

COURSE STRUCTURE AND SYLLABUS FOR PHD PROGRAMME
DEPARTMENT OF AGRICULTURAL ENGINEERING AND TECHNOLOGY,
SCHOOL OF ENGINEERING AND TECHNOLOGY
NAGALAND UNIVERSITY, KOHIMA CAMPUS

Sl. No.	Course Code	Name of the Paper	Credit [L+T+P]
1	SETP01	Research Methodology	4+0+0=4
2	SETP02	Research and Publication Ethics	2+0+0=2
3	AETP01	Seminar	0+0+2=2
4	AEPEL*	Elective 1	3+0+0=3
5	AEPEL*	Elective 2	3+0+0=3
Total Credit:			14

*Elective courses			
Course Code	Course Title	L – T – P	Credits
AEP EL 01	Stochastic Hydrology	3 – 0 – 0	3
AEP EL 02	Simulation and Modelling of Soil and Water Systems	3 – 0 – 0	3
AEP EL 03	Application of Geoinformatics in Natural Resource Management	3 – 0 – 0	3
AEP EL 04	Climate Change and Impact on Water Resource	3 – 0 – 0	3
AEP EL 05	Advance Techniques in Watershed Management	3 – 0 – 0	3
AEP EL 06	Application of Computer in Agriculture	3 – 0 – 0	3
AEP EL 07	Advances in Farm Mechanization and Management	3 – 0 – 0	3
AEP EL 08	Ergonomics in Agriculture	3 – 0 – 0	3
AEP EL 09	Precision Agricultural Machinery	3 – 0 – 0	3
AEP EL 10	Instrumentation on Farm Agricultural Application	3 – 0 – 0	3
AEP EL 11	Advances in Farm Machinery and Power Engineering	3 – 0 – 0	3
AEP EL 12	Advances in Bio-Energy Resources	3 – 0 – 0	3
AEP EL 13	Energy Management and Planning in Farm Machinery	3 – 0 – 0	3
AEP EL 14	Interfacial Phenomenon of Nanomaterials	3 – 0 – 0	3
AEP EL 15	Advances Synthesis, Application, and Adaptation of Biochar	3 – 0 – 0	3
AEP EL 16	Transport Phenomena in Food Processing	3 – 0 – 0	3
AEP EL 17	Emerging Food Processing Technologies	3 – 0 – 0	3
AEP EL 18	Recent Trends in Food Product Development and Packaging	3 – 0 – 0	3
AEP EL 19	Environmental Issues in Agriculture	3 – 0 – 0	3

Ph.D Course Syllabus
Department of Agricultural Engineering and Technology

SETP01	Research Methodology (4-0-0 = 4)
Unit I:	Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research Process, Criteria of Good Research, Common Problems for Researchers
Unit II	Research Problem What is a Research Problem?, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem Research Design Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs. Principles of Experimental Designs.
Unit III	Interpretation & Report Writing Meaning of interpretation, technique of interpretation, Types and structures of research documentation; Approaches and guidelines for documenting and reporting research process and outcomes; plagiarism, software for plagiarism; scientific publication writing: elements of a scientific paper including abstract, introduction, materials & methods, results, discussion, references; publishing scientific papers - peer review process and problems, recent developments such as open access and non-blind review; ethical issues; scientific misconduct.
Unit IV	Intellectual Property Right (IPR) issues IPR introduction and origin, Basics of patents: types of patents, Indian Patent Rules and validity, International Patent Rules and validity, Necessity and advantage-disadvantage of doing Patent to an invention. patent infringement- meaning, scope, litigation, case studies and examples; Commercialization of patented innovations; licensing – outright sale, licensing, royalty; patenting by research students and scientists university/organizational rules in India and abroad, collaborative research.
References	<ol style="list-style-type: none"> 1. C. R. Kothari, Research Methodology: Methods and Techniques, New Age Publishers. 2. Krishnan Nallaperumal, Engineering Research Methodology 3. Online materials on WIPO and IPR. 4. On Being a Scientist: a Guide to Responsible Conduct in Research. (2009). Washington, D.C.: National Academies Press. 5. Gopen, G. D., & Smith, J. A. The Science of Scientific Writing. American Scientist, 78(Nov-Dec 1990), 550-558

