analysis of renewable energy power systems. Optimum design of hybrid renewable energy systems: Concept, considerations, and methodologies.

Design of renewable energy systems: Design concept, operational parameters, consideration, and rational values for agro-industrial applications.

Performance analysis of renewable energy systems: Standards and test codes, optimum performance records, evaluation and maintenance aspects, uses of HOMER (Hybrid Optimization Model for Electric Renewable) software.

Practical:

1. Estimation and assessment of renewable energy sources in India
2. Thermodynamic principles of energy conversion
3. Design and operational parameters of biogas plant
4. Design of an updraft gasifier using solid biomass
5. Design of solar photovoltaic plant for a hostel/building
6. Life cycle assessment and financial assessment of a photovoltaic plant for a hostel/ building
7. Study on standards of renewable energy systems
8. Study on test codes of renewable energy systems

Suggested Readings:

1. Boyle G 1996. *Renewable Energy: Power for Sustainable Future*. Oxford Univ. Press, England.
2. Culp AW 1991. *Principles of Energy Conservation*. Tata McGraw-Hill, New Delhi.
3. Duffie J A and Beckman W A 1991. *Solar Engineering of Thermal Processes*. John Wiley, Hoboken, North America.
4. Garg H P and Prakash J 1997. *Solar Energy: Fundamentals and Application*. Tata McGraw-Hill, New Delhi.
5. Grewal N S, Ahluwalia S, Singh S and Singh G 1997. *Hand Book of Biogas Technology*. TMH New Delhi.
6. Mittal KM 1985. *Biomass Systems: Principles and Applications*. New Age International, New Delhi.
7. Patel M K 1999. *Wind and Solar Power Systems*. CRC Press, Florida.
8. Manwell J F, McGowan J G, and Rogers A L 2003. *Wind Energy Explained*. John Wiley, Hoboken, North America.
9. Lambert T and Lilienthal P 2004. *HOMER: The Micro-Power Optimization Model*. National Renewable Energy Lab., Philippines.

ALTERNATE FUELS AND APPLICATIONS**REE 535****Credit 2(2+0)****Course Outcome:**

Students will understand various properties of alternate fuels like methanol, ethanol, fuel cells, and hydrogen fuel for energy-efficient utilization.

Syllabus:

Introduction to alternate fuels: Methanol, ethanol, biogas, producer gas, hydrogen, and fuel cell. Production composition and properties, combustion characteristics, comparison with conventional fuels, potential, possibilities, and problems.

Fuel cell: Principle, classification, system efficiency. Life cycle assessment of fuel cell systems.

Hydrogen fuel: Production, gas cleanup, challenges, and opportunities. Hydrogen storage and energy economy.

Utilization: Thermal and mechanical applications. Environmental impact and safety factors of alternate fuel, efficiency, economics, and commercial considerations.

Practical:

1. Performance of I.C. engines on alternate fuels (biogas, producer gas, and biodiesel)
2. Measurement of flue gas parameters.
3. Thermal applications of alternate fuels (biogas, producer gas, and biodiesel)
4. Hydrogen production.
5. Biomass-based fuel cell.
6. Integrated biomass-based gasifier for power generation.

Suggested Readings:

1. San P A 1980. *Biochemical and Photosynthetic: Aspects of Energy Production*. Academic Press, London.
2. Bungay H R 1981. *Energy, the Biomass Options*. John Wiley & Sons, New York.
3. Twidell J W and Weir A D 1986. *Renewable Energy Sources*. E & FN Spon Ltd., New York.
4. Dahiya A 2014. *Bioenergy: Biomass to Biofuels. Engines*. Springer, New York City, New York.
5. Klass D L 1998. *Biomass for Renewable Energy, Fuels, and Chemicals*. Academic Press, Cambridge, England.
6. Demirbas A 2010. *Biodiesel: A Realistic Fuel Alternative for Diesel Chemicals*. Academic Press, Cambridge, England.
7. Babu M K G and Subramanian K A 2013. *Alternative Transportation Fuels: Utilization in Combustion Engines*. CRC Press, Florida.
8. Mukunda H S 2011. *Understanding Clean Energy and Fuels from Biomass*. Wiley India.
9. Speight J G and Loyalka S K 2007. *Handbook of Alternative Fuel Technologies*. CRC Press, Florida.

SOLAR PHOTOVOLTAIC SYSTEM DESIGN AND ANALYSIS

REE 536

Credit 2(1+1)

Course Outcome:

The student is able to design different solar photovoltaic systems for power generation with system integration and economic analysis.

Syllabus:

Physics of solar cells: Crystal structure, band theory, semiconductor, p-n junctions, absorption of radiation, generation, recombination, and carrier separation. Standard solar cell structure: I, V characteristics, conversion efficiency, losses in solar cell, the impact of radiation and temperature.

Solar PV module technologies, First generation: Silicon wafer-based technology, Second generation: Thin-film technologies, Third generation/emerging PV technologies: Organic PV, Dye-sensitized PV, Quantum-dot, Hot-carrier, up-conversion, and down-conversion. Latest benchmark efficiencies: Laboratory and manufacturing. Fabrication technologies.

Solar PV systems: Balance of System (BoS), SPV system design guideline and methodologies, introduction to PV Syst, designing of standalone/grid-connected PV systems for domestic/commercial use. Rooftop business models: CAPEX and RESCO, canal top, floating PV system design.

Materials and devices for energy storage: Batteries, Carbon Nano-Tubes (CNT), fabrication of CNTs, CNT-polymer composites, ultra-capacitors etc.

Practical:

1. To demonstrate the I-V and P-V characteristics of PV modules with
2. varying radiation and temperature levels and efficiency determination.
3. To demonstrate the I-V and P-V characteristics of the series combination of PV modules and efficiency determination.
4. To demonstrate the I-V and P-V characteristics of the parallel combination of PV modules and efficiency determination.
5. To show the effect of variation in tilt angle on PV module power.
6. To demonstrate the effect of shading on module output power and efficiency determination.
7. Study on SPV fabrication technologies.
8. Study on system integration and BoS matching.
9. PV software's operation and utilization.
10. Design and estimation of SPV systems components for agro-based industrial applications.
11. Battery performance testing.

Suggested Readings:

1. Solanki C S 2011. *Solar Photovoltaics: Fundamentals, Technologies, and Applications*. PHI Learning Private Ltd., Delhi.
2. Duffie J A and Beckman W A 1991. *Solar Engineering of Thermal Processes*. John Wiley, New Jersey.
3. Garg HP 1990. *Advances in Solar Energy Technology*. D. Publishing Company, Tokyo.
4. Kreith F and Kreider J F 1978. *Principles of Solar Engineering*. McGraw-Hill, New York.
5. Veziroglu T N 1977. *Alternative Energy Sources*. Vol.5. McGraw-Hill, New York.
6. Sze S M and Kwok K Ng 2007. *Physics of Semiconductor Devices*. 3rd Edn. John Wiley & Sons, New Jersey.
7. Green M A 1981. *Solar Cells Operating Principles, Technology, and System Applications*. Prentice Hall, Upper Saddle River, New Jersey.
8. Luque A and Hegedus S 2011. *Handbook of Photovoltaic Science and Engineering* Education. John Wiley & Sons, New Jersey.

Application of Engineering Properties in Food Processing

PFE 513

3(2+1)

Course Outcomes: To acquaint the students with different techniques of measurement of engineering properties and their application in the design of processing equipment.

Syllabus:

Physical characteristics of different food grains, fruits and vegetables: Shape and size, description of shape and size, volume and density, porosity, surface area; Rheology: ASTM standard, terms, physical states of materials, classical ideal material, rheological models and equations, visco-elasticity, creep-stress

relaxation, non-Newtonian fluid and viscometry, rheological properties, force, deformation, stress, strain, elastic, plastic behaviour.

Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness; Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity.

Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow; Electrical properties: Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high frequency electric field.

Application of engineering properties in design and operation of agricultural equipment and structures.

Practicals:

1. To determine the size of grains, pulses, oil seeds, spices, fruits and vegetables.
2. To determine the shape of various food grains and fruits and vegetables.
3. To determine the bulk density of food grains and fruits and vegetables.
4. To determine the particle density/true density and porosity of solid grains.
5. To study the comparison pycno-meter for finding the particle density of food grains.
6. To determine the angle of repose of grains, oilseeds etc.
7. To find the coefficient of external friction for different food grains.
8. To determine the coefficient of internal friction of different food grains.
9. To plot the normal stress vs. shear stress curves for different food grains.
10. To study the separating behaviour of a grain sample in a vertical wind tunnel (Aspirator column).
11. To study the thermal properties (thermal conductivity, thermal diffusivity and specific heat) of food grains.
12. To determine the Rheological properties: firmness and hardness of grain, fruits, stalk and vegetables.
13. To study the electrical properties (dielectric constant, dielectric loss factor) of various food materials.
14. To study the electrical properties (loss tangent and A.C. conductivity) of various food materials.

