Department of Agricultural Engineering

Ph.D. Course Work

(Applicable for the scholars admitted from the AY: 2024-25)

The credit requirement for the Ph.D. course work is a minimum of 12 credits including the courses on 'Research Methodology' and 'Research and Publication Ethics' for 2 credits each. The candidate must complete two domain-specific courses of 3 credits each, recommended by the respective Department Research Committee (DRC). These courses can be completed through MOOCs.

The candidate must present two research seminars before the completion of course work, typically within the first year. The first research seminar shall be before the end of first semester on introduction to the proposed research work, and the second seminar shall be before the end of the second semester or after the completion of course work on the research proposal, as per the format provided. Each research seminar will have one credit weightage. The course structure is presented in Table 1 and list of domain-specific courses is presented in Table 2.

Table 1: Course Structure

S.No.	Course Code	Name of the Course	Credit (s)
1	246UC001	Research Seminar -I	1
2	246UC002	Research Seminar -II	1
3	246UC003	Research Methodology	2
4	246UC004	Research and Publication Ethics	2
5	-	Domain Specific Course -I	3
6	-	Domain Specific Course -II	3
Total			**12**

Table 2: List of Domain-Specific Courses

S.No.	Course Code	Name of the Course
1	246AE001	Design of Farm Power and Machinery Systems
2	246AE002	Soil Dynamics in Tillage and Traction
3	246AE003	Testing and Evaluation of Tractors and Farm Equipment
4	246AE004	Design and Analysis of Renewable Energy Conversion Systems
5	246AE005	Tractor Design
6	246AE006	Soil and Water Systems Simulation and Modelling
7	246AE007	Flow through porous media
8	246AE008	Watershed Management & Modelling
9	246AE009	Crop Environmental Engineering
10	246AE010	Dryland Technology
11	246AE011	Agricultural Drainage Systems
12	246AE012	Fruits & Vegetables Process Engineering
13	246AE013	Transport Phenomena in Food Processing
14	246AE014	Food Processing Equipment Design
15	246AE015	Advances in Food Processing
16	246AE016	Advances in Drying of Food Materials
17	246AE017	Milling of Food Materials
18	246AE018	Machine Learning for Soil and Crop Management
19	246AE019	Design, Operation & Evaluation of Pressurised Irrigation System

Research Methodology

Course Code: 246UC003

UNIT -I:
Research Design
Overview of research process and design, Use of Secondary and exploratory data to answer the research question, Qualitative research, Observation studies, Experiments and Surveys. Case Studies.

UNIT-II:
Data Collection and Sources
Measurements, Measurement Scales, Questionnaires and Instruments, Sampling and methods. Data - Preparing, Exploring, examining and displaying.

UNIT-III:
Data Analysis and Reporting
Overview of Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

UNIT-IV:
Intellectual Property Rights
Intellectual Property – The concept of IPR, Evolution and development of concept of IPR, IPR development process, Trade secrets, utility Models, IPR & Bio diversity, Role of WIPO and WTO in IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

UNIT-V: Patents
Patents – objectives and benefits of patent, Concept, features of patent, Inventive step, Specification, Types of patent application, process E-filling, Examination of patent, Grant of patent, Revocation, Equitable Assignments, Licenses, Licensing of related patents, patent agents, Registration of patent agents.

Text Books:

1. Research Methodology: A Step-by-Step Guide for Beginners, Ranjit Kumar, Sage Publications, 4th Edition, 2015.
2. Intellectual Property: A Very Short Introduction, Siva Vaidhyanathan, Oxford University Press, 2017.
3. Intellectual Property: The Law of Trademarks, Copyrights, Patents, and Trade Secrets" Deborah E. Bouchoux, Cengage India, 4th Edition, 2013.

Reference Books:

1. Research methodology: an introduction for science & engineering students, Stuart Melville and Wayne Goddard, Juta Academic, 2nd Edition, 2014.
2. Research design: Qualitative, quantitative, and mixed methods approaches, Creswell, J.W. and Creswell, J.D., Sage publications, 2017.
3. Intellectual Property in New Technological Age, Robert P. Merges, Peter S. Menell, Mark A. Lemley, Clause 8 Publishing; Volume I: Perspectives, Trade Secrets & Patents; 2023.

Web Links:
1. https://archive.nptel.ac.in/courses/121/106/121106007/#
2. https://onlinecourses.swayam2.ac.in/ntr24_ed08/preview

Research and Publication Ethics

Course Code: 246UC004

Unit-I: Philosophy & Ethics
Introduction to Philosophy: Definition, Nature & Scope, Concept, Branches
Ethics: Definition, Moral Philosophy, Nature of Moral Judgements & Reactions

Unit-II: Scientific Conducts
Ethics with respect to Science and Research, Intellectual Honesty & Research Integrity
Scientific Misconducts: Falsification, Fabrication & Plagiarism
Redundant Publications: Duplicate & Overlapping Publication, Salami Slicing, SelectiveReporting & Misrepresentation of Data

