Course code	**FMPE 501**
Course title	**Design of farm power and machinery systems**
Course credit	**3+1**
Objective of Course	• To develop knowledge and skill for technical education and research in design of farm power and machinery. • To develop the ability of the students for formulating and solving solutions to problems pertaining to farm machinery design. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Modern trends, principles, procedures, fundamentals and economic considerations for design and development of farm power and machinery systems. Design considerations, procedure and their applications in agricultural tractors & typical machines. Reliability criteria in design and its application. UNIT II Analytical design considerations of linkages/ components in farm machinery and its application. UNIT III Design of selected farm equipment: – tillage, seeding, planting, intercultural, plant protection, harvesting and threshing. Design of rotary, vibrating and oscillating machines. UNIT IV Design and selection of matching power unit. UNIT V Safety devices for tractors & farm implements. **Practical** Statement and formulation of design problems. Design of farm power systems. Design of mechanisms & prototypes in farm machinery.
References:	• Arther W Judge 1967. *High Speed Diesel Engines*. Chapman & Hall. • Barger EL, Liljedahl JB & McKibben EC 1967. *Tractors and their Power Units*. Wiley Eastern. • Bernacki C, Haman J & Kanafajski CZ.1972. *Agricultural Machines.* Oxford & IBH. • Bindra OS & Singh Harcharan 1971. *Pesticides Application Equipments* Oxford & IBH. • Bosoi ES, Verniaev OV & Sultan-Shakh EG. 1990. *Theory, Construction and Calculations of Agricultural Machinery.* Vol. I. Oxonian Press. • Klenin NI, Popov IF & Sakoon VA. 1987. *Agricultural Machines. Theory of Operations, Computing and Controlling Parameters and the Condition of Operation.* Amrind Publ. • Lal R & Dutta PC. 1979.*Agricultural Engineering* (through solved examples). Saroj Parkashan. • Maleev VL. 1945. *Internal Combustion Engines*. McGraw

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<tr><td></td><td>Hill.
● Mathur ML & Sharma RP. 1988.A Course in Internal Combustion Engines. Dhanpat Rai & Sons.
● Ralph Alcock.1986. Tractor Implements System. AVI Publ.
● Raymond N, Yong Ezzat A & Nicolas Skiadas 1984.Vehicle Traction Mechanics.
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● Theory and Construction. Vol. I. U.S. Dept. of Commerce, National Technical Information Service, Springfield, Virginia.
● Thornhill EW & Matthews GA. 1995. Pesticide Application Equipment forUse in Agriculture. Vol. II. Mechanically Powered Equipment. FAO Rome
● William. R Gill & Glen E Vanden Berg. 1968. Soil Dynamics in Tillage and Traction. US Govt. Printing Office, Washington, D.C.
● Yatsuk EP.1981. Rotary Soil Working Machines Construction, Calculation and Design. American Publ. Co</td></tr>
<tr><td>Course Outcomes</td><td>At the end of the course, learners will be able
CO1: To acquaint and equip with the principles, fundamentals and economic considerations for design and development of farm power and machinery systems.
CO2: Acquire knowledge on farm implements design considerations.
CO3: To design components and farm equipment.
CO4: To solve the analytical problems related to the matching power unit.
CO5:To get acquaint with safety devices for tractors and farm implements</td></tr>
<tr><td colspan="2">Mapping between Cos, POs and PSOs
<table>
<tr><th rowspan="2">CO</th><th colspan="12">PO</th><th colspan="3">PSO</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Course code	**FMPE 502**
Course title	**Soil dynamics in tillage and traction**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill for technical education and research in soil dynamics. • To develop the ability of the students for formulating and solving solutions to problems pertaining to soil dynamics. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Dynamic properties of soil and their measurement, stress-strain relationships, theory of soil failure. UNIT II Mechanics of tillage tools and geometry of soil tool system, design parameters and performance of tillage tools. UNIT III Dimensional analysis of different variables related to soil-tyre system; soil vehicle models; mechanics of steering of farm tractor; special problems ofwet land traction and floatation. UNIT IV Introduction of traction devices, tyres-types, function & size, their selection; mechanics of traction devices. Deflection between traction devices and soil, slippage and sinkage of wheels, evaluation and prediction of traction performance, design of traction and transport devices. Soil compaction by agricultural vehicles and machines. **Practical** Relationship of soil parameters to the forces acting on tillage tools, wheel slippage and tyre selection, design and performance of traction devices and soil working tools.
References:	• Daniel Hill. 1962. *Fundamentals of Soil Physics*. Academic Press. • Gill & Vandenberg.1968. *Soil Dynamics in Tillage and Traction*. Supdt. of Documents, U.S. Govt. Printing Office, Washington, D.C. • Sineokov GN. 1965.*Design of Soil Tillage Machines*. INSDOC, New Delhi. • Terzaghi K & Peck Ralph B.1967.*Soil Mechanics in Engineering Practices*. John Wiley & Sons.
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with the principles of dynamic properties of soil and its effect on soil tyre performance. **CO2:** Acquire knowledge on basics of soil failure and tillage tool design **CO3**: Understand the application of dimensional analysis to soil dynamics problems. **CO4**: To solve the analytical problems related to the soil dynamics.

	CO5:To predict the traction performance of the tyre.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 503**
Course title	**Testing and evaluation of tractors and farm equipment**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill for technical education and research in testing of farm power and machinery. • To develop the ability of the students for formulating and solving solutions to problems pertaining to farm power and machinery testing. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Types of tests; test procedure, national and international codes. UNIT II Test equipment; usage and limitations. Power losses in dynamometers and hydraulic test equipment. UNIT III Prototype feasibility testing and field evaluation. Laboratory and field testing of selected farm equipment. Non-destructive testing techniques UNIT IV Tractor performance testing, evaluation and interpretation of results. UNIT V Review and interpretation of test reports. Case studies **Practical** Laboratory and field-testing of selected farm equipment. Interpretation and reporting of test results. Material testing and its chemical composition. Accelerated testing of fast wearing components. Non-destructive testing techniques
References:	• Anonymous. 1983. *RNAM Test Code & Procedures for Farm Machinery*. Technical Series 12. • Barger EL, Liljedahl JB & McKibben EC. 1967. *Tractors and their Power Units*. Wiley Eastern. • *Indian Standard Codes for Agril. Implements*. Published by ISI, New Delhi. • Inns FM. 1986. *Selection, Testing and Evaluation of Agricultural Machines and Equipment*. FAO Service Bull. No. 115. • Lal R & Dutta PC. 1979. *Agricultural Engineering* (through solve examples). Saroj Parkashan, • Metha ML, Verma SR, Mishra SK & Sharma VK. 1995.*Testing and Evaluation of Agricultural Machinery.* National Agricultural Technology Information Centre, Ludhiana. • Nebraska Tractor Test Code for Testing Tractor, Nebraska, USA. • Smith DW, Sims BG & O'Neill D H. 2001. *Testing and Evaluation of Agricultural Machinery and Equipment* -

	Principle and Practice. FAO Agricultural Services Bull. 110
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with standards of farm power and machinery testing. **CO2:** Acquire knowledge on basics of test procedures **CO3**: Understand the working of test equipment. **CO4**: To test the selected farm equipment **CO5**:To interpret the test report.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 504**
Course title	**System simulation and computer aided problem solving in engineering**
Course credit	**1+1**
Objective of Course	• To develop knowledge and skill for technical education and research in system simulation and computer aided problem solving. • To develop the ability of the students for formulating and solving solutions to problems pertaining to farm power and machinery using computer. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Concept, advantages and limitation of dimensional analysis, dimensions and units, fundamental and derived units, systems of units, conversion of units of measurement, conversion of dimensional constants, conversion of equations in different units, complete set of dimensionless products and their formulation methods- the Rayleigh's method, Buckingham's Pi theorem and other methods. UNIT II Mathematical modelling and engineering problem solving. UNIT III Computers and softwares – software development process – Algorithm design, – program composition- quality control-documentation and maintenance – software strategy. UNIT IV Approximation- round off errors- truncation errors. Nature of simulation-systems models and simulation- discreet event simulation- time advance mechanisms- components of discreet event simulation model. Simulation of singular server que-programme organization and logic- development of algorithm UNIT V Solving differential equation on computers- modelling engineering systems with ordinary differential equations-solution techniques using computers
References:	• Averill M. Law & W David Kelton.2000. *Simulation Modeling and Analysis*. McGraw Hill. • Balagurusamy E. 2000. *Numerical Methods.* Tata McGraw Hill. • Buckingham E. 1914. *On Physical Similar System*. Physical Reviews 4:345. • Langhar H. 1951. *Dimensional Analysis and Theory of Models*. John Wiley & Sons. • Murphy J. 1950. *Similitude in Engineering*. The Roland Press Co. • Robert J Schilling & Sandra L Harries. 2002. *Applied Numerical Methods for Engineers Using MATLAB and C*.

	Thomson Asia. • Simpson OJ. 2000. *Basic Statistics*. Oxford & IBH. • Singh, RP. 2000. *Computer Application in Food Technology*. Academic Press. • Steven Chopra & Raywond Canale. 1989. *Introduction to Computing for Engineers*. McGraw Hill. • Veerarajan T & Ramachnadran T. 2004.*Numerical Methods with Programmes in C and C++*. Tata McGraw Hill. • Wilks SS. 1962. *Mathematical Statistics*. John Wiley & Sons.
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with concept of dimensional analysis. **CO2:** Acquire knowledge on basics of mathematical modeling **CO3**: Understand the simulation modeling **CO4**: To develop software for problem solving. **CO5**: To solve the engineering problems using computers.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 505**
Course title	**Applied instrumentation in farm machinery and stress analysis**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill of instruments used for technical education and research in farm power and machinery. • To develop the ability of the students to use instruments pertaining to farm power and machinery testing. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Strain and stress, strain relationship, strain gauges. Mechanical, optical, electrical acoustical and pneumatic etc. and their use. Various methods of determining strain/stresses experimentally. Measuring devices for displacement (linear and rotational), velocity, force, torque and shaft power. Strain gauges: types and their application in two and three dimensional force measurement. Design and analysis of strain gauges. UNIT II Introduction to functional elements of instruments. Active and passive transducers, Analog and digital modes, Null and deflection methods. Performance characteristics of instruments including static and dynamic characteristics. UNIT III Devices for measurement of temperature, relative humidity, pressure, sound, vibration, flow etc. Recording devices and their type. Measuring instruments for calorific value of solid, liquid, and gaseous fuels. Measurement of gas composition using GLC. UNIT IV Basic signal conditioning devices - data acquisition system - micro computers for measurement and data acquisition. Data storage and their application. **Practical** Calibration of instruments, Experiment on LVDT, strain gauge transducer, inductive and capacitive pick-ups, speed measurement using optical devices, vibration measurement exercises , making of thermocouples and their testing- basic electronic circuits and application of linear ICs.
References:	• Ambrosius EE. 1966.*Mechanical Measurement and Instruments*. The Ronald Press. • Beckwith TG. 1996. *Mechanical Measurements*. Addison-Wesley. Doeblin EO. 1966.*Measurement System - Application and Design* . McGraw Hill. • Ernest O Doebelin.1995. *Measurement Systems - Application and Design*. McGraw Hill. • Holman P 1996. *Experimental Methods for Engineers*.

	McGraw Hill. • Nachtigal CL. 1990. *Instrumentation and Control. Fundamentals and Application*. John Wiley & Sons. • Oliver FJ. 1971. Practical; Instrumentation Transducers. Hayden Book Co. Perry CC & Lissner HR.1962. *The Strain Gauge Primer*. McGraw
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with functional elements of instruments. **CO2:** Acquire knowledge on basics of stress and strain measurement. **CO3**: Understand the basics of signal conditioning devices **CO4**: Gain knowledge on measuring instruments for velocity, force, torque and shaft power **CO5**: Know devices for measurement of temperature, relative humidity, pressure, sound, vibration, flow etc

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 506**
Course title	**System engineering and productivity**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill for technical education and research in system engineering and productivity. • To develop the ability of the students for solving solutions to problems pertaining to farm power and machinery. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I System definition and concept. System engineering function, management and problems. Classification of system analysis models. Economic analysis techniques: Interest and interest estimation of single and multiple alternatives, break even analysis. UNIT II Mathematical modelling and analysis: Application of linear programming, Network theory – CPM and PERT, queuing theory and its application, assignment & transportation models and job scheduling/ allocation for the synthesis of agriculture machine systems. UNIT III Dynamic programming, Markov chains, application of forecasting in agricultural engineering systems and products. Concept utilization and mathematical formulation of the labor, equipment and material factors affecting productivity. UNIT IV Computer use in solving problems of optimization, writing of algorithms for problem solutions and decision-making. **Practical** Extensive practice on the packages mentioned in theory.
References:	• Danovan SS. 2000. *System Programming*. Tata McGraw. • Gillett G. 2001. *Introduction to Operations Research*. Tata McGraw Hill. • Grawham WJ & Vincent TL. 1993. *Modern Control System Analysis and Design*. John Wiley & Sons. • Lewis FL & Syrmos VL. 1995. *Optimum Control*. 2nd Ed. John Wiley & Sons. • Loomba D. 2000. *Linear Programming*. Tata McGraw. • Puttaswamaiah K. 2001. *Cost Benefits Analysis*. Oxford & IBH.
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with concept of system and system analysis. **CO2:** Acquire knowledge on basics of mathematical modeling and analysis **CO3**: Understand the dynamic programming and Markov chain application.

	CO4:To develop concept utilization and mathematical formulation. **CO5**:To solve the engineering optimization problems using computers.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 507**
Course title	**Farm machinery dynamics, noise & vibrations**
Course credit	**3+1**
Objective of Course	• To develop knowledge and skill for technical education and research in theoretical aspects of farm machinery. • To develop the ability of the students for understand the vibration and noise in farm power and machinery. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Principles of soil working tools: shares, discs, shovels, sweeps and blades, rota-tillers and puddlers. UNIT II Metering of seeds and granular fertilizers with various mechanism, effect of various parameters on distribution of seed and fertilizer in seed cum fertilizer drills and planters, flow of seeds and fertilizers through tubes and boots. Kinematics of trans planters. UNIT III Theory of atomization, specific energy for atomization, electrostatic spraying and dusting, spray distribution patterns. Kinematics of reapers/harvesting machines. Theory of mechanical separation of grains from ear heads/pods. Parameters affecting performance of threshers aerodynamic properties of straw and grain mixture, theory of root crop harvesters, power requirement of various components of field machines. UNIT IV Noise and vibration theory- Definition, units and parameters of measu and their importance. Types of vibrations- free and forced, in damped without damped analysis of one, two and multiple degree of freedom and their solution using Newton's motion, energy method, longitudina transverse and torsional vibrations, Raleigh's methods, Lagrange equa UNIT V Introduction of transient vibration in systems, vibration of continuous media. Balancing of single rotating weight and number of weights in same plane and different planes. Complete balancing of reciprocating parts of engine. **Practical** Study of vibration measurement and analysis equipment, Study of different vibration measurement and evaluation, Measurement and analysis of vibration on different components of thresher, combine, reaper, power tiller and tractor. Determination of modulus of elasticity, rigidity, and MI by free vibration test. Evaluation of logarithmic decrement and damping factor. Whirling of shaft. Heat motion in two pendulum system. Detailed analysis of multi- degree of freedom system.
References:	• Ballaney PL. 1974. *Theory of Machines*. Khanna Publ. • Bosoi ESO, Verniaev V, Smirnov & Sultan-Shakh EG. 1990.*Theory, Construction and Calculations of Agricultural Machinery*. Vol. I. Oxonian Press Pvt. Ltd. No.56.

- Getzlaff GE. 1993.*Comparative Studies on Standard Plough Body*. *Engineering Principles of Agricultural Machines.* ASAE Text Book No. 6.
- Grover GK. 1996. *Mechanical Vibrations*. New Chand & Bros., Roorkee.
- Harris CM & Crede CE. 1976. *Shock and Vibration Hand Book*. McGraw Hill.
- Holowenko AR. 1967. *Dynamics of Machinery*. McGraw Hill.
- Kelly SG. 2000. *Fundamental of Mechanical Vibration*. 2nd Ed. McGraw Hill.
- Kepner RA, Bainer R & Berger EL. 1978. *Principles of Farm Machinery*. AVI Publ. Co.
- Klenin NI, Popov IF & Sakoon VA. 1987. *Agricultural Machines. Theory of Operations, Computing and Controlling Parameters and the Condition of Operation*. Amrind Publ. Co.
- Marples.1969. *Dynamics of Machines*. McGraw Hill.
- Meirovitch L. 1986. *Elements of Vibration Analysis*. 2nd Ed. McGraw Hill.
- Nartov PS. 1985.*Disc Soil Working Implements*. A. A. Balkema, Rotterdam.
- Srivastav AC. 2001. *Elements of Farm Machinery*. Oxford & IBH.
- Steidal.1986. *Introduction to Mechanical Vibrations*. Wiley International & ELBS Ed.
- William T Thomson. 1993. *Theory of Vibration with Application.* Prentice Hall

Course Outcomes

At the end of the course, learners will be able

CO1: To acquaint and equip with principles of soil working tools.
CO2: Acquire knowledge on seed and fertilizer metering.
CO3: Understand the atomization.
CO4: To develop understanding on noise and vibration theory.
CO5: To learn the concept of balancing.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 508**
Course title	**Tractor design**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill for technical education and research in design of tractor. • To develop the ability of the students, understand latest design procedures of tractor and its systems • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Technical specifications of tractors available in India, modern trends in tractor design and development, special design features of tractors in relation to Indian agriculture. UNIT II Parameters affecting design of tractor engine and their selection. Design of fuel efficient engine components and tractor systems like transmission, steering, front suspension, hydraulic system & hitching, chassis, driver's seat, work-place area and controls. Tire selection UNIT III Mechanics of tractor. Computer aided design and its application in agricultural tractors **Practical** Extensive practices on the packages mentioned in the theory
References:	• Arther W Judge 1967. *High Speed Diesel Engines*. Chapman & Hall. • Barger EL, Liljedahl JB & McKibben EC. 1967. *Tractors and their Power Units*. Wiley Eastern. • Macmillan RH.*The Mechanics of Tractor - Implement Performance, Theory and Worked Example*. University of Melbourne. • Maleev VL. 1945. *Internal Combustion Engines*. McGraw Hill. • Ralph Alcock 1986. *Tractor Implements System*. AVI Publ. Co
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with the modern trends in tractor design and development. **CO2:** Acquire knowledge on parameters affecting design of tractor engine and their selection **CO3**: To design fuel efficient engine components and tractor systems. **CO4**: To know computer aided design and its application in agricultural tractors **CO5**: To get acquaint with mechanics of tractor.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															

CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 509**
Course title	**Operations research in farm power & machinery management**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill for technical education and research in operation research for farm machinery management. • To develop the ability of the students for solving solutions to problems pertaining to farm power and machinery management. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Nature, methods, impact and scope of operational research; linear programming and integer programming models and applications. Network terminology, shortest route and minimal spanning tree problems, maximal flow problem, project planning and control with PERT and CPM. UNIT II System approach in farm machinery management and application of programming techniques to the problems of farm power and machinery selection. UNIT III Maintenance and scheduling of operations. Replacement of old machines, repair and maintenance of agricultural machinery, inventory control of spare parts, work study, productivity, method study. First order Markov chains and their applications in sales forecasting and in problems of inventory control and modelling of workshop processes and quality control UNIT IV Time and motion study. Man-machine task system in farm operations, planning of work system in agriculture. Computer application in selection of power units and to optimize mechanization system. **Practical** Management problems and case studies.
References:	• Carville LA. 1980. *Selecting Farm Machinery*. Louisiana Cooperative Extn. Service Publication. • Culpin C & Claude S. 1950.*Farm Mechanization; Costs and Methods*. McGraw Hill. • Culpin C & Claude S. 1968.*Profitable Farm Mechanization*. Crosby Lockwood & Sons. • FAO. 1984.Agricultural *Engineering in Development: Selection of Mechanization Inputs*. Agricultural Service Bulletin. • Hunt D. 1977.*Farm Power and Machinery Management*. Iowa State University Press. • Waters WK. 1980.*Farm Machinery Management Guide*.

	Pennsylvania Agric. Extn. Service Spl. Circular No. 1992
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with concept of operational research. **CO2:** Acquire knowledge on basics of maintenance and scheduling of operations. **CO3**: Understand the system approach in farm machinery management. **CO4**: To get knowledge of man-machine task system. **CO5**: To solve the problems of farm power and machinery selection.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 510**
Course title	**ERGONOMICS AND SAFETY IN FARM OPERATIONS**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill of ergonomic aspects for

	technical education and research in design of farm power and machinery. • To develop the ability of the students for considering human factors in farm power and machinery design. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Concept and design criteria for optimum mutual adjustment of man and his work: Importance of ergonomics and its application in agriculture, liberation and transfer of energy in human body, concept of indirect calorimeter, work physiology in various agricultural tasks. UNIT II Physiological stress indices and their methods of measurement: Mechanical efficiency of work, fatigue and shift work. UNIT III Anthropometry and Biomechanics: Anthropometric data and measurement techniques, joint movement and method of measurement, analysis and application of anthropometric data, measurement of physical and mental capacities. UNIT IV Human limitations in relation to stresses and demands of working environments. Mechanical environment; noise and vibration and their physiological effects, thermal environment; heat stress, thermal comfort, effect on performance and behavior, field of vision, color discrimination, general guidelines for designing visual display, safety standards at work place during various farm operations and natural hazards on the farm. Farm safety legislation. UNIT V Man-machine system concept. Human factors in adjustment of man and his work. Design aspects of foot and hand controls on tractors and farm equipment. Design of operator's seat for tractors and agricultural equipment Practical Laboratory experiments on measurement of physical and mental capacities and limitations of human-being in relation to the stress and environment, anthropometric measurements, study of human response to dust, noise and vibrations, case studies on ergonomics.
References:	• Bridger RS. 1995. *Introduction to Ergonomics*. McGraw Hill. • Charles D Reese. 2001. *Accident / Incident Prevention Techniques*. Taylor & Francis. • Gavriel Salvendy. 1997.*Hand Book of Human Factors and Ergonomics*. John Wiley & Sons. • Kromer KHE. 2001. *Ergonomics*. Prentice Hall. Mathews J & Knight AA.1971. *Ergonomics in Agricultural Design*. National Institute of Agric. Engineering, Wrest Park Silsoe, Bedford.

	• Mathews J Sanders, Cormicks MS & MCEj. 1976.*Human Factors in Engineering and Design*. 4th Ed. McGraw Hill. • William D McArdle. 1991. *Exercise Physiology*.1991. Lea & Febiger. Zander J. 1972. *Principles of Ergonomics*. Elsevier. • Zander J.1972. *Ergonomics in Machine Design.* Elsevier
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with ergonomic aspects in farm power and machinery design. **CO2:** To get acquaint with physiological stress indices. **CO3**: Acquire knowledge on anthropometry and biomechanics. **CO4**: To know human limitations in relation to working environments. **CO5**: To get used to man-machine concept in designing.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 511**
Course title	**Engineering properties of biological materials**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill of measurement of engineering properties for technical education and research in biological material handling equipment. • To develop the ability of the students for considering engineering properties in farm power and machinery design. • To strengthen the knowledge among students for Industry and

	R&D organizations.
Course Content	**Theory** UNIT I Physical characteristics of different food grains, fruits and vegetables; Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology; ASTM standard, terms, physical state of materials, classical ideal material, rheological models and equations, viscoelasticity, creep-stress relaxation, Non Newtonian fluid and viscometry, rheological properties; force, deformation, stress, strain, elastic, plastic behaviour. UNIT II Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity. UNIT III Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high- frequency electric field. UNIT IV Application of engineering properties in design and operation of agricultural equipment and structures. **Practical** Determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, thermal properties like thermal conductivity, thermal diffusivity and specific heat, firmness and hardness of grain, fruits and stalk, electrical properties like dielectric constant, dielectric loss factor, loss tangent and A.C. conductivity of various food materials.
References:	• Hallstrom B, Meffert HF, Th Spesis WEL & Vos G. 1983.Physical Properties of Food. Elsevier. • Mohesenin NN. 1980. Physical Properties of Plant and Animal Materials. Gordon & Breach Science Publ. • Mohesenin NN. 1980.*Thermal Properties of Foods and Agricultural Materials*. Gordon & Breach Science Publ. • Peleg M & Bagelay EB. 1983. *Physical Properties of Foods*. AVI Publ. Co.