Suggested Readings

1. Ludger F and Teixeira AA 2007. Food Physics Physical Properties - Measurement and Application. Springer. ISBN: 9783540341918.
2. Mohesenin NN 1980. Thermal Properties of Foods and Agricultural Materials. First Edition, Gordon and Breach Science Publisher, London. ISBN: 9780677054506.
3. Mohesenin NN 1970. Physical Properties of Plant and Animal Materials. First Edition, Gordon and Breach Science Publisher, London. ISBN: 9780677023007.
4. Peter B 2007. The Chemical Physics of Food. Wiley-Blackwell, New Jersey. ISBN: 9781405121279.
5. Peleg M and Bagelalay EB 1983. Physical Properties of Foods. AVI Publisher, West Port. ISBN: 978-0870554186.

6. Rao MA, Rizvi SSH and Datta K Ashim. 2005. Engineering Properties of Foods. Third Edition, CRC Press, Boca Raton. ISBN: 9780824753283.
7. Sitkei G. 1986. Mechanics of Agricultural Materials. Elsevier, New York. ISBN: 9780444995230.
8. Singhal O P and Samuel DVK 2003. Engineering Properties of Biological Materials. Saroj Prakasan, Allahabad. ISBN: 9788170976257.

Storage Engineering and Handling of Agricultural Produce

PFE 514

3(2+1)

Course Outcomes: To acquaint and equip the students with the safe storage of food materials, design of storage structures and the design of different material handling equipment used in the industries.

Syllabus:

Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements.

Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system.

Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards.

Physical factors influencing flow characteristics, mechanics of bulk solids, flowthrough hoppers, openings and ducts; design of belt, chain, screw, roller, pneumatic conveyors and bucket elevators, principles of fluidization, recent advances in handling of food materials.

Practicals:

1. Determination of angle of repose
2. Determination of coefficient of internal friction
3. Determination of coefficient of external friction
4. Physical factors influencing flow characteristics
5. Determination of flow properties using Shear apparatus
6. Determination of Yield locus, Time yield locus and effective yield locus from Mohr's circle
7. Flow through hoppers, openings and ducts
8. Design of belt conveyors
9. Design of chain conveyors
10. Design of screw conveyors
11. Design of bucket elevators
12. Design of roller conveyors
13. Design of pneumatic conveyors
14. Principles of fluidization
15. Recent advances in handling of food materials

Suggested Readings

- FAO 1984. Design and Operation of Cold Stores in Developing Countries. FAO.
- Hall C W 1970. Handling and Storage of Food Grains in Tropical and Sub-Tropical Areas. FAO Publisher Oxford & IBH
- Henderson S and Perry SM 1976. Agricultural Process Engineering. 5th Ed. AVI Publisher.
- Ripp B E 1984. Controlled Atmosphere and Fumigation in Grain Storage. Elsevier.
- Shefelt RL and Prussi S E 1992. Post Harvest Handling: A System Approach Academic Press.
- Vijayaraghavan S 1993. Grain Storage Engineering and Technology. Batra Book Service.

Thermal Environmental Engineering for Agricultural Processing

PFE 515

3(2+1)

Course Outcomes: To acquaint and equip the students with the concept of thermodynamic properties of air and its application in food processing.

Syllabus:

Requirements of temperature and moisture in food preservation, processing, storage, animal and plant production systems, human comfort etc.

Thermodynamic properties of moist air, psychrometric chart, psychrometric processes and applications; Mass transfer and evaporation of water from free surfaces, theory of psychrometer, direct contact transfer processes between moist air and water-air washer, cooling tower, heating and cooling of moist air by extended surface coils, dehumidification using moisture absorbing materials; Solar irradiations on structures, calculation of heating and cooling loads in buildings/ storage structures.

Design of air conditioning systems, air distribution and duct design, air flow pattern and control, equipment, components and controls; Instruments for measurement and control of temperature and moisture.

Thermal insulation materials for environmental control systems, applications of environmental control in green house, dairy industry, potato storage etc.

Practicals:

1. Study on thermal energy requirement for food preservation process
2. Design calculation for reefer vans for the transport of food materials
3. Study on cryogenic cooling
4. Study on instruments for measuring humidity
5. Experiment on thermal energy transfer in a cooling tower
6. Study on thermal insulation materials for environmental control systems
7. Experiment on environmental control chamber
8. Design of duct for cooling a laboratory
9. Study on air distribution systems
10. Design of pipe layout and sizing procedure for a processing industry
11. Problems on mass transfer in adsorption, distillation and evaporation process
12. Performance evaluation of evaporative cooler
13. Comparative evaluation of different Air Conditioning systems in terms of energy saving
14. Application of CFD in drying

15. Study on air flow pattern in blast freezer

Suggested Readings

1. Threlkeld JL. Thermal Environmental Engineering, Pearson.
2. Perry's Chemical Engineers' Handbook, Section 12. (2007).
3. Thomas H Keuhn, James W Ramsey and Threlkeld JL. Thermal Environmental Engineering, third edition, New Jersey.

Agri-Project Planning and Management

PFE 516

3(2+1)

Course Outcomes: To acquaint and equip the students with the techniques of project development and evaluation along with different standards. Special emphasis will be provided on project formulation as also on various tools and techniques for project appraisal and control.

Syllabus:

Project development, market survey and time motion analysis.

Selection of equipment, technology option, techno-economic feasibility and processing in production catchment.

Product and process design, PERT, CPM, transport model, simplex, linear and dynamic programming, operation log book; Material balance and efficiency analysis, performance testing, performance indices, energy requirement and consumption; Marketing of agricultural products, market positioning.

BIS/FSSAI/ISO standards/ guidelines on best practices, equipment and their design and operation for handling, processing and storage of food/feed.

Practicals:

1. To study the preparation of project and feasibility report.
2. To design salient features, design and layout of MSME.
3. Design and layout of different food processing units: MSME, large processing units.
4. To study record keeping related to production.
5. To study record keeping related to finance and marketing.
6. To conduct experiment on agro project management and design techno-economic feasibility.
7. To conduct SWOT analysis for different Start-ups.

Suggested Readings

1. Ahmed T 1997. Dairy Plant Engineering and Management. 4th Ed Kitab Mahal.
2. Ananda Jayasekaram P 2004. Agricultural Project Planning and Analysis.
3. Albert L 2017. Project Management, Planning and Control.
4. Patel, B. M. (2000). Project Management: Strategic financial planning, evaluation and control. Vikas Publishing House Pvt Ltd.
5. Peter, O. O., Eze, E. C., & Anthony, A. A. (2019). Assessment of Quantity Surveying Firms' Process and Product Innovation Drive in Nigeria. SEISENSE Journal of Management, 2(2), 22-38.
6. UNIDO, Guidelines For Project Evaluation , Oxford, IBH.

Farm Structures and Environmental Control

PFE 517

3(2+1)

Course Outcomes: To acquaint and equip the students with the different types of farm structures and techniques, to control atmospheric parameters and to create favourable environment in the agricultural structures.

Syllabus:

Farmstead planning, survey and data collection for information bank; Analysis of data, Lay outs; Cost estimation and appraisal; Project development; Time, motion and input analysis, flow charts and drawings and case studies.

Farm structures (farmstead, livestock, poultry, storage godowns, farm machinery storage, biogas, green house, net house etc), their design, constructional details and design of low cost structures; Heating, ventilating and exhaust systems, air distribution and air cleaning, combustion of fuels and equipment.

Drying and dehumidification system, air-water contact operations and evaporation, process and product air conditioning, energy efficient environmental control practices; Rural electrification, households electric wiring, rural water supply and sanitation.

Instruments and measurements: Codes and standards.

Practicals

1. Planning and layout of a farmstead.
2. Instruments for measurements of environmental parameters.
3. Design of a farm fencing system.
4. Study of moisture migration behaviour in storage bins.
5. Design aspect of Septic tank.
6. Design aspect of Net house.
7. Design aspect of Grain storage structures.
8. Design aspect of Green house.
9. Design aspect of Cold storage.
10. Design of a feed/fodder storage structures.
11. Design of a biogas plant.
12. Calculation of heating and cooling load.
13. Design calculation of moisture condensation in agricultural buildings.
14. Design of ventilation system for dairy and poultry house.
15. Visit to Green/ Net house and cold storage.

Suggested Readings

1. Albright L D 1990. Environmental Control for Animals and Plants. ASAE Textbooks.
2. Esmay ML and Dixon JE 1986. Environmental Control for Agricultural Buildings. The AVI Corp.
3. Gaudy A F and Gaudy E T 1988. Elements of Bioenvironmental Engineering. Engineering Press.
4. Moore FF 1994. Environmental Control Systems: Heating, Cooling, Lighting. Chapman and Hall.
5. Threlkeld J L 1970. Thermal Environmental Engineering. Prentice Hall.

Dairy Product Processing

PFE 522

3(2+1)

Course Outcomes: To acquaint and equip the students with the various dairy products, processing methods and related equipment.

Syllabus:

Procurement, transportation and processing of market milk, cleaning and sanitization of dairy equipment; Special milks such as flavoured, sterilized, recombined and reconstituted toned and double toned.