Unit-III: Publication Ethics
Publication Ethics: Definition, Introduction and Importance
Best Practices/ Standard Setting Initiatives and Guidelines: COPE, WAVE, etc., Conflictsof Interest
Publication Misconduct: Definition, Concept, Problems that lead to unethical behaviour and vice-versa, types, Violation of Publication Ethics, Authorship and Contributorship, Identification of Publication Misconduct, Complaints and Appeals, Predatory Publishers and Journals

Unit-IV:Open Access Publishing
Open Access publications and Initiatives, SHERPA/ RoMEO online resource to check publisher copyright and self-achieving policies, Software tool to identify predatory publications developed by SPPU, Journal Finder/ Journal Suggestion tools viz. JANE, ELSEVIER, SPINGER, Journal suggester etc.

Unit-V: Publication
Misconduct Group
Discussions:
Subject-specific Ethical issues, FFP, Authorship, Conflicts of Interest, Complaints and Appeals: Examples and fraud from India and Abroad
Software tools:
Use of Plagiarism software like Turnitin, Urkund and other open source software tools
Database and Research Metrics:
Database:
Indexing database, Citation database: web of science, Scopus etc.
Impact factor of journal as per journal citation report, SNIP, SJR, IPP, cite score
Metrics: h-index, g-index, i-10 index, AL metrics etc.

Text Books:
1. Philosophy in Science, Bird A, Routledge, 2006.
2. A Short History of Ethics, MacIntyre, London, 1967.

Reference Book:
1. Ethics in Science, Education and Governance, Indian National Science Academy, 2019.

Weblinks:

1. www.niehs.nih.gov/research/resources/bioethics/whatis
2. https://onlinecourses.swayam2.ac.in/nou22_ge73/preview

Design of Farm Power and Machinery System

Course Code: 246AE001

Unit-I:
Modern Trends and Economic Considerations in Design
Covers modern trends, principles, and economic considerations for the design and development of farm power and machinery systems, focusing on tractors and typical farm machines.

Unit-II:
Reliability Criteria and Analytical Design of Linkages/Components
Explores reliability criteria in design, analytical considerations for linkages/components, and their applications.

Unit-III:
Design of Selected Farm Equipment
Delves into the design of selected farm equipment, including tillage, seeding, planting, interculture, plant protection, harvesting, and threshing.

Unit-IV:
Design of Rotary, Vibrating, and Oscillating Machines
Focuses on the design of rotary, vibrating, and oscillating machines, along with the design and selection of matching power units.

Unit-V:
Safety Devices for Tractors and Farm Implements
Emphasizes safety devices for tractors and farm implements, including safety standards and best practices.

Textbooks:

1. Srivastava, A. K., Goering, C. E., Rohrbach, R. P., and D. R. Buckmaster. *Engineering Principles of Agricultural Machines.* New Delhi, Jain Brothers, 2006.
2. Liljedahl, J. B., Turnquist, P. K., Smith, D. W., and M. Hoki. *Tractors and Their Power Units.* New Delhi, Agrotech Publishing Academy, 2008.

Reference Books:

1. Kepner, R. A., Bainer, R., and E. L. Barger. *Principles of Farm Machinery.* New Delhi, CBS Publishers and Distributors, 2005.
2. Jain, S. C., and C. R. Rai. *Farm Tractor Maintenance and Repair.* New Delhi, Standard Publishers Distributors, 2002.

Web Links:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=13
2. https://elearning.icar.gov.in/DisplayPG_ECoursesContent.aspx?CourseCode=W!se43HIX5DUd/obLjOrJw==

Soil Dynamics in Tillage and Traction

Course Code: 246AE002

Unit-I:
Dynamic Properties of Soil and Stress-Strain Relationships
Introduces the dynamic properties of soil, their measurement, stress-strain relationships, and the theory of soil failure.

Unit -II:
Mechanics of Tillage Tools and Soil-Tool System
Covers the mechanics of tillage tools, geometry of soil-tool systems, and the design parameters and performance of tillage tools.

Unit -III:
Traction Devices: Types, Functions, and Mechanics
Discusses traction devices, including types of tyres, their functions, size, and selection, as well as the mechanics of traction devices.

Unit-IV:
Interaction of Traction Devices with Soil
Focuses on the interactions between traction devices and soil, covering deflection, slippage, sinkage, performance evaluation, and traction prediction
.
Unit -V:
Soil Compaction and Methods to Mitigate it
Addresses soil compaction by agricultural vehicles and machines, including the design of traction and transport devices and methods to mitigate compaction.

Textbooks:

1. Gill, W. R., and G. E. Vanden Berg. *Soil Dynamics in Tillage and Traction.* New Delhi, CBS Publishers and Distributors, 2006.
2. Barger, E. L., Liljedahl, J. B., and M. J. McKibben. *Tractors and Their Power Units.* New Delhi, Agrotech Publishing Academy, 2008.