	• Rao MA & Rizvi SSH. (Eds.). 1986. *Engineering Properties of Foods*. Marcel Dekker. • Ronal Jowitt, Felix Escher, Bengt Hallsrram, Hans F, Th. Meffert, Walter EC Spices & Gilbert Vox. 1983. *Physical Properties of Foods*. Applied Science Publ. • Singhal OP & Samuel DVK. 2003. *Engineering Properties of Biological Materials*. Saroj Prakasan
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with physical characteristics of biological materials. **CO2:** To get acquaint with physiological stress indices. **CO3**: Acquire knowledge on thermal and electrical properties. **CO4**: To measure different properties. **CO5**: To apply engineering properties in design and operation of agricultural equipment

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 512**
Course title	**Agro-energy audit and management**
Course credit	**2+0**
Objective of Course	• To develop knowledge and skill for technical education and research in agro energy management. • To develop the ability of the students for solving solutions to problems pertaining to farm power and machinery management. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I 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. Pattern of energy consumption and their constraints in production of agriculture. Direct and indirect energy. UNIT II Energy audit of production agriculture, and rural living and scope of conservation. UNIT III 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 UNIT IV Energy conservation planning and practices. Energy forecasting, Energy economics, Energy pricing and incentives for energy conservation, factors effecting energy economics. Energy modeling.
References:	● Kennedy WJ Jr. & Wayne C Turner.1984. *Energy Management*. Prentice Hall. ● Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*. CRC ● Fluck RC & Baird CD.1984. *Agricultural Energetics*. AVI Publ. ● Rai GD. 1998. *Non-conventional Sources of Energy*. Khanna Publ. ● Twindal JW & Anthony D Wier 1986. Renewable *Energy Sources*. E & F.N Spon Ltd. ● Verma SR, Mittal JP & Surendra Singh 1994. *Energy Management and Conservation in Agricultural Production and Food Processing*. USG Publ. & Distr., Ludhiana
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with concept of agro energy. **CO2:** Acquire knowledge on basics of energy management and planning. **CO3**: Understand the energy audit and energy conservation techniques. **CO4**:To get knowledge of energy analysis techniques and methods. **CO5**:To know the techniques for energy forecasting and economics.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 513**
Course title	**Design and analysis of renewable energy conversion systems**
Course credit	**3+0**
Objective of Course	• To develop knowledge and skill for technical education and research in different energy sources. • To develop the ability of the students for solving solutions to problems pertaining to farm power and machinery management. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Energy cycle of the earth; water flow and storage; ocean currents and tides. Energy heat flow and energy storage; photosynthesis

	and biomass; renewable energy sources. UNIT II Thermodynamics of energy conversion; conversion of solar energy, wind energy, water flows, heat, biomass, etc.; other conversion processes. UNIT III Development and use of biogas, alcohols and plant oils, plant oil esters in I.C.engines. Study of various parameters for measuring the performance of the output. UNIT IV Design of bio-fuel production units: design of gasifiers, gas flow rates, bio- gas plants. Establishment of esterification plant, fuel blending
References:	• Boyle Godfrey. 1996. *Renewable Energy: Power for Sustainable Future*. Oxford Univ. Press. • Culp AW. 1991. *Principles of Energy Conservation*. Tata McGraw Hill. • Duffle JA & Beckman WA. 1991.*Solar Engineering of Thermal Processes*. John Wiley. • Garg HP & Prakash J.1997. *Solar Energy - Fundamental and Application*. Tata McGraw Hill. • Grewal NS, Ahluwalia S, Singh S & Singh G. 1997. *Hand Book of Biogas Technology. Solar Energy Fundamentals and Applications*. TMH New Delhi. • Mittal KM. 1985. *Biomass Systems: Principles & Applications*. New Age International • Odum HT & Odum EC. 1976. *Energy Basis for Man and Nature*. Tata McGraw Hill. • Rao SS & Parulekar BB.1999. *Non-conventional, Renewable and Conventional*. Khanna Publ. • Sukhatme SP.1997. *Solar Energy - Principles of Thermal Collection and Storage*. 2nd Ed. Tata McGraw Hill
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with conventional and non-conventional energy sources. **CO2:** Acquire knowledge on basics of energy from biomass. **CO3**: Understand the conversion techniques of energy from biomass. **CO4:** To prepare and assess the bio gas and bio fuels. **CO5:** To design of bio-fuel production units.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 514**
Course title	**Research methodology**
Course credit	**0+1**
Objective of Course	• To develop knowledge and skill for research. • To develop the ability of the students for solving solutions to problems through research methodology. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Practical** The research problem -literature review -types of research, experimental & quasi-experimental research-causal comparative & correlation research Survey research- sampling techniques. Optimization software – GAMES –applications, electronic spread sheet – solver. Image analysis software –applications. General computational software for research – MATLAB – applications – statistical applications, Report writing – interpretation and reporting. Scientific writing techniques. Presentation -techniques
References:	• Hamdy A Taha. 2001. *Operations Research*. Prentice Hall of India. • Holman JP 1996. *Experimental Methods for Engineers*. McGraw Hill. • Rudra Pratap. 2003. *Getting Started with MATLAB. A Quick Introduction for Scientists and Engineers*. Oxford Univ. Press.

	• Santhosh Gupta. 1979. *Research Methodology and Statistical Techniques*. Khanna Publ. • Stephen J Chapman. 2003. *MATLAB Programming for Engineers*. Eastern Press. • Steven C Chapra & Raymond P Canale. 2000. *Numerical Methods for Engineers with Programming and Software Applications*. Tata McGraw. • William J Palm. 2001. *Introduction to Matlab 6 for Engineers*. McGraw Hill
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint and equip with solving a research problem, **CO2:** Acquire knowledge on basics of optimization softwares. **CO3**: To get aware on image analysis softwares. **CO4:** To get knowledge of general computational software for research. **CO5:**To know the techniques of report and scientific writing.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 601**
Course title	**Advances in farm machinery and power engineering**
Course credit	**3+1**
Objective of Course	• To develop knowledge and skill for technical education and research in modern developments in construction, design and analysis of advanced farm machinery system. • To develop the ability of the students to use computer analysis for farm machinery design. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** 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. **Practical** Development of computer programs for Half interval search method. Single and double-tie-rod steering systems, Development of mathematical models and its computer aided solutions. Design problems using CAD.
References:	• Bevan T. 1962. The Theory of Machines. Longman.Close CM, Fredrick DK & Newwell IC. 2001. Modelling and Analysis of Dynamic System. • John Wiley & Sons.Franklin GF & Powell JD. 1980. Digital Control of Dynamic System. Addison Wesley Publ. Kepner RA, • Bainer R & Berger EL. 1978. Principles of Farm Machinery. AVI • Publ.Mabie HH & Ocrirk FW.1987. Mechanism and Dynamics of Machinery. • John Wiley & Sons.Shigley JE & Uicker JJ. 1980.Theory

	of Machinery and Mechanism. McGraw Hill
Course Outcomes	**CO1**: To aware about the advances in farm machinery systems. **CO2:** To get knowledge to formulate of design problem. **CO3**: Understand the mathematical modeling. **CO4**: Acquire knowledge on force analysis in tractor implement combinations. **CO5:** To develop models for design and analysis purpose.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 602**
Course title	**Simulation modelling in farm machinery and power engineering**

Corse credit	**2+0**
Objective of Course	• To develop knowledge and skill to do mathematical modelling of farm machinery for technical education and research. • To develop the ability of the students for developing models using various techniques pertaining to farm power and machinery using computer. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I System performance and modelling methodologies – transformation of units of measurement – dimensional homogeneity. Buckingham's Pi Theorem. Simulation for system modelling, Formulations of simulation model, validation and testing of the simulation model UNIT II Experimentation with physical models and their application in farm machinery design. Sensitivity of models, scale effects, scale factors. Use of models. Complete similarity, kinematics and dynamic similarity. Model laws, empirical methods in model engineering. Principle of similarity in mathematical investigations. Mathematical modelling and its limitations, etc. UNIT III Mathematical modelling through ordinary differential equation of first order, second order, partial differential equations. Similarity conditions and abstract parameters determining characteristics of engines. Similitude in tillage tool studies, prediction models for traction devices **Practical** Problems in simulation models & Buckingham's Pi theorem. Problems in scale effects, scale factors and mathematical modelling. Analysis of modelling behaviour in problems related to tillage, traction and earth moving equipment
References:	• Langhaar HL.1954. Dimensional Analysis and Similitude. McGraw Hill. • Sedov LI. 1991. Similarity and Dimensional Methods in Mechanics. Mir Publ., Moscow
Course Outcomes	**CO1**: To acquaint and equip with concept of dimensional analysis. **CO2:** Acquire knowledge on basics of models and model laws. **CO3**: Understand the development of mathematical modeling. **CO4**:To get knowledge to apply similitude study.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															

CO4															

Course code	**FMPE 603**
Course title	**Energy conservation and management in farm power and machinery**
Course credit	**2+0**
Objective of Course	• To develop knowledge and skill regarding energy use pattern in agriculture production systems for technical education and research. • To develop the ability of the students to take energy conservation measures in different operations in agricultural production systems. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Energy requirement of different operations in agricultural production systems viz. crop, livestock and aquaculture. UNIT II Energy conservation through proper management and maintenance of farm machinery, planning and management of agricultural production systems for energy conservation and energy returns assessment. UNIT III Development of computer program for efficient energy management in a given agricultural production system. Energy use planning and forecasting for a given system.
References:	• Mittal JP, Panesar BS, Singh S, Singh CP & Mannan KD. 1987. Energy in Production Agriculture and Food Processing. ISAE and School of Energy Studies, Ludhiana. ISAE Publ. • Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC Press.
Course Outcomes	**CO1**: To acquaint and equip with estimation of energy requirement of different operations in agricultural production systems. **CO2:** Acquire knowledge on energy conservation measures. **CO3**: To assess energy economics for agricultural production systems. **CO4**: To design integrated energy supply system. **CO5**: To develop the energy use plan and forecast energy for a given system.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 604**
Course title	**Computer aided analysis and design of farm machinery**
Course credit	**2+1**
Objective of Course	• To develop knowledge and skill for technical education and research in design of farm power and machinery using CAD. • To develop the ability of the students for design, analysis and manufacturing of farm machinery with the help of CAD • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** <u>UNIT I</u> Introduction to CAD – the design process – modelling using CAD –architecture of CAD system. Geometric modelling – requirements – geometric construction methods – representation of curve – desirable modeling facilities. – CAD standards – Graphical Standard system – Exchange of modeling data. <u>UNIT II</u> System analysis – Relevance of system approach to biological systems and engineering systems. Role of a system analyst in design of a system and development of computer systems. Characteristics of Agricultural systems. Tools of structured analysis. -The data flow model. Object oriented approach. Feasibility study – Steps in feasibility analysis – cost analysis. System design process – structured design. <u>UNIT III</u> Application to farm machinery scheduling problem. Application to farm – factory co-ordination – case study. Design of farm machinery with the help of CAD **Practical** Practical on CAD software, its uses and application in design of farm machinery. Design procedures. Exercise on agricultural engineering system analysis. Description of the machinery scheduling problem in harvesting and transport system. Investigation of existing software models – cases studies
References:	• Chris McMahon & Jimmie Browne. 2000. CAD /CAM/ Principles, Practice and Manufacturing Management. Pearson Edu. • Grover Mikell P. 2003.Automation, Production Systems and Computer Integrated Manufacturing. Prentice-Hall of India. • Ramakrishna P, Subramanyan S & Raju V. 2003. CAD/CAM/CIM. New Age International. • Rao PN. 2002. CAD/CAM Principles and Applications. Tata McGraw Hill.

	• Zeid Ibrahim.1998. CAD/CAM Theory and Practice. Tata McGraw Hill.
Course Outcomes	**CO1**: To acquaint and equip with the basics of CAD. **CO2:** Acquire knowledge on system analysis. **CO3**: To aware about tools of structured analysis. **CO4**: To solve the analytical problems related to the farm machinery scheduling. **CO5**: To design farm machinery with the help of CAD.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 605**
Course title	**Machinery for natural resource management and precision farming**
Course credit	**3+1**

Objective of Course	• To develop knowledge and skill in hardware system used in precision agriculture for technical education and research. • To develop the ability of the students for using systems for precision agriculture. • To strengthen the knowledge among students for Industry and R&D organizations.
Course Content	**Theory** UNIT I Functional design, specifications, requirements and working of farm machinery needed for natural resources management like rotavator, Precision sowing and planting machines, laser guided leveller, power sprayer, straw chopper cum spreader, straw bailer, combine harvester etc. UNIT II Ag GPS parallel swathing option, data base management, functional systems documentation. Application of relevant software. UNIT III An introduction to precision farming. GIS/GPS positioning system for precision farming, Yield monitoring and mapping, soil sampling and analysis. Computers and Geographic information systems. Precision farming- Issues and conditions. Role of electronics in farm machinery for precision farming. UNIT IV Engineering fundamentals related to earth moving machinery: Swell, shrinkage and compaction measurements. Use of tractors & Crawlers and effects of altitude & temperature on their performance. Grade resistance and gradability UNIT V Land cleaning and reclamation equipment. Land leveling equipment. Power shovels, drag lines, cam shells. Rubber tire for earth moving machinery. Trenching machineries and wagons. Economic analysis of land development machinery. Application of PERT and CPM to the problems related to land development **Practical** Introduction to GIS and GPS, study of models vis-à-vis farm machinery usage. Precision farming using GIS and GPS – case study. Study the mechanism of power shovels, drag lines, earth diggers, clamshells etc. earth work estimation, unit cost of operation, work scheduling, machinery maintenance, entrepreneurship
References:	• De Mess M. N. Fundamental of Geographic Information System. John Willy and Sons, New York • Dutta SK. 1987. Soil conservation and land management. International distributors, Dehradun. • Kuhar, John. E. 1977. The precision farming guide for agriculturalist. Lori J. Dhabalt, USA. • Lille Sand, T and Kaiffer, R. Remote Sensing and Image Interpretation, John Willy and Sons, London. • Nichols HL& Day DH.1998. Moving the earth. The work book of excavation. Mcgraw Hill.

	• Peurifoy RL 1956.Construction, planning, equipment and methods. Mcgraw Hill Sabbins, F. Remote Sensing Principle and Interpretation. Freeman, New York • Singh G.1991. Manual of soil and water conservation engineering. Oxford and IBH, Co. • Sigma & Jagmohan.1976. Earth moving machinery. Oxford & IBH Wood & Stuart. 1977. Earth moving machinery. Prentice Hall.
Course Outcomes	**CO1**: Get aware about farm machinery needed for natural resources management. **CO2:** To acquire ability for basics of GPS technology. **CO3**: To know the precision farming and it's techniques. **CO4:** Acquire knowledge on land development machinery. **CO5**: To acquaint with engineering fundamentals related to earth moving machinery.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**FMPE 606**
Course title	**Advances in hydraulics and electro pneumatic controls**
Course credit	**2+0**
Objective of Course	• To develop knowledge and skill for hydraulic and pneumatic systems for technical education and research. • To develop the ability of the students for designing simple hydraulic and pneumatic circuits. • To strengthen the knowledge among students for Industry and R&D organizations.

Course Content	**Theory** UNIT I Fluid power, its advantages, properties of hydraulic fluids, viscosity, bulk modulus, density. Concepts of energy of hydraulic systems, laws of fluid flow. UNIT II Distribution system, pressure rating of tubing and hoses, couplings. Basics of hydraulic flow and hydraulic circuit analysis – pumps, types and theory of operation. Pressure intensifiers. Fluid power actuators, hydraulic rams, gear motors, piston motors and their performance characteristics, electro hydraulic motors and hydrostatic transmissions, control components. UNIT III Directional pressure safety and servo valves. Hydraulic circuit design. Regenerative pump unloading, pressure intensifier circuits. Speed control of hydraulic motors, mechanical hydraulic servo systems for tractors. UNIT IV Pneumatic circuits – properties of air. Compressors, control elements. Design of pneumatic circuits. Electrical control for fluid power circuits. Electronic sensors/ circuits used as controls in modern farm equipment. Maintenance of hydraulic and pneumatic circuits and devices. Trouble shooting.
References:	• Anthony Esposito. 2003. Fluid Power with Applications.Pearsons Edu . • Krutz G.1984.Design of Agricultural Machines. John Wiley & Sons. • Merritt HE. 1991. Hydraulic Control System. John Wiley a& Sons. • Majumdar SR. 2003. Oil Hydraulic System. Tata McGraw Hill.
Course Outcomes	**CO1:** To acquaint with fundamentals of fluid power systems. **CO2:** Acquire knowledge on working of fluid power actuators, hydraulic motors, and hydraulic components. **CO3:** Understand the hydraulic circuit design for the applications in farm power and machinery. **CO4:** To know the components and working of pneumatic circuits. **CO5:** To get knowledge for the maintenance of hydraulic and pneumatic circuits and devices

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 501**
Course title	**WATERSHED HYDROLOGY**
Corse credit	2+1
Objective of Course	To acquaint and equip the students about hydrological process and analysis of hydrological data required for design process.
Course Content	Theory UNIT I Hydrologic processes and systems; Hydrologic problems of small watersheds; Hydrologic characteristics of watersheds. UNIT II Measurement and analysis of hydrologic parameters, rainfall-runoff models, stream flow measurement and analysis of data. UNIT III Hydrograph analysis; Unit hydrograph theory; Synthetic and dimension less hydrograph, convolution of unit hydrograph. UNIT IV Concept of hydraulic flood routing, flood routing (reservoir and channel routing). UNIT V Definition and concept of different types of hydrologic models for simulation of hydrologic problems Practical Rainfall analysis, runoff computation, construction of hydrographs, Delineation of watershed, hydrograph analysis, reservoir and channel routing, hydrologic models, visit to dam sites
References:	• Chow VT, David, M & Mays LW. 1988. Applied Hydrology. McGraw Hill. • Ghanshyan Das 2000. Hydrology and Soil Conservation Engineering. Prentice Hall. • Tideman EM. 1996. Watershed Management. Omega Scientific Publ
Course Outcomes	At the end of the course, learners will be able to CO1: Comprehend hydrologic processes, watershed characteristics, and solve small watershed hydrologic issues by applying fundamental principles and analysis techniques. CO2: Proficiently measure, analyze, and interpret hydrologic parameters, utilizing rainfall-runoff models and stream flow data for comprehensive hydrologic assessments. CO3: Apply unit hydrograph theory, synthetic hydrographs, and dimensionless hydrograph techniques to conduct hydrograph analysis and understand convolution principles.

	CO4: Evaluate the principles of hydraulic flood routing, employing flood routing methods including reservoir and channel routing for effective flood management. CO5: Demonstrate a comprehensive understanding of diverse hydrologic models, effectively simulating hydrologic problems through practical applications such as rainfall analysis, runoff computation, hydrograph construction, watershed delineation, routing techniques, and site visits to dams for practical insights.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 502**
Course title	**DESIGN OF FARM IRRIGATION SYSTEMS**
Corse credit	2+1
Objective of Course	To acquaint and equip with the irrigation principles, design consideration of surface irrigation and micro irrigation systems and their evaluation system
Course Content	Theory UNIT I Concepts of Irrigation; Irrigation principles, losses, conveyance, distribution; Application, scheduling parameters, water budgeting. UNIT II Surface irrigation, hydraulics of water advance and recession, hydraulic resistance to flow, gravity irrigation. UNIT III Design of Border irrigation, furrow irrigation, check basin irrigation; Sub Irrigation methods and concepts UNIT IV Preliminary design criteria of sprinkler and micro irrigation systems, hydraulics of sprinkler and micro irrigation systems. Design of lateral, submain and main line of sprinkler and micro irrigation. Fertigation aspects. UNIT V Underground water conveyance system; Evaluation of irrigation systems and practices. Practical Design and evaluation of border, furrow, check basin, sprinkler and micro irrigation, computation of frictional losses, Design of underground water conveyance systems, economics of irrigation methods, visit to mechanized farms
References:	• Finkel HJ. 1983.Handbook of Irrigation Technology. Vols. I-II. CRC Press. • Ivan E Henk. 1951. Irrigation Engineering. Vol. I. John Wiley & Sons. • Karmeli D, Peri G & Todes M. 1985.Irrigation Systems: Design and Operation. Oxford Univ. Press. • Pillsbury AF. 1972. Sprinkler Irrigation. FAO Agricultural Development Paper No. 88, FAO. • Rydzewski 1987. Irrigation Development Planning. John Wiley & Sons. • Sivanappan RK, Padmakumari O & Kumar V. 1987. Drip Irrigation. Keerthy Publ. House. • Sivanappan RK. 1987. Sprinkler Irrigation. Oxford & IBH
Course Outcomes	At the end of the course, learners will be able

	CO1: Acquire a comprehensive understanding of irrigation concepts, principles, losses, conveyance, distribution, application, scheduling parameters, and water budgeting for effective water management in agriculture. CO2: Demonstrate proficiency in the hydraulics of surface irrigation, including water advance and recession, hydraulic resistance to flow, and the principles underlying gravity irrigation. CO3: Apply design principles to create effective border, furrow, and check basin irrigation systems while understanding the concepts and methods associated with sub-irrigation techniques. CO4: Demonstrate advanced knowledge in the preliminary design criteria of sprinkler and micro irrigation systems, including hydraulic aspects, design of lateral, submain, and main lines, and integration of fertigation techniques. CO5: Evaluate underground water conveyance systems, assess various irrigation systems and practices, and apply economic considerations to understand the efficiency and feasibility of different irrigation methods, incorporating real-world insights through visits to mechanized farms.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 503**
Course title	**AGRICULTURAL DRAINAGE SYSTEMS**
Corse credit	2+1
Objective of Course	To acquaint and equip with the importance and phenomenon of drainage system along with design consideration of surface and sub-surface drainage systems
Course Content	Theory UNIT I 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 Principle and applications of Earnst, Glover Dumm, Kraijenhoff-van-de-leur equations. UNIT III Salt balance, leaching requirement and management practices under drained conditions. UNIT IV Design of different components of sub-surface drainage systems, theories of vertical drainage and multiple well point system. UNIT V Disposal of drainage effluents, Management of drainage projects of water- logged and saline soils, case studies Practical Measurement of in-situ hydraulic conductivity, estimation of drainage coefficient and leaching requirements, Delineation of waterlogged areas through isobar, isobath and topographic maps. Design of surface and sub- surface drainage systems, design of filter and envelop materials
References:	• Battacharaya AK & Micheal AM. 2003. Land Drainage. Vikas Publ. • Clande Ayres & Daniel Scoates A.E. 1989.Level Drainage and Reclamation. McGraw Hill. • Luthin JN. 1978. Drainage Engineering. Wiley Eastern. • Ritzema HP. (Ed.). 1994. Drainage Principles and Applications. ILRI • Roe CE 1966. Engineering for Agricultural Drainage. McGraw Hill
Course Outcomes	At the end of the course, learners will be able CO1: Understand and apply theories of surface and sub-surface drainage, including steady-state and unsteady-state equations, for varied soil compositions and drainage scenarios.

	CO2: Apply advanced equations such as Earnst, Glover Dumm, and Kraijenhoff-van-de-leur equations in drainage applications and comprehend their practical significance. CO3: Analyze and manage salt balance, leaching requirements, and implement effective strategies for soil management under drained conditions. CO4: Design diverse components of sub-surface drainage systems, evaluate theories related to vertical drainage, and demonstrate proficiency in multiple well point system applications. CO5: Develop comprehensive skills in the disposal of drainage effluents, manage projects in waterlogged and saline soils, and critically assess and solve real-world drainage-related case studies for efficient land and water management.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 504**
Course title	**GROUNDWATER ENGINEERING**
Corse credit	2+1
Objective of Course	To acquaint and equip with the occurrence, development and hydraulics of groundwater flow.
Course Content	Theory UNIT I Properties affecting groundwater storage and movement, groundwater balance studies. UNIT II Well hydraulics, two dimensional flow, steady and unsteady state flow in confined, unconfined and semi-confined aquifers, steady flow in sloping aquifers, partial penetrating wells. Analysis of multi-aquifers. UNIT III Flow analysis in interfering wells. Pumping tests and determination of aquifer parameters. UNIT IV Groundwater modeling for water resources planning. UNIT V Techniques for groundwater recharge Practical Water table contour maps and determination of groundwater flow, estimation of aquifer characteristics, problems on non leaky and leaky aquifers, analysis of pumping test data; Computation of interference of wells; groundwater computer simulation models
References:	• Boonstra J & de Ridder NA. 1981.Numerical Modeling of Groundwater Basins. ILRI. • Domenico PA. 1972.Concept and Models in Groundwater Hydrology. McGraw Hill. • Hantush MS. (Ed.). 1964. Advances in Hydro Sciences. Vol. I. Academic Press. • Harr ME 1990. Ground Water and Seepage. Wiley Eastern. • Huisman L. 1972. Groundwater Recovery. MacMillan. • Polubarinova Kochina P Ya 1962.Theory of Ground Water Movement. Princeton Univ. Press. • Raghunath HM. 1992. Ground Water. Wiley Eastern. • Todd DK. 1997. Ground Water Hydrology. Wiley Eastern
Course Outcomes	At the end of the course, learners will be able CO1: Comprehend the properties governing groundwater storage

	and movement, and conduct groundwater balance studies for effective analysis and management of groundwater resources. CO2: Analyze well hydraulics, including two-dimensional flow, steady and unsteady state flow in different aquifer types (confined, unconfined, semi-confined), and apply this knowledge to assess partial penetrating wells and multi-aquifer systems. CO3: Perform comprehensive analysis of interfering wells' flow and conduct pumping tests to determine aquifer parameters, developing proficiency in characterizing aquifers through practical applications. CO4: Utilize groundwater modeling techniques for water resources planning, demonstrating the ability to apply theoretical knowledge to simulate and assess groundwater systems for effective resource management. CO5: Apply various techniques for groundwater recharge and demonstrate practical skills in creating water table contour maps, estimating aquifer characteristics, analyzing pumping test data, computing well interference, and utilizing groundwater computer simulation models for real-world applications.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 505**
Course title	**SOIL AND WATER CONSERVATION ENGINEERING**
Corse credit	2+1
Objective of Course	To acquaint and equip students with the process of degradation soil and water conservation and their remedial measures including design of structures
Course Content	Theory UNIT I Probability and continuous frequency distribution; Fitting empirical distributions. UNIT II Layout and planning of soil and water conservation measures; Design principles of soil and water structures including contour bunds and terraces; Gully control measures. UNIT III Hydraulic jump and energy dissipaters for soil conservation structures; Hydrologic, hydraulic and structural design of drop structures. UNIT IV Sediment deposition process. Estimation of sediment load, earthen dams, seepage through dams and stability analysis. UNIT V Rainwater harvesting, Flood control and stream bank protection measures. Practical Design of Drop spillway, chute spillway, drop inlet spillway, hydraulic jump Calculation, design of bench terrace, contour bunds and contour trenches, Design and problems on earthen dam, silt detention tanks and check dams, visit to soil conservation structures sites.
References:	• Garde RJ & Ranga Raju KG. 1977. Mechanics of Sediment Transport and Alluvial Stream Problems. Willey Eastern. • Gurmel Singh et al. 1994. Manual of Soil and Water Conservation Practices. Oxford & IBH. • Hudson N.1971. Soil Conservation. B.T. Batsford Ltd. • Murthy VVN. 1998. Land and Water Management Engineering. Kalyani. • USDA 1969. A Manual on Conservation of Soil and Water. Oxford & IBH
Course Outcomes	At the end of the course, learners will be able CO1: Understand and apply probability concepts and continuous frequency distributions to analyze soil and water conservation data, incorporating empirical distribution fitting for practical applications.