Condensed milk: Methods of manufacture and related equipment, evaluation of condensed and evaporated milk; Dried milk: Definition, methods of manufacture of skim and whole milk powder, instantiation, physiochemical properties, evaluation, defects in dried milk powder; Cream: Cream separation, neutralization, sterilization, pasteurization and cooling of cream, defects in cream, Butter: methods of manufacture, defects in butter.

Ice cream: Methods of manufacture and related equipment, defects in ice cream, technology of softy manufacture; Cheese: Methods of manufacture, cheddar, Gouda, cottage and processed cheese, defects in cheese.

Indigenous milk products: Method of manufacture of *yoghurt, dahi, khoa, burfi, kalakand, gulabjamun, rosogolla, srikhand, chhana, paneer, ghee, lassi* etc. Pro-biotic milk product.

Practicals:

1. Estimation of fat and SNF in milk.
2. Operation of LTLT and HTST Pasteurizer.
3. Standardization of milk.
4. Preparation of special milks.
5. Cream separation: parts of separator and the process.
6. Preparation of table butter using the power driven churn.
7. Preparation of plain and fruit flavoured ice cream.
8. Preparation and analysis of khoa from cow and buffalo milk.
9. Preparation and analysis of chhana from cow and buffalo milk.
10. Preparation and analysis of paneer from cow and buffalo milk.
11. Preparation and analysis of lassi from cow and buffalo milk.
12. Preparation of ghee from cream and butter.
13. Preparation of rosogolla and gulabjamun.
14. Preparation of srikhand and burfi.
15. Visit to dairy plant.

Suggested Readings

1. Adnan T 2009. Dairy Powders and Concentrated Products (Society of Dairy Technology). Wiley-Blackwell.
2. Adnan T 2006. Probiotic Dairy Products (Society of Dairy Technology series). Wiley Blackwell.
3. Britz 2008. Advanced Dairy Science and Technology. Blackwell Publisher: Blackwell Publisher Professional.

4. De 2001. Outlines of Dairy Technology. Oxford.
5. Hui Y H 1992. Dairy Science and Technology Handbook. Voll, II, and III Wiley.
6. Spreer E 2017. Milk and Dairy Product Technology. Taylor and Francis.
7. Walstra P, Jan T M, Wouters and Geurts T J 2006. Dairy Science and Technology. CRC, Taylor and Francis.

Food Processing Technologies

PFE 523

3(2+1)

Course Outcomes: To acquaint and equip the students with different unit operations to be performed in food industries and related equipment.

Syllabus:

Mixing and homogenization; Principles of solid and liquid mixing, types of mixers for solids, liquid and pastes homogenization; Emulsification: Principles and equipments.

Novel dehydration technologies; Osmotic dehydration, foam mat drying, puff drying, freeze drying, microwave drying, dehumidified air drying; Extrusion: Theory, equipment, applications.

Non-thermal processing; Principles and equipment involved in ohmic heating, pulsed electric field preservation, hydrostatic pressure technique (vacuum processing, high pressure processing of Foods), ultrasonic technology, irradiation, quality changes and effects on microorganisms, nanotechnology in food processing.

Distillation, leaching and extraction: Principles and equipment for distillation, crystallization, phase equilibria, multistage calculations, leaching principles and equipment, solvent extraction, super-critical fluid extraction, near critical fluid extraction: Equipment and experimental techniques used in NCF extraction and industrial application, advanced methods for extraction of food components and aroma recovery.

Food plant hygiene; Cleaning, sterilizing; waste disposal methods; Food processing plant utilities, steam requirements in food processing; HACCP in food processing industries.

Practicals:

1. Conducting experiments and solving problems on mixing and mixing indices.
2. To conduct the experiment on homogenization.
3. To study the process of crystallization.
4. To conduct the experiment on extraction.
5. Experimentation on leaching process.
6. To study the membrane separation process.
7. To conduct the experiment on reverse osmosis technique.
8. To conduct the experiment on ultra-filtration process.
9. Design of plate and packed tower.
10. Visit to related food industry.

Suggested Readings

1. Brennan J G, Butters J R, Cowell N D and Lilly A E V. 1990. Food Engineering Operations. American Elsevier Applied Science, New York. ISBN-978-1851664440.
2. Earle R L. 1985. Unit Operations in Food Processing. Second edition, Pergamon Press, Oxford. ISBN-0-08-025537-X.

3. Fellows P J. 1988. Food Processing Technology: Principles and Practice. Third Edition, CRC Press, New York. ISBN- 978-1845692162.
4. Geankoplis J C. 1999. Transport Process and Unit Operations. Allyn & Bacon, Boston. ISBN- 978-0205059393.
5. Gould G W. 1999. New Methods of Food Preservation. Aspen Publishers Inc. ISBN- 0-75140048-3.
6. Heldman D R and Lund B D. 1992. Hand Book of Food Engineering. Second Edition, CRC Press, New York. ISBN-978-0-8247-5331-3.
7. McCabe W L, Smith J C and Harriott, P. 2004. Unit Operations of Chemical Engineering. Seventh Edition, McGraw-Hill, New Delhi. ISBN- 0-07-112738-0.
8. Sahay K M and Singh K K. 2004. Unit Operation of Agricultural Processing. Second Edition Vikas Publ. House, India. ISBN- 978-8125911425.
9. Singh R P and Heldman D R. 2013. Introduction to Food Engineering. Fifth Edition, Academic Press. ISBN- 978-0123985309.
10. Toledo R T. 2000. Fundamentals of Food Process Engineering. Second Edition, CBS Publisher, India. ISBN- 978-8123915517.

Seed Process Engineering

PFE 524

3(2+1)

Course Outcomes: To acquaint and equip the students with seed processing along with the design features of the equipment used in their processing.

Syllabus:

Processing of different seeds and their engineering properties; principles and importance of seed processing.

Performance characteristics of different unit operations such as pre-cleaning, grading, conveying, elevating, drying, treating, blending, packaging and storage, seed processing machines like scalper, de-breader, huller, velvet separator, spiral separator, cleaner-cum-grader, specific gravity separator, indent cylinder, disc separator, and colour sorter, seed treater, weighing and bagging machines, their operation and maintenance, installation and determination of their capacity, seed quality maintenance during processing, plant design and layout, economy and safety consideration in plant design.

Seed drying principles and methods; theory of seed drying, introduction to different types of heated air dryers; significance of moisture equilibrium, method of maintaining safe seed moisture; thumb rule and its relevance.

Importance of scientific seed storage, types of storage structures to reduce temperature and humidity, management and operation/cleanliness of seed stores, packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and their impact, design features of medium and long term seed storage building.

Practicals:

1. To study seed processing equipment such as pre-cleaners, scalpels and their performance evaluation.
2. To study graders and their performance evaluation.
3. To study air screen cleaners and their performance evaluation.
4. To study spiral and pneumatic separators and their performance evaluation.
5. To study seed treating equipment, bag closures, scale and their performance evaluation.
6. To study design and layout of seed processing plant and its economics.

7. To analyze the cost of operation and unit cost of processed product.
8. To study the effect of drying temperature and duration of seed germination and storability.

Suggested Readings

1. Desai. B B. 2004. Seeds Handbook: Processing and Storage. Second Edition, CRC, U K. ISBN- 978-0824748005.
2. Gaur S C. 2012. A Handbook of Seed Processing and Marketing Agrobios. ISBN- 978- 8177544558.
3. Henderson S and Perry S M. 2012. Agricultural Process Engineering. 5th Ed. Springer, Germany. ISBN- 978-1468468663.

Design of Aqua-cultural Structures

PFE 525

3(2+1)

Course Outcomes: To acquaint and equip the students with aquaculture structures and their design features.

Syllabus:

Inland fish farming and associated considerations.

Fish physiology and micro-climatic considerations; Site selection for aquaculture structures.

Design of dykes, sluice, channels etc; Aeration and feeding systems: Design of fish rearing structures, hatcheries, containers for live fish, fingerlings, fish seeds.

Aquaculture in re-circulatory systems, oxygen and aeration, sterilization and disinfection; Recirculation of water: Reuse systems, water exchange, design of reuse systems, Inlet and outlet structures and water treatment plants.

Practicals:

1. Study of aeration systems of fish ponds.
2. Study of feeding systems of fish ponds.
3. Design of dykes in fish farming structures.
4. Design of feeder canals in fish farming structures.
5. Design of drainage canals in fish farming structures.
6. Design of drain ditch in fish farming structures.
7. Design of internal pond drains in fish farming structures.
8. Design of borrow pits in fish farming structures.
9. Design of internal harvesting pits in fish farming structures.
10. Study of waste water management through aquaculture.
11. Design of re-circulatory ponds for waste water treatment in fish farms.
12. Different types of containers for live fish.
13. Design of re-use systems in fish farms.
14. Different types of inlet and outlet structures in fish farms.

Suggested Readings

1. Misra R and Dora K C. 2015. A text Book on Aquaculture Engineering, Narendra Publishing House, New Delhi. ISBN- 978- 9384337049.