Reference Books:

1. McKyes, E. *Soil Cutting and Tillage.* Amsterdam, Elsevier Scientific Publishing Company, 1985.
2. Gupta, C. P. *Soil Dynamics in Agriculture.* New Delhi, Oxford and IBH, 1999.

Web Links:

1. https://elearning.icar.gov.in/DisplayPG_ECoursesContent.aspx?CourseCode=W!se43HIX5CltEOPFrjFrw==
2. http://ecoursesonline.iasri.res.in/course/view.php?id=68

Testing and Evaluation of Tractors and Farm Equipment

Course Code: 246AE003

Unit-I:
Types of Tests and Test Procedures
Covers the types of tests conducted on tractors and farm equipment, test procedures, and national and international codes.

Unit-II:
Test Equipment, Usage, and Power Loss Analysis
Focuses on test equipment, their usage and limitations, and the analysis of power losses in dynamometers and hydraulic test equipment.

Unit-III:
Prototype Testing and Field Evaluation
Discusses prototype feasibility testing and field evaluation, as well as laboratory and field testing of selected farm equipment.

Unit-IV:
Non-Destructive Testing and Performance Evaluation
Introduces non-destructive testing techniques and tractor performance testing, including the evaluation of results.

Unit-V:
Review and Interpretation of Test Reports
Emphasizes the review and interpretation of test reports through case studies of field performance and testing outcomes.

Textbooks:

1. Srivastava, A. C. *Testing and Evaluation of Agricultural Machinery.* New Delhi, Jain Brothers, 2012.
2. Kepner, R. A., Bainer, R., and E. L. Barger. *Principles of Farm Machinery.* New Delhi, CBS Publishers and Distributors, 2005.

Reference Books:

1. Herbert, L. *Performance Testing of Agricultural Equipment.* New Delhi, Agrotech Publications, 2011.
2. Yadav, R. *Farm Machinery Testing and Evaluation.* New Delhi, Jain Brothers, 2008.

Web Links:

1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2265
2. https://openknowledge.fao.org/server/api/core/bitstreams/78b49b6a-baed-439d-8436-de27b7389947/content

Design and Analysis of Renewable Energy Conversion Systems

Course Code: 246AE004

Unit-I:
Energy Cycle and Renewable Energy Sources
Introduces the energy cycle of the earth, covering water flow, storage, ocean currents, tides, photosynthesis, and biomass as renewable energy sources.

Unit-II:
Thermodynamics of Energy Conversion
Focuses on the thermodynamics of energy conversion and the conversion processes for solar energy, wind energy, water flows, and biomass.

Unit-III:
Biogas, Alcohols, and Plant Oils in I.C. Engines
Explores the development and use of biogas, alcohols, plant oils, and plant oil esters in I.C. engines.

Unit-IV:
Performance Parameters and Energy Efficiency
Discusses the parameters for measuring the performance of renewable energy systems and considerations for energy efficiency.

Unit-V:
Case Studies and Emerging Trends in Renewable Energy
Includes case studies on renewable energy technologies and emerging trends in renewable energy conversion.

Textbooks:

1. Rai, G. D. *Non-Conventional Energy Sources.* New Delhi, Khanna Publishers, 2019.
2. Khan, B. H. *Non-Conventional Energy Resources.* New Delhi, Tata McGraw Hill, 2009.

Reference Books:

1. Sukhatme, S. P., and J. K. Nayak. *Solar Energy: Principles of Thermal Collection and Storage.* New Delhi, Tata McGraw Hill, 2008.
2. Garg, H. P., and S. Prakash. *Solar Energy: Fundamentals and Applications.* New Delhi, Tata McGraw Hill, 2000.

Web Links:

1. https://www.mdpi.com/2071-1050/13/19/10590
2. https://www.sciencedirect.com/book/9780128235386/renewable-energy-conversion-systems

Tractor Design

Course Code: 246AE005

Unit-I:
Technical Specifications and Modern Trends in Tractor Design
Introduces the technical specifications of tractors available in India and modern trends in their design and development, with a focus on Indian agriculture.

Unit-II:
Design Parameters and Fuel-Efficient Engine Components
Covers the parameters affecting tractor engine design and the selection and design of fuel-efficient engine components.

Unit-III:
Design of Tractor Systems
Discusses the design of tractor systems such as transmission, steering, front suspension, hydraulics, and hitching.

Unit-IV:
Design of Chassis, Seat, Controls, and Tire Selection
Focuses on the design of the chassis, driver's seat, work-place area, and controls, along with tire selection and the mechanics of tractors.

Unit-V:
Application of Computer-Aided Design (CAD) in Tractor Design
Introduces the application of computer-aided design (CAD) in agricultural tractor design, including simulation and modeling of tractor systems

Textbooks:

Sharma, D. N., and Mukesh Chandra. *Design of Tractor.* New Delhi, Jain Brothers, 2002.
Yadav, R., and T. P. Ojha. *Tractor and Power Units.* New Delhi, Oxford and IBH Publishing, 2014.

