

Department of Renewable Energy Engineering
College of Technology & Engineering, MPUAT, Udaipur- 313001
Post Graduate Programme (Renewable Energy Engineering) w.e.f. 2022-23
Semester-wise Scheme for Post Graduate Program in Renewable Energy Engineering
 Details of P.G. Programme courses offered for the award of Ph.D. (Agricultural Engineering)
 Renewable Energy Engineering Degree

Course Title	Course No.	Credit	Semester			
			I	II	III	IV
Core Courses						
Total 6 credits (3 credits in each semester); 1 course in the first semester and 1 course in the second semester to be evaluated externally.						
Advances in Renewable Energy Systems	REE 611	3(2+1)	3		-	-
Renewable Energy for Industrial Application	REE 621	3(2+1)		3	-	-
Major Courses						
Total 6 credits (3 credits in each semester); one course in the first and second semester each.						
Biochemical Conversion of Biomass	REE 612	3(2+1)	3			
Thermochemical Conversion of Biomass	REE 613	3(2+1)	3		-	-
New Alternate Energy Systems	REE 614	3(2+1)	3			
Fuels and Combustion	REE 615	3(2+1)	3			
Advances in Biogas Technology	REE 616	3(2+1)	3		-	-
Solid Waste and Waste Water Management	REE 622	3(2+1)		3		
Advanced Photovoltaic Power Generation	REE 623	3(2+1)		3		
Energy Planning, Management, and Economics	REE 624	3 (3+0)		3	-	-
Bio-fuel Technologies and Applications	REE 625	3(2+1)		3	-	-
Energy Modeling and Simulation	REE 626	3(2+1)		3		
Minor & Supporting Courses:						
Total 6 credits for Minor courses; one course in the first semester (3 credits) and one course in the second semester (3 credits). Total 5 credits for supporting courses; one course in the first semester (2/3 credits) and one course in the second semester (3/2 credits).						
Energy Conservation and Management in Production Agriculture	FMP 613	3 (2+1)	3	-	-	-
Ergonomics in Working Environment	FMP 624	3 (2+1)	-	3	-	-
Mechatronics and Robotics in Agriculture	ME 529	2(2+0)	-	2	-	-
Textural and Rheological Characteristics of Food Materials	PFE 612	3(2+1)	3	-	-	-
Mathematical Modeling in Food Processing	PFE 613	3(2+1)	3	-	-	
Post Harvest Engineering	PFE 614	3(2+1)	3	-	-	-
Milling of Food materials	PFE 615	3(2+1)	3	-	-	-
Bioprocess Engineering	PFE 622	3(2+1)	-	3	-	-
Agricultural Waste and By-Products Utilization	PFE 623	3(2+1)	-	3	-	-
Design of Grain Storage structures	PFE 624	3(2+1)	-	3	-	-
Design of Food Process Equipments	PFE 625	3(2+1)	-	3	-	-
Rheology of Foods	PFE 626	3(2+1)	-	3	-	-
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 531	1(1+0)	-	-	1	-

Seminar (0+1)	REE 691 & REE 692	1	1	1		-
Preliminary Examination	REE 633	NC			NC	
Research (Thesis).	REE 699	75	-	-	-	75
Total credits to be offered		100	13	12	-	75

A Ph.D. student must take a minimum of two 600 series core courses but may also take 500 series courses if not studied during the master's Programme as per ICAR guidelines. +* Exempted for those who have cleared these in the Master's Programme (permission to be sought from the Dean, CTAE).

COURSE SUMMARY (Ph. D)

Courses	No. of Courses							Credit Hours
	Semester							
	I	II	III	IV	V	VI	Total	
Core	1 (3)	1 (3)	-	-	-	-	2 (6)	6
Major	1 (3)	1 (3)	-	-	-	-	2 (6)	6
Minor	1 (3)	1 (3)	-	-	-	-	2 (6)	6
Supporting	1 (3)	1 (2)	-	-	-	-	2 (5)	5
Seminar (691&692)	1 (1)	1(1)	-	-	-	-	2 (2)	2
Preliminary Examination	-	-	1	-	-	-	1 (0)	Non Credit (graded as satisfactory/ non satisfactory)
Research (Thesis)	-	-	-	-	-	1	1(75)	75 (graded as satisfactory/ non satisfactory)
Compulsory Courses*	-	-	-	-	-	-	-	Non Credit
Total	5 (13)	5 (12)	1	-	-	1	12 (25)	100

*Exempted for those who have cleared these in Master's Programme.

RENEWABLE ENERGY ENGINEERING

COURSE CONTENT

ADVANCES IN RENEWABLE ENERGY SYSTEMS

REE 611

3(2+1)

Course Outcome:

The student is able to design and analyzed the renewable energy systems and relevant technologies critically with economic feasibility.

Syllabus:

Solar thermal energy systems: Kinetics and heat transfer analysis, modeling studies. Design and performance of solar thermal systems, mathematical models, power plants, design, and performance.

Photovoltaics: Thermodynamic limitations of photocells. Semiconductors: P-n and n-p junctions, module design, sizing, power control and storage, space charge control, low-pressure diode, cesium converter. Photoelectrochemical cells, photoelectrolysis cells.

Wind power: Rotor design procedure, betz limit, ideal horizontal axis wind turbine, wake rotation, momentum theory and blade element theory, blade shape for ideal rotor without wake rotation, performance prediction wind turbine rotor dynamics, and dynamic models.

Designing of water pumping windmills: Electric power, power transformers, electrical machines, ancillary electrical equipment, wind power to consumer/grid. Wind turbine: Siting, installation and operation issues, offshore wind farms, operation in severe climates.

Practicals:

1. Design parameters of air collectors.
2. Thermal analysis and heat loss,
3. Regularity models of heliostatic fields
4. Design of power plant.
5. Photovoltaic cell's characteristic curves.
6. Analysis of water pumping with photovoltaic cells.
7. Power control systems.
8. Grid control devices.
9. Design of windmills.
10. Rotor design procedure
11. Momentum theory and blade element theory
12. Installation of the windmill.
13. Windmill operation issues.

Suggested Readings:

1. Sukhatme S P and Nayak J 2008. *Solar Energy: Principles of Thermal Collection and Storage*. Tata McGraw Hill Publishing Company Limited, New Delhi, India.
2. Kishore V V N 2008. *Renewable Energy Engineering and Technology—A Knowledge Compendium*. TERI Press, New Delhi, India.
3. Rai G D 1994. *Nonconventional Sources of Energy*. Khanna Publishers, New Delhi, India.
4. Anderson E E 1983. *Fundamentals of Solar Energy Conversion*. Addison Wesley publication Company, Boston, United State.
5. Rao S and Parulekar B B 1994. *Energy Technology Nonconventional, Renewable and Conventional*. Khanna Publishers, New Delhi, India.
6. Solanki C S 2011. *Solar Photovoltaics: Fundamentals, Technologies and Applications*. PHI Learning Private Limited, New Delhi, India.

7. More H G and Maheshwari R C *Wind Energy Utilization in India*. Technical Bulletin No.CIAE/82/38,CIAE, Bhopal.
8. Sitharthan R and Geethanjali M 2014. *Wind Energy Utilization in India: A Review*.Middle-East Journal of Scientific Research, Pakistan.
9. Powar A G and Mohod A G 2010. *Wind Energy Technology*. Jain Publication, NewDelhi, India.