	CO2: Demonstrate proficiency in planning, designing, and implementing various soil and water conservation measures, including contour bunds, terraces, and gully control techniques. CO3: Apply knowledge of hydraulic principles to design effective soil conservation structures, including drop structures, energy dissipaters, and hydraulic jump calculations for water conservation purposes. CO4: Evaluate sediment deposition processes, estimate sediment load, and assess the design and stability of earthen dams, focusing on seepage control and sedimentation management for sustainable water resource conservation. CO5: Integrate rainwater harvesting methods, flood control strategies, and stream bank protection measures into comprehensive soil and water conservation practices, emphasizing effective water management and conservation techniques.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 506**
Course title	**CROP ENVIRONMENTAL ENGINEERING**
Corse credit	2+0
Objective of Course	To acquaint and equip with the process of soil-water-plant relationship and their interaction for crop growth
Course Content	Theory UNIT I Aerial and edaphic environments for plant growth, energy and mass transfer in and above crop canopies. UNIT II Climatic changes and plant response to environmental stresses, evapo- transpiration models. Instrumentation and techniques for monitoring plant environments. UNIT III Processes and aspects of growth and development, soil-root interface, root sink functions. UNIT IV Water movement in soil-plant atmosphere continuum, artificial environments and plant behaviour. UNIT V Design and operation of controlled environment facilities and their instrumentation. Crop growth and yield modeling.
References:	• Ghildyal BP & Tripathy RP. 1987. Fundamental of Soil Physics. Wiley Eastern. • Slatyor OP. 1967. Plant Water Relationship. Academic Press.
Course Outcomes	At the end of the course, learners will be able CO1: Comprehend the aerial and edaphic environments influencing plant growth, demonstrating an understanding of energy and mass transfer within crop canopies for effective crop management practices. CO2: Analyze the impact of climatic changes on plants and their response to environmental stresses, utilizing evapotranspiration models and instrumentation techniques for monitoring and understanding plant environments. CO3: Understand the processes and dynamics of growth and development in plants, focusing on the soil-root interface and root sink functions essential for plant health and productivity. CO4: Evaluate the continuum of water movement within the soil-plant atmosphere system, exploring artificial environments and their influence on plant behavior, thus enhancing strategies for efficient water management in agriculture.

	CO5: Demonstrate proficiency in designing and operating controlled environment facilities, utilizing instrumentation for plant research, and applying crop growth and yield modeling techniques for optimal agricultural production and management.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 507**
Course title	**DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE**
Corse credit	2+0
Objective of Course	To acquaint and equip with requirement of pumps for irrigation and drainage system and their design features
Course Content	Theory UNIT I Basic hydraulic design of centrifugal pump, water hammering problem in centrifugal pump. UNIT II Principle and performance characteristics of vertical turbine pump, submersible pump and axial flow pump and their design. UNIT III Non-conventional energy sources for pumping, wind mills, micro turbines, solar pumps, hydraulic ram- their selection and design criteria. UNIT IV Design of pumping station, techno-economic evaluation. Energy conservation measures for pumping systems
References:	• Church AH & Jagdish Lal 1973 Centrifugal Pumps and Blowers. Metropolitan Book Co. • Michael AM & Khepar SD. 1989. Water Well and Pump Engineering. Tata McGraw Hill. • Michael AM. 1990. Irrigation Theory and Practice. Vikas Publ. House. • Modi PN & Seth SM. 2000 Hydraulic and Fluid Mechanics. Standard Book House.
Course Outcomes	At the end of the course, learners will be able

	CO1: Understand the fundamental principles of hydraulic design related to centrifugal pumps, including the analysis of water hammering problems and their mitigation strategies. CO2: Analyze the principles, performance characteristics, and design aspects of various pump types such as vertical turbine pumps, submersible pumps, and axial flow pumps. CO3: Evaluate non-conventional energy sources for pumping systems, such as windmills, micro turbines, solar pumps, and hydraulic ram pumps, demonstrating the ability to select and design them based on specific criteria. CO4: Demonstrate proficiency in designing pumping stations, conducting techno-economic evaluations, and implementing energy conservation measures for pumping systems to optimize efficiency. CO5: Apply theoretical knowledge and practical skills to design and optimize different pump systems, integrating traditional and non-conventional energy sources while considering techno-economic factors and energy conservation practices.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 508**
Course title	**OPEN CHANNEL FLOW**
Corse credit	3+0
Objective of Course	To acquaint and equip with the hydraulics of surface water flow phenomenon in open channels
Course Content	Theory UNIT I Open channel and their properties, energy and momentum, critical flow computation and application. UNIT II Uniform flow; gradually varied flow theory and analysis,

	methods of computation UNIT III Practical problems such as design of transitions, flow passing Islands etc. spatially varied flow, rapidly varied flow. UNIT IV Hydraulic jump and its use as energy dissipator, flow through channel of non-linear alignment and flow through non-prismatic channel sections. UNIT V Unsteady flow, gradually varied unsteady flow and rapidly varied unsteady flow.
References:	• Chaudhry MH. 1993. Open Channel Flow. Prentice Hall. • Chow VT. 1959. Open Channel Hydraulics. Mc-Graw Hill. • Henederson FM. 1966. Open Channel Flow. MacMillan
Course Outcomes	At the end of the course, learners will be able CO1: Understand the properties of open channels, including the principles of energy and momentum, critical flow, and their computation, demonstrating proficiency in their practical application. CO2: Analyze uniform flow and gradually varied flow theory, and apply computational methods for solving practical problems related to transitions, flow passing islands, spatially varied flow, and rapidly varied flow. CO3: Apply theoretical knowledge to design transitions and handle flow through channels of non-linear alignment and non-prismatic channel sections, utilizing hydraulic jump principles as energy dissipators. CO4: Evaluate the principles and practical applications of unsteady flow, including gradually varied unsteady flow and rapidly varied unsteady flow, showcasing an understanding of these dynamic flow conditions in open channels. CO5: Demonstrate proficiency in solving complex problems related to open channel flow, integrating theoretical understanding into practical scenarios involving various flow conditions and configurations.
Mapping between COs with POs and PSOs **Please refer mapping of PO and PSO for the style of mapping.**	

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															

CO2															
CO3															
CO4															
CO5															

Course code	**SWE 509**
Course title	**FLOW THROUGH POROUS MEDIA**
Corse credit	2+0
Objective of Course	To acquaint and equip with the hydraulics and process of water flow in the water bearing formation under saturated as well as unsaturated conditions.
Course Content	Theory UNIT I Aquifer and fluid properties, forces holding water in soils, hydrodynamics in porous media and limitations of governing laws. UNIT II Differential equations of saturated flow, initial and boundary conditions. Dupuit and Business approximations and linearization techniques. UNIT III Stream functions, potential functions and flow net theory. Analysis of seepage from canals and ditches. UNIT IV Unsaturated flow theory, Infiltration and capillary rise flux dynamics. Hydro-dynamic dispersion in soil-aquifer system.
References:	• Harr Milton E. 1962. Groundwater and Seepage. McGraw-Hill. • Jacob Beer 1972. Dynamics of Fluid Flow in Porous Media. Elsevier. • Muskat M & Wyckoff RD. 1946. The Flow of Homogeneous Fluids through Porous Media. JW Edwards. • Patrick A Domenico & Schwartz FW. 1998.Physical and Chemical Hydrogeology. John Wiley & Sons. • Remson I, Hornberger GM & Moiz Fred J. 1971. Numerical Methods in Subsurface Hydrology. Wiley Interscience
Course Outcomes	At the end of the course, learners will be able CO1: Understand aquifer properties, fluid behavior in soils, and the forces governing water retention, demonstrating knowledge of hydrodynamics in porous media and recognizing the limitations of governing laws in the context of groundwater. CO2: Apply differential equations governing saturated flow, define initial and boundary conditions, and utilize Dupuit and Boussinesq approximations along with linearization techniques for practical applications in groundwater flow modeling. CO3: Analyze concepts related to stream functions, potential

	functions, and flow net theory, demonstrating the ability to apply these theories for the analysis of seepage from canals and ditches in practical scenarios. CO4: Comprehend unsaturated flow theory, infiltration dynamics, and capillary rise flux, demonstrating understanding and application of these concepts in analyzing groundwater movement in partially saturated conditions. CO5: Evaluate hydrodynamic dispersion in soil-aquifer systems, showcasing a comprehensive understanding of how dispersion affects groundwater movement and quality in practical contexts.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 510**
Course title	**WATER RESOURCES SYSTEM ENGINEERING**
Corse credit	**3+0**
Objective of Course	To acquaint and equip with the techniques for optimization of water resources for achieving maximum output
Course Content	Theory UNIT I Concepts and significance of optimization in water resources, objective functions, deterministic and stochastic inputs. UNIT II Mathematical programming techniques, linear programming and

	its extension: gradient method, simplex method, non-linear programming classical optimization. UNIT III Geometric programming and dynamic programming, application of optimization techniques for water resources. UNIT IV Development and management including conjunctive use, crop production functions and irrigation optimization
References:	Larry WM. 1996. Water Resources Handbook. McGraw-Hill. Loucks DP et al. 1981.Water Resource System Planning and Analysis. Prentice Hall. Rao SS. 1978. Optimization Theory and Applications. Wiley Eastern**.**
Course Outcomes	At the end of the course, learners will be able CO1: Understand the principles and significance of optimization in water resources management, including the formulation of objective functions and the distinction between deterministic and stochastic inputs in water management problems. CO2: Apply mathematical programming techniques such as linear programming, simplex method, gradient method, and classical nonlinear programming to solve optimization problems in water resources effectively. CO3: Apply advanced optimization methodologies like geometric programming and dynamic programming specifically tailored for water resource applications, demonstrating proficiency in their practical implementation. CO4: Analyze and implement optimization techniques for the development and management of water resources, including conjunctive use, crop production functions, and irrigation optimization, showcasing the ability to enhance water utilization efficiency and sustainability. CO5: Evaluate and propose optimized solutions for water resource management problems using various optimization techniques, demonstrating the ability to address complex issues in water resources through mathematical programming and optimization methodologies.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															

CO5															

Course code	**SWE 511**
Course title	**GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCE MANAGEMENT**
Corse credit	2+1
Objective of Course	To acquaint and equip with the techniques of Remote Sensing and application of GIS for land and water resources management
Course Content	Theory UNIT I Basic principles of remote sensing and sensors. Elements of photogrametry. UNIT II Electromagnetic spectrum. Energy interaction with surface features, Aerial photo and satellite imagery. Photo and image interpretation. UNIT III Principles of Geographical Information System tools, their types and capabilities, Advantages of GIS over conventional methods. UNIT IV Importance of ground truth establishment, GIS and remote sensing for land and water resources data collection, analysis and interpretation, Application of GIS in water and land resource development and management Practical Familiarization with remote sensing and GIS hardware, software and their principle of working, Methods of establishing ground truth, Comparison between ground truth and remotely sensed data, Application of GIS packages.
References:	• De Mess MN. 2004. Fundamental of Geographic Information System. John Wiley & Sons. • Lille Sand T & Kaiffer R.1987. Remote Sensing and Image Interpretation. John Wiley & Sons. • Sabbins F.1987. Remote Sensing Principle and Interpretation. Freeman
Course Outcomes	At the end of the course, learners will be able CO1: Demonstrate an understanding of the fundamental principles of remote sensing, including sensor technology and photogrammetry elements, essential for data collection and analysis. CO2: Analyze the electromagnetic spectrum and comprehend the interaction of energy with surface features, utilizing aerial photos and satellite imagery for interpretation and analysis purposes. CO3: Apply the principles of Geographical Information System

	(GIS) tools, understanding their types, capabilities, and advantages over conventional methods for spatial data management and analysis. CO4: Evaluate the significance of ground truth establishment and utilize GIS and remote sensing for the collection, analysis, and interpretation of land and water resources data, demonstrating proficiency in applying GIS techniques in water and land resource development and management. CO5: Demonstrate proficiency in operating remote sensing and GIS hardware and software, understand their functioning principles, establish ground truth, compare ground truth data with remotely sensed data, and apply GIS packages for practical applications in data analysis and interpretation.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 512**
Course title	**WATERSHED MANAGEMENT AND MODELING**
Corse credit	2+1
Objective of Course	To acquaint and equip the students with the watershed management modeling and modeling systems
Course Content	Theory UNIT I Problems of desertification and degradation. Models of sediment yield UNIT II Survey, monitoring, reclamation and conservation of agricultural and forest lands, hill slopes and ravines UNIT III Concept of operational watershed. National land use policy, legal and social aspects UNIT IV Watershed management research instrumentation and measurement, problem identification, simulation and synthesis

	UNIT V Modelling of flood and drought phenomenon, drought management and dry farming Practical Preparation of watershed development proposal, preparation of water shed evaluation report. Application of Models of flood and drought phenomenon. Application of watershed models.
References:	• Isobel W Heathcote. 1998. Integrated Watershed Management: Principles and Practice. Wiley Publ. • Kenneth N Brooks, Peter F Ffolliott, Hans M Gregersen, Leonard F DeBano. 1991.Hydrology and the Management of Watersheds.Wiley-Blackwell**.**
Course Outcomes	At the end of the course, learners will be able CO1: Understand and analyze issues related to desertification, degradation, and sediment yield modeling, essential for addressing soil erosion problems and land degradation. CO2: Demonstrate proficiency in surveying, monitoring, and implementing strategies for land reclamation, conservation of agricultural and forest lands, and hill slope management to mitigate degradation. CO3: Comprehend the concept of operational watershed, incorporating legal, social, and national land use policy aspects into watershed management practices. CO4: Apply research methods, instrumentation, and simulation techniques to identify and address problems in watershed management effectively. CO5: Analyze, model, and implement strategies for managing flood and drought phenomena, including drought management and dry farming techniques, contributing to effective water resource management and conservation.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 513**
Course title	**LAND DEVELOPMENT AND EARTH MOVING MACHINERY**
Corse credit	2+0
Objective of Course	To acquaint and equip the students with the Land Development and Earth Moving Machinery modeling and modeling systems
Course Content	Theory UNIT I Objectives, methods and equipment for land clearing and development. Machinery selection, mechanics of operation and vegetation types. UNIT II Earth moving machinery and earthmoving mechanics. Grading of sloppy lands. Principles of mechanisms used in crawler mounted tractors. UNIT III Earth diggers and ditchers. Bull dozers and scrapers. Elevating and self powered graders. Automation of earth moving and grading machines. Lazer guided leveler with global positioning system. UNIT IV Boring machines. Different methods of boring.
References:	• Dutta SK. 1987. Soil Conservation and Land Management. International Distributors, Dehradun. • Eric C Orlem.1997. Earth-Moving Machines. Motorbooks International. • Kuhar JE. 1977. The Precision Farming Guide for Agriculturalist. Lori J. Dhabalt, USA. • Nichols HL & Day DH.1998. Moving the Earth. The Work Book of Excavation. McGraw Hill. • Peurifoy RL. 1956.Construction, Planning, Equipment and Methods.McGraw Hill. • Roger V Amato & Donald J Heimburger 2003. Classic Vintage Crawlers and Dozers. B Heimburger House Publ. • Singh G.1991. Manual of Soil and Water Conservation Engineering. Oxford & IBH
Course Outcomes	At the end of the course, learners will be able CO1: Demonstrate an understanding of the objectives, methods, and equipment utilized for land clearing and development, including machinery selection and mechanics of operation tailored for various vegetation types. CO2: Analyze earthmoving machinery, mechanics, and principles involved in grading sloped lands, as well as

	understanding the mechanisms employed in crawler-mounted tractors for effective land development. CO3: Evaluate earth diggers, ditchers, bulldozers, scrapers, elevating and self-powered graders, and comprehend the automation techniques used in earth moving and grading machines, including technologies like laser-guided leveling with the global positioning system. CO4: Understand the functioning and various methods employed by boring machines, demonstrating proficiency in different techniques utilized in boring processes for land development purposes.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 601**
Course title	**ADVANCED HYDROLOGY**
Corse credit	**3+0**
Objective of Course	To acquaint and equip the students with advanced hydrological process, analysis of hydrological data and their application for modeling
Course Content	Theory UNIT I Hydrologic models, processes and systems. Uncertainty in hydrological event. Statistical homogeneity. UNIT II Probabilistic concept. Frequency analysis. Co-relation and regression analysis. Probability distribution of hydrological variables. UNIT III Time series analysis. Markov processes. UNIT IV Formulation of various steps of statistical models and their application in hydrology.
References:	• Garg SK.1987. Hydrology and Water Resources Engineering. Khanna Publ. • Hann CT. Advanced Hydrology. Oxford Publ. House. • Linseley RK Jr., Kohler MA & Paulhus JLH. 1975. Applied Hydrology. McGraw Hill. • Mutreja KN.1986. Applied Hydrology. Tata McGraw Hill
Course Outcomes	CO1: Understand and evaluate hydrological models, systems, and processes, recognizing and addressing uncertainties associated with hydrological events while emphasizing the concept of statistical homogeneity in hydrological data. CO2: Apply probabilistic concepts in hydrology, including conducting frequency analysis, correlation, and regression analysis, and proficiently determine probability distributions of hydrological variables for comprehensive analysis. CO3: Analyze time series in hydrology, demonstrating proficiency in Markov processes and time-based data analysis methods essential for understanding sequential patterns in hydrological data. CO4: Develop and apply statistical models in hydrology, demonstrating the ability to formulate, interpret, and implement these models for assessing and predicting hydrological phenomena effectively. CO5: Utilize statistical techniques and models for analyzing hydrological data, enabling comprehensive assessments and predictions regarding various aspects of water resource management and hydrological events.
Mapping between COs with POs and PSOs **Please refer mapping of PO and PSO for the style of mapping.**	
Mapping between Cos, POs and PSOs	

CO	**PO**	**PSO**

	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	SWCE 602
Course title	Soil and Water Systems Simulation and Modeling
Corse credit	2+1
Objective of Course	To acquaint and equip the students with the simulation of soil water systems and modeling techniques
Course Content	Theory UNIT I Systems engineering for water management; Complexity of resources management process, systems analysis. UNIT II Rainfall-runoff models - Infiltration models, Simulation methods, structure of a water balance model. UNIT III Channel flow simulation - parameters and calibration - Streamflow statistics, surface water storage requirements. UNIT IV Flood control storage capacity; total reservoir capacity - surface water allocations. Ground water models. UNIT V Design of nodal network, General systems frame work – Description of the model; Irregular boundaries, General –Numerical approaches Practical Rainfall - Runoff models - Infiltration models - Stanford watershed model (SWM) - channel flow simulation problems - stream flow statistics – model parameters and input data requirements of various softwares of surface hydrology and groundwater – Hydrologic Modelling System – Soil Water Management Model – Soil Water Assessment Tool – Catchments, Simulation Hydrology Model – Stream flow model and use of dimensionless unit hydrograph – Generalized groundwater models.
References:	• Biswas AK. 1976. Systems Approach to Water Management. McGrawHill. • Cox DR & Mille HD. 1965.The Theory of Stochastic Processes. John Wiley & Sons.

	• Eagleson PS. 1970. Dynamic Hydrology. McGraw Hill. • Himmel Blau DM & Bischoff KB. 1968. Process Analysis and Simulation Deterministic Systems. John Wiley & Sons. • Linsley RK, Kohler MA & Paulhus JLH. 1949. Applied Hydrology.McGraw Hill. • Schwar RS & Friedland B. 1965. Linear Systems. McGraw Hill. • Ven Te Chow, David R Maidment & Mays LW. 1998. Applied Hydrology. McGraw Hill.
Course Outcomes	CO1: Analyze and apply systems engineering principles in water management, comprehending the complexities involved in resource management processes through effective systems analysis. CO2: Demonstrate proficiency in utilizing rainfall-runoff models, infiltration models, and simulation methods, understanding the structure and implementation of water balance models for hydrological assessments. CO3: Evaluate channel flow simulation parameters, streamflow statistics, and surface water storage requirements, showcasing competence in hydrological modeling for effective water resource management. CO4: Assess flood control storage capacity, reservoir capacity, surface water allocations, and ground water models, integrating this knowledge for comprehensive water resource assessment and management. CO5: Demonstrate the ability to design nodal networks, utilize general systems frameworks, and apply various numerical approaches in hydrological modeling, facilitating effective assessment and prediction of water resource systems.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 603**
Course title	**MODELING SOIL EROSION PROCESSES**

Corse credit	2+1
Objective of Course	To acquaint and equip the students with the advance erosion process along with tools required and application of soil erosion models.
Course Content	Theory UNIT I Overland flow, basic theory of particle movement and sediment transport; sediment deposition process. UNIT II Estimation of sediment load; mechanics of soil erosion by water and wind. UNIT III Water and wind erosion control measures. UNIT IV Universal soil loss equation; stochastic models and dynamic models Practical Computation of soil erosion index; Estimation of soil erodibility factor; Design of erosion control structures. Computation of suspended load and sediment load using empirical formulae; Application of sediment yield models, prediction of sediment loss – computation of reservoir sedimentation – sounding method
References:	• Garde RJ & Ranga Raju KG. 1977. Mechanics of Sediment Transport and Alluvial Stream Problems. Wiley Eastern Ltd. • Morgan RPC. (Ed. D. A. Davidson). 1986. Soil Erosion and Conservation. ELBS,Longman. • USDA. 1969. A Manual on Conservation of Soil and Water. Oxford & IBH
Course Outcomes	CO1: Understand the principles of overland flow, sediment transport, and deposition, comprehending erosion processes and their implications. CO2: Apply methods for estimating sediment load and grasp the mechanics of soil erosion by water and wind, demonstrating proficiency in erosion assessment techniques. CO3: Implement erosion control measures effectively for both water and wind erosion, showcasing the ability to apply preventative strategies. CO4: Apply the Universal Soil Loss Equation (USLE) and other relevant models to predict and control soil erosion, demonstrating competence in erosion modeling. CO5: Demonstrate practical skills in computing soil erosion indices, estimating erodibility factors, designing erosion control structures, and applying sediment prediction models for various real-world applications such as reservoir sedimentation.
Mapping between COs with POs and PSOs **Please refer mapping of PO and PSO for the style of mapping.**	
Mapping between Cos, POs and PSOs	

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
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Course code	**SWE 604**
Course title	**ADVANCED HYDO-MECHANICS IN SOIL AQUIFER SYSTEMS**
Corse credit	**3+0**
Objective of Course	To acquaint and equip the students with the advance soil-aquifer-water mechanics and various techniques for the analysis of the system
Course Content	Theory UNIT I Soil aquifer system. Flow of water in partially saturated soils. Partial differential equation of flow. UNIT II Determination of unsaturated hydraulic conductivity and models for its estimation. UNIT III Infiltration and exfiltration from soils in absence and presence of water table. Movement of groundwater in fractured and swelling porous media. UNIT IV Spatial variability. Theory of krigging. Statistical approaches in soil water dynamics
References:	• Kirkham & Powers.1972. Advanced Soil Physics. John Wiley & Sons. • Muskut M.1937. The Flow of Homogeneous Fluid through Porous Media. McGraw Hill
Course Outcomes	CO1: Understand the dynamics of soil aquifer systems, including the flow of water in partially saturated soils and the application of partial differential equations to model water flow in these systems. CO2: Demonstrate proficiency in determining unsaturated hydraulic conductivity and utilizing various models for its estimation, essential for analyzing water movement in partially saturated soils. CO3: Analyze infiltration and exfiltration processes in soils, especially in the presence and absence of a water table, and comprehend the movement of groundwater in fractured and swelling porous media. CO4: Evaluate spatial variability in soil water dynamics, including the theory of kriging and the application of statistical approaches, essential for understanding and managing variability in soil water content. CO5: Apply theoretical knowledge to practical scenarios,

	demonstrating proficiency in understanding soil water dynamics, conducting estimations, and employing statistical methods for effective soil water management and analysis.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**SWE 605**
Course title	**HYDRO-CHEMICAL MODELING AND POLLUTANT MANAGEMENT**
Corse credit	3+0
Objective of Course	To acquaint and equip the students with the hydrodynamics of fluid and pollutant flow and the impact analysis of contaminant transport through modeling
Course Content	Theory UNIT I Hydrodynamics in flow through porous media, Hydrodynamic dispersion, diffusion, convection equation. UNIT II Analytical and numerical models of contaminant transport in unsaturated soil profile and ground water. UNIT III Water quality management in lakes and reservoirs; physical characteristics; hydrologic and chemical budgets; bio-geochemical processes of pollutants; assessment methods. UNIT IV Classical wastewater problems; Water reclamation, reuse, water quality constraints and considerations for reuse in irrigation and industry; Biological wastewater treatment. UNIT V Modern stream pollution problem. Quality of groundwater and souces of contaminants. Cost economics – environment impact assessment.
References:	• Larry W Mays 1996. Water Resources Handbook. McGraw Hill. • Metcalf and Eddey 1994. Wastewater Treatment Engineering and Reuse. John Wiley. • Soli J Arceivala 1998. Wastewater Treatment for Pollution Control. Tata McGraw-Hill.
Course Outcomes	CO1: Understand hydrodynamics in the flow through porous media, including hydrodynamic dispersion, diffusion, and the convection equation, essential for comprehending fluid movement in porous materials.