Reference Books:

Liljedahl, J. B., Turnquist, P. K., Smith, D. W., and M. Hoki. *Tractors and Their Power Units.* New Delhi, Agrotech Publishing Academy, 2008.
Nicholson, R. *Modern Tractor Design.* London, Agricultural Press, 1998.

Web Links:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=505
2. https://link.springer.com/book/10.1007/978-3-030-32804-7

Soil and Water Systems Simulation and Modelling

Course Code: 246AE006

UNIT-I:
Systems Engineering for Water Management

Systems engineering for water management: complexity of resources management process, systems analysis.

UNIT-II:
Rainfall-Runoff Models

Rainfall- runoff models, Infiltration models, Simulation methods, structure of a water balance model.

UNIT-III:
Channel Flow Simulation

Channel flow simulation- parameters and calibration-Streamflow statistics, surface water storage requirements.

UNIT-IV:
Flood Control and Ground Water Models

Flood control storage capacity; total reservoir capacity–surface water allocations. Ground water models.

UNIT-V:
Design of nodal network

Design of nodal network, General systems frame work-Description of the model; Irregular boundaries, General-Numerical approaches.

Text Books:

1. Biswas AK. 1976. Systems Approach to Water Management.Mc Graw Hill.
2. Cox DR & Mille HD.1965. The Teory of Stochastic Processes. John Wiley & Sons.

Reference Book:

1. Eagleson PS 1970. Dynamic Hydrology. Mc Graw Hill.
2. Himmel Blau DM & Bischoff KB.1968. Process Analysis and Simulation Deterministic Systems. John Wiley & Sons.

Web links:

1. https://fmtcndl.iari.res.in/Division/PGcourse/2024-10-29_11-43-07_SWCE_602.pdf
2. https://nihroorkee.gov.in/nihnewsevents/training-course-hydrological-modelling-using-soil-and-water-assessment-tool-swat

Flow Through Porous Media

Course Code: 246AE007

UNIT-I:
Properties of Fluid Systems
Physical properties of water occurrence of water, physico-chemical nature of water, its structure and its three phases. Energy required for transformation of water from one state of another. Properties of fluid systems in porous media, concept of Continumm, forces on fluid elements, Newtonian viscous fluids, concept of potential, fluid acceleration.

UNIT-II:
State of Water in Soil
Static water in soil, structure of water, forces and energy in water, Van der Walls-London (V-L) forces, dispersion of soil colloids surface tension. The state of water in the soil, energy state of soil water. Quantitative expression of soil water potential, soil moisture characteristics curve, Hysteresis.

UNIT-III:
Dynamics of Fluids in Porous Media
Dynamics of fluids in porous media, Darcy‟s law, Poiseuille‟s law, Flow in films and small tubes, Homogenity and Isotropy, Factors affecting permeability, Fundamentals of Groundwater flow, General hydrodynamic equations: velocity potential. Two-dimensional flow, Stream function, Streamlines and equipotential lines, Boundary conditions, the flow net.

UNIT-IV:
Seepage Analysis
The basic seepage equation. The continuity equation. Non-uniform seepage of an Incompressible fluid. Axisymmetric confined seepage of an Incmpressible fluid, General Hydrodynamic Equations, velocity potential. Fundamentals of seepage analysis, Richard's equation, cylindrical coordinates. Application of the Dupuit theory of unconfined flow.

UNIT-V:
Hydrodynamics in Porous Media
Hydrodynamics in porous media; and the limitations of the governing laws, initial and boundary conditions, Dupuit and Boussinesque approximations and linearization techniques, use of flow net in subsurface flow quantification, simulation of soil moisture dynamics, Analysis of seepage (lateral & upward) from earthen dams and canals. Conformal mapping & hodograph transformation, Laplace, its derivation & solution in various forms.

Text Books:

1. Collins, R.E., Flow of Fluids Through Porous Materials; Reinhold publishing cooperation, New York, 1961, chapter 1.
2. A.T. Core, Flow in Porous Media.

Reference Book:

1. Daniel Hillel, 1980. Fundamentals of Soil Physics, Academic press, New York, pp. 413. J:1(C) MO, 174741
2. De Wiest Roger J.M., 1969. Flow Through porous media, academic press, New York,

pp. 530. D28, K9:1, 47814.

Web links:

1. https://archive.nptel.ac.in/courses/103/105/103105160/
2. http://sdnbvc.digimat.in/nptel/courses/video/103105160/L26.html

Watershed Management & Modelling

Course Code: 246AE008

UNIT-I:
Soil Erosion Models
Soil erosion models, Rainfall simulators and scope of their use in soil erosion studies.

UNIT-II:
Instantaneous Unit Hydrograph and Artificial Ground water Recharge
IUH estimation using geomorphological methods, Artificial groundwater recharge.

UNIT-III:
GIS and Remote Sensing
Use of GIS and remote sensing tools in watershed management, Watershed based water management, Economics of water management, Participatory mode of water management.

UNIT-IV:
Delineation of Watershed
Delineation and codification of small watersheds. Characteristics of small watershed as related to hydrologic processes infiltration, channel flow and storage. Different conservation practices biological, mechanical and structural and their effects on watershed behaviour.