2. Wheaton F W. 2017. Aquacultural Engineering, Medtech, New York. ISBN-978-9385998782.
3. Boyd C E. 1982. Water Quality Management for Pond Fish Culture, Elsevier Scientific Ltd., New York. ISBN- 978-0444420541.
4. Lawson T B. 1991. Fundamentals of Aqua-cultural Engineering, Chapman and Hall, New York, USA. ISBN- 0412065118.
5. Boyd C E and Tucker C S. 1991. Pond Aquaculture Water Quality Management Kluwer Academic Publisher, Massachusetts. ISBN- 978-1-4615-5407-3.
6. Egna H S and Boyd C E. 1991. Dynamics of Pond Aquaculture, CRC Press LLC, USA. ISBN- 1-56670-274-7.
7. Punmia B C, Jain A K and Jain A K. 2011. Surveying Volume - I, Laxmi Publications, New Delhi. ISBN- 978-8170088530.
8. Dutta B N. 2013. Estimation and Costing in Civil Engineering (Theory & Practice), UBS Publishers Distributors Limited, New Delhi. ISBN- 978-8174767707.
9. FAO 1983. Inland Aquaculture Engineering. ISBN 92-5-102168-6.

Processing of Meat, Poultry and Fish

PFE 526

3(2+1)

Course Outcomes: To acquaint and equip the students with processing of meat, fish and poultry and the design features of the equipment used for their processing.

Syllabus:

Meat: Genetic engineering of farm animals for better meat quality, automation for the modern slaughterhouse, hot-boning of meat, new spectroscopic techniques for online monitoring of meat quality, real-time PCR for the detection of pathogens in meat, new developments in decontaminating raw meat, automated meat processing, developments in chilling and freezing of meat, high pressure processing of meat, approaches for the development of functional meat products, new techniques for analyzing raw meat, modified atmosphere packaging, perspectives for the active packaging of meat products.

Poultry: Breeding and quality of poultry, stunning and slaughter of poultry, processing and packaging of poultry, new techniques of preservation of poultry, production of turkeys, geese, ducks and game birds, microbial hazards in poultry production and processing, latest trends in measuring quality of poultry and poultry products, treatment and disposal of poultry processing waste.

Fish and seafood: Fresh fish handling and chill storage, modified atmospheric packaging of sea foods, fish odours and flavours, assessment of freshness of fish and sea foods, traditional dried and salted fish products, proteolysed fish products, minced fish technology, retort pouch processing technology, irradiation and microwave in fish handling and processing, advanced freezing technology for fish storage, high pressure processing of sea foods, value addition of freshwater and aqua cultured fish products, application of enzymes in fish processing and quality control, toxins, pollutants and contaminants in fish and sea foods.

Milk: Physical, chemical and nutritional properties of milk components, improvements in the pasteurization and sterilization of milk; Flavour generation in dairy products, controlling texture of fermented dairy products, functional dairy products, on-line measurement of product quality in dairy processing, high pressure processing of milk products, novel separation technologies to produce dairy ingredients, new technologies to increase shelf-life of dairy products, genetic engineering of milk proteins, production and utilization of functional milk proteins, methods of improving nutritional quality of milk, significance of milk fat in dairy products, chromatographic, spectrometric, ultrasound and other techniques for analysis of milk lipids.

Practicals:

1. Analysis of fresh and processed meat products
2. Analysis of fresh and processed fish products
3. Analysis of fresh and processed poultry products
4. Analysis of fresh and processed milk products

5. Preservation of fresh meat and fish
6. Processing and production of different products from fresh meat
7. Processing and production of different products from fresh fish
8. Processing and production of different products from fresh poultry
9. Processing and production of different products from fresh milk
10. Shelf life studies on different meat, fish and milk products
11. Visit to processing plants

Suggested Readings

1. Chouksey M K and Basu S. 2004. Practical Manual on Fish Processing and Quality Control. CIFE, Kochi, India.
2. Chouksey M K 2003. Fish Processing and Product Development. CIFE, Kochi, India.
3. Hall G M 1997. Fish Processing Technology. Second Edition, Blackie Academic and Professional, London, U K. ISBN- 0751402737.
4. Lawrie R A. 1985. Developments in Meat Sciences. Vol-III Applied Science Publishers.
5. Mead G C. 1995. Processing of Poultry. Springer Science and Business Media. ISBN- 978-1-4615-2059-7.
6. Pearson A M, Tauber F W and Kramlich W E. 1984. Processed Meats. AVI Publishers. ISBN- 9780870554612.
7. Stadelman W J and Cotterill O J. 1980. Egg Science and Technology. AVI Publishers. ISBN- 9781560228554.

Food Package Engineering

PFE 527

2(1+1)

Course Outcomes: To acquaint and equip the students with packaging methods, packaging materials, packaging machineries, modern packaging techniques etc.

Syllabus:

Introduction of packaging: Package, functions and design; Principle in the development of protective packaging; Deteriorative changes in foodstuff and packaging methods of prevention.

Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks, corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminum as packaging material; Evaluation of packaging material and package performance.

Packaging equipment: Food packages, bags, types of pouches, wrappers, carton and other traditional package; Retortable pouches: Shelf life of packaged foodstuff.

Methods to extend shelf life; Packaging of perishables and processed foods; Special problems in packaging of food stuff.

Package standards and regulation: Shrink packaging, aseptic packaging, CA and MAP; Biodegradable packaging: Recent advances in packaging, active packaging, smart packaging, antioxidant and antimicrobial packaging, edible films and biodegradable packaging, microencapsulation and nano-encapsulation.

Practicals:

1. Familiarization of types of packaging material

2. Determination of thickness of different types of packaging materials
3. To determine water absorption capability of flexible packaging materials
4. Determination of tensile strength of packaging material
5. Determination of compressive strength of packaging material
6. Determination of water vapour transmission rate of packaging material
7. Determination of gas transmission rate of packaging material
8. Identification of different types of plastic films
9. Testing of chemical and grease resistance of packaging materials
10. Determination of bursting strength of packages
11. Drop test for food package strength
12. Vacuum packaging of various food products
13. Nitrogen packaging of food products
14. To study the effect of shrink wrapping on shelf life of fruits and vegetables
15. To study the effect of active modified atmosphere packaging on shelf life of fruits and vegetables
16. Visit to relevant industries

Suggested Readings

1. Crosby N T. 1981. Food Packaging Materials. Applied Science Publisher. ISBN: 9780853349266.
2. Frank A. 1992. A Handbook of Food Packaging. Springer. ISBN- 9781461528104.
3. Mahadeviah M and Gowramma R V. 1996. Food Packaging Materials. Tata McGraw Hill.
4. Palling S J 1980. Developments in Food Packaging. Elsevier Applied Science Publisher. ISBN- 978-0853349174
5. Robertson G L. 2013. Food Packaging-Principles and Practice. Third Edition, Taylor & Francis. ISBN- 9781138628052.
6. Sacharow S and Grittin R C. 1980. Principles of Food Packaging. AVI Publisher. ISBN- 978-0870553479.

Food Quality and Safety

PFE 528

2(1+1)

Course Outcomes: To acquaint and equip the students with the latest standards to maintain food quality and safety.

Syllabus:

Food safety: Need for quality control and safety, strategy and criteria, microbiological criteria for safety and quality, scope of food toxicology, toxic potential and food toxicants, biological and chemical contaminants.

Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, intrinsic factors, establishing a safe raw material supply, safe and achievable shelf life.

Process equipment and machinery auditing, consideration of risk, environmental consideration, mechanical quality control.

Personnel hygienic standards, preventative pest control, cleaning and disinfecting system, biological factors underlying food safety; Preservation and stability, contaminants of processed foods, adulteration,

prevention and control, FSSAI, ISO, Codex, GMP, BIS and HACCP; Practices, principles, standards, specifications, application establishment and implementation, HACCP and quality management system; Food Safety Management Systems (FSMS), Traceability.

Practicals:

1. To test microbiological contamination of food.
2. To conduct hazard analysis.
3. To study the premises design for food safety and quality.
4. To study the HACCP project plan.
5. To prepare CCP and CCP Decision tree.
6. To prepare HACCP control chart.
7. To conduct the Survey and study BIS- standards and specifications.
8. To study the FPO standards and specifications.
9. To study the codex standards and specifications.
10. Visits to food industries to study the various quality and safety aspects adopted.