	CO2: Analyze both analytical and numerical models used for contaminant transport in unsaturated soil profiles and groundwater, demonstrating proficiency in assessing and predicting contaminant movement. CO3: Evaluate water quality management in lakes and reservoirs, comprehending physical characteristics, hydrologic and chemical budgets, as well as bio-geochemical processes of pollutants, demonstrating the ability to assess and manage water quality in these environments. CO4: Analyze classical wastewater problems, explore water reclamation and reuse strategies, understand water quality constraints for reuse in irrigation and industry, and apply biological wastewater treatment methods. CO5: Assess modern stream pollution issues, groundwater quality, and sources of contaminants, demonstrating proficiency in cost economics related to environmental impact assessments for sustainable water resource management.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**SWE 606**
Course title	**PLANT GROWTH MODELING AND SIMULATION**
Corse credit	3+0
Objective of Course	To acquaint and equip the students with the simulation and modeling techniques in the soil, plant and water environment for crop growth
Course Content	Theory UNIT I Introduction to crop growth modeling. Simulation and simulation techniques. Types of models and modeling approaches. UNIT II Relational diagram for principal process, structures of a generalized agricultural simulator. UNIT III Input environment and techniques of monitoring plant environment, process and aspect of growth and development. Input yield models. UNIT IV Quantitative analysis of plant processes light photo-syntheses, respiration, growth, water uptake etc. and their mathematical modeling.
References:	• Loomis RS, Connor DJ.1992. Crop Ecology: Productivity and Management in Agricultural System. Cambridge Univ. Press. • Spedding CRW. 1979.An Introduction to Agricultural Systems. Applied Science Publ. • Thornley JHM & Johnson IR. 1990.Plant and Crop Modelling. A Mathematical Approach to Plant and Crop Physiology. Clarendon Press. Oxford Science Publ
Course Outcomes	CO1: Understand the fundamentals of crop growth modeling, simulation techniques, and the various types of models and approaches used in agricultural modeling. CO2: Analyze relational diagrams for principal processes and structures within agricultural simulators, demonstrating proficiency in the design and layout of generalized agricultural simulation models. CO3: Evaluate the input environment and techniques for monitoring plant environments, comprehending the growth and developmental processes, and utilizing input-yield models in agricultural simulation. CO4: Conduct quantitative analysis of plant processes such as light photosynthesis, respiration, growth, water uptake, etc., and demonstrate proficiency in their mathematical modeling within the context of crop growth. CO5: Apply theoretical knowledge and mathematical modeling skills to analyze and simulate plant processes effectively, integrating these models for a comprehensive understanding of crop growth and development in agricultural systems.
Mapping between COs with POs and PSOs **Please refer mapping of PO and PSO for the style of mapping.**	
Mapping between Cos, POs and PSOs	

CO	PO												PSO		
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Course code	**SWE 607**
Course title	**ADVANCES IN IRRIGATION AND DRAINAGE**
Corse credit	2+0
Objective of Course	To acquaint and equip the students with the advance application of irrigation and drainage system along with applicability of various models.
Course Content	Theory UNIT I Advances in surface irrigation systems- surge irrigation: effect of surgingon surface flow hydraulics, cablegation: water supply management. UNIT II Atomization in sprinkler and micro irrigation system; multipurpose and special uses of micro irrigation. UNIT III Synthetic materials for drainage systems. Environmental issues related to drainage. Socio-economic impacts of drainage systems. UNIT IV Controlled drainage for reducing agricultural non point pollution. Application of simulation models for drainage systems.
References:	• FAO. 1982. Mechanized Sprinkler Irrigation. FAO Irrigation & Drainage Paper 35. • FAO. 1989. Guidelines for Designing and Evaluating Surface Irrigation System. FAO Irrigation & Drainage Paper 45. • Keller J & Bliesner RD. 1990. Sprinkler and Trickle Irrigation. Chapman & Hall. • Ritzema HP. (Ed.). 1994. Drainage Principles and Applications. ILRI. • Walker WR & Skogerboe GV. 1987.Surface Irrigation: Theory and Practice. Prentice Hall
Course Outcomes	CO1: Comprehend and analyze advancements in surface irrigation systems, including surge irrigation and cablegation, understanding their impact on surface flow hydraulics and effective water supply management. CO2: Evaluate atomization techniques in sprinkler and micro irrigation systems, demonstrating an understanding of their varied applications and specialized uses in agricultural contexts. CO3: Assess synthetic materials utilized in drainage systems, critically examining the environmental issues linked to drainage, and analyzing the socio-economic impacts associated with the implementation of drainage systems.

	CO4: Understand the concept of controlled drainage aimed at reducing agricultural non-point pollution and proficiently apply simulation models to design and optimize drainage systems for effective pollution control. CO5: Apply theoretical knowledge and analytical skills to assess and propose solutions for optimizing irrigation and drainage systems, integrating advancements and techniques for sustainable agricultural practices.

Mapping between COs with POs and PSOs
Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Please label the file with the Department Name

Post Graduate Master Program in Renewable Energy Engineering (OLD)

Course code	**Solar Energy System**
Course title	**REN 501**
Corse credit	**3 (2+1)**
Objective of Course	1. To provide knowledge, understanding and application oriented skills on renewable energy sources and relevant technologies towards their effective utilization. 2. To provide knowledge of solar energy, biomass energy concept and applications. 3. To understand the important parts of a biogas plant, design and principle of bio-diesel. 4. To understand the design of wind mills and applications, turbines and generators for small scale hydroelectric generation. 5. To impart knowledge of geothermal, ocean and tidal energy and their applications.
Course Content	**Theory** **UNIT I** Importance of solar energy and its application in crops drying, air and water heating, cooking, lighting, seed treatment and preservation. **UNIT II** Principles and design criteria of solar water heaters, solar crop dryers, solar cookers and solar absorption refrigeration systems, storage of energy by rock, water and phase change medium . **UNIT III** Measurement of solar radiation, reflectivity, absorptivity, transmissivity and thermal conductivity. **UNIT IV** Design of photovolatic cells. Economics of various solar energy systems. Operation and maintenance of solar operated appliances systems and equipments **Practicals:** 1. Study of the environmental parameters measuring instruments. 2. Measurement and estimation of solar radiation availability. 3. Determination of LAT, day length 4. Estimation of thermal losses, overall heat loss co-efficient of FPC. 5. Testing and performance evaluation of solar air heater. 6. Testing and performance evaluation of the solar water heater. 7. Testing and performance evaluation of the solar dryers 8. Study of the selective coatings. 9. Performance study of solar still. 10. Design and Performance evaluation of solar PV systems. 11. Visit of Solar Energy Application & Testing Centers
References:	1. Sukhatme S.P. Solar Energy. Tata McGraw-Hill Publishing company ltd., New Delhi. 2. Grag H.P. and Prakash J. solar energy fundamentals and applications. Tata McGraw-Hill publishing company Ltd.,New Delhi. 3. J A Duffie and W.A.Beckman. Solar Engineering of Thermal processes.

John Wiley.
4. F Kreith and J.F.Kreider, Principles of solar Engineering McGraw-Hill , 1978.
5. Garg H.P. Treatise on solar Energy , Wiley Inter science Publication , New York.
6. Hall. C.W. Drying Farm Crops. AVI publishing co. west port connecticut.

Course Outcomes

At the end of the course, learners will be able

CO1: To provide knowledge with a solid foundation for developing the use of renewable energy systems in society.

CO2: To study different suitable solar technology for those who wish to work with renewable energy systems.

CO3: To understand the renewable energy systems, its components and interactions between the components. This includes all renewable energy technologies, different storage technologies, distribution grid, smart grid including sensors. Regulation and control, and both "stand alone" systems and large integrated distribution systems.

CO4: To acquaint the skill to understand technical aspects and principles of renewable energy characteristics of the resource base (solar radiation, wind energy, bio energy, etc.) In a further steps an economic analysis of supply technologies.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**Wind Energy Technology**
Course title	**REN 502**
Corse credit	**3 (2+1)**
Objective of Course	1.To acquire the in-depth knowledge of wind energy conversion systems. 2.To study the wind potential mapping, estimation and analysis of wind data. 3.To acquire knowledge regarding mechanism of wind energy and different types of wind machines available to harness wind power. 4.To design wind turbine for irrigation as well as for power generation.
Course Content	**Theory:** **UNIT I** Wind machine types, classification, parameters. wind resource assessment-measurement, prediction and wind mapping, Wind velocity and power from the wind, Concept of wind energy and its use in water power generation. **UNIT II** Wind turbine aerodynamics, momentum theories, basic aerodynamics, airfoils and their characteristics, Horizontal Axis Wind Turbine (HAWT) - Blade Element Theory, wake analysis, Vertical Axis Wind Turbine (VAWT) aerodynamics. HAWT rotor design considerations, number of blades, blade profile, 2/3 blades and teetering, coning, power regulation, yaw system, tower. **UNIT III** Wind turbine loads, aerodynamic loads in steady operation, wind turbulence, static, WECS control system, requirements and strategies. Wind Energy Conversion System (WECS) siting, rotor selection, Annual Energy Output (AEO). Synchronous and asynchronous generators and loads, integration of wind energy converters to electrical networks, inverters. Testing of WECS. Noise. Miscellaneous topics. Mechanical and electrical applications, wind farms, Interfacing, Maintenance, Management of crops irrigated by wind pumps. Management of power generated by wind mill . **Practical** 1. Study of wind measuring instruments. 2. Energy estimation from wind data. 3. Design study of wind mill rotor blades. 4. Studies on Wind power generators 5. Problems on forces on the blades and thrust on turbines. 6. Study of water wind pumps. 7. Design calculations of wind pump for drip irrigation 8. Studies on velocity and power duration curves . 9. Visit to wind farms and studies on wind farm economics. 10. Study on wind energy storage system
References:	1. D.M.Simons, Wind Power, Noyes Data Corporations, 1975 2.T.N.Veziroglu (Ed), Alternative Energy Sources, Vol. 5, Mcgraw Hill, 1977. 3.Thomas Ackermann Wind Power in Power Systems.
Course Outcomes	At the end of the course, learners will be able to acquire knowledge regarding mechanism of wind energy and different types of wind machines available to harness wind power. Able to design wind turbine for irrigation as well as for power generation. **CO1:** To describe how wind energy is harnessed to create electricity. **CO2:** To state the major pros and cons of using wind energy.

	CO3: To demonstrate how wind energy can be utilized to create work. **CO4:** To contribute to the complex task of wind farm project development. **CO5:** To simulate and analyze the design of wind farms, lay outs etc.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**Biomass Energy Engineering**
Course title	**REN 503**
Corse credit	**3 (2+1)**
Objective of Course	1. To understand the bio-conversion technologies and fuels system, types of biomass derived fuels and energy, thermochemical conversion of biomass to heat and power, value adding of agro-residues. 2. To study various properties thermochemical and biochemical properties of biomass. 3. To design different biomass based technology for energy generation. 4. To provides overall information on concepts, tools and techniques for converting the different biomass into various energy forms for starting the biomass based energy production and its management.
Course Content	**Theory:** UNIT I Identification of various forms of biomass. biomass production and potential in India, Plantation for renewable energy i.e. wood as a fuel charcoal, producer gas. Different types of species for Energy plantation. clean development mechanism CDM UNIT II Thermo-chemical conversion of biomass, reactor configuration, gas conditioning systems, fast pyrolysis technologies, technologies for production of bio-liquids, standards of bio-oils, sizing/selection of gasifiers, open - top reburn down draft gasifier, performance evaluation of different gasifiers, furnaces, stores, briquetting plants. Biomass cogeneration, application of biomass for thermal applications, briquetting, water pumping, power generation , cooking. Technologies for conversion of biomass to electricity. Economics of various systems of biomass run plants, equipments, operation and maintenance. Design of rural base industries run on biomass **Practicals:** 1. Proximate analysis of solid fuels. 2. ultimate analysis of solid fuels. 3. Calculation of High Heat Value of solid and liquid fuels. 4. Calculation of Low Heat Value of gaseous fuels. 5. Determination of stoichiometric air requirement and excess air. 6. Gravimetric analysis, volumetric analysis and conversion. 7. Study and use of Bomb calorimeter. 8. Study of Junker's gas calorimeter. 9. Study of Gas Chromatography. 10 Study of different types of furnaces. 11. Testing of down draft gasifier. 12. Testing of open core gasifier. 13 Study of briquetting machines and wood burning stoves.
References:	1. D O Hall, G W Barnard, and P A Moss, Biomass for Energy in the Developing Countries, Current Roles, Potential, Problems, Propects. Pergamon Press Ltd, 1982. 2. L P White, L G Claskett, Biomass as Fuel. Academic Press, 1981. 3. T B Read, Biomass Gasification Principles and Technology. Energy

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<tr><td></td><td>Technology Review, No. 67, Noyes Data Corporation, USA, 1981.
4. V J Patel, A New Strategy for High Density Agroforestry. Jivraj Patel Agroforestry Centre, Gujarat, 1988.
5. A Kaupp and J R Goss, State of Art Report For Small Scale Gas Producer Engine Systems. Friedr Vieweg & Sohn Verlag Sgesellschaft mbh, Braunschweig, 1984.
6. D W Robinson and R C Mollan, Energy Management and Agriculture. Elsevier Science Publishers, 1982.</td></tr>
<tr><td>Course Outcomes</td><td>At the end of the course, learners will be able
CO1: To understand the bio-conversion technologies and fuels system, types of biomass derived fuels and energy, thermochemical conversion of biomass to heat and power, value adding of agro-residues.
CO2: To develop knowledge in properties of biomass and energy conversion process.
CO3: To compare the characteristics of products obtained from biomass pyrolysis.
CO4: To understand the basics of biomass gasification and gasifier design
CO5: To assess the potential of electrical power production from biomass.</td></tr>
<tr><td colspan="2">Mapping between COs with POs and PSOs
Please refer mapping of PO and PSO for the style of mapping.</td></tr>
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<tr><td>CO1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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Course code	**Biogas Technology and Mechanism**
Course title	**REN 504**
Corse credit	**3 (2+1)**
Objective of Course	1. To provide the in-depth knowledge about biogas technology and its mechanism in detail to use the biogas as domestic as well as commercial fuel. 2. To select, estimate and analyzed the biogas technology, chemical and physical conditions and get acquainted with various biogas appliances. 3. To understand the important parts of a biogas plant. 4. To analyze the different effluent materials generated by industries and based on availability to design appropriate size of biogas plant.
Course Content	**Theory:** UNIT I **Biogas Technology:** Introduction, historical background, digestion process, factors enhancing/ inhibiting biogas production. **Bio-chemical and Microbial Aspects:** Biogas mechanism, enhancing the biogas production and its purification. **Biogas Plant:** Systems, Types of biogas plants, classification, design of a biogas plant (cow dung and organic waste), structural strength, selection of site and size, construction technique material requirement, high rate digesters, night soil linked biogas plant. UNIT II **Biogas Distribution and Utilization:** Properties of biogas, different uses, design of biogas distribution system, pressure and flow measuring devices, safety devices, biogas fittings, principles of dual fuel biogas engines, its limitations, biogas appliances including thermal and cooking efficiency test. **Effluent**: Handling of effluent of biogas plant (cow dung based, sanitary latrine attached and agro industrial wastes), effluent treatment and management effect of slurry on crop and fish production. Integrated recycling of organic wastes. **Alternate Feed Material**: Study of biogas plant for distillery and sugar mills effluent, willow dust, agro-wastes, agro and processing industry wastes. UNIT III **Repair and Maintenance**: Repair and maintenance of biogas plants **Practical:** 1. Study on fixed dom type biogas plants. 2. Study on floating drum type biogas plants. 3. Study on determination of calorific value of biogas. 4. Study on design calculation of floating drum type biogas plant. 5. Determination of N, P and K contents of the fresh and digested slurry by chemical analysis. 6. Study of constructional details of willow dust based biogas plants. 7. Testing of biogas burner for heat transfer, thermal and cooking efficiency.

	8. Testing of biogas lamp 9. Determination of BOD/COD 10 Visit of biogas bottling plant
References:	1. Khandelwal, K.C. and S.S Mahdi.; Biogas Technology: A Practical Hand Book, Tata McGraw Hill Pvt. Co. 2. Chawla, O.P., Advances in Biogas Technology, I.C.A.R., New Delhi Rathore N.S., Kurchania A.K., Biomethanation Technology, Apex Publications, Udaipur, 2006 3. Mathur, A.N. and N.S Rathore; Biogas production management and utilization-Himanshu Publication.
Course Outcomes	At the end of the course, learners will be able **CO1:** To characterize different biomass feedstocks and wastes based on its constituents and properties **CO2:**To understand and evaluate various biomass pre-treatments and processing techniques in terms of their applicability for different biomass type for biomass conversion processes **CO3:** To understand the process of combustion, pyrolysis, gasification and liquefaction for production of value added bio-products, biogas, bio-CNG generation etc. **CO4:**To understand basics of biofuels, their production technologies and applications in various energy utility routes

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
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CO2															
CO3															
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Course code	**Direct Energy Conversion System**
Course title	**REN 505**
Corse credit	**2 (2+0)**
Objective of Course	1. To develop a comprehensive technological understanding in solar PV system components. 2. To provide in depth understanding of design parameters to help design and simulate the performance of a solar PV power plant. 3. To pertain knowledge about design, planning, project implementation and operation of solar PV power generation. 4. Design and simulate a PV power plant using software tool, Plan, project implementation, operation and maintenance. 5. Carry out techno-economic environmental performance evaluation of a solar PV power plant.
Course Content	**Theory:** UNIT I Basic science of energy conversion. Physics of semiconductor, fabrication and evaluation of various cells. UNIT II Solar energy and its utilization, solar cell, thermo-electric and thermonic devices, wind energy, fuel cell, magneto hydrodynamic energy conversion, biogas theory, design of energy converters with special reference to rural living. UNIT III Applications of solar cells in photovoltaic power.
References:	1. Non- conventional Energy sources by G. D. Rai, Khanna Publishers, 2-B, Nath Market, Nai Sarak, Delhi-110006. 2. D.M.Simons, Wind Power, Noyes Data Corporations, 1975 3. T.N.Veziroglu (Ed), Alternative Energy Sources,Vol.5, Mcgraw Hill, 1977. 4. Thomas Ackermann Wind Power in Power Systems 5. Grag H.P. and Prakash J. solar energy fundamentals and applications. Tata McGraw-Hill publishing company Ltd.,New Delhi. 6. Garg H.P. Treatise on solar Energy , Wiley Inter science Publication , New York. 7 Tony Burton, David Sharp and Nick Jenkins; Wind Energy: Handbook, John Wiley & Sons Ltd., West Sussex, England.2001.
Course Outcomes	At the end of the course, learners will be able **CO1:** To understand the physical principles of the photovoltaic (PV) solar cell and what are its sources of losses. **CO2:** To know the electrical (current-voltage and power-voltage) characteristics of solar cell, panel or generator and how the environment parameters influence it. **CO3:** To know the most important characteristics of the elements within a PV system, battery and charge controller, DC/DC converter, DC/AC converter (inverter) and loads. **CO4:** To understand the role of solar energy in the context of regional and global energy system, its economic, social and environmental implications, and the impact of technology on a local and global context. **CO5:** To know the main lines of research in the field of photovoltaic

	technology and solar energy.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**Alternate Fuels Technology and Applications**
Course title	**REN 506**
Corse credit	**3 (2+1)**
Objective of Course	1. To get acquainted with various alternate fuels, their applications and also to learn safety factors of alternate fuel, efficiency, economics and commercial considerations. 2. To impart the knowledge of basics of alternative fuels for internal combustion engine and alternative drive systems for automobiles, principle of solar energy collection 3. To impart the knowledge of methods of production of bio gas, methanol, ethanol, SVO, bio diesel and various aspects of electrical and hybrid vehicles 4. To study the use of various gaseous fuels and hydrogen for internal combustion engine application.
Course Content	**Theory** UNIT I Bioconversion Techniques, direct combustion, Pyrolysis, Flash pyrolysis, Formulation and gasification. UNIT II Utilization of industrial waste such as Biogases, improved cook stoves. Industrial biomass combustion systems gasification sizing beneficiation of Fuels, various sources of biofuels, Processing of various agro products for biofuels combustion characteristics of biofuels, working process in IC engines. Fuels efficiency, Fuel blends dual Fuel operation, Bio - gas generation and purification technology, biogas as cooking and IC engine fuel, performance evaluation of biogas as vehicle fuel, environmental pollution with conventional and alternate fuels. UNIT III Current biofuels scenario in India. availability of raw material technology for production of biofuels and developments in the sector. standardization and specifications for biofuels, clean development mechanism and biofuels. **Practicals:** 1. Proximate and ultimate analysis of solid fuels. 2. Calculation of High Heat Value of solid and liquid fuels. 3. Calculation of Low Heat Value of gaseous fuels. 4. Study of the Bio fuels characteristics – proximate analysis and ultimate analysis 5 Determination of calorific value of bio-fuels and biogas. 6. Design of fixed dome type and movable drum type biogas plants. 7. Study of the biogas purification 8. Study of the bio-fuels purification 9. Performance evaluation of biogas as IC engine fuel 10. Performance evaluation of biofuels as IC engine fuel
References:	1. Pathak B.S. and Srivastva NSL. Biomass based Decentralized Power Generation . SPRERI. 2. Selected Web sites www.ybiofuels.org/bio-fuels/history-biofuels.html 3. Gerpen J. Van, Shanks, Pruszko R. Clements D and Knothe G 2004. Bio-diesel Production Technology August-2002-January 2004. National

	Renewable Energy Laboratory (www.nrel.gov),US.
Course Outcomes	At the end of the course, learners will be able **CO1:** To understand broad comprehension of alternative transportation fuels and their production technologies. **CO2:** To explain various properties, methods of production of Bio gas, methanol, ethanol, SVO, Bio diesel. **CO3**: To illustrate the use of hydrogen and various gaseous fuels, reformulated conventional fuels & future alternative fuels for internal combustion engine application.. **CO4:** To explain the various aspects of electrical and Hybrid vehicles. **CO5:** To discuss economic considerations of alternative fuels.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**System Simulation and Computer Aided Problems Solving in Engineering**
Course title	**REN 507**
Corse credit	**2 (1+1)**
Objective of Course	1. To impart fundamental knowledge to students in the latest technological topics on Computer Aided Design, Computer Aided Manufacturing and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas of Renewable Energy. 2. To create congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations. 3. To broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation. 4. To provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.
Course Content	**Theory** UNIT I Concept, advantages and limitation of dimensional analysis, dimensions and units, fundamental and derived units, systems of units, conversion of units of measurement, conversion of dimensional constants, conversion of equations in different units, complete set of dimensionless products and their formulation methods- the Rayleigh's method, Buckingham's Pi theorem and other methods. UNIT II Mathematical modeling and engineering problem solving. UNIT III Computers and softwares – software development process – Algorithm design, – program composition- quality control- documentation and maintenance – software strategy. UNIT IV Approximation- round off errors- truncation errors. Nature of simulationsystems models and simulation- discreet event simulation- time advance mechanisms- components of discreet event simulation model. Simulation of singular server que- programme organization and logic- development of algorithm. UNIT V Solving differential equation on computers- modeling engineering systems with ordinary differential equations- solution techniques using computers
References:	1. Averill M. Law & W David Kelton.2000. *Simulation Modeling and Analysis*. McGraw Hill. 2. Balagurusamy E. 2000. *Numerical Methods*. Tata McGraw Hill. Buckingham E. 1914. *On Physical Similar System*. Physical Reviews 4:345. 3. Langhar H. 1951. *Dimensional Analysis and Theory of Models*. John Wiley & Sons. Murphy J. 1950. *Similitude in Engineering*. 4. The Roland Press Co. Robert J Schilling & Sandra L Harries. 2002. *Applied Numerical Methods for Engineers Using MATLAB and C*. 5. Thomson Asia. Simpson OJ. 2000. *Basic Statistics*. Oxford & IBH.Singh

RP. 2000.
6. *Computer Application in Food Technology*. Academic Press. Steven Chopra & Raywond Canale. 1989.
7. *Introduction to Computing for Engineers*. McGraw Hill.
8. Veerarajan T & Ramachnadran T. 2004. *Numerical Methods withProgrammes in C and C++*. Tata McGraw Hill.
9. Wilks SS. 1962. *Mathematical Statistics*. John Wiley & Sons

Course Outcomes

At the end of the course, learners will be able

CO1: To apply/develop solutions or to do research in the areas of Design and simulation in Renewable Energy Engineering.

CO2: To develop abilities and capabilities in developing and applying computer software and hardware to mechanical design and manufacturing fields.

CO3: To formulate relevant research problems; conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools.