UNIT-V:
Watershed Management
Effect of land use changes. Physiography of small watersheds and hydrologic measurement. Space time characteristic of precipitation and design application models to field problems. Environmental impact assessment of watersheds. Quantitative evaluation of management techniques.

Text Books:

1. Tideman, E.M. (1999). Watershed Management (Guidelines for Indian Conditions), Omega Scientific Publishers, New Delhi.
2. Dhruvanarayana, V.V. Sastry, G., Patnaik, U.S. Watershed Management.Publ. and Inf.D.v, ICAR, Krishi Anusandhan Bhavan, New Delhi.

Reference Book:

1. Singh, Raj Vir. (2000). Watershed Planning and Management. Second Edition Yash Publishing House, Bikaner.
2. Lal, R. (1996). Methods and Guidelines for Assessing Sustainable use of Soil and Water Resources in the Tropics. Jagmander Book, Karol Bagh, New Delhi.

Web links:

1. https://archive.nptel.ac.in/courses/105/101/105101010/
2. http://courseware.cutm.ac.in/courses/watershed-planning-and-management/

Crop Environmental Engineering

Course Code: 246AE009

UNIT-I:
Plant Growth Environment
Aerial and edaphic environments for plant growth, energy and mass transfer in and above crop canopies.

UNIT-II:
Effect of Climate Change on Plant Growth
Climatic changes and plant response to environmental stresses, evapotranspiration models. Instrumentation and techniques for monitoring plant environments.

UNIT-III:
Plant Growth and Development
Processes and aspects of growth and development, soil-root interface, root sink functions.

UNIT-IV:
Water Movement in Plant
Water movement in soil-plant atmosphere continuum, artificial environments and plant behavior. Water requirement of crops in controlled environment.

UNIT-V:
Design of Controlled Environment Facilities
Design and operation of controlled environment facilities and their instrumentation. Crop growth and yield modelling. Remote sensing based modelling.

Text Books:

1. Ghildyal BP and Tripathy RP. 1987. Fundamental of Soil Physics. Wiley Eastern.
2. Slatyor OP. 1967. Plant Water relationship. Academic Press.

Reference Book:

1. Gomtia N.K. & Tiwari K.N. 2008. Irrigation Scheduling & Crop water Stress using Remote sensing & GIS, Lamber Publication
2. Majumdar. 2018. Irrigation Water Management. PHI Learning Private Limited.

Web links:

1. https://ebook.icar.org.in/index.php/bookprocess/pgengg_list#Crop%20Environmental%20Engineering
2. https://www.scientificpubonline.com/bookdetail/crop-environmental-engineering/9789390749454/40

Dryland Technology

Course Code: 246AE010

UNIT-I:
Land Development
Land shaping and land development for soil moisture conservation. Improvement of tillage and soil management by implements and engineering practices.

UNIT-II:
Soil and Moisture Conservation
Soil and moisture conservation for rainfed lands through improved implements and engineering practices.

UNIT-III:
Water Harvesting
Water harvesting-microcatchments, their types and design; recycling of runoff water for better utilization. Crops and cropping practices related to soil and moisture conservation. Fertility management in dry land farming.

UNIT-IV:
Development of Watershed
Planning and development of watersheds from engineering view point-case studies.

UNIT-V:
Application of Remote Sensing
Application of aerial photography in surveys and planning of watersheds for rainfed agriculture. Use of Remote Sensing in soil moisture estimation.

Text Books:

1. Singh, R.V. 2003. Watershed Planning and Management. Second Edition. Yash Publishing House, Bikaner.
2. Murty, V .V. N. 1998. Land and Water Management Engineering. 2nd Ed. Kalyani Publishers Ludhiana.

Reference Book:

1. Singh, Gurmel. Manual of Soil Water Conservation Practices in India.
2. Somani, L. L. (2004). Dryland Agriculture in India. Agrotech Publisher, Udaipur.

Web links:

1. https://agritech.tnau.ac.in/agriculture/agri_majorareas_dryland_drylandtechnologies.html
2. https://www.icrisat.org/dryland-academy

Agricultural Drainage Systems

Course Code: 246AE011

UNIT-I:
Applications of Drainage Systems
Theories and applications of surface and sub-surface drainage, steady state, unsteady state drainage equations for layered and non-layered soils, horizontal sub-surface drainage.

UNIT-II:
Applications of Drainage Equations
Principle and applications of Ernst, Glover Dumm, Kraijenhoff-van –deleur equations.

UNIT-III:
Salt Balance
Salt balance, leaching requirement and management practices under drained conditions.

UNIT-IV:
Design of Sub-Surface Drainage Systems
Design of different components of sub-surface drainage systems, theories of vertical drainage and multiple well point system.

UNIT-V:
Disposal systems
Disposal of drainage effluents, Management of drainage projects of water-logged land saline soils, case studies.