RENEWABLE ENERGY FOR INDUSTRIAL APPLICATION

REE 621

3(2+1)

Course Outcome:

Students will be acquainted with energy quantification techniques, design of the system, economic evaluation and utilization of renewable energy sources for agro-industrial applications.

Syllabus:

Elucidation of unit operations in the industry. Energy quantification techniques, system boundary, estimation of productivity, plant capacity utilization, energy density ratio, and energy consumption pattern. Energy flow diagram conservation opportunities identification.

Solar energy for industrial application: Solar water heating, steam solar cooking system, industrial solar dryer, and solar process heat, solar cooling system (refrigeration, air conditioning, and solar architecture technology), solar furnace, and solar greenhouse technology for high-tech cultivation. Solar photovoltaic technology for industrial power.

Bioenergy for industrial application: Quantification of industrial bio-waste, characterization, power generation through bio-methanation, gasification, and dendro thermal power plant.

Wind energy: Aero generator of a new era and national and international state of art in wind power generation. Other renewable energy sources: Magnetohydrodynamics, fuel cell technology, and micro-hydro energy technology.

Practicals:

1. Elucidation and energy consumption for unit operations in the industry.
2. Study of energy quantification and identification of opportunities for RETs
3. Design of solar dryers.
4. Design of solar photovoltaic system.
5. Design of gasifiers for thermal energy and power generation.
6. Design of combuster (gasifier stove).
7. Study of the solar greenhouse.
8. Study of biogas engine generator set.
9. Case study of agro-industrial energy estimation
10. Visit to RSE power generation site.

Suggested Readings:

1. Singh P, Kurchania A K, Rathore N S and Mathur A N 2005. Sustainable Development through Renewable Energy Sources. Yash Publications, Bikaner, Rajasthan.
2. Rathore N S, Kurchania A K and Panwar N L 2007. Non-Conventional Energy Sources. Himanshu Publications, Udaipur, Rajasthan.
3. Duffie J A and Beakman W A 2006. Solar Energy Thermal Process. John Wiley and Sons, New York.
4. Sayigh A A M 2012. Solar Energy Engineering. Academic Press, New York.
5. Kumar S 2011. Energy Conservation Building User Code Guide. Bureau of Energy Efficiency, New Delhi.

BIOCHEMICAL CONVERSION OF BIOMASS

REE 612

3(2+1)

Course Outcome:

The student will be able to design, analyze and evaluate the various biomass conversion technologies and parameters related to biomass for utilization of it for fuel extraction.

Syllabus:

Biomass formation: Energy recovery and recycling. Biochemical conversion of organic wastes: Methane production, vertical through digesters, high solid digestion, sludge treatment.

Lagoons: Composting, contact and filter digestion, reactors, physical and chemical removal of dissolved materials. Activated sludge and other suspended culture process parameters. Waste waters, biological film flow processes, sanitation land fill, pre-digestion of waste.

Engineering design of biogas units: Biogas boosters, structural behaviour, alternate construction materials, multi-criteria optimization, immobilization, modular biogas for tropical areas, kinetic models. Bioconversion of biomass to alcohol: Types and pre-treatment of biomass, production process. Fermenter design and process parameters. Economics of bio-alcohol production, reaction kinetics, gasohol. Bio-hydrogen from algae/biomass.

Practicals:

1. Lagoons and composting.
2. Analysis of biogas systems.
3. Determination of methane production rate and parameters.
4. Biogas storage, purification.
5. Biogas storage utilization and kinetic equations.
6. Alcohol production, optimization of process parameters.
7. Fermenter designing and evaluation.
8. Economic calculations of biogas and alcohol.

Suggested Readings:

1. Klan E 1985. *Energy from Biomass and Wastes*. Institute of Gas Technology, Chicago.
2. Culp A W 1979. *Principles of Energy Conversion*. McGraw Hill Book Company, New York, USA.
3. Wilson D G and Reinhold V N 1977. *Hand Book of Solid Waste Management*. McGraw Hill Book Company, New York, USA.
4. Kiang Y H 1981. *Waste Energy Utilization Technology*. Marcel Dekkar, New York, USA.

THERMO-CHEMICAL CONVERSION OF BIOMASS

REE 613

3(2+1)

Course Outcome:

Students will enable critical analysis of combustion of fuel and system design for thermo- chemical conversion technologies for domestic and industrial applications

Syllabus:

Biomass: Characterization, resources, and energy recovery. Thermo-chemical conversion of organic wastes. Chemical thermodynamics, stoichiometry, and thermodynamics.

Combustion of fuels: Solid fuels, stoker, types, fluidized bed. Liquid fuels: Atomization, vapor concentration, combustion phenomena. Gaseous fuel: Flame characteristics, inflammability limits, submerged combustion, combustion with explosion flame, pulsating combustion.

Biomass Gasification: Gasifier configurations, classification, entrained flow, fluidized bed, moving bed, plasma gasification. Coal gasification technologies. Syngas characteristics. Tar and particulates in

gasification. Integrated coal gasification. Gas turbine technologies.

Pyrolysis: Models, regimes, kinetics, and effect of process parameters. Radiant heat flux, heterogeneous reactions, wall heat transfer. Fluidized bed reactors: Heat transfer circulating beds, moving bed reactor.

Torrefaction and charcoal production: Carbonization parameters, temperature zone, input-output, energy density ratios, and characterization of finished products.

Practicals:

1. Combustion thermodynamics and phenomenon in solid, liquid, and gaseous fuels
2. Determination of efficiency of improved chulha through water boiling test procedure.
3. Thermo-gravimetric analysis of biomass sample
4. Study of liquid burners
5. Study of gaseous burners
6. Flame studies and flue gases
7. Study on heat budgeting
8. Study on kinetics of fluidized bed gasifier
9. Producer gas-based power generation systems
10. Kinetic and model studies for Torrefaction
11. Kinetic and model studies for charcoal production.
12. Kinetic and model studies for bio-oil production.

Suggested Readings:

1. Rezaian J and Cheeremisinoff N P 2005. *Gasification Technologies—A Primer for Engineers and Scientists*. CRC Press, Taylor and Francis group, New York, USA.
2. Tchobanoglous G and Eliassen H T R 1978. *Solid Wastes*. McGraw Hill Book Company, New York, USA.
3. Klan E 1985. *Energy from Biomass and Wastes*. Institute of Gas Technology, Chicago.
4. Glassman I 1987. *Combustion*. Academic Press Inc. Orlando, Florida, USA.
5. Culp A W 1979. *Principles of Energy Conversion*. McGraw Hill Book Company, New York, USA.
6. Wilson D G and Reinhold V N 1977. *Hand Book of Solid Waste Management*. VanNostrand Reinhold Company, New York.
7. Kiang Y H 1981. *Waste Energy Utilization Technology*. Marcel Dekkar, New York, USA.

NEW ALTERNATE ENERGY SYSTEMS

REE 614

3(2+1)

Course Outcome:

Students are able to understand the various recent and emerging alternate energy sources and their utilization for meeting the increasing energy demand.