CO4: To design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of renewable energy.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															

Course code	**Green House Technology and Management**
Course title	**REN 508**
Corse credit	**3 (2+1)**
Objective of Course	1. To provide the in-depth knowledge about greenhouse design, energetics, production technique, passive heating concept and evaporative cooling etc. 2. To get knowledge of thermal energy flows, analysis of green house, instrumentation and control in green house. 3. To equip with fundamental understanding, knowledge and skills to contribute in the practice of energy efficient green house. 4. To design and develop a different types of energy efficient green house.
Course Content	**Theory** UNIT I Introduction: Importance, Scopes, types of greenhouses and economics. UNIT II Greenhouse construction: Orientation, selection of site, floor plan, and construction materials designs and layout of greenhouse, load calculation and construction metrology. UNIT III Greenhouse environment and controls: Constituents of greenhouse environment and their effect on crop growth, type of heat loss, and calculation of heat requirement, greenhouse heating systems, heat sources, conservation of energy in greenhouse, different types of greenhouse cooling system, design of greenhouse cooling systems, greenhouse lighting system and design considerations, greenhouse environment control systems and automation, mathematical modeling of greenhouse environment greenhouse environment control instrumentation. UNIT IV Root Substrate Management: Soil based and soil less substrates, soil solarization and soil temperature modeling hydroponics techniques, greenhouse irrigations systems and controls, fertigation programmes, nutrition management, insect and disease management in greenhouse Post Harvest UNIT V Technology & Marketing : Packaging, grades & standards, post harvest of fresh flowers, market system of greenhouse products. **Practicals:** 1. Studies on greenhouse cooling system. 2. Performance evaluation of fan-pad cooling system. 3. Studies on greenhouse irrigation system. 4. Studies on greenhouse automation systems. 5. One week training/internships in greenhouse technology and management. 6. Studies on different root substrates and hydroponics cultivation. 7. Studies on greenhouse lighting system.
References:	1. Paul V.Welson; Greenhouse operation & management prentic Hali,New Jersey. 2. Hauon,J.J.,Holley,W.D. and Golds berry, K.L. Greenhouse Management, Springer- verlag,Berlin. 3. Robert MC Mohan; Introduction to greenhouse production, Ohio Agril. Edu. Curriculum materials Service.

	4. Bailey, B.J. and Takakura, T. Editer: A. kauo, Greenhouse Environment Control and automation. 5. G.N.Tiwari, R.K.Goyal; Greenhouse Technology, Narosa Publication, Delhi.
Course Outcomes	At the end of the course, learners will be able **CO1:** To understand the physical basis of the natural greenhouse effect, including the meaning of the term radiative forcing **CO2:** To get detailed knowledge about the importance of passive solar architecture and passive systems design at various building typologies. **CO3:** To articulate the elements of energy efficiency in green house and its importance for all. **CO4:** To acquire the knowledge on effects of micro-climate in cooling and energy efficiency of green house environments. **CO5:** To demonstrate knowledge related to human comfort due to ambient heat exchange in green house.

Mapping between COs with POs and PSOs
Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Integrated Rural Energy Planning and Organization**
Course title	**REN 509**
Corse credit	**3 (3+0)**
Objective of Course	1. To provide an understanding and experience of different aspects of Rural Development. 2. To develop expertise in planning and management of rural development programmes with focus on participatory development using renewable energy concepts. 3. To develop innovative, skill and employment oriented to attract bright students to the discipline of rural development. Thus, ensuring University – Industry interface under CSR Programme
Course Content	**Theory** UNIT I Importance and scope of rural energy planning and organisation present status and future thrusts. UNIT II Objectives of integrated rural energy planning, conventional and non-conventional sources of energy, biomass, photosynthesis, efficiency of energy conversion by different plant species, plantation for energy, wood as a fuel, charcoal, producer gas, biogas, their production, equipment required and application, design of integrated systems using solar, biomass, biogas and wind for lighting, cooking, water pumping, power generation for various uses in Agriculture both for renewable sources of energy, development of pilot villages, industries run solely on integrated sources of renewable energy. UNIT III Operation and maintenance of industries and plant.
References:	1. N.S.Rathore, A.N.Mathur and A.S. Solanki. Integrated Rural Energy Planning . Agrotech Publishing Academy, Udaipur. 2. Somasehhura N. Rural Energy. Sterling Publishers Pvt. Ltd., New Delhi 3. R.A. Meyers, Hand Book of Energy Technology. Jhon Wileys Sons., New York, 1983. 4. Elmahgary Y. and Biswas, A.K., Integrated Rural Energy Planning, Butter Warth, U.K., 1985.
Course Outcomes	At the end of the course, learners will be able **CO1:** To pursue Rural Development Specialist / Analyst as a career. **CO2:** To start a Non- Governmental Organisation or Voluntary agency to serve for the welfare of the rural poor. **CO3:** To develop ability to conduct Research on Rural Development using different renewable energy gadgets.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															

Course code	**Heat Transfer In Solar Energy**
Course title	**REN 510**
Corse credit	**3 (2+1)**
Objective of Course	1. To articulate the technical and economic fundamentals of solar thermal energy conversion useful to society and industry. 2. To describe the spectrum of possible solar thermal technologies to assist industrial processing or power production. 3. To assess solar thermal technologies to identify the greatest solar utility for a client in a given locale.
Course Content	**Theory** UNIT I Principles of heat transfer, theory of heat conduction, Mathematical and numerical analysis of heat conduction problems, transient and static heat conduction. Theory of convective heat transfer, heat transfer in duct flows. Boiling condensation and heat exchangers. Radiation heat transfer between black and gray bodies. UNIT II Heat transfer in solar air and water heaters. Energy balance equations and performance prediction analysis. Heat transfer and energy balance equations of solar distillation, soil solarization, solar drying and green house systems. **Practicals:** 1. Computer programming and performance prediction of box type solar cooker 2. Computer programming and performance prediction of solar air heating system. 3. Computer programming and performance prediction of solar distillation system. 4. Computer programming and performance prediction of solar green house system. 5. Computer programming and performance prediction of soil solarization system. 6. Computer programming and performance prediction of water heating system 7. Computer programming and performance prediction of solar drying system
References:	1. Duffie J.A. Beckman solar Engineering of Thermal processes . wiley Inter Science 2. Stine W.B. , Harrigan R.W. Solar Energy Fundamentals and Design with computer applications . 3.Wong H.Y. Heat Transfer for Engineers Longman London & New York
Course Outcomes	At the end of the course, learners will be able **CO1:** To investigate and experiment with basic thermodynamic concepts and solar thermal application in the laboratory. **CO2:** To familiarize with thermodynamic aspects of various materials **CO3:** To use various equipments used for measuring solar radiation and to provide hands on experience in operation of solar water heaters.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															

Course code	**Energy and Environmental Engineering**
Course title	**REN 511**
Corse credit	**3 (3+0)**
Objective of Course	1. To provide detail knowledge of carbon cycle, ecosystem, climate change and global environmental change and interlinkages of renewable energy sources. 2. To understand the relationship between carbon cycle, energy policies, energy use and economic growth and factors affecting environment. 3. To impart basic knowledge about current energy scenario, energy analysis in transportation, buildings etc. 4. To inculcate systematic knowledge and skill about assessing the environment impact of energy use.
Course Content	**Theory** UNIT I Sources of energy impact of fossil fuels on environment new and improved energy technologies, energy consumption strategies to meet demands for energy and environment quality, renewable sources of energy, air, water and soil pollution and its control, environmental impact of current agricultural technologies and engineering systems for pollution control and conservation and utilization of natural resources. UNIT II Waste management in agro industries, handling, storage and processing of waste, reclamation of waste water, use of waste land for energy generation, role and application of renewable energy for clean environment. Case studies, Biofilters, Biodegradable plastics for mulching.
References:	1. Twidell John W. and A. D. Weir; Renewable Energy Sources 2. Dune, P. D.; Renewable Energies: Sources, Conversion and Applications 3. Hopes G. Puppy; Energy and Environment, Mankind and Energy Needs, Elsevir Pub. Co., New York 4. Rao C. S.; Environmental Pollution Control Engineering 5. Rathore N.S., Kurchania A.K., Climatic Changes & Their Remedial Measures, Shubhi Publications, Gurgaon, 2001 6. Mathur A. N., Rathore N. S. and V. K. Vijay; Environmental Awareness 7. David Coley. Energy and Climate Change. Jhon Wiley & Sons, Ltd.U.K.
Course Outcomes	At the end of the course, learners will be able **CO1:** To study current emerging technologies and Effectively apply basic principles of the natural and social sciences to current issues of natural resources and the environment. **CO2:** To understand and appropriately use the vocabularies of the natural and social sciences relevant to issues of natural resources and the environment. **CO3:** To understand various components of the environment and interfaces and ecosystem and its various component and functions. **CO4:** To acquire the knowledge on ecology, and ecological dynamics. **CO5:** To understand the various ecosystem services and their role in sustaining the environment.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															

CO2															
CO3															
CO4															
CO5															

Course code	**Agro Energy and Audit Management**
Course title	**REN 512**
Corse credit	**2 (2+0)**
Objective of Course	1. To acquaint and equip about the sources of energy, conservation of energy and its management. Energy use scenario in agricultural production system, agro-based industry. Study of energy efficiency, energy planning, forecasting and energy economics. 2. To study the energy efficiency, energy planning, forecasting and energy economics. 3. To understand the concept of energy auditing, conservation and management. 4. To study the quantification, conservation opportunity and retrofitting of energy efficient system integration is expected from the course.
Course Content	**Theory** UNIT I 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. Pattern of energy consumption and their constraints in production of agriculture. Direct and indirect energy. UNIT II Energy audit of production agriculture, and rural living and scope of conservation. UNIT III 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 UNIT IV Energy conservation planning and practices. Energy forecasting, Energy economics, Energy pricing and incentives for energy conservation, factors effecting energy economics. Energy modeling.
References:	1. Kennedy WJ Jr. & Wayne C Turner.1984. Energy Management. Prentice Hall. 2. Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC 3. Fluck RC & Baird CD.1984. Agricultural Energetics. AVI Publ. 4. Rai GD. 1998. Non-conventional Sources of Energy. Khanna Publ. 5. Twindal JW & Anthony D Wier 1986. Renewable Energy Sources. E & F.N. Spon Ltd. **6.** Verma SR, Mittal JP & Surendra Singh 1994. Energy Management and Conservation in Agricultural Production and Food Processing. USG Publ. & Distr., Ludhiana
Course Outcomes	At the end of the course, learners will be able **CO1:** To understand the concept of agro energy auditing, conservation and management and to outline energy scenario, audit and management. **CO2:** To learn in-depth knowledge about the quantification, conservation opportunity and retrofitting of energy efficient system integration. **CO3:** To apply energy conservation policy, regulations in industrial practices. **CO4:** To evaluate energy economics and Identify opportunities for rational use of energy.

	CO5: To analyze electrical systems for energy conservation and thermal systems for energy efficiency.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Design and Analysis of Renewable Energy Conversion Systems**
Course title	**REN 513**
Corse credit	**3 (3+0)**
Objective of Course	1. To keep the knowledge of students upgraded with the current thoughts and newer technology options along with their advances in the field of the utilization of different renewable energy technologies for energy production. 2. To design and analyze renewable energy conversion systems, thermodynamics involved in it and performance of renewable energy systems. 3. To design of various energy conversion systems, standards and test codes of renewable energy systems and their performance analysis.
Course Content	**Theory** UNIT I Energy cycle of the earth; water flow and storage; ocean currents and tides. Energy heat flow and energy storage; photosynthesis and biomass; renewable energy sources. Thermodynamics of energy conversion; conversion of solar energy, wind energy, water flows, heat, biomass, etc.; other conversion processes. UNIT II Development and use of biogas, alcohols and plant oils, plant oil esters in I.C. engines. Study of various parameters for measuring the performance of the output. Design of bio-fuel production units: design of gasifiers, gas flow rates, biogas plants. Establishment of esterification plant, fuel blending.
References:	1. Boyle Godfrey. 1996. Renewable Energy: Power for Sustainable Future. Oxford Univ. Press. 2. Culp AW. 1991. Principles of Energy Conservation. Tata McGraw Hill. Duffle JA & Beckman WA. 1991. Solar Engineering of Thermal Processes. John Wiley. 3. Garg HP & Prakash J.1997. Solar Energy - Fundamental and Application. 4. Tata McGraw Hill. 5. Grewal NS, Ahluwalia S, Singh S & Singh G. 1997. Hand Book of Biogas Technology. Solar Energy Fundamentals and Applications. TMH New Delhi. 6. Mittal KM. 1985. Biomass Systems: Principles & Applications. New Age International. 7. Odum HT & Odum EC. 1976. Energy Basis for Man and Nature. Tata McGraw Hill. 8. Rao SS & Parulekar BB.1999. Non-conventional, Renewable and Conventional . Khanna Publ. 9. Sukhatme SP.1997. Solar Energy - Principles of Thermal Collection and Storage. 2nd Ed. Tata McGraw Hill.
Course Outcomes	At the end of the course, learners will be able **CO1:** To study the design technology and system on renewable and carbon-neutral energy. **CO2:** To analyse energy economics and business model. **CO3:** To formulate energy policy and planning. **CO4:** To develop interdisciplinary research in energy systems engineering. **CO5:** To understand professional and ethical responsibility in renewable energy.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Engineering Instrumentation and Control**
Course title	**REN 514**
Corse credit	**3 (2+1)**
Objective of Course	The course focuses on imparting the principles of measurement which includes the working mechanism of various sensors and devices, that are in use to measure the important physical variables of various mechatronic systems.
Course Content	**Theory** UNIT I Introduction to functional elements of an instrument, active and passive transducers, analog and digital modes, null and deflection methods, performance characteristics of instruments including static and dynamic characteristics. UNIT II Measuring devices for force, torque and shaft power, strain gauge type devices and their design and application in two and three dimensional force measurement, Design and analysis of strain gauge type tillage tool dynamometers, Devices for measurement of temperature, relative humidity, solar radiation, pressure, sound, vibration, flow etc. Measuring instruments for calorific values of solid, liquid and gaseous fuels, Measurement of gas composition using GLC. Recording devices and their type, UNIT III Data storage systems and their application **Practical** Calibration of instruments, measurement of strain, making of thermocouples and their testing, now measurement in a pipe, humidity measurement, data analysis and interpretation, signal conditioning circuits, testing of pressure transducers
References:	1. Doeblin, E. O. (1966) Measurement Systems -Application and Design, McGraw-Hill, Book Company, 2. Ambrosius, E. E. (1966), Mechanical measurement and Instrumentation, The Ronald Press Company, New York. 3. Oliver, F. J. (1971), Practical Instrumentation Transducers, Hayden Book company Inc., New York, 4. Perry, C. C. and Lissner, H.R. (1962), The Strain Gauge Primer, McGraw-Hill Book Company, , 5. Nachtigal, C.L. (1990), Instrumentation and Control: fundamentals and Applications, John Wiley and Sons.
Course Outcomes	At the end of the course, learners will be able **CO1:** To select appropriate device for the measurement of parameters like temperature, pressure, speed, stress, humidity, flow velocity etc., and justify its use through characteristics and performance. **CO2:**To identify, formulate and solve problems in various fields of Instrumentation & Control engineering such as Process, Environmental, Agriculture Instrumentation and Building Automation etc. **CO3:**To demonstrate an ability to design and prepare experimental set ups and conduct experiments, analyze and interpret data.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															

Course code	**Statistical Methods**
Course title	**REN 515**
Corse credit	**3 (3+0)**
Objective of Course	1. To impart knowledge on Statistical concepts like Data Collection, Measures of Central Tendency and Dispersion, Probability and Distributions, Statistical Methods, Inference, Sampling methods, Experimental Designs, Economical and Vital Statistics, SQC, reliability and Operations Research. 2. To impart knowledge on Actuarial Science concepts like basics of Economics, Financial Accounting and Mathematics, Surviving models, life contingences, Business communication, Actuarial Statistics , Mortality and Insurance. 3. To equip students with good quality to appear for competitive examinations.
Course Content	**Theory** UNIT I Classical and recently developed statistical procedures, basic principles of statistical inference and the rationale underlying the choice of these procedures. UNIT II Problems of estimation, hypothesis testing, large sample theory, probability, regression.
References:	1. Kapur, K. (2000). Elements of Practical Statistics. Oxford & IBH Publishing Co. Pvt. Ltd. 2. Simpson, O.J. (2000). Basic Statistics. Oxford & lBH Publishing Co. Pvt. Ltd. 3. Milton, J. S. and Arnold, J. C. 1995). Introduction to Probability and Statistics: Principles and Applications for Engineering and Computing Sciences. McGraw Hill.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the have the basic knowledge on data collection and various statistical elementary tools. **CO2:** Made a bridge between the elementary statistical tools and probability theory. **CO3:** Find the inter-relation between two or more phenomena with the help of curve fitting and correlation-regression analysis.

Mapping between COs with POs and PSOs
Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															

Course code	**Masters' Seminar**
Course title	**REN 591**
Corse credit	**1 (0+1)**
Objective of Course	1. To prepare students to compete for a successful career in Renewable Energy Engineering profession through global education standards. 2. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Renewable Energy Engineering problems. 3. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints. 4. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts. 5. To create an awareness among the students about the need for life long learning to succeed in their professional career.
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To get the knowledge and to demonstrate the ability to identify, formulate and solve engineering problems. **CO2:** To demonstrate the ability to design and conduct experiments, analyze and interpret data. **CO3:** To visualize the ability and work on laboratory and multi-disciplinary tasks. **CO4:** To demonstrate the skills to use modern engineering tools, software's and equipment to analyze problems. **CO5:** To demonstrate the knowledge of professional, ethical responsibilities and in both verbal and written form and to develop confidence for self education and ability for life-long learning.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Special Problem**
Course title	**REN 592**
Corse credit	**1 (0+1)**
Objective of Course	1. To provide a comprehensive understanding of the concepts and methodologies for problem identification, analysis of problem, report preparation, problem evaluation.
Course Content	-
References:	-
Course Outcomes	

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Industry/Institute Training**
Course title	**REN 595**
Corse credit	**NC**
Objective of Course	To expose the students to the industry.
Course Content	Institutional In-plant training in the relevant Renewable energy devices/process during manufacturing, assembly, testing and installation of equipments. To study the actual working of the equipment and various unit operations. The evaluation will be based on the written report of the student and the comments of the factory managers. The duration of training shall be three weeks. The student shall be required to do training in the institute other than the institute in which he/she is enrolled.
References:	-
Course Outcomes	**CO1:** Industrial Training can make the students aware of the Industry Norms and to work in a real work environment which can help them in understanding how an organization works. **CO2:** To understand aware about the new/latest technologies used in the industry.

Mapping between COs with POs and PSOs
Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															

Course code	**Master's Research**
Course title	**REN 519**
Corse credit	**20 (0+20)**
Objective of Course	2. To provide a comprehensive understanding of the concepts and methodologies for project identification, project preparation, project evaluation and project financing 3. To make the student understand the project cycle and their wide socio-economic and environmental impacts. 4. To make the student learn how to evaluate a project in view of global concern about sustainable development of energy and environment projects
Course Content	
References:	
Course Outcomes	At the end of the course, learners will be able **CO1:** To identify various Renewable Energy Engineering and Environmental features of a project. **CO2:** Laboratory and field based study. **CO3:** Small and comprehensive projects for renewable energy engineering development and sustainability. **CO4:** To develop a project with suitable technology/systems and global environmental impacts as well as energy saving. **CO5:** To carry out techno-economic evaluation of Renewable Energy Engineering projects compared with other conventional systems as well as environmental considerations.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Post Graduate Doctor of Philosophy (Ph.D.) Program in Renewable Energy Engineering (OLD)

Course code	**Advanced Energy Systems For Industrial Applications**
Course title	**REN 601**
Corse credit	**3 (3+0)**
Objective of Course	1. To describe advanced biochemical and thermochemical conversion system. 2. To characterize different wastes/biomass utilize in thermochemical conversion system. 3. To study design criteria for advance energy conversion system. 4. To study the quantification, conservation opportunity and retrofitting of energy efficient system integration for industry utilization.
Course Content	**Theory** Gasification combined cycle (IGCC), Fuels for power generation, Advance energy storage systems, Hydrogen power clean coat technologies, Pressurized fluidised bed combustion, Natural gas cycles, Integrated generation, Fuel cells, Energy conservation in power plant. Power plants, Bio fuel technology plants, bio fuel purification and compression technology. Biogas bottling plant.
References:	1. Nik Khartchenko, Advanced Energy Systems. Taylor & Francis; 1 edition. 2. Xianguo Li, Principles of Fuel Cells University of Waterloo, Ontario, Canada 3. Fuel Cell Technology Handbook, Editor(s): Gregor Hoogers, Trier University of Applied Sciences, Birkenfeld, Germany 4. Caye Drapcho, John Nghiem, Terry Walker Biofuels Engineering Process Technology, McGraw Hills. 5. Biofuel Technology Handbook, Free Download Book from http://artikel-software.com/blog/2008/06/16/biofuel-technology-handbook
Course Outcomes	At the end of the course, learners will be able **CO1:** To understand the concept of different energy conversion routes. **CO2:** To learn in-depth knowledge about biochemical and thermochemical conversion system. **CO3:** To apply energy conservation system for thermal as well as power generation system for industrial applications. **CO4:** To evaluate energy economics and Identify opportunities for rational use of energy.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															

Course code	**Computer Aided Analysis And Design Of Renewable Energy Systems**
Course title	**REN 602**
Corse credit	**3 (2+1)**
Objective of Course	1. To train students as competent professionals in renewable energy engineering. 2. To impart skill development for a rapidly changing technological environment using different software's in renewable energy engineering. 3. To collaborate with the industry in research and allied activities for a better industry-institute interaction. 4. To serve the society by imparting quality education and providing ethical, professional leadership quality to students to find solutions for societal problems.
Course Content	**Theory** Introduction to computer-aided design, Autolips,Geometric modeling and interactive graphics, Computer-aided analysis and synthesis of common Renwable Energy systems. Application of numerical methods and optimal techniques to machine design, problems, Computer-aided selection of standard mechanical components, Introduction to FEM. Computer aided design of Renewable Energy Systems viz. solar air heating systems, solar dryers, Greenhouses, biomass gasifier and biogas plant. 3D rendering and animation. MATLAB programming language for the machine components. **Practicals** Preparation of engineering drawings of equipment/machine, energy balance eequations and programming of solar air heating, solar drying, greenhouse. Design calculation and analysis of biomass gasifier and biogas systems. Estimating and costing of RE systems.
References:	1. Ramamurty, T. (2001). Computer Aided Mechanical Design and Analysis, Tata McGraw-Hill, New Delhi. 2. Mukhopadhyay, M. (2000). Matrix, Finite Element, Computer and Structural Analysis, Oxford & IBH Publishing Co. Pvt. Ltd. 3. Krishnamoorty, G. (2001). Finite Element Analysis: Theory and Programming Tata McGraw-Hill, New Delhi. 4. Kundra, C. V. (2000). Numerical Control and Computer Aided Manufacturing Tata McGraw-Hill, New Delhi. 5. Zeid, K. (2000). CAD/CAM Theory and Practice, Tata McGraw-Hill, New Delhi.
Course Outcomes	At the end of the course, learners will be able **CO1:** To implement structural engineering projects as an individual or member in design and execution team. **CO2:** To carry out novel research in computer aided structural and multidisciplinary domains. **CO3:** To effectively examine materials and technical reports and ensure sustainable construction practices as per updated codes.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**

CO1															
CO2															
CO3															

Course code	**Energy Lab**
Course title	**REN 603**
Corse credit	**3 (0+3)**
Objective of Course	1. To provide exposure and hands-on-skills practice to the students on various aspects of renewable energy sources and technology. 2. To get detailed insights into the design and operational aspects of renewable energy devices and systems. 3. To expose real working environment and get acquainted with the literature available of the various research challenges in the field of Energy Technology. 4. To promote and develop presentation skills and import a knowledgeable society.
Course Content	**Practicals** 1. Study of Solar cell characteristic. 2. Study of Solar P. V. System 3. Study of Plank's constant by radiation law 4. Study of Solar Still and calculation of its efficiency 5. Study of agricultural wastes fired gasifier for power generation. 6. Study of Solar Powered Refrigeration system. 7. Study of Gas Chromatograph and determination of composition of biogas, producer gas and flue gases. 8. Development of solid and liquid fuel from biomass. 9. Study and testing of dual fuel engine running on biogas and diesel. 10. Development of biodiesel from Jatropha oil. 11. Study of Bomb Calorimeter and measurement of calorific value of different biomass. 12. Study of Proximate and Ultimate analysis of biomass 13. Testing of portable type of Improved Cook stoves 14. Study the harnessing the power from wind. 15. Study of Integrated Energy System
References:	1. Rathore N.S., Kurchania A.K., Panwar N.L., Renewable Energy: Theory & Practice, Himanshu Publications, 2006 2. Khandelwal, K.C. & Mahdi, S.S. Biogas Technology, 1990. 3. Rai, G.D. Non-Conventional Energy Sources, Kh Publishers, New Delhi.
Course Outcomes	At the end of the course, learners will be able **CO1:** To locate the I-V and P-V characteristic with variation in temperature and radiation under series and parallel combination. **CO2:** To impart knowledge on fundamentals of economic principles and their applications in the broad field of supply and demand of energy **CO3:** To make inquisitive about the problems of energy economics and arousing their interest on practical problem solving skills.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															

CO2															
CO3															

Course code	**Numerical Analysis**
Course title	**REN 604**
Corse credit	**3 (2+1)**
Objective of Course	1. To develop of theory and practice in the use of advanced numerical methods for efficient solution of differential equation in renewable energy engineering. 2. To formulate the renewable energy device performance in the form of numerical equations
Course Content	**Theory** UNIT I Numerical methods for systems of linear equations, eigen values, interpolation, differentiation, least squares. UNIT II Numerical solution of differential equations and non-linear equations in several variables. **Practical:** Practice on matrix manipulation, Exercises on solution of the systems of linear and non-linear equations, solution of differential equations.
References:	1. Scarborough, G. (2000). Numerical Mathematical Analysis. Oxford & IBH Publishing -Co. Pvt. Ltd. 2. Chapra, C. (2000). Numerical Methods for Engineers. Tata McGraw-Hill, Delhi. 3. Atkinson, K. (1993). Elementary Numerical Analysis. 2nd Ed. John Wiley 4. Epperson. J.F. (2002). An Introduction to Numerical Methods and Analysis. John Wiley.
Course Outcomes	At the end of the course, learners will be able **CO1:** To apply mathematical concepts and principles in renewable energy technology and perform abstract mathematical reasoning. **CO2:** To understand the application of Fourier transform in engineering application. **CO3:** To apply conformal mapping for heat flow & fluid flow problems. **CO4:** To develop Finite difference methods for elliptical and parabolic equations.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															

Course code	**Agricultural Waste And By-Products Utilization**
Course title	**REN 605**
Corse credit	**3 (2+1)**
Objective of Course	1. To acquaint and equip proper utilization of agricultural waste and by-products and development of value added products from wastes 2. To provide in depth knowledge, understanding and application oriented skills on sources, quality, classification and characteristics of agricultural waste and by-products along with municipal and compost treatment and remote sensing technologies for agricultural waste management. 3. To estimate, characterize and design of agricultural waste management conversion system. 4. To understand the energetic and kinetics of anaerobic treatment, sanitation land fill, pre-digestion of waste etc.
Course Content	**Theory** UNIT I Generation of by-products, agricultural and agro industrial byproducts/ wastes, properties, on site handling, storage and processing. UNIT II Collection of wastes, utilization pattern as fuel, agricultural waste fired furnaces: Mechanism, construction and efficiency, suitability of wastes as fuel, fuel briquettes, briquetting process, equipment, factors affecting briquetting. UNIT III Utilization of wastes for paper production, production of particle board, utilization, by-products from rice mill, rice husk, rice bran, utilisation. UNIT IV 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. **Practical** Exercises on stepped grate and fixed grate rice husk furnaces, waste fired furnace, briquette machine, production of alcohol from waste materials, production and testing of paperboards and particleboards from agricultural wastes.
References:	1. ASAE Standards. 1984. *Manure Production and Characteristics*. 2. Bor S Luh (Ed.). 1980. *Rice: Production and Utilization*. AVI Publ. 3. Chahal DS.1991. *Food, Feed and Fuel from Biomass*. Oxford & IBH. 4. Chakraverty A. 1989. *Biotechnology and other Alternative Technologies for Utilisation of Biomass/ Agricultural Wastes*. Oxford & IBH. 5. David C Wilson. 1981. *Waste Management - Planning, Evaluation,Technologies*. Oxford. 6. Donald L Klass & Emert H George 1981. *Fuels from Biomass and Wastes*. Ann. Arbor. Science Publ. 7. Srivastava PK, Maheswari RC & Ohja TP. 1995. *Biomass Briquetting and Utilization*. Jain Bros. 8. USDA 1992. *Agricultural Waste Management Field Handbook*. USDA.