Suggested Readings

1. David A Shapton, Norah F Shapton. 1991. Principles and Practices for the Safe Processing of Foods. First Edition, ISBN: 978-0-7506-1121-3. DOI <https://doi.org/10.1016/C2013-0-04583-5>. Butterworth Heinemann Ltd, Oxford.
2. N. Chesworth. 2011. Food Hygiene Auditing. ISBN: 978-1-4613-8054-2. DOI [https://doi.org/10.1016/S0950-3293\(97\)00033-5](https://doi.org/10.1016/S0950-3293(97)00033-5). Blackie Academic Professional, Chapman and Hall.
3. Sara Mortimore and Carol Wallace. 2013. HACCP-A practical approach. Third Edition, ISBN: 978-1-4614-5027-6. DOI:10.1007/978-1-4614-5028-3. Chapman and Hall.
4. Concon. Jose M. 1987. Food Toxicology, Principles and concepts Part-A (Food Science and Technology), First Edition, ISBN: 0-8247-7737-9. Marrcel Dekkar Inc. Newyork and Brazil.
5. Jacob M. 1989. Safe Food Handling. First Edition, ISBN: 92-4-154245-4. World Health Organization, Geneva.

Food Processing Equipment and Plant Design

PFE 532

2(1+1)

Course Outcomes:

To acquaint and equip the students with the design features of different food processing equipment being used in the industries along with the layout, planning of different food processing plants.

Syllabus:

Design considerations of processing agricultural and food products.

Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation.

Human factors in design, selection of materials of construction and standard component, design standards and testing standards; Plant design concepts and general design considerations: Plant location, location factors and their interaction with plant location, location theory models, and computer aided selection of the location.

Feasibility analysis and preparation of feasibility report; Plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts.

Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant costs and profitability's, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.

Practicals:

1. Detailed design and drawing of mechanical dryers
2. Detailed design and drawing of milling equipment
3. Design of separators
4. Design of evaporators
5. Design of mixers and separators
6. Project report preparation by students (Individual student will select a processing plant, develop design report include product identification, site selection, estimation of plant size, process and equipment, process flow-sheeting, plant layout, its evaluation and profitability analysis).

Suggested Readings

1. Antonio L G and Gustavo V. Barbosa-Canovas. 2005. Food Plant Design. First Edition, ISBN: 9781138034488. DOI: <https://doi.org/10.1201/9781420027419>. CRC Press.
2. James R. Couper, W. Roy Penney, James R. Fair, Stanley M. Walas. 2012. Chemical Process Equipment. Selection and Design. Third Edition, ISBN: 978-0-12-396959-0. Elsevier, Butterworth-Heinemann.
3. George S and Athanasios E. Kostaropoulos. 2015. Handbook of Food Processing Equipment. Second Edition, ISBN: 978-3-319-25018-2. DOI: 10.1007/978-3-319-25020-5. Springer.

Food Processing Entrepreneurship and Start-up

PFE 533

2(1+1)

Syllabus:

Assessing overall business environment in the Indian economy; Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs; Globalisation and the emerging business/ entrepreneurial environment.

Concept of entrepreneurship; entrepreneurial and managerial characteristics; managing an enterprise; motivation and entrepreneurship development; importance of planning, monitoring, evaluation and follow up; managing competition; entrepreneurship development programs; Social Responsibility of Business.

SWOT analysis, Generation, incubation and commercialization of ideas and innovations; Government schemes and incentives for promotion of entrepreneurship; Government policy on Small and Medium Enterprises (SMEs)/ SSIs; Export and Import Policies relevant to food sector; Venture capital; Contract farming and joint ventures, public-private partnerships; Overview of horticulture inputs industry; Characteristics of Indian food processing and export industry; Communication Skills: Structural and functional grammar; meaning and process of communication, verbal and non-verbal communication; listening and note taking, writing skills, oral presentation skills; field diary and lab record; indexing, footnote and bibliographic

procedures; Reading and comprehension of general and technical articles, précis writing, summarizing, abstracting; individual and group presentations, impromptu presentation, public speaking; Group discussion; Organizing seminars and conferences.

Practicals:

1. Study of a regulated market,
2. Study of a fruit and vegetable market,
3. Study of State and Central Warehousing Corporation
4. Study of functioning of a regional rural bank and commercial bank for loan.
5. Study of food processing enterprise,
6. Formulation of project reports for financing food Industry,
7. Working out repayment plans,
8. Legal Issues in Product Development, Marketing and Market Segments
9. Case studies: Innovations in Dairy industry, Bakery industry, fats and oils industry, fruit and vegetable industry, primary and secondary processing of cereals, brewing industry.

Note: In practical of plant design and project engineering a plant design problem should be assigned to a group of (3-4) students. The students should carry out the conceptual design, flow sheeting, material and energy balance calculations, and cost and profitability analysis of any Food Plant.

Suggested Reading

1. Hu, R. 2005. Food Product Design A Computer-Aided Statistical Approach. First Edition, ISBN: 1-56676-743-1. CRC Press, Boca Raton, Florida.
2. Howard R. Moskowitz, I. Sam Saguy and Straus T. 2009. An Integrated Approach to New Food Product Development, First Edition, ISBN: 978-14200-6553-4. CRC Press, Boca Raton, Florida.
3. Howard R. Moskowitz, Porretta S. and Silcher M. 2005. Concept Research in Food Product Design And Development, First Edition, ISBN: 978-0-813-82424-6. DOI:10.1002/9780470290132. Wiley-Blackwell Publishing Ltd. State Avenue, Ames, Iowa, USA.
4. Max S. Peters and Klaus D.Timmerhaus. 2005. Plant Designs and Economics for Chemical Engineers, Fifth Edition, ISBN: 978-0072392661. McGraw Hill.
5. Ahmad T. 2009. Dairy Plant and Engineering Management. Eighth Edition. ISBN: 9788122501186. Allahabad, Kitab Mahal.

Instrumentation and Sensors in Food Processing

PFE 534

2(1+1)

Course Outcomes: To acquaint and equip the students with instrumentation and use of sensors in food processing operations.

Syllabus:

Basic instrumentation systems and transducer principles; Displacement transducers, Potential meters, LDVT, Piezoelectric and capacitive transducers, Digital transducers, velocity transducers.

Hydraulic load cell, Cantilever type and probing ring; Method of separation of force: Torque, power and energy measuring technique.

Temperature measurement using bi-metals, thermistors, thermocouples, humidity measurement, manometers; Flow transducer, positive displacement, venture-meter, Rota-meter, Drag force, hot wire anemometer.

Theory and classifications of chemical sensors, biosensors, fibre optic sensors, gas sensors etc; Biosensor: Concepts, types of biosensors, methods of immobilizing biosensors, application; Imaging methods: X-ray imaging, Computed tomography, MRI, Ultrasound, Hyper-spectral imaging; Spectroscopy and chemometrics: UV and visual spectroscopy, NIR spectroscopy, FTIR spectroscopy.

Practicals:

1. Identification of components of generalized measuring system for temperature, pressure, relative humidity, moisture etc.
2. Calibration of moisture measuring equipment
3. Calibration of temperature control and measuring devices
4. To study the working of Bourdon Pressure Gauge and to check the calibration of the gauge in a deadweight pressure gauge calibration set up.
5. To study various temperature measuring instruments e.g. Mercury-in-glass thermometer, Thermocouple, Electrical resistance thermometer, laser thermometer and to estimate their response times
6. To determine the calorific value of different food products using a bomb calorimeter having temperature sensing device
7. To study a Linear Variable Differential Transformer (LVDT) and use it in a simple experimental set up to measure a small displacement
8. To measure torque of a rotating shaft using torsion meter/strain gauge torque transducer
To measure the speed of a motor shaft with the help of non-contact type pick-ups (magnetic or photoelectric)
9. To measure static/dynamic pressure of fluid in pipe/tube using pressure transducer/pressure cell
10. To determine the hardness/firmness of food samples using a texture analyzer
11. To study the effect of vibrations during transportation on the quality of food (damage/ bruising/ texture etc) using a simulated vibration test
12. To study and use the data logging and data storage devices
13. To study and understand the working principle of UV and visual spectroscopy for measurement of food properties
14. To study and understand the working principle of NIR and FTIR spectroscopy for measurement of food properties
15. To study the working principle of X-ray imaging, computed tomography, MRI, Ultrasound and Hyper-spectral imaging for measurement of food quality

Suggested Readings

1. Ernest O. Doebelin. 2003. Measurement Systems Applications and Design. Fifth Edition, ISBN: 9780072922011. Columbia, MO, USA, Tata McGraw Hill.
2. Erika Kress-Rogers and Christopher J. B. Brimelow. 2001. Instrumentation and Sensors for the Food Industry. Second Edition, ISBN: 9780849312236. Liverpool, UK, CRC Wood head.
3. J. R. J. Pare and J. M. R. Belanger. 1997. Instrumental Methods in Food Analysis. First Edition, ISBN: 9780444540683. Exeter, UK, Elsevier Academic Press.
4. B. C. Nakra and K. K. Chaudhary. 2004. Instrumentation, Measurement and Analysis. Second Edition, ISBN: 0-07-048296-9. New Delhi, Tata McGraw Hill.
5. Octavian A. Postolache, Subhas C. Mukhopadhyay, Krishanthi P. Jayasundera and Akshya K. Swain. 2017. Sensors for Every Day Life. First Edition, ISBN: 978-3-319-47318-5. DOI: 10.1007/978-3-319-47319-2. Lisbon, Portugal, Springer.
6. Mohd S. A. Rahman, Subhas C. Mukhopadhyay and Pak-Lam Yu. 2014. Novel Sensors for Food Inspection: Modelling, Fabrication and Experimentation. First Edition, ISBN: 9783319042749. DOI: 10.1007/978-3-319-04274-9-1. Switzerland, Springer.