SETP02	Research and Publication Ethics (2-0-0 = 2)
Unit I:	Philosophy and Ethics <ol style="list-style-type: none"> 1. Introduction to philosophy definition, nature and scope, branches. 2. Ethics: definition moral philosophy, nature of moral judgments and reactions.
Unit II	Scientific Conduct <ol style="list-style-type: none"> 1. Ethics with respect to science and research. 2. Intellectual honesty and research integrity. 3. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP). 4. Redundant publications duplicate and overlapping publications, salami slicing. 5. Selective reporting and misrepresentation of data.
Unit III	Publication Ethics <ol style="list-style-type: none"> 1. Publication ethics: definition, introduction and importance. 2. Best practices / standards setting initiatives and guidelines: COPE, WAME, etc. 3. Conflicts of interest. 4. Publication misconducts: 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.
Unit IV	Open Access Publishing <ol style="list-style-type: none"> 1. Open access publication and initiatives. 2. HERPA/RoMEO online resource to check publisher copyright & self-archiving policies. 3. Software tool to identify predatory publication developed by SPPU. 4. Journal finder/ journal suggestion tools viz. JANE, Elsevier Journal Finder, Springer Journal Suggested, etc.
Unit V	Publication Misconduct <ol style="list-style-type: none"> A) Group Discussions 1. Subject specific ethical issues, FFP, authorship.

	<p>2. Conflicts of interest.</p> <p>3. Complaints and appeals: examples and fraud from India and abroad.</p> <p>B) Software tools</p> <p>Use of plagiarism software line Turnitin, Urkund and other open source software tools.</p>
Unit VI	<p>Databases and Research Metrics</p> <p>A) Databases</p> <p>1. Indexing databases.</p> <p>2. Citation databases: Web of Science, Scopus, etc.</p> <p>B) Research Metrics</p> <p>1. Impact factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score.</p> <p>2. Metrics: h-index, g index, i10 index, Altmetrics,</p>
References	<ol style="list-style-type: none"> Bird, A (2006). Philosophy of Science. Routledge Macintyre, Alasdair (1967) A short History of ethics. London P. Chaddah, (2018) Ethics in Competitive Research: Do not get scooped; do not get plagiarized, ISBN: 978-9387480865 National Academy of sciences, National Academy of Engineering and Institute of Medicine (2009). On Being a scientist: A Guide to responsible Conduct in research: third Edition. National Academics Press Resnik, D.B (2011). What is ethics in research & why is it important. National Institute of Environmental health Science, 1-10. Retrieved from https://www.niehs.nih.gov/research/resources/bioethics/whatis/index.cfm Beall, J. (2012). Predatory publishers are corrupting open access. Nature, 489(7415), 179- 179. https://doi.org/10.1038/489179a Indian National Science Academy (INSA), Ethics in Science Education, Research and Governance (2019), ISBN: 978-81-939482-1-7. http://www.insaindia.res.in/pdf/Ethics_Book.pdf

AETP01	Seminar	(0-0-2 = 2)
<ol style="list-style-type: none"> Identify academic documents from the literature which are related to her/his areas of interest. Read and apprehend an academic document from the literature which is related to her/ his areas of interest. Prepare a presentation about an academic document. Give a presentation about an academic document. Prepare a technical report. 		

AEP EL 01	Stochastic Hydrology	(3-0-0 = 3)
Unit I:	Probabilistic modelling of hydrological process: data requirement, plotting position, continuous probability distribution functions, parameter estimation techniques, goodness of fit test, estimation of return period.	
Unit II	Risk and reliability concept in hydrology: Computation of risk, discrete probability distribution functions. Time series analysis and forecasting of hydrological processes.	
Unit III	Sequential generation of hydrological data, stream flow forecasting. Regional frequency analysis, analysis of low flows. Range and storage analysis	
References	<ol style="list-style-type: none"> Statistical Methods in Hydrology, C.T. Hann, East West Press, 2002. Stochastic Hydrology, P.J. Reddey, Laxmi Publication Pvt. Ltd., New Delhi, 1997. Introduction to Time Series and Forecasting, P.J. Brockwell and R.A. Davis, Springer, New York, 2002. Time Series Analysis, Forecasting and Control, G.E.P. Box, G.M. Jenkins, G.C. Reinsel and G.M. Ljung, John Wiley and Sons Inc., New Jersey, 2015. 	