Text Books:

1. Ritzema HP.(Ed.) 1994. Drainage Principles and Applications. ILRI
2. Roe CE 1966. Engineering for Agricultural Drainage. Mc Graw Hill.

Reference Book:

1. Bhattacharaya AK & Michael AM.2003. Land Drainage..Vikas Publ.
2. Clande Ayres & Daniel Scoates A.E. 1989. Level Drainage and Reclamation. Mc.Graw Hill.

Web links:

1. http://ecoursesonline.iasri.res.in/course/view.php?id=550
2. https://nptel.ac.in/courses/126105010

Fruits & Vegetables Process Engineering

Course code: 246AE012

Unit-I:
Unit operations
Fruits and vegetables -Washing fruits and vegetables; scalding and blanching; peeling fruits and vegetables for processing; object of grading; effect of variety and maturity; effect of temperature; grading for quality; size grading fruits and vegetables.

Unit-II:
Canning process
Introduction to quality control; Canning and preparation of syrup for canning; syruping machine; brines and brining; object of exhausting; relation of temperature of exhausting to degree of vacuum; measuring vacuum; type of exhaust boxes; filling cans and vapour sealing principles of processing of canned fruits and vegetables; theoretical and practical processing times.

Unit-III:
Processing equipment
Introduction to processing methods and equipment; flow diagram of canning for apples; cherries; grapes; pears; plums; orange; pineapples canned dried fruits and vegetable; raw products canning; flow charts for green beans, carrots, corn, lime, beans, peas, tomatoes and spinach; spoilage of canned foods; discoloration, corrosion and perforation of the plate.

Unit-IV:
Drying and dehydration
Introduction to micro-organisms causing spoilage. Sun drying - Sun drying of fruits, equipment for sun drying. Dehydration - Dehydration of fruits such as apples, bananas, cherries; dehydration of vegetables. Introduction to pickling -Types of pickles; introduction to flow diagram for production of pickles of cucumber, onion etc.

Unit-V:
Freezing
Freezing - Physical changes during freezing and thawing, rates of cooling and freezing; methods of freezing; storage temperature; use of sulphur dioxide in frozen pack fruits; ascorbic and citric acids; brief description for freezing of fruits and vegetables such as apples, apricots, grapes, mangoes, peaches, cherries, pineapple, fruit juices concentrates, cauliflower, carrot, peas, tomatoes and potato, types of freezers.

Text Books:
1. Barrett MJ, Somogyi L &Ramoswamy H. 2005. Processing Fruits- Science and Technology. Francis and Taylor, CRC press.
2. Cruess, W.V.2000.Commercial Fruit and Vegetable Products. McGraw Hills Book Company, Inc., New York.
Reference Books:
1. Girdhari Lal &Tandon, G. L. 1986. Preservation of Fruits and Vegetables Published by Publications and Information Division, ICAR, New Delhi-12.

2. Sun Da Wen. 2006. Handbook of Frozen Food Processing and Packaging. Francis and Taylor, CRC press.

Web Links:

1. https://ecoursesonline.iasri.res.in/mod/page/view.php?id=123997
2. https://archive.nptel.ac.in/courses/126/105/126105023/

Transport Phenomena in Food Processing

Course Code: 246AE013

Unit-I:
Conduction
Introduction to heat and mass transfer and their analogous behaviour, steady and unsteady state heat conduction, analytical and numerical solution of unsteady state heat conduction equations, use of Gurnie-Lurie and Heisler Charts in solving heat conduction problems.

Unit-II:
Convection
Convective heat transfer in food processing systems involving laminar and turbulent flow, Convective heat transfer – flow over flat plate - forced & natural convection, flow over cylinder - forced & natural convection; flow over spheres - forced & natural convection, laminar vs. turbulent flow.

Unit-III:
Radiation
Radiation heat transfer and its governing laws, its applications in food processing. Molecular diffusion in gases, liquids and solids.

Unit-IV:
Mass Transfer
Molecular diffusion in biological solutions and suspensions molecular diffusion in solids, unsteady state mass transfer and mass transfer coefficients.

Unit-V:
Diffusion of gases
Molecular diffusion with convection and chemical reaction, diffusion of gases in porous solids and capillaries, mass transfer applications in food processing.

Text Books
1. Earle RL. 1985. Unit Operations in Food Processing. Pergamon Press.
2. Geankoplis J Christie 1999. Transport Process and Unit Operations. Allyn& Bacon.
3. Holman JP. 1992. Heat Transfer. McGraw-Hill.
4. McCabe WL & Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill.
Reference Books:
1. Pitts DR& Sisson LE. 1988. Theory and Problems of Heat Transfer. Ms Graw Hill.
2. Yanniotis S. 2007. Solving Problems in Food Engineering. Springer.
Web Links:
1.https://books.google.co.in/books/about/Transport_Phenomena_in_Food_Processing.html?id=DGPLBQAAQBAJ&redir_esc=y
2.https://www.taylorfrancis.com/books/edit/10.1201/9781420006261/transport-phenomena-food-processing-jorge-velez-ruiz-jorge-welti-chanes

Food Processing Equipment Design

Course code: 246AE014

Unit-I:
Material of construction
Choice of materials, physical and economic factors, generalized properties and fields of application of different metals such as ferrous metals and non-ferrous metals.