Syllabus:

Hydrogen production: Water splitting, electrolytic methods, chemical cycle, photo splitting, photo galvanic, photo chemical. Hydrogen storage and utilization. Fuel cells: Reactions, types, design, applications, conversion and problems. Thermoelectric convertor and thermionic convertors. Magneto hydro dynamic system (MHD). Electro gas dynamics (EGD): Principles, types. Tidal energy: Operating mode, energy content. Estimation of wave power, tidal power sites and ocean thermal energy cycle (OTEC): Baseline design, heat design, power cycle design, plant working.

Geothermal energy system: Classification, binary cycle conversion, waterfed heat pumps, electric generation, steam generation, steam field. Heat mining, Darcy's law, volcano related heat resources, sedimentary basins, hot dry rocks.

Power generation through alternative sources. Environmental pollution: Measurements and control methods, instrumentation, pollution standards, social cost estimates, CO₂ reduction potential, CO₂ sequestration.

Practicals:

1. Design parameters of air collectors.
2. Thermal analysis and heat loss,
3. Regularity models of heliostatic fields
4. Testing of the electrolysis plant
5. Testing of photoelectric plant
6. Testing of photo plant.
7. Design criteria of fuel cell
8. Design considerations for alternative energy systems

Suggested Readings:

1. Culp J A 1979. *Principles of Energy conversion*. McGraw-Hill Book The company, London.
2. Thielhein K D 1977. *Alternate Energy Sources*. International compendium, Hemisphere publishing company, London.
3. Blomen L J M J and Mugerwa M N 1993. *Fuel Cell System*. Plenum Press, New York, USA.
4. Appleby A C 1987. *Fuel cells: Trends in Research and Application*. Hemisphere, Washington

FUELS AND COMBUSTION

REE 615

3(2+1)

Course Outcome:

Students will be able to design, estimate, and critical analysis of various combustion techniques for efficient utilization of fuels.

Syllabus:

Solid and liquid fuels: Type and availability, oxidation, hydrogenation of solid fuel, and processing of solid fuels. Liquid Fuels: Processing, properties testing of liquid fuels and refining. Liquid fuels from other sources: Preparation and storage. Production technologies for solid and liquid fuel.

Gaseous Fuels: Types, processing, and testing of gaseous fuels, gases from biomass refinery gases, LPG, oil gasification, cleaning, and purification of gaseous fuels. Gaseous fuel production technologies.

Combustion Stoichiometry: Thermodynamics and kinetics, solid, liquid, and gaseous fuels. Combustion of solid fuels. Biomass combustion, stages of wood combustion, industrial biomass combustion concepts, and types of the combustion system.

Combustion of liquid fuels: Atomization, vapor concentration, droplet, and ignition. Liquid fuel burners: Atomizing air burners, pressure jet atomizing burners, thin fluid burners, rotary atomizing burners.

Combustion of gaseous fuel: Character, shape, and size of the flame. Flame stabilization of bluff bodies. Effect of equivalence on reaction rate and extinction velocity, submerged combustion, combustion with explosion flame, pulsating combustion.

Practicals:

1. Determination of fuel properties of solid fuels.

2. Determination of fuel properties of liquid fuels.
3. Determination of fuel properties of gaseous fuels.
4. Determination of efficiency of combustion system using solid fuels.
5. Determination of efficiency of combustion system using liquid fuels.
6. Determination of efficiency of combustion system using gaseous fuels.
7. Standard testing of burners for thermal efficiency for solid.
8. Standard testing of burners for thermal efficiency for liquid fuel.
9. Standard testing of burners for thermal efficiency for gaseous fuel.

Suggested Readings:

1. Glassman I 1987. *Combustion*. Academic Press Inc. Orlando, Florida, USA.
2. Sarkar S 1990. *Fuels and Combustion*. Orient Longmans, Bombay.
3. Babu M K G and Subramanian K A 2013. *Alternative Transportation Fuels: Utilization in Combustion Engines*. CRC Press, Boca Raton, Florida.
4. Mukunda H S 2011. *Understanding Clean Energy and Fuels from Biomass*. Wiley India Publication, New Delhi, India.
5. Speight J G and Loyalka S K 2007. *Handbook of Alternative Fuel Technologies*. CRC Press, Boca Raton, Florida.

ADVANCES IN BIOGAS TECHNOLOGY

REE 616

3(2+1)

Course Outcome:

The student is able to analyse the various aspects of biogas energy management systems, Carry out techno-economic feasibility for biogas plant, to apply the knowledge in planning and operations of biogas energy system.

Syllabus:

Worldwide review of anaerobic digesters, realistic potential of biogas, analysis of biogas system and proposed means for their prospects. Engineering design of biogas units for biogas production from solid and liquid wastes.

Design parameters: Affecting and failure of biogas systems, structural behaviour and conditions of fixed dome digesters, alternate construction materials, gas holders for gas production in colder regions, heating, stirring etc.

Multi-criteria optimization design of fermentation systems, immobilization, modular biogas for tropical rural areas. Toxicity effect of pesticides herbicides on the anaerobic digestion process. Kinetic models, design equations, contact and anaerobic filter digesters, high rate digesters.

Scrubbing, purification and compression of biogas. Scaling-up and standardization of biogas plant for power generation and heating. Advanced biofuels: Bio-CNG/renewable natural gas (RNG) as vehicle fuel. Liquefaction of biogas.

Practicals:

1. Engineering design and analysis of biogas system
2. Development of kinetic equations
3. Biogas purification, compression and liquefaction
4. Industrial applications of biogas
5. Preparation of Detailed Project Reports for commercial biogas projects

Suggested Readings:

1. Mittal K M 1996. *Biogas Systems: Principles and Applications*. New Age international

Publication Limited, New Delhi.

2. Abbasi T, Tauseef S M and Abbasi S A 2012. *Biogas Energy*. Springer publications, New York, USA.
3. Chawala O P 1986. *Advances in Biogas Technology*. ICAR, New Delhi.
4. Rohlich G A, Walbot V, Connor L J, Golueke C G, Hinesly T D, Jones P H, Lapp H M, Loehr R C, LueiHing 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.
5. Abbasi S A and Nipanay P C 1993. *Modeling and Simulation of Biogas System Economies*. Ashish Publication House, New Delhi.

SOLID WASTE AND WASTE WATER MANAGEMENT

REE 621

3(2+1)

Course Outcome:

The student is able to estimate, characterize and design of solid waste conversion system and also able to understand the energetics and kinetics of anaerobic treatment, sanitation landfill, pre-digestion of waste, etc.

Syllabus:

Solid waste: Sources, quality, classification and characteristics, collection and reduction at source, handling, storage, transportation, and disposal methods.

Reactor for anaerobic digestion: Contact and filter digestion, homogenous and non-homogeneous reactors. Energetic and kinetics of anaerobic treatment.

Gas transfer, mass models, bubble aeration, film flow oxygen transfer, stripping, solids removal. Activated sludge and other suspended culture process parameters. Biosorption of contact stabilization.

Sanitation landfill, municipal, and compost treatment. Predigestion of waste. Sensors, ICT, and remote sensing technologies for waste management.

Practicals:

1. Design principles in waste treatment
2. Specification of equipment for waste treatment
3. Instrumentation for waste treatment
4. Mathematical modeling of BOD and COD reduction rate
5. Development of computer code for Mathematical modeling of BOD and COD reduction rate
6. Recovery by batch distillation.