AEP EL 02	Simulation and Modelling of Soil and Water Systems	(3-0-0 = 3)
Unit I:	Hydrological modeling of small watershed: introduction, physical characteristics of watersheds, instrumentation and data collection, generation of hydrologic information	
Unit II	Hydrologic simulation overview: types of mathematical models, hydrologic simulation models: classification, components, steps; Optimization models in hydrology.	
Unit III	Erosion and sediment yield: sediment yield process and modelling. Event Based Streamflow Simulation (EBSS): data needs, structure, building of EBSS models, calibration parameters, example EBSS models.	

References	<ol style="list-style-type: none"> 1. Introduction to Physical Hydrology, M.R. Hendricks, Oxford University Press, New York, 2010. 2. Hydrology of Small Watersheds, P.V. Seethapathi, D. Dutta and R.S. Kumar, TERI Press, Darbari Seth Block, New Delhi, 2008. 3. Elementary Hydrology, V.P. Singh, Prentice-Hall of India Pvt. Ltd., New Delhi, 1994. 4. Introduction to Hydrology, W. Viessman and G.L. Lewis, Prentice-Hall of India Pvt. Ltd., New Delhi, 2008. 5. Remote Sensing and its Applications, L.R.A. Narayan, University Press (India) Ltd., Hyderabad, 1999. 6. Remote Sensing in Water Resources, S.M. Ramasamy, Rawat Publications, Jaipur, 2005.
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AEP EL 03	Application of Geoinformatics in Natural Resource Management	(3-0-0 = 3)
Unit I:	Remote sensing: fundamentals, physics of remote sensing, electromagnetic radiation, interaction of ENR with atmosphere, earth surface, soils, water and vegetation.	
Unit II	Data acquisition; photographic system and imaging systems; visible, NIR, SWIR, and TIR imagery; photogrammetry: vertical photographs, photo interpretation, visual analysis, stereoscopic analysis. Digital image processing: image rectification, enhancement, classification and its accuracy	
Unit III	Geographic Information System (GIS) approach to integration of spatial and attribute data for capturing, analysis, manipulation and portrayal of natural resources; data types/ formats; integration of GIS with remote sensing and Global Positioning System	
Unit IV	Application of RS and GIS technologies in water resources and watershed management; case studies	
References	<ol style="list-style-type: none"> 1. Remote Sensing and Image Interpretation, T.M. Lillesand and R.W. Keifer, John Wiley and Sons Inc., New York, 2000. 2. Concept and Techniques of Geographic Information System, C.P. Lo and A.K.W. Yeung, PHI Learning Pvt. Ltd., 2002. 3. Remote Sensing in Water Resources, Ramasamy SM, Rawat Publication, 2005. 4. Fundamentals of Geographic Information System, M.N. Demers, John Willey & Sons, 2005. 5. Remote Sensing and its Applications, L.R.A. Narayan, Universities Press, 1999. 	

AEP EL 04	Climate Change and Impact on Water Resource	(3-0-0 = 3)
Unit I:	Basic concept of climate, climate and weather, climatic classification; drivers of climate change, overview of changing climate, analysis of climate change.	
Unit II	Hydrologic system overview, global and national water budget, rainfall and temperature variability, An overview of climate change effects on water (runoff, ET, soil moisture, groundwater) and soil (sediment) resources; climate change and droughts and floods; atmospheric circulation	
Unit III	Climate forecast: GCM and RCM; overview of future climate scenarios; assessment of future water resources (surface/ groundwater/ soil moisture) status and vulnerability	
Unit IV	Application of hydrologic models in present and future resources assessment; climate change adaptation, capacity and methods analysis	
References	<ol style="list-style-type: none"> 1. Climatology - An Atmospheric Science, J.E. Oliver and J.J. Hidore, Pearson Education Inc., New Delhi, 2011. 2. IPCC and NIPCC Reports 3. Hydrology and Hydroclimatology: Principles and Applications, M. Karamouz, S. Nazif and M. Falahi, CRC Press, Florida, 2013. 	