DESIGN OF TRACTOR SYSTEMS

FMPE 513

3 (2+1)

Course outcome: The student will have an overview of the philosophy guiding the design of a tractor and also design tractor systems and components.

Syllabus:

Design and types, research, development, design procedure, technical specifications of tractors, modern trends in tractor design and development, special design features of tractors in relation to Indian agriculture. Engine related terminology. Selection of stroke-bore ratio. Design of engine components: Piston, connecting rod, cylinder, cylinder head, crank shaft etc.

Design of tractor systems like clutch, gearbox, steering, steering geometry, turning force, hydraulic system & hitching, chassis, operator's seat, work-place area and controls. Tire selection, aspect ratio etc. Mechanics of tractor stability. Computer aided design and its application in farm tractors.

Practical:

Engine design calculations- Stroke-bore ratio determination - Design of radiator - Balancing of crankshaft- Calculation of volumetric /thermal efficiencies, Transmission component design calculations- Design of clutch, gear box and calculation of speed ratios. Design of Ackerman steering. Calculation of turning radius. Design of brakes (mechanical and hydraulic). Design of hydraulic system. Calculation for determination of centre of gravity of tractor, moment of inertia and stability. Practice on the Computer Aided Design (CAD) packages for design of various components.

References:

1. Sharma P C and Agarwal D K 2000. Machine Design. S K Kataria and Sons, Delhi.
2. Barger E L Liljedahl J B and McKibben E C 1967. Tractors and their Power Units. Wiley Eastern Pvt. Ltd. 13
3. Macmillan R H 2002. The Mechanics of Tractor – Implement Performance and Worked Example. University of Melbourne, Australia.

MACHINERY FOR PRECISION AGRICULTURE

FMPE 524

3(2+1)

Course Outcome:

Knowledge about the principles guiding the concept of precision agriculture and Farm Machinery and equipment systems that make use of this principle.

Syllabus:

Importance of precision agriculture. Mapping in farming for decision making. Geographical concepts of PA. Understanding and identifying variability.

Geographical Position System (GPS) Basics (Space Segment, Receiver Segment, Control Segment), Error and correction, Function and usage of GPS. Introduction to Geographic Information system (GIS), function of GIS, use of GIS for decisions. IDI devices usage in Precision Agriculture Yield monitor, variable rate applicator for fertilizers, seed, chemicals etc. Remote sensing Aerial and satellite imagery. Above ground (non-contact) sensors.

Data analysis, concepts of data analysis, resolution, Surface analysis. Analysis application interpretive products (map, charts, application map etc).

Electronics and Control Systems for Variable rate applications, Precision Variable Equipment, Tractor-Implement interface technology, Environmental Implications of Precision Agriculture.

Goals based on end results of Precision Agriculture, Recordkeeping, Spatial Analysis, Variable Rate Application, Reducing of negative environmental impact, Crop/technology cost optimization. Economic of precision agriculture and determining equipment and software, review of Cost/Benefit of Precision Agriculture, System vs. Parcels. Making a selection.

Practicals:

Calculation of the benefits of Data and Mapping, Determining Latitude/Longitude, UTM or State Plane Position Navigation with Waypoints, Configuring a GPS System. Defining area of field for prescriptive treatment. Making the Grid, The Grid Sampling Process, generation of yield maps, Thematic or Spatial Resolution, Yield Map Example, Surface Analysis in ArcView.

References:

1. Shannon D K, Clay D E and Kitchen N R (editors) 2018. Precision Agriculture Basics American Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585Gulford Rd, Madison, WI 53711
2. Clay S A, Clay D E, and Bruggeman S A 2017. Practical Mathematics for Precision Farming American Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585Gulford Rd, Madison, WI 53711
3. Henten E J V, Goense D and Lokhorst C 2009. Precision Agriculture. Wageningen Academic Publishers
4. Singh A K and Chopra U K 2007. Geoinformatics Applications in Agriculture. New India Publishing Agency, PritamPura, New Delhi
5. Ram T, Lohan S K, Singh R and Singh P 2014. Precision Farming: A New Approach. Astral International Pvt. Ltd., New Delhi., ISBN: ISBN 978-81-7035-827-5 (Hardbound) ISBN 978-93-5130-258-2 (International Edition)
6. Shannon D K, Clay D E and Kitchen N R (editors) 2018. Precision Agriculture Basics American Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585Gulford Rd, Madison, WI 53711
7. Clay S A, Clay D E, and Bruggeman S A 2017. Practical Mathematics for Precision Farming American Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585Gulford Rd, Madison, WI 53711
8. Henten E J V, Goense D and Lokhorst C 2009. Precision Agriculture. Wageningen Academic Publishers
9. Singh A K and Chopra U K 2007. Geoinformatics Applications in Agriculture. New India Publishing Agency, PritamPura, New Delhi
10. Ram T, Lohan S K, Singh R and Singh P 2014. Precision Farming: A New Approach. Astral International Pvt. Ltd., New Delhi., ISBN: ISBN 978-81-7035-827-5 (Hardbound) ISBN 978-93-5130-258-2 (International Edition)

Computer Aided Design of Machinery**FMP 532****2(0+2)**

Course Outcomes: To learn the practice of designing components and assemblies based on computer aided drafting technique.

Practicals:

1. Learning 2d drafting: controlling display settings, setting up units, Drawing limits and dimension styles.
2. Drawing and dimensioning simple 2d drawings, keyboard shortcuts.
3. Working with blocks, block commands. Exercise in simple assembly in orthographic.
4. Exercise in measuring and drawing simple farm machinery parts.
5. Learning 3d drafting: advantages of virtual prototyping-starting The 3d drafting environment, self-learning tools, help and tutorials. Familiarizing with user interface, creating files and file organization, Structuring and streamlining. Features of document window.
6. Concept of coordinate system: working coordinate system, Model coordinate system, screen coordinate system, graphics Exchange standards and database management system.
7. Working with feature manager and customizing the environment. Planning and capturing design intent.

8. Documentation of design. Using design journal and design binder. Preliminary design review and layout.
9. Practice in drawing 2d sketches with sketcher and modifying sketch entries.
10. Adding reference geometry: planes and axes. Adding relations and working with relations. Dimensioning a sketch. Exercises.
11. Parts and features: sketched features and applied features, Pattern and mirror features. Documenting design.
12. Assembly: creating and organizing assemblies, connecting parts And subassemblies with mates.
13. Organizing the assembly by using layouts.
14. Exercise in creating drawing: setting up and working with Drawing formats, creating drawing views from the 3d model, Making changes and modifying dimensions.
15. Case studies: measuring and drawing assemblies of farm implements and their components.

Suggested Readings

1. Jankowski G and Doyle R. 2007. Solid Works® For Dummies®, 2nd Edition, Published by Wiley Publishing, Inc. ISBN: 978-0-470-12978-4
2. Shih R H. 2014. AutoCAD 2014 Tutorial-First Level: 2D Fundamentals. SDC Publications

MACHINERY FOR HORTICULTURE AND PROTECTED AGRICULTURE

FMPE 534

2(2+0)

Course Outcome:

Knowledge about different principles of mechanizing cultivation of horticultural crops and in protected agriculture.

Syllabus:

Vegetable cultivation, nursery machinery, tray seeders, grafting machines, vegetable transplanters. Machinery for planting crops on raised beds, mulch laying and planting machines. Harvesting of vegetable crops: Harvesting platforms and pickers.

Machinery for orchard crops: Pit diggers, inter-cultivators and basin forming equipment for orchards. Machinery for transplanting of trees. Harvesters for fruit crops: Shaker harvesters, types and principle of operation. Elevated platforms for orchard management and harvesting. Pruning machines.

Machinery for orchards, vineyard machinery spraying machines, inter-cultivation machines. High clearance machines and special purpose machinery for crops on trellis. Machinery for special crops: Tea leaf harvesters, pruners and secateurs.

Machinery for lawn and garden: Grass cutters, special machinery for turf maintenance. Turf aerators and lime applicators.

Protected agriculture: Principles, mechanical systems of greenhouse, ventilation systems, shading system, water fogging system, irrigation system, sensors, electrical and electronic system. Intelligent Control system for greenhouses. Machinery for processing of growth media, tray filling machines-tray sowing machines, transplanting machines. Robotic grafting machines. Weeding and thinning equipment. Crop protection and harvest under protected agriculture.

Suggested Readings:

1. Good Agricultural Practices for Greenhouse Vegetable Production in the South East European countries FAO Rome 2017
2. Bell B and Cousins S 1997. Machinery for Horticulture. Old Pond Publishing Ltd ISBN10: 0852363699, ISBN-13: 978-0852363690

3. Ponce P, Molina A, Cepeda P, Lugo E and MacCleery B 2014. Greenhouse Design and Control. CRC Press, ISBN 9781138026292 - CAT K23481, 1st Edition.