Suggested Readings:

1. Kreith F and Tchobanoglous G 2002. *Handbook of Solid Waste Management*. McGrawHill Book Company, New York.
2. Ramachandra T V 2006. *Management of Municipal Solid Waste*. Capital Publication Company, New Delhi.
3. Bridgwater A V and Mum-ford C J 1979. *Waste Recycling and Pollution Control Handbook*. Van Nostrand Reinhold Company, New York.
4. Tchobanoglous G, Theisenand H and Elliassen R 1978. *Solid Wastes*. McGraw Hill Book Company, New York.

ADVANCED PHOTOVOLTAIC POWER GENERATION

REE 622

3(2+1)

Course Outcome:

The student will be able to design different solar photovoltaic systems for power generation. Design and simulate a PV power plant using a software tool, Plan, project implementation, operation, and maintenance. Carry out techno-economic-environmental performance evaluation of a solar PV power plant.

Syllabus:

Semiconductors: Transport properties, junctions, dark and illumination characteristics. Single junction and multi-junction films. Solar PV concentrator cells and systems. Thin-film solar cells: Nano, micro, and polycrystalline solar cells.

Systems for remote applications and large solar PV power plants: System integrations, rooftop system, sizing methodology, power control, storage, tracking, and control. PCID simulation of industrial solar cell structure, software's in solar cell simulation.

Space charge control, low-pressure diode, MMPT, cesium converter, system considerations. Photo electrochemical cells and materials. Photogalvanic cells: Recent development.

Conjunctive use of photoconversion systems: Photo-agriculture system, components, integration, and economics. Software for PV system integration and designing. PV system for ground-mounted and rooftop plants with shadow analysis.

Practicals:

1. Typical applications of Photovoltaic (PV) systems
2. Applications of Photovoltaic systems in water pumping
3. Study of Solar PV tracking and mechanical clock tracking
4. Testing of power control system for output regulation
5. Charging and discharging characteristics of storage by PV panels.

Suggested Readings:

1. Solanki C S 2011. *Solar Photovoltaic: Fundamentals, Technologies and Applications*. PHI Learning Private Limited, Delhi.
2. Duffle J A and Beckman W A 1991. *Solar Engineering of Thermal Processes*. John Wiley, New Jersey.
3. Garg H P 1990. *Advances in Solar Energy Technology*. Springer Publishing Company, Dordrecht, Netherland.
4. Kreith F and Kreider J F 1978. *Principles of Solar Engineering*. McGraw Hill, New York.
5. Veziroglu T N 1977. *Alternative Energy Sources*. McGraw Hill, New York.
6. Sze S M and Kwok K N 2007. *Physics of Semiconductor Devices*. John Wiley & Sons, New Jersey.
7. Green M A 1981. *Solar Cells Operating Principles, Technology, and System Applications*. Prentice Hall, New Jersey.
8. Fonash S J 1982. *Solar Cell Device Physics*. Academic Press, Cambridge, England.
9. Luque A and Hegedus S 2011. *Handbook of Photovoltaic Science and Engineering Education*. John Wiley and Sons, New Jersey.

ENERGY PLANNING, MANAGEMENT, AND ECONOMICS

REE 623

3(3+0)

Course Outcome:

The student will be able to quantify, analyze and forecast the demand and supply of different energy for an 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. A pattern of energy consumption and their constraints in the production of agriculture. Direct and indirect energy. Energy audit of production agriculture and rural living and scope of conservation. 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.

Energy forecasting, energy economics, energy pricing and incentives for energy conservation, factors affecting energy economics. Techno-economic evaluation of RETs, computation of program for efficient energy management.

Suggested Readings:

1. Kennedy W J and Turner W C 1984. *Energy Management*. Prentice Hall, 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 Publication, United State.
4. Rai G D 1998. *Nonconventional Sources of Energy*. Khanna Publication, New Delhi.
5. Twindal J W and Wier A D 1986. *Renewable Energy Sources*. E & F N Spon, New York.

BIO-FUEL TECHNOLOGIES AND APPLICATIONS

REE 624

3(2+1)

Course Outcome:

The student will be able to understand the biofuel production technologies with financial viability and applications of bio-fuel in different sectors of development.

Syllabus:

Liquid biofuels: Non-edible oilseeds, oil extraction, pre-processing, characterization. World scenario: Liquid fuel challenges and some solutions. Liquid bio-fuel applications.

Bioethanol: First and second generation ethanol production technologies. Production of syngas from biomass, production of methanol from syngas, and production of ethanol from lingo-cellulosic biomass. Syngas and poly-generation, chemical conversion of syngas to methanol and ethanol, and some advanced fuels like biobutanol, and bio-propanol.

BioCNG: Biogas to green vehicle fuel, anaerobic digestion. Biogas opportunities: Landfill gas, agricultural and industrial wastewater, and additional sources of methane.

Biodiesel: Feedstock for biodiesel, manufacturing processes for biodiesel, value addition by utilization of by-products, environmental impacts of biodiesel, biodiesel from algae, and biodiesel engines.

Pyrolysis oil: Fast pyrolysis technologies, composition, and issues of bio-oil. Bio-oil upgradation technologies.

Practicals:

1. Evaluation of liquid fuel system for heat and power generation.
2. Characterization of liquid fuel.
3. Transesterification process.

4. Engine performance on biodiesel.
5. Biogas-engine system for a transport vehicles.
6. Bio-oil production by pyrolysis.

Suggested Readings:

1. Kishore VVN 2008. *Renewable Energy Engineering and Technology–A Knowledge Compendium. Education*. TERI Press, Delhi.
2. Klass D 1998. *Biomass for Renewable Energy, Fuels, and Chemicals*. EntechInternational, Barrington, Illinois, USA.
3. Boyle G 2008. *Renewable Energy*. Atlantic Publishing Company, New Delhi.
4. Gonsalves J B 2006. *An Assessment of the Biofuels Industry in India*. Wiley & Sons, New Delhi.

ENERGY MODELLING AND SIMULATION

REE 625

3(2+1)

Course Outcome:

Students will get thorough knowledge about energy modeling of gasification, pyrolysis, biogas system, fermentation, biodiesel production system, solar and wind technologies, etc.

Syllabus:

Model: Basics, system, boundary, interaction, types of models, physical, analogy models, and applications. Mathematical models: Concepts, input, output model, stochastic, deterministic, empirical models, linear, non-linear models, the interdependence of energy, economy, environment, modeling concept, and application.

Energy Modelling: Review of various energy sector models, energy demand analysis and forecasting, energy supply assessment and evaluation, energy demand, supply balancing, and energy modeling in the context of climate change.

Model studies in gasification, pyrolysis, biogas, fermentation, biodiesel, solar, wind technologies, and heat transfer applications. Moving boundary models.

Energy economics of energy sources: Investment and cost management in various energy technologies. Economics of energy generation, energy conservation economics, financial analysis, sensitivity and risk analysis.

Practicals:

1. Formulating dimensionless numbers.
2. Applications of dimensionless numbers.
3. Types of models for dimensionless numbers.
4. Mathematical model formulation and types.
5. Software's and model evaluation.
6. Development of models in thermo-chemical
7. Development of models in biochemical conversion processes.
8. Studies on model development in solar technologies.
9. Studies on model development in wind technologies
10. Economics of energy generation and conservation
11. Financial analysis.

Suggested Readings:

1. Desai A V 1990. *Energy Planning and Economics*. New Age International Publication Limited, New Delhi.
2. Munasinghe M and Meier P 1993. *Energy Policy Analysis and Modelling (Cambridge Energy Environment Series)*. Cambridge University Press, England.