AEP EL 05	Advance Techniques in Watershed Management	(3-0-0 = 3)
Unit I:	Concept of integrated watershed management; consequences of watershed deterioration; watershed management strategies and responses to problems	
Unit II	Farming system and production technology in watershed; use of agro-forestry in management of hilly watersheds Concept of operational watershed, national land use policy, legal and social aspects	
Unit III	Watershed modelling: scope, classification, technology and analysis, case studies Watershed planning processes, watershed and environment, monitoring and evaluation of watershed projects	

References	<ol style="list-style-type: none"> 1. Watershed Planning and Management, R.V. Singh, Yash Publishing House, Bikaner, 2000. 2. Hydrology and Soil Conservation Engineering: Including Watershed Management, G. Das, Prentice-Hall of India Learning Pvt. Ltd., New Delhi, 2008. 3. Watershed Management, V.V. Dhruva Narayana, G. Sastry and U.S. Patnaik, ICAR Publication, New Delhi, 1997. 4. Integrated Watershed Management: Principles and Practice, I.W. Heathcote, John Wiley & Sons Inc., New Jersey, 2009.
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AEP EL 06	Application of Computer in Agriculture	(3-0-0 = 3)
Unit I:	Introduction to programming and problem solving. Programming basics: loops and decisions, structures, functions, objects and classes, arrays and strings, pointers.	
Unit II	Introduction to C programming, fundamentals, structure, constants, variables, data types, expressions using operators, managing input and output operations, decision making, looping.	
Unit III	One and two dimensional arrays and strings. Function: Pass by value and pass by reference, recursion, and pointers. Visual basic.net: GUI design, controls, data handling, input and output operations, decision making. Microsoft excel: Data handling, analysis, and presentation using graphs and charts.	
Unit IV	C and visual basic programming, and spread sheet for agricultural applications: Implement matching, farm machinery design and traction analysis.	
References	<ol style="list-style-type: none"> 1. Infinity Science Press, Yashwant K, Let Us C, 2008. 2. Introduction to Programming with Visual Basic .NET, Bronson G J, Rosenthal D, Jones & Bartlett, 2005. 3. Microsoft Excel Functions & Formulas, Held B., Wordware Publishing, Inc., 2007. 	

AEP EL 07	Advances in Farm Mechanization and Management	(3-0-0 = 3)
Unit I:	Status of mechanization. Mechanization and its stages. Factor affecting mechanization.	
Unit II	Selection of power units, machine capacity, field machinery management, matching machines to create an efficient system.	
Unit III	Cost analysis of farm machinery: Valuation of machines. Identifying, monitoring and reducing machinery costs. Break-even analysis.	
Unit IV	Financing machinery, finance schemes and selection of appropriate scheme. Alternatives to ownership, contracting, hire schemes. Maintenance management. Machinery replacement.	
Unit V	Analysis and organization of various operation management programmes. Inventory control of spare parts, work study, productivity, method study, use of computer in machinery management.	
References	<ol style="list-style-type: none"> 1. Farm Machinery Selection, Investment and Management, Landers, A. Resource Management Series Farming Press, 2002. 2. Hunt, D. Farm Power and Machinery Management. Iowa State University Press, Ames., 2001. 	

AEP EL 08	Ergonomics in Agriculture	(3-0-0 = 3)
Unit I:	Tractor hazards such as instability, runover, power-take-off (PTO), etc.; machinery hazards; respiratory hazards in structure and environment; chemical and other hazards.	
Unit II	Definition and causes of accident; severity of injury; effect of season, workplace, age, working time etc.; agricultural injury picture.	
Unit III	Occupational safety and health principles in agriculture; Hazards and injury prevention and control: industrial safety and health approach, public health approach.	
Unit IV	Safety engineering principles; Hierarchy hazard control; roll over protective structure (ROPS); warning sign and warning labels; machine guarding.	
Unit V	Provincial, national and international regulations and legislation for prevention of accidents; injury compensation.	

References	<ol style="list-style-type: none"> 1 Safety and Health for Production Agriculture, Murphy, 1st edition ,D.J., ASAE publication, 1992. 2 System Safety Engineering and Management ,Roland, Harold E. and Moriarty, Brian, John Wiley and Sons, Inc., USA,1990. 3 Safety Engineering, CoVan, James, Wiley, New York. 1995.
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AEP EL 09	Precision Agricultural Machinery (3-0-0 = 3)
Unit I:	Basics of precision agriculture, tools for implementation of precision agriculture. Information Technology. Spatial location, GPS, computer vision systems, information acquisition.
Unit II	Site-specific nutrient management, data sources and decision making for site-specific nutrient management. Economic, ecological and social impacts of site-specific nutrient management. Grain quality and yield.
Unit III	Site-specific weed management, weed distribution, stability of weed populations, weed monitoring and control. Site-specific herbicide application. Agro-chemicals and fertilisers, patch spraying.
Unit IV	Use of microprocessor based systems and computer in precision agriculture, Automation.
Unit V	Crop yield monitors. Decision support systems; artificial intelligence. Remote sensing for precision agriculture. Field plot machines.
References	<ol style="list-style-type: none"> 1. The Precision Farming Guide for Agriculturists, Ess, D., Morgan, M. and Reynolds, R. John Deere Publishing. USA. 1997. 2. Precision Agriculture for Grain Production Systems, Whelan B, Taylor J, , Csiro Publishing, 2013. 3. Precision Agriculture Technology for Crop Farming, Zhang Q., CRC Press, 2016.