Unit-II:
Steel
Steel and their uses; alloy steel; non-ferrous metal and their alloys; generalized properties and field of application of non-metals.

Unit-III:
Pipe line
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. Sizing process lines; piping specifications; piping layout and arrangement; pipe insulation and installation.

Unit-IV:
Vessels and storage tanks
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.

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

Text Books:
1. Joshi MV. 1981. Process Equipment Design. Macmillan India Ltd., New Delhi
2. Rase HF& Barrow MH. 1967. Project Engineering of Processing Plants. John Wiley & Sons Inc., New York. Ch. 2, 3, 5, 12, 13, 14, 18, 20 and 21.
3. Foust AS & others 2001. Principle of Unit Operations, John Willey and Sons INC., New York.
Reference Books:
1. Sinnott RK. 1983. Chemical Engineering and Introduction to Chemical Engineering Design Vol VI, Pergamon Press, Oxford.
2. Soares C. 2002. Process Engineering Equipment Handbook. McGraw Hills.
Web Links
1. https://onlinelibrary.wiley.com/doi/book/10.1002/9783527634361
2. https://ecoursesonline.iasri.res.in/mod/page/view.php?id=124495

Advances in Food Processing

Course code: 246AE015

Unit-I:
Preservation
Preservation of foods – Physical and chemical methods-microbiological aspects, thermo bacteriology, process calculation and selection, principles and application – Methods of preservation – Preservatives.

Unit-II:
Low temperature processing
Low temperature effefts - Freezing and chilling - Freezing curve theory. Cooling and cold storage - freeze concentration, Types of freezers.

Unit-III:
Non- Thermal Processing
Membrane separation, Hurdle technology - principles and applications - food irradiation - advantages and applications, microwave processing - interaction with food materials-microwave equipment.

Unit-III:
Novel Technologies
Ultra-sonification – hydrostatic pressure processing – equipment and effect on microorganisms – electrical resistance heating of food - heat generation, ohmic heater, heating models - pulsed electric field.

Unit-V:
Extrusion Process
Extrusion cooking - Recent developments, methods, equipment, design criteria of extruders. Influence on microorganisms and food ingredients.

Text Books:
1. Brennan JG. 2006. Food Processing Handbook. Wiley-VCH Publication.
2. Goldblith SA. I.Rey & Rothmayr WW. 1975. Freeze Drying and Advanced Food Technology. Academic Press, London.
3. Gould GW. (Ed).1996. New Methods of Food Preservation. First Edition. Blackie Academic & Professional, London.
4. Heldman DR & Lund DB. 2007. Handbook of Food Engineering. Francis and Taylor, CRC press.
Reference Books
1. Heldman DR & Lund DB.1992. Hand Book of Food Engineering. Marcel Dekker Inc. New York.
2. Leniger HA & Beverloo WA. 1975. Food Process Engineering. First Edition. D. Reidel Publishing Company, Dordrecht, Holland.
3. Riaz MN. 2000. Extruders in Food Applications. Francis and Taylor, CRC press.

Web Links

1. https://www.taylorfrancis.com/books/edit/10.1201/9781003369394/advanced-research-methods-food-processing-technologies-junaid-ahmad-malik-megh-goyal-preeti-birwal-ritesh-watharkar
2. https://books.google.co.in/books/about/Advances_in_Food_Chemistry.html?id=RZ-TEAAAQBAJ&redir_esc=y

Advances in Drying of Food Materials

Course code: 246AE016

Unit-I:
Drying Mechanism
Mechanism of moisture removal from food, feed and seed materials. Parameters of drying for various commodities and drying systems. Drying of low, medium and high moisture materials such as grains, seeds, fruits and vegetables etc.

Unit-II:
Mathematical Modelling
Mathematical modelling and stimulation of drying, Luikov's set differential equations and solution for single kernel, thin layer and deep bed drying. Semi-empirical and empirical equations, Thompson and MSU models.

Unit-III:
Dryer Equipment
Types of dryers and their applications, batch and continuous dryers, concurrent, counter flow and cross flow dryers. Sources of heat for drying, solar, biomass, electricity and fuels.

Unit-IV:
Testing of Drying Equipment
Testing of grain dryers. Special drying techniques and dryers for specific commodities; spray, drum, rotary, fluid bed and freeze dryers, their application, design and management.

Unit V:
Heat and Mass Transfer
Theoretical foundation of drying technology, heat and mass transfer in granular porous media, mathematical methods and kinetics of heat and mass transfer with phase change in porous media, drying theories, their bases and limitations as applied to food and grains, review on recent development on drying of food material, mass transfer in convective drying.