Energy Conservation and Management in Production Agriculture

FMPE 613

3(3+0)

Course Outcome: Ability to understand design and operate PA systems.

Syllabus:

Global navigation satellite system (GNSS). Satellite ranging: Accuracy, standards, components of GIS, data layers, map component, attribute table component, function of aGIS, resolution. Data formats: Vector or raster. GIS for precision farming, data analysis, field calculator, convert to grid, interpolation, reclassification, image classification, band math, interpretation of analysis, farm management information systems, and crop intelligence. Yield Monitors: Components, Differential GPS Receiver, GNSS Receiver, mass flow sensors. Impact plates, measuring volume with a photoelectric sensor. Using microwave radiation, and Gamma rays to estimate volume, volumetric flow sensing and alternatives. Grain moisture sensor, fan speed sensor, elevator speed sensor, header position, yield monitor data, cotton yield monitors.

Sources of soil variability, general soil sampling basics, systematic variability, selecting a soil sampling strategy. Parameters: Electrical conductivity, electromagnetic sensors, sensing mechanical impedance. Proximal plant sensing systems, crops canopy reflectance and fluorescence. Machine vision thermal sensors, mechanical sensors, acoustic sensors.

Remote sensing platforms: Aircraft or satellite. Sensors: Imaging or non imaging, active or passive. Making use of reflected energy or emitted energy. The spectral signature of vegetation, vegetation indices, application to agriculture, nutrient management, weed management, disease and insect management, water management.

Practical:

Simple programming for automating precision farming calculations. Mathematics of longitude and latitude. Spatial statistics, soil sampling and understanding soil testing results for precision farming, calculations. Supporting management zones, understanding soil, water and yield variability in precision farming. Developing prescriptive soil nutrient maps, essential plant nutrients, fertilizer sources, and application rates calculations. Deriving and using an equation to calculate economic optimum fertilizer and seeding rates cost of crop production.

References:

1. Singh S and Singh R S 2014. *Energy for Production Agriculture*. DKMA, ICAR, New Delhi, India.
2. Mittal J P, Panesar B S, Singh S, Singh C P and Mannan K D 1987. *Energy in Production Agriculture and Food Processing*. ISAE and School of Energy Studies for Agriculture, PAU Ludhiana, ISAE Publication.
3. Pimental D 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press. Boca Rotan, USA

Ergonomics in Working Environment

FMPE 624

2(2+1)

Course Outcome:

Ability to design working environment of different agricultural machinery for efficient and safe operations.

Syllabus:

Musculoskeletal problems in sitting and standing postures-behavioral aspects of posture, body mechanics. Workspace design for standing and seated workers. Display units, controls and human-machine interaction, design of static work.

Noise and noise control. Measurement of noise and safe limits. Protection from noise. Vibration and health. Vibrations generated by agricultural machines. Types of vibrations: Whole body vibrations and hand transmitted vibrations. Methods of measurements of vibrations, hazards of vibrations. Vibration White Fingers (VWF). Vibration reductions in agricultural machines.

Working environment-heat and cold stress conditions. Thermal balance of human body. Measurement of thermal environment. Heat and cold stress condition. Thermoregulatory system of human body. Heat and cold acclimatization. Effect of climate on human performance. Environmental dust and its measurement: Organic and inorganic dust. Types of dust and their hazards: Respirable, thoracic and inhalable dust. Personal protection from dust.

Time motion study and its purpose. Application of Time motion study in agricultural and processing operations. Recent research works related to ergonomics in agriculture.

Practical:

1. Design of workspace for static work in standing or sitting posture
2. Study of body mechanics and posture in design of
3. agricultural machinery
4. Study of displays and controls in tractors
5. Calibration of subjects on ergometer and treadmill
6. Human workload and its assessment
7. Study of work and rest schedule
8. Measurement of visibility to tractor operators
9. Measurement of noise in tractors and self-propelled machines
10. Measurement of machine component vibration
11. Measurement of hand arm vibrations
12. Measurement of whole body vibrations
13. Study of dust generated in agricultural operations
14. Case study of design improvement in agricultural machine/ tool through ergonomic concept
15. Practical examination

References:

1. Bridger R S 2009. *Introduction to Ergonomics*. 3rd edition CRC Press, Boca Raton, USA.
2. Sanders M S and McCormick E J 1993. *Human Factors in Engineering and Design*. McGraw Hill, New York, USA.
3. Astrand P O, Rodahl K, Dahl H A and Stromme S B 2003. *Textbook of Work Physiology: Physiological Bases of Exercise*. Champaign IL: Human Kinetics.
4. Gite L P, Majmudar J, Mehta C R and Khadatkar A 2009. *Anthropometric and Strength Data*

of Indian Agricultural Workers for Farm Equipment Design. Central Institute of Agricultural Engineering, Bhopal, India.

5. Pearsons K 2003, *Human Thermal environments: The Effects of Hot, Moderate and Cold Environment on Human Health, Comfort and Performance*. Taylor and Francis, New York, USA.
6. Kroemer K H E and Grandjean E 1997. *Fitting the Task to the Human: A Textbook of Occupational Ergonomics*. Taylor & Francis, Philadelphia, USA.
7. Gite L P, Agrawal K N, Mehta C R, Potdar R R and Narwariya B S. 2019. *Handbook of Ergonomical Design of Agricultural Tools, Equipment and work Places*. Jain Brothers, New Delhi.

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. Ogate: *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.

Textural and Rheological Characteristics of Food Materials

PFE 612

3(2+1)

Course Outcome: To acquaint and equip the students with advances in measurement of textural and rheological characteristics affecting the food quality.

Syllabus:

Rheological properties of foods; Food rheology, physical states of materials, classical ideal material, rheological models, elements in the models, electrical equivalence, Maxwell model, Kelvin model and four element burger's model, stress-strain behavior; Elastic-plastic behavior, visco-elastic behavior, creep behavior, dynamic visco-elastic behavior, flow behavior of fluids, creep, stress relaxation.

Viscometry; Capillary viscometry, Casson model, flow rate equation, friction losses in pumping, turbulent flow, Newtonian fluid, power law fluid, cone and plate viscometry, parallel plate viscometry, mixer viscometry; Flow through a converging die, Cogswell's equations, Gibson's equations, empirical method; Applications of stress and strain, shear modulus and shear loss modulus, storage compliance and loss compliance, comparison of Moduli and compliances.

Objective and subjective measurements of texture; Texture classification, relation of food texture with structure and rheology, principles and practices of objective or instrumental texture measurements, fundamental rheological tests, physiological aspects, mechanical aspects and viscosity measurements and relationship between fundamental tests and sensory evaluation; Imitative and empirical measurements of texture; Tendero-meter, Brabender Farino-graph, firmness meter, texture profile method, dynamic methods for evaluation of food texture, dimensional analysis of food texture, firmness and hardness measurement.

Mathematical models and their application along with pipe line design and pump selection for non-Newtonian fluids; Recent advances in textural, rheological and visco-elastic characteristics of foods and their associated mathematical models.