AEP EL 10	Instrumentation on Farm Agricultural Application (3-0-0 = 3)
Unit I:	Generalized configuration, structure and functional description of measuring instruments. Active and passive transducer, analogue and digital mode of operation, null and deflection method.
Unit II	Performance characteristics of instruments including static and dynamic. Transfer function, signals and noise. Static and dynamic errors, and their statistical analysis.
Unit III	Measuring devices for temperature, displacement, stress, strain, force, pressure, velocity, torque, acceleration, moisture content, noise, vibration etc.
Unit IV	Signal conditioning elements: Deflection bridges, amplifiers etc. Signal processing elements and software: Analogue-to-digital (A/D) conversion, and digital-to-analogue conversion (D/A).
Unit V	Data acquisition, manipulating, compiling and compensating devices. Data transmission and recording. Telemetry.
References	<ol style="list-style-type: none"> 1. Principles of Measurement Systems Bentley J P, Pearson Education Limited, England. , 2005. 2. Measurement Systems: Application and Design, Doebelin, E.O. McGraw Hill Co., New York., 1980.

AEP EL 11	Advances in Farm Machinery and Power Engineering (3-0-0 = 3)
Unit I:	Farm machinery system, its characteristics and evaluation. Identification of dynamic characteristics of related components of engine and agricultural machines. Mechanism of dynamic elements and analysis of forces, displacement and their equilibrium in machines.
Unit II	Statement and formulation of design problems. Computer-aided design of mechanical power transmission systems. Half interval search method. Single and double-tie-rod steering systems, development of mathematical models and its computer-aided solutions.
Unit III	Analysis of forces in tractor implement combinations under two and three dimensional conditions. Vibrations, transmissibility and effect of damping on various agricultural machine systems like engine, cutter-bar, straw walker, threshing cylinder and reaper- binder.
Unit IV	Application of various vibration analysis methods. Tractor dynamics; development of the model. Checking, interpretation and statistical analysis of results.

References	<ol style="list-style-type: none"> 1. Bevan T. 1962. The Theory of Machines. Longman. 2. Close CM, Fredrick DK & Newwell IC. 2001. Modelling and Analysis of Dynamic System. John Wiley & Sons. 3. Franklin GF & Powell JD. 1980. Digital Control of Dynamic System. Addison Wesley Publ. 4. Kepner RA, Bainer R & Berger EL. 1978. Principles of Farm Machinery. AVI Publ. 5. Mabie HH & Ocirk FW. 1987. Mechanism and Dynamics of Machinery. John Wiley & Sons. 6. Shigley JE & Uicker JJ .1980. Theory of Machinery and Mechanism. McGraw Hill.
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AEP EL 12	Advances in Bio-Energy Resources (3-0-0 = 3)
Unit I:	Biomass resource assessment, properties of biomass, different energy conversion methods: combustion, gasification, pyrolysis, liquification, biomass pre-treatment and processing.
Unit II	Biofuel: Introduction, sources and comparison of different types of biofuel. Solid, liquid and gaseous biofuels. Economics of different biofuel sources with non-renewable sources
Unit III	Biodiesel: Scope, sources, merits and demerits, cultivation practices of different sources of biodiesel. Physical and chemical properties of raw bio-diesel. Extraction, refining processes.
Unit IV	Design of bio-fuel production units: design of gasifiers, gas flow rates, biogas plants. Establishment of esterification plant, fuel blending.
References	<ol style="list-style-type: none"> 1. Bio-diesel: Basics and Beyond: A comprehensive guide to production and use for Home and Farm. Kemp, William H. New Society Publishing, Canada. , 2006. 2. Biodiesel Production Technologies Mehla,, S.K., Eastern Book Corporation, New Delhi., 2007. 3. Biofuels: Production, Application and Development Scragg , A H,, CABI, 2009. 4. Biomass Gasification and Pyrolysis: Practical Design and Theory, Basu P., Academic press, 2010