	9. Wilfred A Cote.1983. *Biomass Utilization*. Plenum Press.
Course Outcomes	At the end of the course, learners will be able **CO1:** To apply the knowledge about the operation of agricultural waste to energy plants. **CO2:** To analyze the various aspects of agricultural waste utilization for energy generation. **CO3:** To apply the knowledge in planning & operation of agricultural waste to energy plants. **CO4:** To introduce role of biotechnology in agricultural waste and by products management.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															

Course code	**Doctoral Seminar-I**
Course title	**REE 691**
Corse credit	**1 (1+0)**
Objective of Course	1. To prepare students to compete for a successful career in Renewable Energy Engineering profession through global education standards. 2. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Renewable Energy Engineering problems. 3. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints. 4. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts. 5. To create an awareness among the students about the need for life long learning to succeed in their professional career.
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To get the knowledge and to demonstrate the ability to identify, formulate and solve engineering problems. **CO2:** To demonstrate the ability to design and conduct experiments, analyze and interpret data. **CO3:** To visualize the ability and work on laboratory and multi-disciplinary tasks. **CO4:** To demonstrate the skills to use modern engineering tools, software's and equipment to analyze problems. **CO5:** To demonstrate the knowledge of professional, ethical responsibilities and in both verbal and written form and to develop confidence for self education and ability for life-long learning.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Doctoral Seminar-II**
Course title	**REE 692**
Corse credit	**1 (1+0)**
Objective of Course	1. To prepare students to compete for a successful career in Renewable Energy Engineering profession with multi-disciplinary aspects through global education standards. 2. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Renewable Energy Engineering with other discipline related problems. 3. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints. 4. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts. 5. To create an awareness among the students about the need for life long learning to succeed in their professional career.
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To get the knowledge and to demonstrate the ability to identify, formulate and solve engineering problems. **CO2:** To demonstrate the ability to design and conduct experiments, analyze and interpret data. **CO3:** To visualize the ability and work on laboratory and multi-disciplinary tasks. **CO4:** To demonstrate the skills to use modern engineering tools, software's and equipment to analyze problems. **CO5:** To demonstrate the knowledge of professional, ethical responsibilities and in both verbal and written form and to develop confidence for self education and ability for life-long learning.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Special Problem**
Course title	**REN 693**
Corse credit	**1 (0+1)**
Objective of Course	To provide a comprehensive understanding of the concepts and methodologies for problem identification, analysis of problem, report preparation, problem evaluation.
Course Content	-
References:	-
Course Outcomes	

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Case Study**
Course title	**REN 694**
Corse credit	**1 (0+1)**
Objective of Course	To describe an individual situation (case) in renewable energy discipline in detail; identify the key issues of the case; analyse the case using relevant theoretical concepts from your unit or discipline; and recommend a course of action for that particular case (particularly for problem-solving case studies)
Course Content	-
References:	-
Course Outcomes	Case studies are effective ways to get students to practically apply their skills and their understanding of learned facts to a real-world situation. They are particularly useful where situations are complex and solutions are uncertain.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Doctoral Research**
Course title	**REE 699**
Corse credit	**45 (0+45)**
Objective of Course	1. To provide a comprehensive understanding of the concepts and methodologies for project identification, project preparation, project evaluation and project financing 2. To make the student understand the project cycle and their wide socio-economic and environmental impacts 3. To make the student learn how to evaluate a project in view of global concern about sustainable development of energy and environment projects
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To identify various practical issues related Renewable Energy Engineering and Environmental features of a project. **CO2:** Laboratory/machine/ gadget development and field based study. **CO3:** Small and comprehensive projects for renewable energy engineering development and sustainability. **CO4:** To develop a project with suitable technology/systems and global environmental impacts as well as energy saving. **CO5:** To carry out techno-economic evaluation of Renewable Energy Engineering projects compared with other conventional systems as well as environmental considerations.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Advanced Photovoltaic Power Generation**
Course title	**REE 608**
Corse credit	**2 (1+1)**
Objective of Course	6. To develop a comprehensive technological understanding in solar PV system components. 7. To provide in depth understanding of design parameters to help design and simulate the performance of a solar PV power plant. 8. To pertain knowledge about design, planning, project implementation and operation of solar PV power generation. 9. Design and simulate a PV power plant using software tool, Plan, project implementation, operation and maintenance. 10. Carry out techno-economic environmental performance evaluation of a solar PV power plant.
Course Content	**Theory:** **Unit I** 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. **Unit -II** Systems for remote applications and large solar PV power plants: System integrations, roof top system, sizing methodology, power control, storage, tracking and control. PCID simulation of industrial solar cell structure, software's in solar cell simulation. **Unit III** Space charge control, low pressure diode, MMPT, cesium converter, system considerations. Photo electro chemical cells and materials. Photo galvanic cells: Recent development. **Unit IV** Conjunctive use of photo conversion systems: Photo-agriculture system, components, integration and economics. Software's for PV system integration and designing. PV system for ground mounted and rooftop plants with shadow analysis. **Practicals:** PV systems for typical applications, water pumping, solar PV tracking and mechanical clock tracking. Testing of power control system for output regulation, charging and discharging characteristics of storageby PV panels.
References:	1. Duffle JA and Beckman WA. 1991. *Solar Engineering of Thermal Processes*. John Wiley, NewJersey. 2. Fonash SJ. 1982. *Solar Cell Device Physics*. Academic Press, Cambridge, England. 3. Garg HP. 1990. *Advances in Solar Energy Technology*. Springer Publishing Company, Dordrecht,Netherland. 4. Green MA. 1981. *Solar Cells Operating Principles, Technology, and System Applications.* Prentice Hall, New Jersey. 5. Kreith F and Kreider JF. 1978. *Principles of Solar Engineering.* McGraw Hill, New York. 6. Luque A and Hegedus S. 2011. *Handbook of Photovoltaic Science and Engineering Education.* JohnWiley and Sons, New Jersey. 7. Solanki CS. 2011. *Solar Photovoltaic: Fundamentals, Technologies and*

Applications. PHI Learning Private Limited, Delhi.
8. Sze SM and Kwok KN. 2007. *Physics of Semiconductor Devices*. John Wiley & Sons, New Jersey.
9. Veziroglu TN. 1977. *Alternative Energy Sources*. McGraw Hill, New York.

Course Outcomes

At the end of the course, learners will be able

CO1: To understand the physical principles of the photovoltaic (PV) solar cell and what are its sources of losses.

CO2: To know the electrical (current-voltage and power-voltage) characteristics of solar cell, panel or generator and how the environment parameters influence it.

CO3: To know the most important characteristics of the elements within a PV system, battery and charge controller, DC/DC converter, DC/AC converter (inverter) and loads.

CO4: To understand the role of solar energy in the context of regional and global energy system, its economic, social and environmental implications, and the impact of technology on a local and global context.

CO5: To know the main lines of research in the field of photovoltaic technology and solar energy.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Energy Planning, Management and Economics**
Course title	**REE 609**
Corse credit	**3 (3+0)**
Objective of Course	1.To acquaint and equip with energy planning, management and economical evaluation for agricultural production system. 2.To quantify, analyze and forecast the demand and supply of different energy for agriculture production system. 3.To evaluate the techno economics of RET's use in industry and domestic purposes.
Course Content	**Theory:** **Unit I** 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. Pattern of energy consumption and their constraints in production of agriculture. Direct and indirect energy. **Unit -II** Energy audit of production agriculture and rural living and scope of conservation. Identification of energy efficient machinery systems, energy losses and their management. **Unit III** Energy analysis techniques and methods: Energy balance, output and input ratio, resource utilization, conservation of energy sources. Energy conservation planning and practices. **Unit IV** Energy forecasting, energy economics, energy pricing and incentives for energy conservation, factors effecting energy economics. Techno-economic evaluation of RET's, computation of programme for efficient energy management.
References:	1. Fluck RC and Baird CD. 1984. *Agricultural Energetics*. AVI Publication, United State. 2. Kennedy WJ and Turner WC. 1984. *Energy Management.* Prentice Hall, New Jersey. 3. Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press, Florida. 4. Rai GD. 1998. *Nonconventional Sources of Energy.*Khanna Publication, New Delhi. 5. Twindal JW and Wier AD. 1986. *RenewableEnergy Sources*. E & F N Spon, New York. 6. Verma SR, Mittal JP and Singh S. 1994. *Energy Management and Conservation in Agricultural Production and Food Processing*. USG Publication, Chicago.
Course Outcomes	At the end of the course, learners will be able **CO1:** To understand the current energy scenario along with energy management and strategies **CO2:** To take action on energy conservation techniques. **CO3:** To acquire the knowledge of financial management **CO4:** To analyze the data for energy monitoring and targeting. **CO5:** To analyse the techno economics of RETs'.
Mapping between COs with POs and PSOs	

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Renewable Energy for Industrial Application**
Course title	**REE 610**
Corse credit	**3 (2+1)**
Objective of Course	1. To provide the knowledge regarding the energy consumption pattern in agro based industries, quantification techniques and identification of opportunities for renewable energy sources. 2. To acquaint with energy quantification techniques, design of system, economic evaluation and utilization of renewable energy sources for agro-industrial applications. 3. To keep the knowledge of current thoughts and newer technology options along with their advances in the field of the utilization of different types of renewable energy technology and wastes for energy production.
Course Content	**Theory:** **Unit I** Elucidation of unit operations in 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. **Unit -II** 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 solararchitecture technology), solar furnace and solar greenhouse technology for high-tech cultivation. Solar photovoltaic technology for industrial power. **Unit III** Bio energy for industrial application: Quantification of industrial bio-waste, characterization, power generation through bio-methanation, gasification and dendro thermal power plant. **Unit IV** Wind energy: Aero generator of new era and national and international state of art in wind powergeneration. Other renewable energy sources: Magneto hydro dynamics, fuel cells technology andmicro-hydro energy technology. **Practicals:** Elucidation and energy consumption for unit operations in industry. Study of energy quantification and identification of opportunities for RET's. Design of solar dryers. Design of solar photovoltaic system. Design of gasifiers for thermal energy and power generation. Design of combustor (gasifier stove). Study of solar greenhouse. Study of biogas engine generator set. Case study of agro-industrial energy estimation and visit to RSE power generation site.
References:	1. Duffie JA and Beakman WA. 2006. *Solar Energy Thermal Process*. John Wiley and Sons,NewYork. 2. Kumar S. 2011. *Energy Conservation Building User Code Guide.* Bureau of EnergyEfficiency,New Delhi. 3. Rathore NS, Kurchania AK and Panwar NL. 2007. *Non Conventional Energy Sources*.Himanshu Publications, Udaipur, Rajasthan. 4. Sayigh AAM. 2012. *Solar Energy Engineering*. Academic Press, New York. 5. Singh P, Kurchania AK, Rathore NS and Mathur AN. 2005. *Sustainable*

	Development through Renewable Energy Sources. Yash Publications, Bikaner, Rajasthan. Private Limited, Delhi.
Course Outcomes	At the end of the course, learners will be able **CO1:** To apply the knowledge about the operation of waste to energy plants. **CO2:** To analyze the various aspects of different RETs' and waste to energy plant. **CO3:** To apply the knowledge in planning & operation of waste to energy plants.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															

Course code	**Biofuel Technologies and Applications**
Course title	**REE 611**
Corse credit	**2 (1+1)**
Objective of Course	1. To acquaint recent biofuel production technologies and their applications. 2. To perform financial estimations of the biofuel projects. 3. To get insight of the various biofuel technologies. 4. To understand the bio-fuel production technologies with financial viability and applications of bio-fuel in different sector of development.
Course Content	**Theory:** **Unit I** Liquid biofuels: Non-edible oilseeds, oil extraction, pre-processing, characterization. World scenario: Liquid fuel challenges and some solutions. Liquid bio-fuel applications. **Unit -II** Bioethanol: First and second generation ethanol production technologies. Production of syngas from biomass, production of methanol from syngas, production of ethanol from lingo-cellulosic biomass. Syngas and poly-generation, chemical conversion of syngas to methanol and ethanol and some advanced fuels like bio butanol, bio propanol. **Unit III** BioCNG: Biogas to green vehicle fuel, anaerobic digestion. Bio gas opportunities: Landfill gas, agricultural and industrial wastewater and additional sources of methane. **Unit IV** Biodiesel: Feedstock for biodiesel, manufacturing processes for biodiesel, value addition by utilization of by-products, environmental impacts of biodiesel, biodiesel from algae, biodiesel engines. **Unit V** Pyrolysis oil: Fast pyrolysis technologies, composition and issues of bio oil. Bio oil upgradation technologies. **Practicals:** Evaluation of liquid fuel system for heat and power generation and characterization of liquid fuel, trans-esterification process. Engine performance on biodiesel. Biogas engine system for transport vehicle. Bio oil production by pyrolysis.
References:	1. Boyle G. 2008. *Renewable Energy*. Atlantic Publishing Company, New Delhi. 2. Gonsalves JB. 2006. *An Assessment of the Biofuels Industry in* John *India.* Wiley & Sons, New Delhi. 3. Kishore VVN. 2008. *Renewable Energy Engineering and Technology–A KnowledgeCompendium. Education.* TERI Press, Delhi. 4. Klass D. 1998. *Biomass for Renewable Energy, Fuels, and Chemicals.* Entech International, Barrington, Illinois, USA. 5. Mitzlaff KV. 1988. *Engines for Biogas–Theory, Modification, Economic Operation*. Deutsches 6. Zentrum für Entwicklungs technologien–GATE, Germany.

Course Outcomes	At the end of the course, learners will be able **CO1:** To characterize different biomass feedstocks based on its constituents and properties. **CO2:** To understand and evaluate various biomass pretreatment and processing techniques in terms of their applicability for different biomass type for biomass conversion processes. **CO3:** To understand the process of combustion, pyrolysis, gasification and liquefaction for production of value added bio-products, biogas, bio-CNG generation etc. **CO4:** To understand basics of biofuels, their production technologies and applications in various energy utility routes.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															

Course code	**Energy Modelling and Simulation**
Course title	**REE 612**
Corse credit	**2 (1+1)**
Objective of Course	1. To provide in depth knowledge about various mathematical models, interdependence of energy, ecology and environment, energy modelling in the context of climate change. 2. To learn energy modelling of gasification, pyrolysis, biogas system, fermentation, biodiesel production system, solar and wind technologies etc. 3. To impart basic skill of model development and optimization in the field of energy. 4. To develop basic skill of development of energy system model and to enable learners to use system modeling as tool for optimization vis-à-vis decision making on energy related field problems.
Course Content	**Theory:** **Unit I** 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, interdependence of energy, economy, environment, modelling concept and application. **Unit -II** Energy Modelling: Review of various energy sector models, energy demand analysis and forecasting, energy supply assessment and evaluation, energy demand, supply balancing, energymodelling in the context of climate change. **Unit III** Model studies in gasification, pyrolysis, biogas, fermentation, biodiesel, solar, wind technologiesand heat transfer applications. Moving boundary models. **Unit IV** 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:** Formulating dimensionless numbers, applications, types of models, mathematical model formulation and types, Software's and model evaluation. Development of models in thermo- chemical and biochemical conversion processes. Studies on model development in solar and wind technologies, economics of energy generation and conservation, financial analysis.
References:	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 and Environment Series*). Cambridge University Press, England.
Course Outcomes	At the end of the course, learners will be able **CO1:** To comprehend the basic principles of modelling and simulation of energy systems. **CO2:** To demonstrate the ability to formulate, mathematically describe, numerically solve and analyse solar energy conversion processes, using advanced numerical tools such as CFD.

	CO3: To demonstrate the ability to assess the technical and economic performance of PV units and their integration into the energy system. **CO4:** To understand how to develop a model, and how to apply varies strategies for different parametric model. **CO5:** To optimize the energy systems and to understand the working principles econometric modeling.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Doctoral Seminar-I**
Course title	**REE 691**
Corse credit	**1 (0+1)**
Objective of Course	6. To prepare students to compete for a successful career in Renewable Energy Engineering profession through global education standards. 7. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Renewable Energy Engineering problems. 8. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints. 9. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts. 10. To create an awareness among the students about the need for life long learning to succeed in their professional career.
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To get the knowledge and to demonstrate the ability to identify, formulate and solve engineering problems. **CO2:** To demonstrate the ability to design and conduct experiments, analyze and interpret data. **CO3:** To visualize the ability and work on laboratory and multi-disciplinary tasks. **CO4:** To demonstrate the skills to use modern engineering tools, software's and equipment to analyze problems. **CO5:** To demonstrate the knowledge of professional, ethical responsibilities and in both verbal and written form and to develop confidence for self education and ability for life-long learning.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Doctoral Seminar-II**
Course title	**REE 692**
Corse credit	**1 (0+1)**
Objective of Course	6. To prepare students to compete for a successful career in Renewable Energy Engineering profession with multi-disciplinary aspects through global education standards. 7. To enable the students to aptly apply their acquired knowledge in basic sciences and mathematics in solving Renewable Energy Engineering with other discipline related problems. 8. To produce skillful graduates to analyze, design and develop a system/component/ process for the required needs under the realistic constraints. 9. To train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts. 10. To create an awareness among the students about the need for life long learning to succeed in their professional career.
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To get the knowledge and to demonstrate the ability to identify, formulate and solve engineering problems. **CO2:** To demonstrate the ability to design and conduct experiments, analyze and interpret data. **CO3:** To visualize the ability and work on laboratory and multi-disciplinary tasks. **CO4:** To demonstrate the skills to use modern engineering tools, software's and equipment to analyze problems. **CO5:** To demonstrate the knowledge of professional, ethical responsibilities and in both verbal and written form and to develop confidence for self education and ability for life-long learning.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**Doctoral Research**
Course title	**REE 699**
Corse credit	**75 (0+75)**
Objective of Course	4. To provide a comprehensive understanding of the concepts and methodologies for project identification, project preparation, project evaluation and project financing 5. To make the student understand the project cycle and their wide socio-economic and environmental impacts 6. To make the student learn how to evaluate a project in view of global concern about sustainable development of energy and environment projects
Course Content	-
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1:** To identify various practical issues related Renewable Energy Engineering and Environmental features of a project. **CO2:** Laboratory/machine/ gadget development and field based study. **CO3:** Small and comprehensive projects for renewable energy engineering development and sustainability. **CO4:** To develop a project with suitable technology/systems and global environmental impacts as well as energy saving. **CO5:** To carry out techno-economic evaluation of Renewable Energy Engineering projects compared with other conventional systems as well as environmental considerations.

Mapping between COs with POs and PSOs

Please refer mapping of PO and PSO for the style of mapping.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Degree: M. Tech. (Agril. Engg.)

Maor Subject: Processing and Food Engineering

Course code	**PFE – 501**
Course title	**Transport Phenomena in Food Processing**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the principles of heat transfer and its applications in food processing. 2. To acquaint and equip the students with the principles of mass transfer and its applications in food processing. 3. To acquaint and equip the students with the principles of momentum transfer and its applications in food processing.
Course Content	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. Applications in food processing including freezing and thawing of foods. Convective heat transfer in food processing systems involving laminar and turbulent flow heat transfer in boiling liquids, heat transfer between fluids and solid foods. Functional design of heat exchangers: Shell and tube, plate and scraped surface heat exchangers, Jacketed vessels. Radiation heat transfer and its governing laws, its applications in food processing. Molecular diffusion in gases, liquids and solids; molecular diffusion in biological solutions and suspensions molecular diffusion in solids, unsteady state mass transfer and mass transfer coefficients, molecular diffusion with convection and chemical reaction, diffusion of gases in porous solids and capillaries, mass transfer applications in food processing.
References:	• Benjamin G. 1971. Heat Transfer. 2nd Ed. Tata McGraw Hill. • Coulson JM & Richardson JF. 1999. Chemical Engineering. Vol. II, IV.The Pergamon Press. • Earle RL. 1985. Unit Operations in Food Processing. Pergamon Press. EcKert ERG & Draker McRobert 1975. Heat and Mass Transfer. McGraw Hill. • Geankoplis J Christie 1999. Transport Process and Unit Operations. Allyn & Bacon. Holman JP. 1992. Heat Transfer. McGraw Hill. • Kreith Frank 1976. Principles of Heat Transfer. 3rd Ed. Harper & Row. • McCabe WL & Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill. Treybal RE. 1981. Mass Transfer Operations. McGraw Hill. • Warren Gredt H. 1987. Principles of Engineering Heat

	Transfer. Affiliated East-West Press.
Course Outcomes	At the end of the course, learners will be able **CO1**: To impart requisite knowledge about transport phenomenon with respect to heat, mass and momentum transfer which is necessary to understand the food processing operations. **CO2**: At the end of courses, students will be able to understand, analyse and solve numerically the food processing operations where heat/mass/momentum transfer is involved.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					
CO2										-					

Course code	**PFE – 502**
Course title	**Engineering Properties of Food Materials**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint the students with different techniques of measurement of engineering properties 2. To acquaint the students with importance of engineering properties in the design of processing equipment.
Course Content	Physical characteristics of different food grains, fruits and vegetables; Shape and size, description of shape and size, volume and density, porosity, surface area. Rheology; ASTM standard, terms, physical states of materials, classical ideal material, rheological models and equations, visco- elasticity, creep-stress relaxation, Non-Newtonian fluid and viscometry, rheological properties, force, deformation, stress, strain, elastic, plastic behaviour. Contact stresses between bodies, Hertz problems, firmness and hardness, mechanical damage, dead load and impact damage, vibration damage, friction, effect of load, sliding velocity, temperature, water film and surface roughness. Friction in agricultural materials, rolling resistance, angle of internal friction, angle of repose, flow of bulk granular materials, aero dynamics of agricultural products, drag coefficients, terminal velocity. Thermal properties: Specific heat, thermal conductivity, thermal diffusivity, methods of determination, steady state and transient heat flow. Electrical properties; Dielectric loss factor, loss tangent, A.C. conductivity and dielectric constant, method of determination, energy absorption from high- frequency electric field. Application of engineering properties in design and operation of agricultural equipment and structures.