Statistical Methods for Research Work

AST 511

3(2+1)

Course Outcomes: To expose students to various statistical techniques for analysis of data and interpretation of results.

Syllabus:

Probability and probability distributions; Principle of least squares; Linear and non-linear regression; Multiple regression; Correlation analysis; Selection of variables; Validation of models; Sampling techniques; Determination of sample size; Sampling distribution of mean and proportion.

Hypothesis testing; Concept of p-value; Student's t-test; Large sample tests; Confidence intervals; ANOVA and testing of hypothesis in regression analysis; Analysis of variance for one way and two-way classification (with equal cell frequency); Transformation of data.

Advantages and disadvantages of nonparametric statistical tests; Scales of Run-test; Sign test; Median test; Wilcoxon-Mann Whitney test.

Chi-square test; Kruskal-Wallis's one way and Friedman's two-way ANOVA by ranks; Kendall's Coefficient of concordance.

Practicals:

1. Elementary statistics
2. Probability distributions (Binomial, Poisson and Normal)
3. Sampling techniques, Determination of sample size, Sampling distribution of mean and Proportion
4. Large sample (mean, proportion)
5. Student's t-test (Single mean, Difference of mean for independent samples and paired observations) and F-test
6. Analysis of variance (one way and two way), Transformation of data
7. Correlation analysis and testing (Bivariate, Rank, Intra-class, Partial, Fisher's Z-transformation)
8. Multiple linear regression and model validation
9. Testing of coefficient of determination and regression coefficient
10. Selection of variables in regression (Forward substitution method and step-wise regression)
11. Non-Linear regression (Quadratic, exponential and Power)
12. Introduction to Non-parametric and scales of measurements
13. Chi-square test (Goodness of fit, Independence of attributes, homogeneity of variances)
14. One Sample test: Sign test, Median test, Run test, Two sample test: Wilcoxon Sign test, Mann Whitney test, X2 test for two independent samples
15. K-Sample: Kruskal-Wallis's test and Friedman's two way ANOVA, Kendall's coefficient of concordance

Suggested Readings

1. Anderson T W 1958. An Introduction to Multivariate Statistical Analysis. John Wiley. Dillon W R and Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.
2. Electronic Statistics Text Book: <http://www.statsoft.com/textbook/stathome.html>
3. Goon A M, Gupta M K and Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.
4. Goon A M, Gupta M K and Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.
5. Hoel P G. 1971. Introduction to Mathematical Statistics. John Wiley.
6. Hogg R V and Craig T T. 1978. Introduction to Mathematical Statistics. Macmillan.

7. Montgomery and Runger 2014. Applied Statistics and Probability for Engineers. John Wiley
8. Morrison D F. 1976. Multivariate Statistical Methods. McGraw Hill.
9. Siegel S, Johan N and Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley.

BIG DATA ANALYTICS

CSE 528 (AG)

2(1+1)

Course outcome: At the end of the course, the student will be able to: Understand the concept and challenges of Big data, Understand and able to develop Big Data Solutions using the Hadoop Eco System, and Understand and gain hands-on experience on Hive and Pig. Analyze and implement the concept of NoSQL and MongoDB

Syllabus:

Introduction to big data: big data characteristics, types of big data, traditional versus big data, the evolution of big data, challenges with big data, technologies available for big data, infrastructure for big data, use of data analytics, desired properties of the big data system.

Introduction to Hadoop: Core Hadoop components, Hadoop Ecosystem, Hadoop limitations, Hadoop Distributed File system, Processing Data with Hadoop, Managing Resources and Application with Hadoop YARN.

MapReduce programming: Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression

Introduction to Hive: Hive Architecture, Hive Physical Architecture, Hive Data types, Hive Query Language, Introduction to Pig, Anatomy of Pig, Pig on Hadoop, Use Case for Pig, ETL Processing, Data types in Pig running Pig, Execution model of Pig, Operators, functions, Data types of Pig.

Introduction to NoSQL, NoSQL business drivers, NoSQL data architectural patterns, variations of NOSQL architectural patterns using NoSQL to manage big data, introduction to MongoDB- Data Types in MongoDB, MongoDB Query Language.

Practicals:

Implement programs using Hadoop, Hadoop YARN, MapReduce, Hive, NoSQL, and MongoDB to understand the concept and uses of their functions.

Suggested Readings:

1. " Big Data Analytics", Radha Shankarmani, M. Vijaylakshmi, Wiley
2. "Big Data Science & Analytics: A Hands-On Approach", Arshdeep Bahga, Vijay Madiseti, VPT
3. " Big Data and Analytics", Seema Acharya, Subhashini Chellappan, Wiley
4. " Big Data ", Anil Maheshwari, Mc Graw Hill
5. " Big Data & Hadoop", V.K. Jain, Khanna Publication.
6. " Big Data Analytics", Venkat Ankam, Packt publications

ARTIFICIAL INTELLIGENCE

CSE 529 (AG)

2(1+1)

Course outcome: At the end of the course, the student will be able to: Understand the basics of AI, intelligent systems, and searching algorithms, Use adversarial search to analyze various game playing strategies, Understand the concept of knowledge representation and solve facts using resolution and refutation, Understand and learn about learning concepts, neural network, and architecture of the expert system.

Syllabus:

Meaning and definition of artificial intelligence, intelligent agent and environments, nature of the environment, problem-solving, uninformed search strategies, informed search strategies heuristic functions.

Adversarial search, Games, Optimal decision in games, Game playing techniques like minimax procedure, Alpha-beta pruning, Stochastic games, Partially observable games, State-of-the-art game programs, Constraint satisfaction problem.

Knowledge-based agents, Propositional logic, First-order logic, Resolution, Forward chaining Backward Chaining, Unification, Uncertain knowledge and reasoning, Probabilities, and Bayesian networks.

Overview of different forms of learning, supervised base learning, Learning Decision Trees, SVM, Unsupervised based learning, Neural Networks, Introduction to Natural language processing, Robotics, and Expert Systems.

Practical:

Write Python Programs to implement various uninformed and informed search techniques, puzzle problems, and games like chess and tic tac toe, heuristic search and logic programming and to implement various language processing codes using NLTK.

Suggested readings:

1. "Artificial Intelligence: A Modern Approach", Stuart J. Russell & Peter Norvig, Pearson Education.
2. "Introduction to AI & Expert System", Dan W. Patterson, PHI.
3. "Artificial Intelligence –Structure and Strategies of Complex Problem Solving", George F. Luger, Pearson Education.
4. "Artificial Intelligence", Elaine Rich, Kevin Knight, Mc-Graw Hill.

Mechatronics and Robotics in Agriculture

ME 529

2(2+0)

Course Outcomes: To introduce the fundamentals of mechatronics and the concepts behind designing mechatronic systems and their subsystems and their application in automation in agriculture.

Syllabus:

Introduction to mechatronics: Basic definitions, key elements of mechatronics, historical perspective, the development of the automobile as a mechatronic system; Mechatronic design approach, functions of mechatronic systems, ways of integration, information processing systems, concurrent design procedure for mechatronic systems.

System interfacing, instrumentation, and control systems; Input/output signals of a mechatronic system, signal conditioning, microprocessor control, microprocessor numerical control, microprocessor input/output control.

Microprocessor-based controllers and microelectronics: Introduction to microelectronics, digital logic, an overview of control computers, microprocessors and microcontrollers, programmable logic controllers, and digital communications.

Technologies of the robot: Subsystems, transmission system (Mechanics), power generation and storage system, sensors, electronics, algorithms, and software; Servo motor drives types and applications; Stepper motor and its concept; Industrial robots: Classification and sub-systems; Defining workspace area.

Application of robots in agriculture: Harvesting and picking, weed control, autonomous mowing, pruning, seeding, spraying and thinning, phenotyping, sorting and packing; Utility platforms; Use of different agrobots in agriculture.

Suggested Readings:

1. Alciatore DG and Hstand MB. 2002. *Introduction to Mechatronics and Measurement System*. McGraw Hill Pvt Limited, New Delhi.
2. Robert HB. 2002. *Mechatronic HandBook*. CRC Press.
3. Shakhathreh and Fareed. 2011. *The Basics of Robotics*. Lahti University of Applied Sciences Machine and Production Technology.
4. David G. Alciatore, Michael B. Hstand, 2007: Introduction to mechatronics and measurement systems, McGraw-Hill.
5. K. Ogata: Modern Control Engineering, Prentice-Hall of India.
6. B.C. Nakra and K. K. Chaudhry: Instrumentation Measurement and Analysis, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
7. D. S. Kumar: Mechanical Measurements and Control, Metropolitan, New Delhi.
8. Thomas G Beckwith, N. Lewis Buck and Roy D Marangoni: Mechanical Measurements, Narosa Publishing House, New Delhi.

Finite Elements Method

BS 511

3(2+1)

Syllabus:

Introduction; Historical background, Stress equilibrium, boundary condition, stress strain relation, potential energy and equilibrium; Rayleigh-Ritz method; Galerkin method.