AEP EL 13	Energy Management and Planning in Farm Machinery (3-0-0 = 3)
Unit I:	Human, animal, mechanical energy sources, fuel: solid, liquid, gaseous, crop production energy, plantation, rained, irrigated, tractor owned, bullock frames, crop rotation and energy needs, agro industries/ processing and energy needs, animal raising, domestic purpose, emerge requirements.
Unit II	Energy use patterns, different categories of farmers, resource use pattern, input/ output ratio, energy inflow in village ecosystem, self- sufficiency in energy, system planning for energy conservation,
Unit III	Questionnaire and contact procedures for survey, field survey, Yardstick for energy resource analysis and conservation efficiency, reliability and availability , Economics, study on energy needs for household, energy budgeting for crop reduction, energy in – flow, out flow in a typical village.
Unit IV	Energy audit in agro- processing industries like rice mill, oil mill, poultry, dairy etc. Integrated energy system, scope, planning and design of energy, modeling, project preparation strategies, socioeconomic and environmental aspect of energy management. Rural and urban energy planning waste heat recovery. Co-generation with alternate energy system.
References	<ol style="list-style-type: none"> 1. Turner, W.C. (1997). Energy, management Handbook. Fairmont Press. 2. Brookfield, V.T. (1996), Energy Environment and the Economy: Asian Perspectives Edward Elgar Publishing 3. Grubb, M and Walkar. J. (1992). Emerging Energy Technologies: Impact and Policy Implication. Dartmouth Pub. 4. Fowlerm J, H, (1975). Energy and the Environment. McGraw, Hill.

AEP EL 14	Interfacial Phenomenon of Nanomaterials(3-0-0-3)
Unit I:	Fundamentals of Nanomaterials: Introduction to nanomaterials; Terminology and size distribution; DLVO theory and van der Waal forces.
Unit II	Electrokinetics and Colloid Stability: Development of electrostatic surface charges and double layer theories; Electrokinetic phenomena: Streaming potential, electrophoresis; Colloid stability and coagulation phenomena.
Unit III	Surface Tension and Adsorption: Surface tension, capillary rise, equations of Kelvin, Young, and Laplace; Adsorption from solution, spread monolayers, surface pressure, Langmuir trough.

Unit IV	Measurement Techniques and Applications: Measurement techniques for nano-size materials: Light scattering, sedimentation, electrophoresis, surface tension; Applications in environmental fate and transport of contaminants.
References	<ol style="list-style-type: none"> Hiemenz, P.C., Rajagopalan, R. 1997. Principles of colloid and surface chemistry, Marcel Dekker, Inc. New York, USA, 3rd Ed. Elimelech, M., Gregory, J., Jia, X., Williams, R.A. 1995. Particle deposition & aggregation: measurement, modeling and simulation, Butterworth-Heinemann, Woburn, USA. Israelachvili, J.N. 2011. Intermolecular and surface forces, Academic Press, Waltham, MA, USA, 3rd Ed. Birdi, K.S. 2010. Surface and colloid chemistry, principles and applications, CRC Press, Taylor & Francis Group, Boca Raton, FL, USA. Varadan, V.K., Pillai, A.S., Mukherjee, D., Dwivedi, M., Chen, L. 2010. Nanoscience and nanotechnology in engineering, World Scientific, New Jersey, USA.