	Experiments for the determination of physical properties like, length, breadth, thickness, surface area, bulk density, porosity, true density, coefficient of friction, angle of repose and colour for various food grains, fruits, vegetables, spices and processed foods, aerodynamic properties like terminal velocity, lift and drag force for food grains, thermal properties like thermal conductivity, thermal diffusivity and specific heat, firmness and hardness of grain, fruits and stalk, electrical properties like dielectric constant, dielectric loss factor, loss tangent and A.C. conductivity of various food materials.
References:	• Mohesenin NN. 1980. Physical Properties of Plant and Animal Materials, Gordon & Breach Science Publ. • Mohesenin NN. 1980.Thermal Properties of Foods and Agricultural Materials. Gordon & Breach Science Publ. • Peleg M & Bagelay EB. 1983. Physical Properties of Foods. AVI Publ. • Rao MA & Rizvi SSH. (Eds.). 1986. Engineering Properties of Foods. Marcel Dekker. • Ronal Jowitt, Felix Escher, Bengt Hallsrram, Hans F, Th. Meffert, Walter • EC Spices, Gilbert Vox. 1983. Physical Properties of Foods. Applied Science Publ. • Singhal OP & Samuel DVK. 2003. Engineering Properties of Biological Materials. Saroj Prakasan
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to apply properties of food for design of equipment. **CO2:** Student's capability to apply properties of food for design of structures.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1							-		-	-					
CO2							-		-	-					

Course code	**PFE – 503**
Course title	**Advanced Food Process Engineering**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint the students with different unit operations of food industries 2. To acquaint the students with design features of processing equipment.
Course Content	Thermal processing: Death rate kinetics, thermal process calculations, methods of sterilization and equipments involved, latest trends in thermal processing. Evaporation: Properties of

	liquids, heat and. mass balance in single effect and multiple effect evaporator, aroma recovery, equipments and applications. Drying: Rates, equipments for solid, liquid and semi-solid material and their applications, theories of drying, novel dehydration techniques. Non-thermal processing: Microwave, irradiation, ohmic heating, pulsed electric field preservation, hydrostatic pressure technique etc. Freezing: Freezing curves, thermodynamics, freezing time calculations, equipments, freeze drying, principle, equipments. Separation: Mechanical filtration, membrane separation, centrifugation, principles, equipments and applications, latest developments in separation and novel separation techniques. Extrusion: Theory, equipments, applications. Distillation and leaching: Phase equilibria, multistage calculations, equipments, solvent extraction. Solving problems on single and multiple effect evaporator, distillation, crystallisation, extraction, leaching, membrane separation and mixing, experiments on rotary flash evaporator, humidifiers, reverse osmosis and ultra filtration - design of plate and packed tower, visit to related food industry.
References:	• Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990. Food Engineering Operations. Elsevier. • Coulson JM & Richardson JF. 1999. Chemical Engineering. VolS. II, IV. The Pergamon Press. • Earle RL. 1985. Unit Operations in Food Processing. Pergamon Press. • Fellows P. 1988. Food Processing Technology: Principle and Practice. VCH Publ. • Geankoplis J Christie. 1999. Transport Process and Unit Operations. Allyn & Bacon. • Henderson S & Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publ. • McCabe WL & Smith JC. 1999. Unit Operations of Chemical Engineering. McGraw Hill. • Sahay KM & Singh KK. 1994. Unit Operation of Agricultural Processing. Vikas Publ. House. • Singh RP & Heldman DR. 1993. Introduction to Food Engineering. Academic Press. • Singh RP. 1991. Fundamentals of Food Process Engineering. AVI PubL.
Course Outcomes	At the end of the course, learners will be able; **CO1**: Student's capability to understand advanced food processing applications as per requirement of food industries. **CO2**: Student's capability to preserve food products using advance techniques as per requirement of food industries. **CO3**: To acquaint the students with recent technologies in food processing.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															

Course code	PFE 504
Course title	Unit Operations in Food Process Engineering
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with different unit operations applicable in food industries. 2. To understand the scope and importance of various food processing operations with basic engineering mathematics and mass & energy balance. 3. To understand the laws of size reduction, theory of mixing and importance of material handling devices.
Course Content	Review of basic engineering mathematics; Units and dimensions; Mass and energy balance. Psychrometry, dehydration, EMC, Thermal processing operations; Evaporation, dehydration/drying, types of dryers, blanching, pasteurization, distillation, steam requirements in food processing. Refrigeration principles and Food freezing. Mechanical separation techniques, size separation equipments; Filtration, sieving, centrifugation, sedimentation. Material handling equipment, conveyors and elevators; Size reduction processes; Grinding and milling. Homogenization; Mixing- mixers, kneaders and blenders. Extrusion. Membrane technology. Non-thermal processing techniques. Food plant design; Food plant hygiene- cleaning, sterilizing, waste disposal methods, engineering aspects of radiation processing. Food packaging: Function materials, technique, machinery and equipment.
References:	• Brennan JG, Butters JR, Cowell ND & Lilly AEI. 1990. *Food Engineering Operations*. Elsevier. • Earle RL. 1985. *Unit Operations in Food Processing*. Pergamon Press. • Fellows P. 1988. *Food Processing Technology: Principle and Practice*. VCH Publ. • McCabe WL & Smith JC. 1999. *Unit Operations of Chemical Engineering*. McGraw Hill. • Sahay KM & Singh KK. 1994. *Unit Operation of Agricultural Processing*. Vikas Publ. House. • Singh RP & Heldman DR. 1993. *Introduction to Food Engineering*. Academic Press
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint the students with various unit operations in food process engineering. **CO2**: To acquaint the students with various types of dryers,

	blanching, pasteurization processes. **CO3**: To explain the functions of various unit operations and working of size reduction equipments in processing of food materials. **CO4:** To explain the design and working of mixing equipments for powder, high and low viscosity liquids. **CO5:** Classify mechanical separation techniques & equipments and non-thermal processing techniques.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-		-			
CO2										-		-			
CO3										-		-			
CO4										-		-			
CO5										-		-			

Course code	PFE 505
Course title	Energy Management in Food Processing Industries
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with different energy management techniques in food industries. 2. To understand the scope and importance energy auditing in food industries.
Course Content	Energy forms and units, energy perspective, norms and scenario; energy auditing, data collection and analysis for energy conservation in food processing industries. Sources of energy, its audit and management in various operational units of the agro-processing units; passive heating, passive cooling, sun drying and use of solar energy, biomass energy and other non-conventional energy sources in agro-processing industries. Reuse and calculation of used steam, hot water, chimney gases and cascading of energy sources. Energy accounting methods, measurement of energy, design of computer-based energy management systems, economics of energy use. Study of energy use pattern in various processing units i.e., rice mills, sugar mills, dal mills, oil mills, cotton-ginning units, milk plants, food industries etc. Energy udit study and management strategies in food processing plants. Identification of energy efficient processing machines. Assessment of overall energy consumption, production and its cost in food processing plants, visit to related food processing industry.
References:	• Pimental D. 1980. Handbook of Energy Utilization in Agriculture. CRC Press. • Rai GD. 1998. Non-conventional Sources of Energy. Khanna Publ. • Twindal JW & Anthony D Wier 1986. Renewable Energy

	Sources. E & F. N. Spon Ltd. • Verma SR, Mittal JP & Surendra Singh. 1994. Energy Management and Conservation in Agricultural Production and Food Processing. USG Publ. & Distr., Ludhiana.
Course Outcomes	At the end of the course, learners will be able **CO1**: To acquaint the students with various energy perspective and norms in food process engineering. **CO2**: To acquaint the students with various sources of energy and energy auditing. **CO3**: To explain the calculation and steam economy

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-		-			
CO2										-		-			
CO3										-		-			

Course code	PFE 506
Course title	Processing of Cereals, Pulses and Oilseeds
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the post harvest technology of cereals, pulses and oilseeds. 2. To understand the performance evaluation of different types of cleaners and separators, size reduction machines. 3. To understand the laws of size reduction, theory of mixing and milling of cereals, pulses and oilseeds.
Course Content	Production and utilization of cereals and pulses, grain structure of major cereals, pulses and oilseeds and their milling fractions; grain quality standards and physico-chemical methods for evaluation of quality of flours. Pre-milling treatments and their effects on milling quality; parboiling and drying, conventional, modern and integrated rice milling operations; wheat roller flour milling; processes for milling of corn, oats, barley, gram, pulses, paddy and flour milling equipments. Dal mills, handling and storage of by-products and their utilization. Storage of milled products, Expelled and solvent extraction processing, assessment of processed product quality. Packaging of processed products, design characteristics of milling equipments; selection, installation and their performance, BIS standards for various processed products.
References:	• Asiedu JJ.1990. *Processing Tropical Crops*. ELBS/MacMillan. • Chakraverty A. 1995. *Post-harvest Technology of Cereals, Pulses and Oilseeds*. Oxford & IBH. • Morris Lieberman. 1983. *Post-harvest Physiology and Crop Preservation*. Plenum Press. • Pandey PH. 1994. *Principles of Agricultural Processing*. Kalyani.

	• Pillaiyar P. 1988. *Rice - Post Production Manual*. Wiley Eastern. • Sahay KM & Singh KK. 1994. *Unit Operations in Agricultural Processing*. Vikas Publ. House
Course Outcomes	At the end of the course, learners will be able **CO1:** To acquaint the students with various post harvest operations of cereal, pulses and oil seeds. **CO2:** Explain the grain quality standards and physico-chemical methods for evaluation of quality of flours. **CO3:** Explain the different types of milling operations of different cereals, pulses and oilseeds. **CO4:** Explain the pre-milling treatments, oil expellers and solvent extraction processing. **CO5:** Explain food quality control, food laws, standards and BIS standards.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-		-			
CO2										-		-			
CO3										-		-			
CO4										-		-			
CO5										-		-			

Course code	PFE 507
Course title	Food Processing Equipment And Plant Design
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the design features of different food processing equipments being used in the industries and with the layout. 2. To understand the planning of different food and processing plants.
Course Content	Design considerations of processing agricultural and food products. Design of machinery for drying, milling, separation, grinding, mixing, evaporation, condensation, membrane separation. Human factors in design, selection of materials of construction and standard component, design standards and testing standards. Plant design concepts and general design considerations: plant location, location factors and their interaction with plant location, location theory models, computer aided selection of the location. Feasibility analysis and preparation of feasibility report: plant size, factors affecting plant size and their interactions, estimation of break-even and economic plant size; Product and process design, process selection, process flow charts, computer aided development of flow charts. Hygienic design aspects and worker's safety, functional design of plant building and selection of building materials, estimation of capital investment, analysis of plant

	costs and profitabilities, management techniques in plant design including applications of network analysis, preparation of project report and its appraisal.
References:	• Ahmed T. 1997. Dairy Plant Engineering and Management. 4th Ed. Kitab Mahal. • Chakraverty A & De DS. 1981. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH. • Gary Krutz, Lester Thompson & Paul Clear. 1984. Design of Agricultural Machinery. John Wiley & Sons. • Hall CW & Davis DC. 1979. Processing Equipment for Agricultural Products. AVI Publ. • Henderson S & Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publ. • Johnson AJ. 1986.Process Control Instrumentation Technology. 2nd Ed. Wiley International & ELBS. • Rao T. 1986. Optimization: Theory and Applications. 2nd Ed. Wiley Eastern. • Richey CB. (Ed.). 1961. Agricultural Engineers' Hand Book. McGraw Hill. • Romeo T Toledo. 1997. Fundamentals of Food Process Engineering. CBS. • Slade FH. 1967. Food Processing Plant. Vol. I. Leonard Hill Books
Course Outcomes	At the end of the course, learners will be able **CO1:** To acquaint the students with various design considerations of processing agricultural and food products. **CO2:** To acquaint the students with design of machinery for drying, milling, separation, grinding, mixing. **CO3:** To explain the different Plant design concepts and general design considerations. **CO4:** Explain the feasibility analysis and preparation of feasibility report. **CO5:** Explain the management techniques in plant design including preparation of project report.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1										-		-			
CO2										-		-			
CO3										-		-			
CO4										-		-			
CO5										-		-			

Course code	PFE 508
Course title	Fruits and Vegetables Process Engineering
Corse credit	2 (2 + 1)
Objective of Course	1. To acquaint and equip the students with processing of

	fruits and vegetables. 2. To acquaint the design features of the equipments used for their processing.
Course Content	Importance of post harvest technology of fruits and vegetables, structure, cellular components, composition and nutritive value of fruits and vegetables, fruit ripening, spoilage of fruits and vegetables. Harvesting and washing, pre-cooling, preservation of fruits and vegetables, blanching, commercial canning of fruits and vegetables, minimal processing of fruits and vegetables. Cold storage of fruits and vegetables, controlled atmosphere packaging of fruits and vegetables, gas composition, quality of storage. Dehydration of fruits and vegetables, methods, osmotic dehydration, foam mat drying, freeze drying, microwave heating, applications, radiation preservation of fruits and vegetables, irradiation sources. Intermediate moisture foods, ohmic heating principle, high pressure processing of fruits and vegetables, applications, sensory evaluation of fruit and vegetable products, packaging technology for fruits and vegetables, general principles of quality standards and control, FPO, quality attributes.
References:	• Cruesss WV. 2000. Commercial Fruit and Vegetable Products. Agrobios. • Mircea Enachesca Danthy. 1997.Fruit and Vegetable Processing. International Book Publ. • Srivastava RP & Sanjeev Kumar. 1994. Fruit and Vegetable Preservation. Principles and Practices. International Book Distr. • Sumanbhatti & Uma Varma. 1995. Fruit and Vegetable Processing. CBS. • Thompson AK. 1996. Post Harvest Technology of Fruits and Vegetables. Blackwell. • Verma LR & Joshi VK. 2000. Post Harvest Technology of Fruits and Vegetables. Vols. I-II. Indus Publ
Course Outcomes	At the end of the course, learners will be able **CO1:** To acquaint the students with scope and importance of post harvest technology of fruits and vegetables. **CO2:** Explain the composition and nutritive value of fruits and vegetables. **CO3:** Explain the harvesting and washing, pre-cooling, and preservation techniques of fruits and vegetables. **CO4:** Explain the dehydration techniques and preservation methods of fruits and vegetables. **CO5:** Explain food quality control, food laws, standards and FPO standards.

apping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1										-		-			
CO2										-		-			

CO3										-		-			
CO4										-		-			
CO5										-		-			

Course code	**PFE -509**
Course title	**Meat Processing**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with meat and meat products. 2. To impart knowledge on the design features of the equipment used for meat processing.
Course Content	Meat and poultry products: Introduction, kinds of meat animals and poultry birds, classification of meat, composition of meat. Slaughtering: Pre slaughter operations, post slaughter operations, wholesale and retail cuts. Preservation of poultry: different methods, stuffed products, frozen products, poultry concentrates and flavours, synthetic poultry flavour. Different preservation methods of meat: Smoking, curing and freezing, chilling of meat and different methods of chilling, freezing of meat and different methods of freezing of meat, physical and chemical changes during chilling and freezing, packaging of meat and meat products, quality control. Classification, composition and nutritive value of eggs: Grading of eggs, different quality parameters of eggs, Haugh unit, processing of egg, yolk processing, egg breaking mechanisms, freezing of egg, pasteurization, desugarisation and dehydration of egg, different dehydration methods, quality control and specification of egg products. Fish: Nutritional quality of fish and fish products, fillet and steaks, different preservation techniques, chilling, freezing, drying, canning, curing and smoking, quality control in fish processing. Experiments in slaughtering, dressing, wholesale and retail cutting: Curing, preservation of meat and meat products, estimation of quality of egg, Haugh unit, desugarisation, preparation of whole egg powder, yolk powder, freezing of fish, drying of fish, canning of fish, visit to meat and fish processing units
References:	• Chooksey MK & Basu S. 2003. Practical Manual on Fish Processing and Quality Control. CIFE, Kochi. • Chooksey MK. 2003.Fish Processing and Product Development. CIFE, Kochi. • Hall GM. 1997.Fish Processing Technology. Blabie Academic & Professional. • Lawrie RS. 1985.Developments in Meat Sciences. Vol. III. Applied Science Publ. • Mead GC. 1989. Processing of Poultry. Elsevier. • Pearson AM & Tauber FW. 1984. Processed Meats. AVI

	Publ. • Stadelman WJ & Cotterill OJ. 1980. Egg Science and Technology. AVI Publ.
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to process meat, fish and poultry. **CO2**: Student's capability to manufacture value added products of meat as per requirement of food industries.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					
CO2										-					

Course code	**PFE – 510**
Course title	**Food Packaging**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with packaging methods, packaging materials, packaging machineries etc., 2. To acquaint and equip the students with modern packaging techniques for perishable and processed foods 3. To acquaint and equip the students with package standard and regulation used in food industry
Course Content	Introduction of packaging: Package, functions and design. Principle in the development of protective packaging. Deteriorative changes in foodstuff and packaging methods of prevention. Food containers: Rigid containers, glass, wooden boxes, crates, plywood and wire bound boxes, corrugated and fibre board boxes, textile and paper sacks, corrosion of containers (tin plate); Flexible packaging materials and their properties; Aluminium as packaging material; Evaluation of packaging material and package performance. Packaging equipments: Food packages, bags, types of pouches, wrappers, carton and other traditional package; Retortable pouches; Shelf life of packaged foodstuff. Methods to extend shelf life; Packaging of perishables and processed foods; Special problems in packaging of food stuff. Package standards and regulation; Shrink packaging; Aseptic packaging, CA and MAP, Active packaging; Biodegradable packaging.
References:	• Crosby NT. 1981. Food Packaging Materials. Applied Science Publ. • Mahadeviah M & Gowramma RV. 1996. Food Packaging Materials. Tata McGraw Hill. Palling SJ. (Ed). 1980. Developments in Food Packaging. Applied Science Publ. • Sacharow S & Grittin RC. 1980. Principles of Food Packaging. AVI Publ
Course Outcomes	At the end of the course, learners will be able

	CO1: Student's capability to develop packages for all kinds of food products as per requirement of food industries. **CO2:** To acquaint the students with various aspects of advanced food packaging methods and technology for perishable and processed foods. **CO3:** Student's capability to develop knowledge of package standard and regulations used in food industry

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															

Course code	**PFE - 511**
Course title	**Food Quality and Safety**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the need of quality control and scope for food toxicology. 2. To acquaint and equip the students with the latest standards to maintain food quality and safety.
Course Content	Food safety: Need for quality control and safety, strategy and criteria, microbiological criteria for safety and quality, scope of food toxicology, toxic potential and food toxicants, biological and chemical contaminants. Food additives and derived substances, factors affecting toxicity, designing safety in products and processes, intrinsic factors, establishing a safe raw material supply, safe and achievable shelf life. Process equipment and machinery auditing, consideration of risk, environmental consideration, mechanical quality control. Personnel hygienic standards, preventative pest control, cleaning and disinfesting system, biological factors underlying food safety. Preservation and stability, contaminants of processed foods, adulteration, prevention and control, FPO, PFA, Codex, GMP, BIS and HACCP; Practices, principles, standards, specifications, application establishment and implementation; HACCP and quality management system. Microbiological examination of food, hazard analysis, premises design, HACCP project plan; CCP, CCP Decision tree, HACCP control chart. HACCP case studies; Survey, BIS, FPO, Codex standards and specifications. Visits to food industries to study the various quality and safety aspects adopted.
References:	• Chesworth N. 1997. Food Hygiene Auditing. Blackie Academic Professional, Chapman & Hall. • David A Shapton & Norah F Shapton. 1991. Principles and

	Practices for the Safe Processing of Foods. Butterworth-Heinemann. • Jacob M 2004. Safe Food Handling. CBS. • Jose M Concon. 1988. Food Toxicology, Part A. Principles and Concepts, Part B. Contaminants and Additives. Marcel Dekker. • Sara Mortimore & Carol Wallace. 1997. HACCP - A Practical Approach. Chapman & Hall
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to measure food quality as well as ensure food safety in food supply chain. **CO2:** To acquaint the students with various food processing standards. **CO3:** To acquaint the students with quality control and food plant hygiene' and HACCP techniques used in processing and development of food products.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					
CO2										-					
CO3										-					

Course code	**PFE -512**
Course title	**Farm Structures and Environment Control**
Corse credit	2 (1 + 1)
Objective of Course	1. To acquaint and equip the students with the different types of farm structures and techniques, to control atmospheric parameters and to create favorable environment in the agricultural structures. 2. To impart knowledge on low cost farm structures, design and constructions. 3. To impart knowledge on need of control atmospheric parameters (heating, ventilating and exhaust system) to create favorable environment in the farm structures 4. To enable the students to acquire knowledge of energy efficient environmental control practices along with their standard codes and standard used.
Course Content	Thermodynamic properties of moist air, psychorometric chart and computer programmes for thermodynamic properties. Farm structures, their design, constructional details and design of low cost structures. Heating, ventilating and exhaust systems, air distribution and air cleaning, combustion of fuels and equipment. Drying and dehumidification system, air-water contact operations and evaporation, process and product air conditioning, energy efficient environmental control practices. Instruments and measurements; codes and standards.
References:	• Albright LD. 1990. Environmental Control for Animals and

	Plants. ASAE Textbooks. Esmay ML & Dixon JE. 1986. Environmental Control for Agricultural Buildings. The AVI Corp. • Gaudy AF & Gaudy ET. 1988. Elements of Bioenvironmental Engineering. Engineering Press. • Moore FF. 1994.Environmental Control Systems: Heating, Cooling, Lighting. Chapman & Hall. • Threlkeld JL. 1970. Thermal Environmental Engineering. Prentice Hall
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to design new farm structures and create suitable atmosphere within it. **CO2:** To acquaint the students with various aspects of environmental control within the farm structures. **CO3**: Graps the ramifications of the farm structural solution within around and awareness for sustainable development **CO4**: Design solutions for engineering aspects of farm structures and environmental part to fulfil the requirements, giving due regards to public health and safety and environmental factors.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					
CO2										-					
CO3										-					
CO4										-					

Course code	**PFE – 513**
Course title	**Storage Engineering and Handling of Agricultural Products**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the safe storage of food materials. 2. To demonstrate design of storage structures 3. To explain design of different material handling equipment used in the industries.
Course Content	Storage of grains, biochemical changes during storage, production, distribution and storage capacity estimate models, storage capacity models, ecology, storage factors affecting losses, storage requirements. Bag and bulk storage, godowns, bins and silos, rat proof godowns and rodent control, method of stacking, preventive method, bio-engineering properties of stored products, function, structural and thermal design of structures, aeration system. Grain markets, cold storage, controlled and modified atmosphere storage, effects of nitrogen, oxygen, and carbon dioxide on storage of durable and perishable commodities, irradiation, storage of dehydrated products, food spoilage and preservation, BIS standards. Physical factors influencing flow characteristics, mechanics of bulk solids, flow

	through hoppers, openings and ducts; design of belt, chain, screw, roller, pneumatic conveyors and bucket elevators, principles of fluidization, recent advances in handling of food materials. Quality evaluation of stored products, design of storage structures, cold storage, load estimation, construction, maintenance, static pressure drop, experiment on controlled and modified atmosphere storage system, estimation of storage loss, and quality of stored products
References:	• Boumans. 1985. Grain Handling and Storage. Elsevier. • FAO. 1984. Design and Operation of Cold Stores in Developing Countries. FAO. • Golob. 2002. Crop Post-Harvest: Science and Technology. Vol 1 Wiley-blackwell. • Hall CW. 1970. Handling and Storage of Food Grains in Tropical and Sub-Tropical Areas. FAO Publisher Oxford & IBH. • Henderson S and Perry SM. 1976. Agricultural Process Engineering. 5th Ed. AVI Publisher. • Hodges 2004. Crop Post-Harvest: Science and Technology. Vol 2, Wiley-blackwell. • Ripp BE. 1984. Controlled Atmosphere and Fumigation in Grain Storage. Elsevier. • Shefelt RL and Prussi SE. 1992. Post Harvest Handling – A System Approach. Academic Press. • Sharma HK, Kumar N. 2022. Agro-Processing and Food Engineering, Springer • Vijayaraghavan S 1993. Grain Storage Engineering and Technology. Batra Book Service.
Course Outcomes	At the end of the course, learners will be able **CO1**: to understand and undertake mechanical handling of food as per requirement of food industries. **CO2**: to understand storage devices and systems for safe storage of food for longer period of time.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					-
CO2										-					-

Course code	**PFE-514**
Course title	**Seed Drying, Processing and Storage**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with seed processing. 2. To acquaint and equip the students with design features of the equipment used in seed processing

Course Content	Processing of different seeds and their engineering properties, principles and importance of seed processing. Performance characteristics of different unit operations such as precleaning, grading, conveying, elevating, drying, treating, blending, packaging and storage, seed processing machines like scalper, debreader, huller, velvet separator, spiral separator, cleaner-cum-grader, specific gravity separator, indent cylinder, disc separator, and colour sorter, seed treater, weighing and bagging machines, their operation and maintenance, installation and determination of their capacity, seed quality maintenance during processing, plant design and layout, economy and safety consideration in plant design. Seed drying principles and methods, theory of seed drying, introduction to different types of heated air dryers, significance of moisture equilibrium, method of maintaining safe seed moisture, thumb rule and its relevance. Importance of scientific seed storage, types of storage structures to reduce temperature and humidity, management and operation/cleanliness of seed stores, packaging-principles, practices, materials and hermetic packaging, seed treatment methods and machines used, method of stacking and their impact, design features of medium and long term seed storage building. Study of various seed processing equipments such as pre-cleaners, scalpers, air screen cleaners, graders, spiral and pneumatic separators, seed treating equipment, bag closures, scale etc. and their performance evaluation, design and layout of seed processing plant and its economics, analysis of cost of operation and unit cost of processed product, effect of drying temperature and duration of seed germination and storability.
References:	• Gregg et al. 1970. Seed Processing. NSC. • Henderson S and Perry S M. 1976. Agricultural Process Engineering. 5th Ed. AVI Publisher. • Sahay KM and Singh KK. 1994. Unit Operation of Agricultural Processing. Vikas Publisher House.
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to understand seed processing as per requirement of seed industries. **CO2**: Student's capability to understand storage requirement of seed maintaining its vigor and viability, suitable equipment for seed processing.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					
CO2										-					

Course code	**PFE-515**

Course title	**BIOCHEMICAL AND PROCESS ENGINEERING**
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the basic principles of biochemical process like fermentation, bio reactors and enzyme reactors. 2. To acquaint and equip the students with the basic principles of process engineering like energy balance, flow properties etc. 3. To acquaint and equip the students with knowledge of principles of recovery of fermented products in bio-processing and their instrumentation.
Course Content	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. Kinetics of one substitute reactions, kinetics of growth in batch cultures, design consideration for bioreactors, media preparation and sterilization, microprocessor based monitoring of bioprocess parameters.
References:	• Coulson JM & Richadson JF. 1999. Chemical Engineering. Vols. II, IV. The Pergamon Press. • Treybal RE. 1981. Mass Transfer Operations. 3rd Ed. Harper & Row. • Brennan JG, Butters JR, Cavell ND & Lilly AEI. 1990. Food Engineering Operations. Elsevier. • Greanoplis J Christie. 1999. Transport Process and Unit Operation. Allyn & Bacon
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to process food using biochemical processing by fermentation, bio reactors and enzyme reactors. **CO2:** To acquaint the students with noval techniques used in development of food products by using biochemical processing **CO3:** To acquaint the students with knowledge of recovery of fermented food products by using bio-processing.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1										-					
CO2										-					
CO3										-					
CO4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Course code	**PFE-591**
Course title	**Industry / Institute Training**
Corse credit	1 (0 + 1)
Objective of Course	1. To acquaint and equip the students in relevant food processing industry. 2. Preparation of industrial report and presentation
Course Content	In-plant training in the relevant food industry during processing operation of the plant to study the actual working of the equipment and various unit operations. The evaluation will be based on the written report of the student and the comments of the factory managers. The duration of training shall be three weeks. The student shall be required to do training in the institute other than the institute in which he/she is enrolled
References:	-
Course Outcomes	At the end of the course, learners will be able **CO1**: Student's capability to become familiar with industrial environment. **CO2:** To apply the obtained knowledge in real industrial conditions.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															

Processing and Food Engineering

(PG as per Fifth Deans)

Ph. D. (Agril. Engg.)