Practicals

1. Introduction to Texture analyzer
2. Study of different attachments of texture analyzer used in texture analysis of various agricultural commodities.
3. To study the texture profile curve for food material
4. To study the textural profile kinetics of various fruits
5. To study the textural profile kinetics of various vegetables
6. To study the textural profile kinetics of various processed foods
7. To study the textural properties of liquid food
8. To study the Compression, puncture, elongation and bending tests for food materials
9. Introduction to Rapid Visco analyzer
10. Subjective measurement and correlation between subjective and objective measurements of foods.

Suggested Readings

1. Bourne MC. 2002. Food Texture and Viscosity: Concept and Measurement. Academic Press.
2. Deman JM. 1976. Rheology and Texture in Food Quality. AVI Publications.
3. Mohsanin NN. 1989. Physical Properties of Plant and Animal Material. Vol. I, II. Gordon and Breach Science Publications.
4. Steffe JF. 1992. Rheology and Texture in Food Quality. AVI Publications.

Mathematical Modeling in Food Processing

PFE 613

3(2+1)

Course Outcome: To acquaint and equip the students with the mathematical modeling techniques and their applications in food processing

Syllabus:

An overview of the modeling process; Introduction to mathematical, correlative and explanatory models; Formulation, idealization and simplification of the problems.

Probability models, series and linear mathematical approximation, dynamic and interacting dynamic processes.

Applications of mathematical modelling techniques to food processing operations like parboiling, convective drying, pasteurization, dehydration, shelf-life prediction, fermentation, aseptic processing, moisture diffusion, deep fat drying, microwave processing, infrared heating and ohmic heating.

Stochastic finite element analysis of thermal food processes; Neural networks approach to modelling food processing operations.

Practicals

1. Problems in mathematical correlation and explanatory models
2. Problems in explanatory models with idealization
3. Simple problems in Problems in Probability models with applications of food processing
4. Simple dynamic problems in food technology
5. Problems in one dimensional- potential energy approach: Galerkin approach
6. Simple problems in food processing techniques with interacting dynamic processes
7. Problems in food processing operations- parboiling, convective drying
8. Problems in food processing operations- pasteurization, dehydration, shelf-life prediction
9. Problems in food processing operations- fermentation, aseptic processing, moisture diffusion, deep fat drying
10. Problems in food processing operations - microwave processing, infrared heating and ohmic heating.
11. Problems in semi discrete finite element models
12. Semi discrete finite element models time-dependent problems
13. Simple problems in stochastic linear and nonlinear models with food processing
14. Problems in stochastic nonlinear models: Numerical Integration, calculation of Element Matrices (Processor)
15. Problems in assembly of element Equations (Processor) and Imposition of Boundary conditions, Viscous Incompressible fluids - finite element model-using software FEM
16. Problems in stochastic finite element analysis of thermal food processes. Artificial neural network based drying process

Suggested Readings

1. Fischer M, Scholten HJ and Unwin D. 1996. Spatial Analytical Perspectives on GIS. Taylor & Francis.
2. Fish NM and Fox RI. 1989. Computer Application in Fermentation Technology: Modelling and Control of Biotechnological Processes. Elsevier.
3. Gold HJ. 1977. Mathematical Modeling of Biological Systems - An Introductory Guidebook. John Wiley & Sons.
4. Hunt DR. 1986. Engineering Models for Agricultural Production. The AVI Publ.
5. Koeing HE, Tokad Y, Kesacan HK and Hedgers HG. 1967. Analysis of Discrete Physical

Systems. McGraw Hill.

6. Meyer JW. 2004. Concepts of Mathematical Modeling. McGraw Hill.
7. Peart RM and Curry RB. 1998. Agricultural Systems, Modelling and Simulation. Marcel Dekker.
8. Tijms HC. 1984. Modeling and Analysis. A Congrtational Approach. Wiley Publ.

Post Harvest Engineering

PFE 614

3(2+1)

Course Outcomes: The students will learn about the post-harvest technologies of cereals, pulses and oil seeds and related various operations; different types of cleaners and graders; concept of grain quality deterioration; chemical and biochemical methods for quality evaluation.

Syllabus: Weather characteristics and post harvest operations– Weather characteristics including air temperature; rainfall/ RH throughout the year and corresponding EMC of different crops, safe storage of food grain.

Harvest studies on different crops– Evaluation of post harvest losses, transportation, threshing; storage and handling losses and their measurement.

Cleaning and sorting of grains– Definitions; effect of crop and machine variables; different types of cleaners and graders, vibrating screen cleaner; sieve screen method; rotary grain pre cleaner; vertical rotation, screen separator; specific gravity separator.

Grain quality deterioration due to insect and pests – Grain quality storage; different fungus; moulds and bacterial insects and their species, mites and rodents; their control and loss measurement.

Chemical control of stored insects and mites– Principle; chemicals used to control insects and mites in stored grain; fumigants in dried and liquid form.

Various biochemical methods for quality evaluation of the farm produce – Methods for determination of protein, carbohydrate; total oil; ash; volatile oil and fibre content of various cereals; pulses; oilseeds and agricultural waste.

Size Reduction – Principles of commutation; energy and power requirements; Kick's law; Rittinger's and Bond's law; size reduction equipment.

Utilization of by-products for energy; food and feed – Utilization of rice bran and other agricultural waste and methods of their utilization.

Practicals

1. Estimation of storage and handling losses of grains.
2. Determination of EMC of food.
3. Grain size analysis.
4. Estimation of protein content in pulses.
5. Estimation of fat content.
6. Estimation of crude fibre, ash and carbohydrate.
7. Experiments on estimation of power requirement for size reduction.

Suggested Readings

1. Chakravorty A, Majumdar AS & Raghavan GSV. 2003. Handbook of Post Harvest Technology. 2003. Marcel Dekker Inc.
2. Chakravorty A. & De, DE. 1988. Post Harvest Technology of Cereals, Pulses and Oilseeds. Oxford and IBH Publ. Co., New Delhi, Ch. 14, 15 and 17.
3. Muir WE. & Sinha RN. 1973. Grain Storage Part of a system. AVI Publishing Company Inc., Westport. Ch.6.
4. Rahman MS. 2007. Handbook of food preservation. Francis and Taylor, CRC press.

5. Tewari G & Juneja VK. 2007. Advances in Thermal and Non-thermal Food Processing. Blackwell publication.

Milling of Food Materials

PFE 615

3(2+1)

Course Outcome: The students will be acquainted with milling processes/methods of major cereals, pulses and oilseeds and recent developments in milling processes; value addition of by-products and waste utilization.

Syllabus: Milling processes of major cereals, pulses and oilseeds. Design characteristics of milling equipments, their selection, and installation and performance evaluation. Milling of cereals (wheat, rice, maize and sorghum). Grain cleaning, grading, particle size, screen selection, grain structure, composition and proximate analysis. Grain conditioning. Traditional and modern methods of grain milling. Equipments for wheat milling, milling losses and specific energy consumption; modern wheat milling, types of break/ rough/ corrugated rolls, steel rolls their selection, principles of working, flour yield, sieving and sifting, flour analysis and enrichments of flour, value addition of by-products and waste. Equipments for rice milling: Hand pounding, traditional and modern rice milling, dryers and their types, paddy dehuskers, shellers, rubber rollers, rice separator, rice polishers/whiteners. Parboiling of paddy: boilers and milling of parboiled paddy, utilization of by-products such as rice bran and husk. Storage of paddy and rice. Plant layout and management of rice mills. Equipments for pulse milling, and polishers, Recent developments in premilling treatments, enzymatic and sodium- bicarbonate treatment etc. Dry and wet milling, CFTRI method of Pulse Milling. Plant layout and management. Equipment for milling of maize and sorghum: Hand and power operated shellers and dehuskers. Screen analysis of flour: specific energy consumption. Equipment for expelling of oilseeds; Various types of oil-exPELLERS, grain treatment, oil quality. Energy consumption. Traditional and commercial scale milling. Recent developments in oil processing such as use of enzymatic pre-treatment etc. Utilization of product waste. Plant layout and management of oil mill plants.