AEP EL 15	Advances Synthesis, Application, and Adaptation of Biochar(3-0-0-3)
Unit I:	Fundamentals of Biochar Synthesis: Introduction to biochar, Definition, historical context, and importance; Biomass feedstocks and their selection criteria for biochar production; Pyrolysis, hydrothermal carbonization, and other synthesis methods; Factors influencing biochar properties and quality assurance.
Unit II	Biochar Applications in Agriculture and Environmental Remediation: Soil amendment properties of biochar and its impact on soil health; Biochar as a tool for carbon sequestration, climate change mitigation, and soil fertility enhancement; Applications of biochar in phytoremediation and contaminated land restoration; Case studies and practical applications in agriculture and environmental management.
Unit III	Adaptation Strategies for Biochar Technology: Socio-economic factors influencing the adoption of biochar technology; Geographical considerations and regional variations in biochar application; Integration of biochar with local agricultural practices and waste management systems; Community engagement and participatory approaches in biochar utilization.
Unit IV	Advanced Topics in Biochar Technology and Adaptation: Characterization techniques for biochar analysis and quality assessment; Innovations in biochar synthesis and modification for specific applications; Policy frameworks and regulatory aspects governing biochar utilization; Future directions and emerging trends in biochar technology and adaptation
References	<ol style="list-style-type: none"> Lehmann, J., & Joseph, S. (2015). Biochar for Environmental Management: Science, Technology, and Implementation. Routledge, London. ISBN: 9780203762264 Ok, Y.S. et al. (2016). Biochar: Production, Characterization, and Applications. Routledge, London. ISBN 9780367658762

AEP EL 16	Transport Phenomena in Food Processing(3-0-0-3)
Unit I:	Transport processes and flux equations: Overall mass balance, energy balance, special mass balance, momentum balance, diffusive and convective transport, equations for fluxes, equation of continuity and equation of motion.
Unit II	Momentum Transport: Viscosity and the mechanisms of momentum transport, shell momentum balances and velocity distributions in laminar flow for Newtonian and non Newtonian fluids, velocity distributions with more than one independent variable. Fluid flow through porous beds, permeability and Darcy's law, Kozeny- Karman equation, fluidization.
Unit III	Diffusive heat transfer and mass transfer: Diffusive heat/mass transfer in steady/unsteady and one/multiple dimensions, mass transfer with chemical reaction, moving boundary problems, simultaneous heat and mass transfer, analytical solutions to problems of diffusive transport viz. heating, drying, freezing.
Unit IV	Convective heat transfer and mass transfer: Flow inside ducts, dispersion, laminar boundary layers, mass transfer with chemical reactions, simultaneous momentum, heat and mass transfer, natural convection.
Unit V	Multicomponent transport: Binary systems, multi-component flux equations, mass transport in food processing operations such as osmotic dehydration, dimensional analysis. Analytical and Approximate Methods in Transport Phenomena: Governing equations and boundary conditions in Transport processes, application of methods of (i) separation of variable (ii) variation of parameters and (iii) Laplace transform to solve transport problems in food processing.
References	<ol style="list-style-type: none"> Geankoplis, C. J. Transport processes and separation process principles, Prentice Hall of India, New Delhi, 2003. Datta, A. K. Transport Phenomena in Food Processing Engineering, Himalaya Publishing House, 2001. Rao, M. A., Rizvi, S. S. H. and Datta A.K. Engineering Properties of Foods, CRC Press, 2005.

AEP EL 17	Emerging Food Processing Technologies(3-0-0-3)
Unit I:	High Pressure Processing: Principles of high pressure processing, use of high pressure to improve food safety and stability. Effects of high pressure on food quality: Pressure effects on microorganisms, enzyme, texture and nutrients of food. Modelling HP processes. Other applications of high pressure processing.
Unit II	Pulsed electric fields processing: Historical background, PEF treatment systems, main processing parameters. Mechanisms of action: mechanisms of microbial and enzyme inactivation. PEF for processing of liquid foods and beverages, PEF Processing for solid foods. Food safety aspects of pulsed electric fields. Pulsed electric field and high pressure processing.
Unit III	Osmotic dehydration: mechanism of osmotic dehydration, effect of process parameters on mass transfer, determination of moisture and solid diffusion coefficient, application of osmotic dehydration. A thermal membrane concentration of liquid foods and colours: osmotic membrane distillation, direct osmosis, membrane modules, Applications of membrane concentration.
Unit IV	Processing by radio frequency electric fields: radio frequency electric fields equipments, RFEF non-thermal inactivation of yeasts, bacteria and spores, electrical costs. Ultrasound processing: fundamentals of ultrasound, ultrasound as a food preservation and processing aid, effects of ultrasound on food properties. Alternate thermal processing: Microwave heating: dielectric properties of foods, heat and mass transfer in microwave processing, application of microwave processing for foods.
Unit V	Radiofrequency processing: dielectric heating, material properties, radio-frequency heating and drying applications; Ohmic heating: Fundamentals of ohmic heating, electrical conductivity, modeling, treatment of products. Hybrid drying technologies: combined microwave vacuum drying, combining microwave vacuum drying with other processes, equipment for microwave vacuum drying, product quality degradation during dehydration.
References	<ol style="list-style-type: none"> 1. Sun, D. Emerging Technologies for Food Processing, Academic Press, 2005. 2. Barbosa-Canovas, G. V., Tapia, M.S. and Cano, M.P. Novel Food Processing Technologies, CRC Press, 2004. 3. Ohlsson, T. and Bengtsson, N. Minimal Processing technologies in the food industry, Woodhead Publishing Limited, 2002.