Coordinates and shape functions, potential energy approach, element stiffness matrix, Galerkin approach, assembly of global stiffness matrix; The finite element equation, boundary conditions.

Trusses: Two dimensional problems, modeling by constant strain triangle, two dimensional iso-parametric elements, the four-node quadrilateral.

Scalar field problems, steady state heat transfer, torsion, potential flow, seepage and fluid flow index, dynamic analysis, principles.

Practicals:

1. Use of simple FEM software for FEM software for understanding, principles of FEM.
2. Working out simple problems using LISA or any simple software with understanding of operation
3. Solving one dimensional problem, Solution to planar and spatial trusses
4. Solving simple two-dimensional problems, Axisymmetric problems

5. Solution of problems with two dimensional iso-parametric elements
6. Solving simple beams and frames
7. Three dimensional problems, solution to heat transfer problems and flow problems.

Suggested Readings

1. Tirupathi R, Patla C and Belegundu AD. 1999. Introduction to Finite Element in Engineering. Prentice Hall of India Pvt. Ltd, New Delhi
2. Singiresu Rao S. 2001. The Finite Element Method in Engineering. Butter worth Heinemann, New Delhi.
3. Rajasekaran S 1999. Finite Element Analysis in Engineering Design. Wheeler Publishing, Division of A.h.Wheeler and Co. Ltd, Allahabad.
4. Tutorials and Reference Guide, LISA Finite Element Analysis Software Version 8.0.0 2013

Numerical Methods for Engineers

BS 521

3(2+1)

Course Outcomes: To expose students to various numerical methods for solving algebraic equations, ordinary and partial differential equations.

Syllabus:

Solution of Algebraic Equations: Solution of non-linear and transcendental equations in one or more than one variable using bisection, false position, iteration, Newton Raphson, Secant methods. Solution of linear simultaneous equations: Matrix inversion, Gauss elimination, Gauss Jordan, LU decomposition methods, ill conditioned systems.

Solution of Ordinary Differential Equations: Initial Value Problem, Taylor series method, Picard's method, Euler method, Modified Euler method, RK class and predictor corrector class methods. Stiff ODE's and Gear's methods. Boundary Value Problem, Shooting methods, finite difference method. Use of Method of weighted residuals and orthogonal collocation and Galerkin technique to solve BVP in ODEs

Eigen values and Eigen vectors: Maximum and minimum eigenvalue by Power spectral and Inverse Power Method, all eigenvalues by Fadeev-Leverrier method. Introduction to diagonalization and QR Factorization. Approximation Theory.

Finite difference formulae: Forward and backward differences, Richardson's extrapolation, interpolation formulae, polynomial forms, linear interpolation, Lagrange interpolation polynomial, Newton interpolation polynomial.

Solution of Partial Differential Equations: Classification of PDEs (Parabolic, elliptical and hyperbolic equation), Elliptical equations, standard five points formula, diagonal five-point formula. Solution of Laplace equation by Liebman's iteration method. Poisson's equation and its applications. Solution of parabolic equations by Bender-Schmidt method, Bender-Schmidt recurrence equation, Crank-Nicholson difference method.

Practicals:

1. Solution of Algebraic Equations: Solution of non-linear and transcendental equations in one or more than one variable using bisection method.
2. Solution of Algebraic Equations: Solution of non-linear and transcendental equations in one or more than one variable using false position methods.
3. Solution of Algebraic Equations: Solution of non-linear and transcendental equations in one or more than one variable using iteration.
4. Solution of Algebraic Equations: Solution of non-linear and transcendental equations in one or more than one variable using Newton Raphson, Secant methods.
5. Solution of linear simultaneous equations: Matrix inversion, Gauss elimination, Gauss Jordan

- method.
6. Solution of linear simultaneous equations: LU decomposition methods, ill-conditioned systems.
 7. Solution of Ordinary Differential Equations: Initial Value Problem, Taylor series method, Picard's method, Euler method, Modified Euler method
 8. Solution of Ordinary Differential Equations: RK class and predictor corrector class methods. Stiff ODE's and Gear's methods.
 9. Eigen values and Eigen vectors: Maximum and minimum eigenvalue by Power spectral and Inverse Power Method.
 10. Eigen values and Eigen vectors: all eigenvalues by Fadeev-Leverrier method
 11. Introduction to diagonalization and QR Factorization. Approximation Theory.
 12. Finite difference formulae: Forward and backward differences, Richardson's extrapolation, interpolation formulae, polynomial forms.
 13. Finite difference formulae: linear interpolation, Lagrange interpolation polynomial, Newton interpolation polynomial.
 14. Solution of Partial Differential Equations: Classification of PDEs (Parabolic, elliptical and hyperbolic equation), Elliptical equations, standard five points formula, diagonal five-point formula.
 15. Solution of Laplace equation by Liebman's iteration method. Poisson's equation and its applications.
 16. Solution of parabolic equations by Bender-Schmidt method, Bender-Schmidt recurrence equation, Crank-Nicholson difference method.

Suggested Readings:

1. Anderson T W 1958. *An Introduction to Multivariate Statistical Analysis*. John Wiley.
2. Dillon W R and Goldstein M. 1984. *Multivariate Analysis - Methods and Applications*. John Wiley.
3. Electronic Statistics Text Book: <http://www.statsoft.com/textbook/stathome.html>
4. Goon A M, Gupta M K and Dasgupta B. 1977. *An Outline of Statistical Theory*. Vol. I. The World Press.
5. Goon A M, Gupta M K and Dasgupta B. 1983. *Fundamentals of Statistics*. Vol. I. The World Press.
6. Hoel P G. 1971. *Introduction to Mathematical Statistics*. John Wiley.
7. Hogg R V and Craig T T. 1978. *Introduction to Mathematical Statistics*. Macmillan.
8. Montgomery and Runger 2014. *Applied Statistics and Probability for Engineers*. John Wiley
9. Morrison D F. 1976. *Multivariate Statistical Methods*. McGraw Hill.
10. Siegel S, Johan N and Casellan Jr. 1956. *Non-parametric Tests for Behavior Sciences*. John Wiley.

Syllabus of Common Courses for PG programmes

Library and Information Services

PGS 511

(0+1)

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.

Practicals:

Introduction to library and its services; Role of libraries in education, research and technology transfer; Classification systems and organization of library; Sources of information- Primary Sources, Secondary

Sources and Tertiary Sources; Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.); Tracing information from reference sources; Literature survey; Citation techniques/ Preparation of bibliography; Use of CD-ROM Databases, Online Public Access Catalogue and other computerized library services; Use of Internet including search engines and its resources; e-resources access methods.

Intellectual Property and its Management in Agriculture

PGS 512

(1+0)

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.

Syllabus:

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; 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 biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement.

Suggested Readings:

1. Erbis FH and Maredia K. 1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.
2. Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.
3. Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC and Aesthetic Technologies.
4. Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.
5. Rothschild M and Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.
6. Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing
7. *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; The Biological Diversity Act, 2002.*

Technical Writing and Communications Skills

PGS 521

(0+1)

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). Practical (Technical Writing)

- Various forms of scientific writings- theses, technical papers, reviews, manuals, etc.;
- Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion);
- Writing of abstracts, summaries, précis, citations, etc.;

- Commonly used abbreviations in the theses and research communications;
- Illustrations, photographs and drawings with suitable captions; pagination, numbering of tables and illustrations;
- Writing of numbers and dates in scientific write-ups;
- Editing and proof-reading;
- Writing of a review article;
- Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks);
- Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription;
- Accentual pattern: Weak forms in connected speech;
- Participation in group discussion;
- Facing an interview;
- Presentation of scientific papers.

Suggested Readings:

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

Basic Concepts in Laboratory Techniques

PGS 522

(0+1)

Objective

To acquaint the students about the basics of commonly used techniques in laboratory.

Practicals:

- Safety measures while in Lab;
- Handling of chemical substances;
- Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets;
- Washing, drying and sterilization of glassware;
- Drying of solvents/ chemicals;
- Weighing and preparation of solutions of different strengths and their dilution;
- Handling techniques of solutions;
- Preparation of different agro-chemical doses in field and pot applications;
- Preparation of solutions of acids;
- Neutralisation of acid and bases;
- Preparation of buffers of different strengths and pH values;
- Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath;
- Electric wiring and earthing;
- Preparation of media and methods of sterilization;
- Seed viability testing, testing of pollen viability;

- Tissue culture of crop plants;
- Description of flowering plants in botanical terms in relation to taxonomy.

Suggested Readings:

1. Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.
2. Gabb MH and Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.

Agricultural Research, Research Ethics and Rural Development Programmes

PGS 531

(1+0)

Objective

To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.

Syllabus:

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 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.

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. 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.

Suggested Readings:

1. Bhalla GS and Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
2. Punia MS. Manual on International Research and Research Ethics. CCS Haryana Agricultural University, Hisar.
3. Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
4. Singh K. 1998. Rural Development - Principles, Policies and Management. Sage Publ. 2.4