Practicals

1. Study on selection, installation and performance evaluation of milling equipments.
2. Study of modern wheat milling equipment.
3. Calculation of milling losses.
4. Determination of specific energy consumption of milling equipments.
5. Value addition of by-products and wastes.
6. Study of various equipments for rice milling.
7. Study on utilization of by-products such as rice bran and husk.

Suggested Readings

1. Chakravorty A. & De, DE. 1988. Post Harvest Technology of Cereals, Pulses and Oilseeds. Oxford and IBH Pub. Co., New Delhi, Ch. 14, 15 and 17.
2. Kent NL. 1975. Technology of Cereals with Special Reference to Wheat. Pergamon Press, Oxford, New York.
3. Inglett GE 1970. Corn: Culture, Processing, Products. The AVI Publishing Co. INC. Westport.

Bioprocess Engineering

PFE 622

3(2+1)

Course Outcome: To acquaint and equip the students with the basic principles of biochemical process engineering.

Syllabus:

Applications of engineering principles: Mass and energy balance, fluid flow principles, Unit operations of process engineering.

Fundamentals of growth kinetics, maintenance energy and yield concepts, principles of media sterilization, media formulations of industrial fermentation.

Aerobic and agitated rheology of fermentative fluids, design and scale-up of bioreactors, enzyme reactors.

Principles of recovery of fermented products in bio-processing, instrumentation, transport phenomenon.

Practicals

1. To study the instruments used for measurement of temperature, relative humidity, flow rate, pressure, wind velocity, solar radiation etc.
2. Use of units, dimensions and basic mathematical applications.
3. To judge the students ability for solving mass balances problems.
4. To judge the students ability for solving Energy balance problems.
5. To study the kinetics of one substitute reactions.
6. To assess the kinetics of growth in batch cultures.
7. To study the order of reactions involving single/multiple reactants/products.
8. To study the various thermal and structural parameters affecting the design of bioreactors.
9. To assess the student's ability for design of bioreactors by solving related numerical problems.
10. To prepare various media cultures and assess their effectiveness with time.
11. To study the mechanism of sterilization of cultures.
12. To study the various electronic gadgets for continuous monitoring of bioprocess parameters.

Suggested Readings

1. Brennan JG, Butters JR, Cavell ND and Lilly AEI. 1990. Food Engineering Operations. Elsevier Applied Science. ISBN 13: 9781851664443
2. Coulson JM and Richardson JF. 1999. Chemical Engineering. Volume 2, Fifth Edition. The Pergamon Press. ISBN 0 7506 4445 1
3. Geankoplis J Christie. 1999. Transport Process and Unit Operations. Third Edition, Prentice Hall of India, New Delhi. ISBN 0-13-045253-X.
4. Treybal RE. 1981. Mass Transfer Operations. 3rd Ed. Harper & Row. ISBN-13-978-1259029158.

Agricultural Waste and By-Products Utilization

PFE 623

3(2+1)

Course Outcome: To acquaint and equip the students with the techniques of utilization of agricultural waste and by-products and also about development of value added products from wastes.

Syllabus:

Conversion processes: Thermo-chemical conversions, densification, combustion and gasification, extraction, biological conversions, anaerobic digestion, biochemical digestion process, digestion systems, energy from anaerobic digestion, cellulose degradation, fermentation process; Agricultural wastes as paper, boards and fuel.

Briquetting: Briquetted fuel from husk, hull and other wastes selection, design of briquetting machines; Utilization of shell, stem and stalk: Production of activated carbon; By-products of agro-industries: Rice mill, oil mill, cattle feed mill, valuable constituents and composition; Utilization of rice husk: Production of silica and cement from rice husk; Stabilization and storage of rice bran, extraction of rice bran oil.

By-products of oil refining: Fatty acids/soap stock, wax and gum, characteristics and utilization; Rice germ and broken rice; Production of starch and infant food, industrial uses of starch; By-products of oil milling: Oil cake and defatted oil cake, cattle feed and industrial uses; Utilization of starch and other industrial wastes: Microcrystalline cellulose, production of ethanol, wastes of tapioca starch industries, thippi-utilization as fuel, extraction of starch by hydrolysis, utilization of starch for food, adhesives and feed purposes.

By-products of sugar industry: Sugarcane tops, bagasse, molasses and press mud, utilization as animal feed; By-products of fruits and vegetables based agro-industries: Mango seed kernel and pineapple waste.

Practicals

1. To determine of moisture content of biomass.
2. To determine of ash content of biomass.
3. To determine proximate analysis of biomass/waste/residue.
4. Exercises on stepped grate and fixed grate rice husk furnaces.
5. Exercises on waste fired furnaces.
6. Exercises on combustion calculation.
7. To study the briquetting machine.
8. To study the various quality parameters of briquettes.
9. To study the production of alcohol from waste materials.
10. To study the production of paper boards and particle boards from agricultural was
11. To determine the properties of paper boards and particle boards from agricultural wastes.

Suggested Readings

1. ASAE Standards. 1984. Manure Production and Characteristics.
2. Bor SL. (Ed.). 1980. Rice: Production and Utilization. AVI Publishing Co. ISBN : 0870553321.
3. Chahal DS. 1991. Food, Feed and Fuel from Biomass. Oxford & IBH. ISBN : 81-204-0499-8.
4. Chakraverty A. 1989. Biotechnology and other Alternative Technologies for Utilization of Biomass/Agricultural Wastes. Oxford & IBH. ISBN 8120404181, 9788120404182
5. Donald LK and Emert HG. 1981. Fuels from Biomass and Wastes. Ann. Arbor. Science Publ. ISBN: 0250404184 9780250404186
6. Srivastava PK, Maheswari RC and Ohja TP. 1995. Biomass Briquetting and Utilization. Jain Bros.
7. USDA 1992. Agricultural Waste Management Field Handbook. USDA. Open NonWebContent.aspx (usda.gov).

Course Outcome: The students will be acquainted and equipped with designing of grain storage structures; moisture and heat management in storage structures.

Syllabus: Storage structures; bins, bunkers, silos and warehouses; Methods of computing static pressures due to granular materials, Janssen's method, Airy's method, Rimbert's method; Dynamic pressures, L vin's theory, Walter's method, comparison of various methods; flow patterns, pressure in Bunkers; Dead and Live loads, thermal effects, Loads at hoppers; Design of concrete and metal silos; flexible bins. Grain damage and its control, metabolic activities; biological agents; physical and chemical controls; aeration system Design and management; temperature profiles; stored product environment control storage, warehouses, site selection, stack arrangement, moisture and heat management, quality management, codes for construction and management.

Practicals

1. Quality evaluation of stored product
2. Design of storage structures.
3. Design of bag storage.
4. Silo design by Janssen's method.
5. Silo design by Airy's method.
6. Estimation of storage loss.
7. Estimation of quality of stored products.