AEP EL 18	Recent Trends in Food Product Development and Packaging(3-0-0-3)
Unit I:	Innovation product development: Concept, generation of ideas. Desk Research. Screening/appraisal of initial ideas. Detailed study of product, process and market, Planning and developmental activities and evaluating them. Development of prototype product and its testing for acceptance. Development of process and planning for production trials.
Unit II	Market planning: Planning the test market. Evaluation of test results. Launching of the product. Advertising and marketing plans. Introduction to Consumer Survey, market Survey. Detailed feasibility analysis.
Unit III	Novel Food Packaging: Active and intelligent packaging: An introduction; Oxygen, ethylene and other scavengers; Antimicrobial food packaging; Non-migratory bioactive polymers (NMBP) in food packaging; Time-temperature indicators (TTIs); The use of freshness indicators in packaging; Packaging-flavour interactions; Moisture regulation.
Unit IV	Developments in modified atmosphere packaging (MAP): Novel MAP applications for fresh-prepared produce; MAP, product safety and nutritional quality; Reducing pathogen risks in MAP-prepared produce; Detecting leaks in modified atmosphere packaging.
Unit V	Optimizing packaging; Legislative issues relating to active and intelligent packaging; Recycling packaging materials; Green plastics for food packaging; Integrating intelligent packaging, storage and distribution; Testing consumer responses to new packaging concepts.
References	<ol style="list-style-type: none"> 1. Ahvenainen, R. Novel food packaging techniques, Elsevier, 2003. 2. Hu, R. Food Product Design A Computer-Aided Statistical Approach, Technomic Publishers, 2005. 3. Moskowitz, H.R., Saguy, S. and Straus, T. An Integrated Approach to New Food Product Development, CRC Press, 2006.

AEP EL 19	Environmental Issues in Agriculture (3-0-0-3)
Unit I:	Introduction Environment Protection: Needs, causes, and perspectives; Environmental Movement in India and abroad; Major issues in India; Green house gas; Water, Air & Land pollution; Deforestation, GAP.
Unit II	Food and the environment Policies, Agencies & Legislations Sanitary and Phytosanitary (SPS) measures; FAO and WTO Guidelines; International and Indian policies, agencies and regulation mechanism for Agriculture, Food and Processed Food; Operation of Eco-mark Scheme of Govt. of India; BIS; EPA; CPCB; Environmental Jurisprudence

<u>Unit III</u>	Wastewater Management Waste water- Sources, nature and characteristics, Estimation of waste water flow rate and fluctuations, Estimation of storm water, Analysis of waste water-determination of BOD, COD, Solids and volatile solids and their significance, BOD progression and its formulations, Design of waste water treatment systems - Primary, secondary and tertiary treatments, screens, grit chambers, sedimentation tanks, chemical precipitation, Biological treatment objectives, methods and design of activated sludge and trickling filter units, sludge-its treatment, disposal and reuse, Effluent standards and disposal
<u>Unit IV</u>	Biofuels and Energy Security Energy security- concept, components and policies, competitiveness of energy security, alternative sources of energy, renewable sources of energy, present scenario of renewable sources of energy, social development and environmental sustainability of renewable sources of energy, biomass resources and potential.
<u>References</u>	<ol style="list-style-type: none"> 1. Arvind Kumar: Environmental Issues and Solution; Daya Publishing House Daya 2. Tamar Adler and Alice Waters: An Everlasting Meal: Cooking with Economy and Grace. 3. Joseph E. Stiglitz: Globalization and Its Discontents: W. W. Norton & Company 4. Roger Scruton: Green Philosophy: How to Think Seriously About the Planet. Atlantic publications 5. Alison Hope Alkon (Editor), Julian Agyeman: Cultivating Food Justice: Race, Class, and Sustainability: MIT Press