Text Books:
1. Chen Xiao Dong & Majumdar AS. 2008. Drying Technologies in Food Processing. Blackwell Publication.
2. Mujumdar AS. 1998. Advances in drying, Vol 1, Hemisphere Publishing Corp. Washington.
3. HeldmanDR& Lund DB. 2007. Handbook of Food Engineering. Francis and Taylor, CRC press.
Reference Books:
1. Singh RP & Heldman DR. 2009. Introduction to Food Engineering. Elsevier.
2. Soares C. 2002. Process Engineering in Food Engineering. McGraw Hill Publication.
Web links
1.https://books.google.co.in/books/about/Advanced_Drying_Technologies_for_Foods.html?id=GiGeDwAAQBAJ&redir_esc=y
2. https://www.intechopen.com/books/12277

Milling of Food Materials

Course code: 246AE017

Unit-I:
Milling Processes
Milling processes of major cereals, pulses and oilseeds. Design characteristics of milling equipment, 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.

Unit-II:
Grain Conditioning
Traditional and modern methods of grain milling. Equipment 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.

Unit-III:
Equipment for Rice Milling
Hand pounding, traditional and modern rice milling, dryers and their types, paddy de-huskers, 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.

Unit-IV:
Equipment for Pulse Milling
Equipment for pulse milling, and polishers, Recent developments in pre-milling 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 de-huskers. Screen analysis of flour: specific energy consumption.

Unit-V:
Equipment for Oil Extraction
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.

Text Books:

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.

Reference Books:

1. Rahman MS. 2007. Handbook of Food Preservation. Francis and Taylor, CRC press.
2. Chakravorty A, Majumdar AS &Raghavan GSV. 2003. Handbook of Post Harvest Technology. Marcel Dekker Inc.

Web Links:

1. https://www.iaom.org/publications/books/
2. https://ecoursesonline.iasri.res.in/mod/resource/view.php?id

Machine Learning for Soil and Crop Management

Course code: 246AE018

Unit-I:
Introduction to Machine Learning and Deep Learning
General Overview of Ml and Dl Applications in Agriculture; Basics of Multivariate Data Analytics.

Unit-II:
Diffuse Reflectance Spectroscopy
Basics And Applications of Diffuse Reflectance Spectroscopy for Crop And Soil; Principal Component Analysis And Regression Applications In Agriculture; Applications Of Classification And Clustering Methods In Agriculture.

Unit-III:
Proximal Soil and Crop Sensors
Use of Ml for Portable Proximal Soil and Crop Sensors; Ml and Dl for Soil and Crop Image Processing.

Unit-IV:
Applications of ML in Agriculture
Uav and Ml Applications in Agriculture; Hyperspectral Remote Sensing and Ml Applications In Agriculture.

Unit-V:
Digital Soil Mapping
Digital Soil Mapping – General Overview; Digital Soil Mapping With Continuous Variables Digital Soil Mapping With Categorical Variables.

Text Books:

1. Introduction to Multivariate Statistical Analysis in Chemometrics by Kurt Varmuza and Peter Filzmoser.
2. Using R for Digital Soil Mapping by Malone, Minasny, and McBratney.

References

1. The Elements of Statistical Learning, by Trevor Hastie, Robert Tibshirani, Jerome H. Friedman.
2. Pattern Recognition and Machine Learning, by Christopher Bishop.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc25_ag06/unit?unit=90&lesson=96
2. https://bioresourcesbioprocessing.springeropen.com/articles/10.1186/s40643-023-00710-y

Design, Operation & Evaluation of Pressurised Irrigation System

Course Code: 246AE019

Unit I:
Filtration and Fertigation Units
Filtration units, drip fertigation, Distribution uniformity of water, Pressure distribution in the system.

Unit II:
Hydraulics of Drip and Sprinkler Irrigation
Basic hydraulics of sprinkler and drip system, Pipe flow analysis, Friction losses and pressure variation, Flow in nozzles and emitters.

Unit III:
Design of Micro Irrigation Systems
Design of sprinkler drip and micro irrigation system in relation to source, soil, climate and topographical conditions, Selection of pipe sizes, pumps and power units, layout distribution, efficiency and economics, Fertilizing through sprinkler and drip system.

Unit IV:
Pressurized irrigation networks system (PINs)
Introduction to PINs, working of PINs and role of PINs in enhancing irrigation coverage and water use efficiency.

Unit V:
Cost economics of different systems, Evaluation of micro and sprinkler irrigation system.

Text Books:

1. Sivanappan, R.K. (1987). Sprinkler Irrigation. Oxford and IBH Publishing Co. New Delhi.
2. Finkel, H.J. (1983). Handbook of Irrigation Technology Vol. I CRC Press, Florida, USA.

References

1. Karmeli, D., Peri, G. and Todes, M. (1985). Irrigation Systems: Design and Operation. Oxford University Press. Captown.
2. Sivanappn, R.K. Padmakumari, O. and Kumar V. (1987). Drip Irrigation. Keerthy Publishing House Coimbature.

Web Links:
1. http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2042
2. https://www.fao.org/4/a1336e/a1336e.pdf