Suggested Readings

1. Bala BK. 1997. Drying and Storage of Cereal Grains. Oxford & IBH Publishing Co. Pvt. Ltd., New Dehi. ISBN:9781119124238, DOI:10.1002/9781119124207.
2. Sinha RN & Muir WE. 1973. Grain Storage, Part of a System. The AVI Publishing Co. INC. ISBN 087055123X, 9780870551239.
3. Shejbal J. 1980. Controlled Atmosphere Storage of Grains. Elsevier Scientific Pub. Co. Oxford. 1st Edition. ISBN: 9780444601025

Design of Food Process Equipments

PFE 625

3(2+1)

Course Outcome: The students will be acquainted with the types of heat exchangers and design of PHE and shell and tube heat exchanger, pipe lines, their layout, insulation and installation; types of pressure vessel and storage tanks, their design for storage of liquids and gas.

Syllabus: Applications of design engineering to post-harvest equipments, design parameters, codes and materials selection, design of materials handling equipments, heat exchangers, seed processing equipments, pressure vessels, optimization of design in respect of process efficiency, energy and cost. Piping - Cast iron and wrought iron pipes and tubing; light wall pipe; tubing, pipe connections and fittings; pipes and tube design data, design of steam piping.

Design of pipe line - Sizing process lines; piping specifications; piping layout and arrangement; pipe insulation and installation.

Design of vessels and storage tanks - Vessel fabrication; welding processes; brazing and soldering; shell plates; heads; theory of pressure vessel design; working formula stress and design considerations.

Design and Selection of Heat Exchangers - Heat exchanger types; heat exchanger design-design procedure; short cut method of design.

Practicals

1. Study of methods of fabrication process.

2. Design of plate heat exchanger.
3. Design of shell and tube heat exchanger.
4. Design of pressure vessels.
5. Design of storage tanks.
6. Design of process line and steam line.

Suggested Readings

1. Bhattacharyya BC. 1991. Introduction to Chemical Equipment Design. CBS Publishers & Distributors. New Delhi. ISBN 108123909454
2. Coulson JM, Richardson JF&Sinnott RK. 1983. Chemical Engineering Vol. 6, Pergamon Press. Second Edition. ISBN: 978-0-08-041865-0. DOI: <https://doi.org/10.1016/C2009-0-11215-1>
3. Evans FL. 1974. Equipment Design Handbook for Refineries and Chemical Plants, Vol II, Gulf Publication Houston, Texas. ISBN-13-978-0872012677
4. Foust AS. 2001. Principle of Unit Operations, John Wiley and Sons INC., New York. DOI: <https://doi.org/10.1002/aic.690270127>.
5. Joshi MV. 1981. Process Equipment Design. Mac Millon India Ltd., New Delhi. ISBN: 0333924185, 9780333924181
6. Soares C. 2002. Process Engineering Equipment Handbook. McGraw Hills. ISBN: 9780070596146, 0-07-059614-X.

Rheology of Foods

PFE 626

3(2+1)

Course Outcome: The students will be acquainted with various textural, rheological and viscoelastic characteristics of foods.

Syllabus: Texture classification. Relation of food texture with structure and rheology. Principles and practices of objective texture measurements, viscosity measurements. Sensory methods of texture and viscosity measurements and their correlation. Rheological properties of foods. Mathematical models and their application along with pipe line design and pump selection for non-Newtonian fluids. Recent advances in textural, rheological and viscoelastic characteristics of foods and their associated mathematical models.

Practicals

1. Determination of viscosity of liquid foods.
2. Determination of rheological properties such as gumminess, chewiness, firmness, springiness and hardness of various fruits, vegetables and processed foods using texture profile measurement.
3. Studies on various rheological models.
4. Correlation between subjective and objective measurements of properties of foods.
5. Sensory evaluation of processed foods.

Suggested Readings

1. Bourne MC. 2002. Food Texture and Viscosity: Concept and Measurement. 2nd Ed. Academic Press. ISBN: 978-0-12-119062-0
2. Deman JM. 1976. Rheology and Texture in Food Quality. AVI Publ. Mohsanin NN. 1989. Physical Properties of Plant and Animal Material. Vol. I, II. Gordon and Breach Science Publ. ISBN-13-978-0870551970
3. Rao MA, Rizvi SSH & Datta ADK. 2005. Engineering Properties of Food. Francis and Taylor, 3rd Ed, CRC press. ISBN 0-8247-5328-3.

4. Sahin S & Sumnu SG. 2006. Physical Properties of Food. Springer. ISBN: 038730780X, 9780387307800.
5. Steffe JF. 1992. Rheology and Texture in Food Quality. 2nd Ed. AVI Publ. ISBN: 0-9632036-1-4.

Research Publication and Ethics

PGS 621

2(1+1)

Course outcome:

By the end of the Course, students will be able to understand the importance of being ethical in carrying out research and publication activities. They will be able to differentiate the quality publication practices and how to be cognizant about dubious publishing practices/publishers.

More importantly, there will be an increased awareness about 'open access' and contribution of research output to open access publishing platforms. The learners will also get acquainted with the software/databases which are necessary for carrying out research work.

Syllabus:

Philosophy and Ethics:

1. Introduction to philosophy: definition, nature and scope, concept, branches
2. Ethics: definition, moral philosophy, nature of moral judgements and reactions.

Scientific Conduct:

1. Ethics with respect to science and research
2. Intellectual honest and research integrity
3. Scientific misconducts: falsification, fabrication, and plagiarism.
4. Redundant publications: duplicate and overlapping publications, salami slicing
5. Selective reporting and misrepresentation of data.

Publication Ethics:

1. Publication ethics: definition, introduction and importance
2. Best practices/standards setting initiatives and guidelines: COPE, WAME, etc.
3. Conflicts of interest
4. Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa, types
5. Violation of publication ethics, authorship and contributor ship
6. Identification of publication misconduct, complaints and appeals
7. Predatory publishers and journals

Practicals:

Open Access Publishing

1. Open access publications and initiatives
2. SHERPA/RoMEO online resource to check publisher copyright and self-archiving policies.
3. Software tool to identify predatory publications developed by SPPU
4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.

Publication Misconduct

A. Group Discussions

1. Subject specific ethical issues, FFP, authorship
2. Conflicts of interest
3. Complaints and appeals: examples and fraud from India and abroad

B. Software tools: Use of plagiarism software like Turnitin, Urkund and other open Source software tools.

Databases and Research Metrics

A. Databases

1. Indexing databases
2. Citation databases: Web of Science, Scopus, etc.

B. Research Metrics

Impact Factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score.

Metrics: h-index, g index, i10 index, altmetrics

Suggested readings:

1. The Ethics of Teaching and Scientific Research By Miro Todorovich; Paul Kurtz; Sidney Hook.
2. Research Ethics: A Psychological Approach By Barbara H. Stanley; Joan E. Sieber; Gary B. Melton
3. Research Methods in Applied Settings: An Integrated Approach to Design and Analysis By Jeffrey A. Gliner; George A. Morgan Lawrence Erlbaum Associates, 2000
4. Ethics and Values in Industrial-Organizational Psychology By Joel Lefkowitz Lawrence Erlbaum Associates, 2003.

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 vascupets;
- 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