Course code	**PFE - 601**
Course title	**Textural and Rheological Characteristics of Food Materials**
Corse credit	3 (3+0)
Objective of Course	1. To acquaint and equip the students with advances in measurement of textural characteristics affecting the food quality. 2. To acquaint and equip the students with advances in measurement of rheological characteristics affecting the food quality 3. To acquaint and equip the students with advances in textural, rheological and viscoelastic characteristics of foods.
Course Content	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.
References:	• Bourne MC. 2002. Food Texture and Viscosity: Concept and Measurement. Academic Press • Deman JM. et al. 1976. Rheology and Texture in Food Quality. AVI Publ. Journal of Food Science and Technology • Mohsanin NN.1989. Physical Properties of Plant and Animal Material. Vol. I, II. Gordon and Breach Science Publ. • Steffe JF. 1992. Rheology and Texture in Food Quality. AVI Publ
Course Outcomes	At the end of the course, learners will be able; CO1: Student's capability to determine textural properties of food materials and their application in control of food processing operations. CO2: Student's capability to determine rheological properties of food materials and their application in control of food processing operations. CO3: To acquaint the students with advancement in textural, rheological and viscoelastic characteristics of foods and their application in control of food processing operations.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1										-					
CO2										-					

CO3										-						

Course code	**PFE -602**
Course title	**Advances in Food Processing**
Corse credit	3 (3 + 0)
Objective of Course	1. To acquaint and equip the students with the modern and latest techniques of food engineering. 2. To acquaint the students with low temperature preservation, hurdle technology in food processing 3. To acquaint and equip the students with advanced technologies viz. microwave, high pressure, pulse electric filed and extrusion in food processing applications.
Course Content	Preservation of foods: Physical and chemical methods, microbiological aspects, thermo bacteriology, process calculation and selection. Low temperature preservation - cooling and cold storage - freeze concentration and membrane separation process - hurdle technology -principles and applications - food irradiation - advantages and applications, microwave processing - interaction with food materials- microwave equipment - hydrostatic pressure treatment of food - equipment, processing and effect on microorganisms Application of heat energy and ultrasound - inactivation of microorganisms and enzymes -electrical resistance heating of food - heat generation, ohmic heater, heating models - pulsed electric field preservation- principles and application - influence on microorganisms and food ingredients - decontamination of microorganisms by surface treatment. Extrusion cooking - recent developments, methods, equipment, design criteria of extruders
References:	• Heldman R Dennis and Lund B Daryl. 1992. Hand Book of Food Engineering.Marcel Dekker. • Goldblith SA, Rey I & Rothmayr WW. 1975. Freeze Drying and Advanced Food Technology. Academic Press. • Gould GW (Ed.).1996.New Methods of Food Preservation. Blackie Academic & Professional • Leniger HA & Beverloo WA. 1975. Food Process Engineering. D. Reidel Publishing Co. • Rao MA & Rizvi SSH.. 1986. Engineering Properties of Foods. Marcel Dekker. • Ronald Jowitt. 1984. Extrusion Cooking Technology. Elsevier
Course Outcomes	At the end of the course, learners will be able; **CO1**: Student's capability to understand advanced food processing applications as per requirement of food industries. **CO2**: Student's capability to preserve food products using advance techniques as per requirement of food industries. **CO3**: To acquaint the students with recent technologies in food processing.
Mapping between Cos, POs and PSOs	

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															

Course code	**PFE -603**
Course title	**Mathematical Modeling in Food Processing**
Corse credit	3 (3 + 0)
Objective of Course	1. To acquaint and equip the students with the mathematical techniques. 2. To acquaint and equip the students with the application of mathematics in food processing applications.
Course Content	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.
References:	• Bailey NTJ, Sendov B &.Tsanev R.1974. Mathematical Models in Biology and Medicine. Elsevier. • Fischer M, Scholten HJ & Unwin D. 1996. Spatial Analytical Perspectives on GIS. Taylor & Francis. • Fish NM & Fox RI. 1989. Computer Application in Fermentation Technology: Modelling and Control of Biotechnological Processes. Elsevier. • Getz WM.1979. Mathematical Modeling in Biology Processes. Elsevier. • Gold HJ.1977.Mathematical Modelling of Biological Systems - An Introductory Guidebook. John Wiley & Sons. • Hunt DR.1986. Enginering Models for Agricultural Production. The AVI Publ. • Kapur JN.1989. Mathematical Modeling. Wiley Eastern. • Koeing HE, Tokad Y, Kesacan HK & Hedgers HG. 1967. Analysis of Discrete Physical Systems. Mc Graw Hill. • Meyer JW. 2004. Concepts of Mathematical Modeling. Mc Graw Hill. • Peart RM & Curry RB.1998.Agricultural Systems, Modelling and Simulation. Marcel Dekker. • Tijms HC. 1984. Modelling & Analysis. A Congrtational Approach. Wiley Publ. • Ver Planck & Teare BR 1954.General Engineering Analysis

	- An Introduction to Professional Methods. John Wiley & Sons
Course Outcomes	At the end of the course, learners will be able; **CO1**: Student's capability to develop models for food processing operations. **CO2**: Student's capability to develop models for prediction and control of operations

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-					
CO2										-					

Course code	PFE 604
Course title	Advances In Drying Of Food Materials
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the latest technologies of dehydration of food products. 2. To study the various types of dryers and design features of different dryers.
Course Content	Importance of drying, principles of drying, moisture determination, equilibrium moisture content, determination of EMC, methods and isotherm models, psychrometry, psychrometric terms, construction and use of psychrometric charts. Air flow and resistance, principles and equipments for air movement and heating, drying methods and theory of drying, driers, classification and other allied equipment, thin layer drying of cereal grains, deep bed and continuous flow drying, drying models. Heat requirements and thermal efficiency of drying system, aeration, tempering and dehydration, operation of driers and their controls, selection of driers, performance testing of grain driers, drying characteristics of cereals, pulses and oilseeds, microwave drying, radio frequency drying and tunnel drying, principles and equipment. Drying of liquid foods, spray drying, drum drying, freeze drying, foam mat drying, heat pump drying, osmotic dehydration; Principles, methods, construction and adjustments, selection of dryers, heat utilization factor and thermal efficiency
References:	• Bala BK. 1998. Drying and Storage of Cereal Grains. Oxford & IBH. • Brooker DB, Bakker Arkema FW & Hall CW. 1974. Drying Cereal Grains. The AVI Publ. • Chakraverty A & De DS. 1999. Post-harvest Technology of Cereals, Pulses and Oilseeds. Oxford & IBH. • Hall CW. 1970. Drying of Farm Crops. Lyall Book Depot. • Tadensz Kudra & Majumdar AS. 2002. Advanced Drying Technologies. Marcel Dekker. • Wallace B Van Arsdel & Michael J Copley. 1963. Food

	Dehydration. AVI Publ
Course Outcomes	At the end of the course, learners will be able **CO1:** To acquaint the students with drying principles and moisture determination in agricultural and food products. **CO2:** Identify various methods for determining moisture content, EMC and drying process. **CO3:** To explain the different principles and equipments for air movement and heating. **CO4:** Explain the heat requirements and thermal efficiency of drying system. **CO5:** Explain the drying equipments for liquid foods with principles and methods.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1										-		-			
CO2										-		-			
CO3										-		-			
CO4										-		-			
CO5										-		-			

Course code	PFE 605
Course title	Agricultural Waste And By-Products Utilization
Corse credit	3 (2 + 1)
Objective of Course	1. To acquaint and equip the students with the proper utilization of agricultural waste and by-products. 2. To acquaint students with development of value added products from wastes.
Course Content	Generation of by-products, agricultural and agro industrial by-products/wastes, properties, on site handling, storage and processing. Collection of wastes, utilization pattern as fuel, agricultural waste fired furnaces: Mechanism, construction and efficiency, suitability of wastes as fuel, fuel briquettes, briquetting process, equipment, factors affecting briquetting. Utilization of wastes for paper production, production of particle board, utilization, byproducts from rice mill, rice husk, rice bran, utilisation. 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.
References:	• ASAE Standards. 1984. Manure Production and Characteristics. • Bor S Luh (Ed.). 1980. Rice: Production and Utilization. AVI Publ.

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Chahal DS.1991. Food, Feed and Fuel from Biomass. Oxford & IBH.
Chakraverty A. 1989. Biotechnology and other Alternative Technologies for Utilisation of Biomass/ Agricultural Wastes. Oxford & IBH.
David C Wilson. 1981. Waste Management - Planning, Evaluation, Technologies. Oxford.
Donald L Klass & Emert H George 1981. Fuels from Biomass and Wastes. Ann. Arbor. Science Publ.
Srivastava PK, Maheswari RC & Ohja TP. 1995. Biomass Briquetting and Utilization. Jain Bros.
USDA 1992. Agricultural Waste Management Field Handbook. USDA.
Wilfred A Cote.1983. Biomass Utilization. Plenum Press

</td></tr>
<tr><td>Course Outcomes</td><td>At the end of the course, learners will be able
CO1: Summarize the importance of sanitation and waste water management.
CO2: Estimate the rate of sewage flow and storm water drainage
CO3: Identify the various characteristics of sewage and plan the treatment system.
CO4: To explain the utilization of wastes for preparation of various products.

CO5: Explain the thermo-chemical conversions, densification, combustion and gasification, extraction and biological conversions.</td></tr>
<tr><td colspan="2">Mapping between Cos, POs and PSOs
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<tr><td>CO5</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>-</td><td></td><td>-</td><td></td><td></td><td></td></tr>
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Department of Irrigation and Drainage Engineering - M.Tech and PhD(Old Course)

Course code	**IDE 501**
Course title	**IRRIGATION PLANNING AND MANAGEMENT**
Corse credit	**3 (2+1)**
Objective of Course	Understanding of irrigation technologies and systems, able to develop irrigation schedule and canal water distribution and operation, assessment and appraisal for water availability in command area, able to evaluate performance of irrigation projects based on water delivery.
Course Content	Basic terminology used in planning of irrigation projects, duty of water, its determination and factors affecting it. Methods of improving duty of canal water. Canal scheduling, assessment and appraisal of water availability in command areas, preliminary planning and investigation in irrigation project formulation. Socio economic aspects of irrigation management, Water management problems in command areas and their possible remedies. Multi objective command area planning for the better management of irrigation water, conjunctive use of canal and groundwater. Root zone water balance, water allocation, real time irrigation scheduling, performance appraisal of irrigation projects- equity, adequacy. Design of on farm water distribution network.
References:	Doorenbos, J. and W. O. Pruitt. (1977). Guidelines for Predicting Crop Water requirement, Irrigation and Drainage Paper No. 24, FAO, UN, Rome. Michael, A. M. (2006) Irrigation-Theory and Practices, Vikas Publishing House Pvt. Ltd., New Delhi. 799 pp. Annonymous, (1982), Organization, Operation and Maintenance of Irrigation Schemes, Irrigation and Drainage Paper No. 40, FAO, UN, Rome. 189 pp. T. B. S. Rajput and A. M. Michal, (1990). Scheduling of canal

	deliveries. Application of the Integrated Canal Scheduling Model, Irrigation and Power Journal 47(1): 17-39. L. Kalu, G. N. Paudyal and A. Dasgupta, (1995). Equity and Efficiency issues in Irrigation Water Distribution. Journal of Agric. Water Management, 28(4): 335-348.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand basic terminology used in irrigation project planning, including duty of water, factors affecting it, and methods for improvement. **CO2:** Analyze canal scheduling, assess water availability in command areas, and apply preliminary planning and investigation techniques for irrigation project formulation. **CO3:** Evaluate the socio-economic aspects of irrigation management, identify water management problems in command areas, and develop solutions to improve efficiency and sustainability. **CO4:** Implement multi-objective command area planning for effective irrigation water management, including conjunctive use of canal and groundwater resources. **CO5:** Analyze root zone water balance, perform water allocation and real-time irrigation scheduling, evaluate irrigation project performance considering equity and adequacy, and design on-farm water distribution networks for optimal water delivery.
Mapping between COs with POs and PSOs	

Mapping between Cos, POs and PSOs

CO	PO												PSO		
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Course code	**IDE 502**
Course title	**DESIGN OF SURFACE IRRIGATION SYSTEMS**
Corse credit	**3 (2+1)**
Objective of Course	Selection of suitable method of surface irrigation based on land irritability and infiltration characteristics, design and evaluation of various surface irrigation methods, design optimum layout, conveyance network for efficient use water in surface irrigation system.
Course Content	Historical evidence of development and progress of farm irrigation systems Land irrigability, Theory of Infiltration and its measurement, Methods of irrigation-their selection and suitability Surface Irrigation Systems- Water advance, wetting, depletion and recession in surface irrigation Field data and performance measures of surface irrigation systems, evaluation and design of surface irrigation methods-border, basin and furrow method, surge irrigation and adaptability and design. Irrigation scheduling and equity in water distribution, optional layout of conveyance network-shortest route and minimum tree spanning tree approach.
References:	Michael, A.M. (2006). Irrigation Theory and Practice. Vikas Publ. New Delhi. Jensen, M.E. (Editor). (1983). Design and Operation of Farm Irrigation Systems, ASAE, Monograph No. 3. USA. Walker, W.R. and G.V. Skogerboe. (1987). Surface Irrigation: Theory and Practice Prentice-Hall Inc. New Jersey, USA James. L.G. (1988). Principles of Farm Irrigation System Design. John Wiley and Sons, New York, USA. Withers, Bruce and Vipond, Stanley. (1974). Irrigation: Design and Practice. B.T. Batsford Ltd., London.

Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the historical development and progress of farm irrigation systems, analyzing their influence on agricultural advancements. **CO2:** Analyze land irrigability based on soil characteristics and water resources, apply the theory of infiltration and its measurement techniques, and select and justify suitable irrigation methods for specific conditions. **CO3:** Explain the principles of surface irrigation, including water advance, wetting patterns, depletion, and recession processes. Analyze field data and performance measures of various surface irrigation systems (border, basin, furrow). **CO4:** Evaluate and design surface irrigation methods (border, basin, furrow), including surge irrigation, considering adaptability and designing appropriate layouts. **CO5:** Implement irrigation scheduling strategies and analyze equity in water distribution within irrigation systems. Design optimal conveyance networks using shortest route and minimum tree spanning tree approaches for efficient water delivery.
Mapping between COs with POs and PSOs	

Mapping between Cos, POs and PSOs

CO	PO												PSO		
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Course code	**IDE 503**
Course title	**RECLAMATION OF IRRIGATED LANDS**
Corse credit	**3 (2+1)**
Objective of Course	Able to identify the various types of problematic soils, develop competency for reclamation of problematic and water logged soils, understanding of leaching requirement, Hydraulic conductivity and design of drainage system.
Course Content	Causes of water logging and soil salinity in irrigated lands, Extent of water logging and soil salinity in arid and semi-arid lands, Field investigations of soil and water salinity components, Movement of water and salts. Control for seepage and leakage from canal network, Groundwater geology considerations, Quality of canal and ground water, Water balance, Salt balance, Use of amendments for reclamation or irrigated lands, leaching of salts. Disposal of drainage water, Reuse of drainage water. Sensor based drainage system.
References:	Ritzema, H.P. (Ed) (1994). Drainage Principles and Applications, Second Edition, International Institute for land Reclamation and Improvement; Wageningen. The Netherlands. Singh, R.V. (Ed) (1991), Drainage and Salinity Control, Himanshu Publication, Udaipur. Rao KVGK, Agrawal MC & Singh OP (1993), Reclamation and Management of Waterlogged Saline soils. CSSRI Karnal.
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the causes and extent of waterlogging and soil salinity in irrigated lands, particularly in arid and semi-arid regions. Conduct field investigations to assess soil and water salinity levels and understand the movement of water and salts within the soil profile. **CO2:** Develop strategies for controlling seepage and leakage from canal networks, considering groundwater geology

	considerations and the quality of both canal and groundwater resources. Perform water and salt balance calculations to assess the current situation and design interventions. **CO3:** Evaluate the use of amendments for reclamation of salt-affected irrigated lands, including leaching techniques to remove excess salts and restore soil health. **CO4:** Design and implement drainage systems for effective waterlogging control, including the disposal of drainage water and potential for reuse. Analyze the feasibility and benefits of sensor-based drainage systems for improved efficiency and automation. **CO5:** Develop comprehensive management plans to address waterlogging and salinity issues in irrigated lands, integrating various control measures like canal seepage reduction, groundwater management, soil amendments, drainage systems, and water reuse strategies for sustainable irrigation practices.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**IDE 504**
Course title	**AGRICULTURAL DRAINAGE SYSTEMS**
Corse credit	**3 (2+1)**
Objective of Course	To acquaint and equip with the importance and phenomenon of drainage system along with design consideration of surface and sub-surface drainage systems
Course Content	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 Principle and applications of Earnst, Glover Dumm, Kraijenhoff-van-de-leur equations Salt balance, leaching requirement and management practices under drained conditions. Design of different components of sub-surface drainage systems, theories of vertical drainage and multiple well point systems Disposal of drainage effluents, Management of drainage projects of water- logged and saline soils, case studies
References:	Battacharaya AK & Micheal AM. 2003. Land Drainage. Vikas Publ. Clande Ayres & Daniel Scoates A.E. 1989.Level Drainage and Reclamation. McGraw Hill. Luthin JN. 1978. Drainage Engineering. Wiley Eastern. Ritzema HP. (Ed.). 1994. Drainage Principles and Applications. ILRI. Roe CE 1966. Engineering for Agricultural Drainage. McGraw Hill.
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the principles and applications of surface and subsurface drainage, including steady-state and unsteady-state drainage equations for layered and non-layered soils, with specific focus on horizontal subsurface drainage. **CO2:** Apply relevant drainage equations like Earnst, Glover Dumm, and Kraijenhoff-van-de-leur to solve drainage problems and design drainage systems effectively. **CO3:** Manage salt balance under drained conditions, determine leaching requirements, and implement appropriate management

	practices for sustainable agricultural production. **CO4:** Design various components of subsurface drainage systems, including vertical drainage and multiple well point systems, considering soil properties and drainage objectives. **CO5:** Develop effective drainage project management plans for waterlogged and saline soils, including strategies for disposal of drainage effluents and analysis of successful case studies for practical implementation.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**IDE 505**
Course title	**OPEN CHANNEL FLOW**
Corse credit	**3 (3+0)**
Objective of Course	To acquaint and equip with the hydraulics of surface water flow phenomenon in open channels
Course Content	Open channel and their properties, energy and momentum, critical flow computation and application. Uniform flow; gradually varied flow theory and analysis, methods of computation. Practical problems such as design of transitions, flow passing Islands etc. spatially varied flow, rapidly varied flow. Hydraulic jump and its use as energy dissipator, flow through channel of non-linear alignment and flow through non-prismatic channel sections. Unsteady flow, gradually varied unsteady flow and rapidly varied unsteady flow.
References:	Chaudhry MH. 1993. Open Channel Flow. Prentice Hall. Chow VT. 1959. Open Channel Hydraulics. Mc-Graw Hill. Henederson FM. 1966. Open Channel Flow. MacMillan.
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the properties of open channels, including energy, momentum, critical flow, and apply these principles to solve related problems. **CO2:** Understand and apply the theory of uniform flow in open channels, analyze gradually varied flow, and utilize various computational methods for different scenarios. **CO3:** Design transitions in open channels, solve flow problems involving islands and other obstructions, and analyze spatially and rapidly varied flow conditions. **CO4:** Understand the principles of hydraulic jump formation and apply it as an energy dissipator in open channel design. Analyze flow through non-linearly aligned and non-prismatic channels.

	CO5: Analyze unsteady flow in open channels, both gradually and rapidly varied, and apply relevant principles to solve practical problems in hydraulic engineering.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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Course code	**IDE 506**
Course title	**GIS AND REMOTE SENSING FOR LAND AND WATER RESOURCE MANAGEMENT**
Corse credit	**3 (2+1)**
Objective of Course	To acquaint and equip with the techniques of Remote Sensing and application of GIS for land and water resources management.
Course Content	Basic principles of remote sensing and sensors. Elements of photogrametry. Electromagnetic spectrum. Energy interaction with surface features, Aerial photo and satellite imagery. Photo and image interpretation. Principles of Geographical Information System tools, their types and capabilities, Advantages of GIS over conventional methods. Importance of ground truth establishment, GIS and remote sensing for land and water resources data collection, analysis and interpretation, Application of GIS in water and land resource development and management.
References:	De Mess MN. 2004. Fundamental of Geographic Information System. John Wiley & Sons. Lille Sand T & Kaiffer R.1987. Remote Sensing and Image Interpretation. John Wiley & Sons. Sabbins F.1987. Remote Sensing Principle and Interpretation. Freeman.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the basic principles of remote sensing and sensors, including the elements of photogrammetry and the interaction of electromagnetic spectrum with surface features. Interpret aerial photographs and satellite imagery for various land and water resource applications. **CO2:** Master the principles of Geographic Information Systems (GIS) tools, their types and capabilities, and the advantages of GIS over conventional methods for data management and analysis. Appreciate the importance of establishing ground truth

	for accurate data interpretation. **CO3:** Utilize remote sensing and GIS technology for efficient land and water resources data collection, analysis, and interpretation. Extract meaningful information from various datasets and interpret them for resource management decisions. **CO4:** Apply GIS in various aspects of water and land resource development and management, including irrigation planning, watershed management, drought monitoring, and land use mapping. Leverage GIS capabilities to analyze spatial relationships and patterns for informed decision-making. **CO5:** Integrate remote sensing and GIS for comprehensive resource assessment and monitoring. Develop and implement effective strategies for sustainable land and water resource management using advanced spatial technologies.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
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Course code	**IDE 507**
Course title	**WATER RESOURCES SYSTEM ENGINEERING**
Corse credit	**3 (3+0)**
Objective of Course	Able to identify objective function and components in water resource planning problems, able to formulate and solve various mathematical programming models of water resource system, able to develop conjunctive use and crop production function optimization models.
Course Content	Concepts of significance of optimization in water resources, objective function, deterministic and stochastic inputs. Mathematical programming technique , linear programming and its extension: gradient method, simplex method, non-linear programming classical optimization. Geometric programming and dynamic programming, application of optimization techniques for water resources. Development and management including conjunctive use, crop production functions and irrigation optimization.
References:	Larry WM. (1996) Water Resources Handbook. Mc-Graw-Hill. Loucks DP et al. (1981). Water Resources System Planning and Analysis Prentice Hall. Rao SS. (1978) Optimization Theory and Application. Wiley Eastern. Wallander WW, BOS M (1990) Water resource system Planning & Management.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the significance of optimization in water resources management, including the concepts of objective functions, deterministic and stochastic input considerations. **CO2:** Apply mathematical programming techniques, particularly linear programming and its extensions (gradient method, simplex method), for solving water resources planning and management problems. **CO3:** Analyze and solve non-linear optimization problems in

	water resources using classical optimization methods, geometric programming, and dynamic programming techniques. **CO4:** Develop and implement optimization models for various water resources management applications, including conjunctive use of surface and groundwater, crop production functions, and irrigation optimization. **CO5:** Apply optimization techniques to effectively manage water resources, considering sustainability, efficiency, and decision-making under uncertainty.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	PO												PSO		
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Course code	**IDE 508**
Course title	**IRRIGATION ECONOMICS PLANNING AND MANAGEMENT**
Corse credit	**3 (2+1)**
Objective of Course	Able to estimate the cost benefit analysis, pricing and investment criteria on irrigation project evaluation and finding their problems, to impart the knowledge of various public and government policy on regulation and allocation of irrigation water.
Course Content	Criteria for investment in irrigation projects. Economics analysis of irrigation projects, cost benefit analysis, pricing and investment criteria on irrigation project evaluation, social benefits, problems and causes of under-utilization. Impact of public policies on regulation and allocation of irrigation water. Relative economic efficiency of alternative irrigation water management models irrigation system improvement by simulation and optimization. Economic and social benefits of irrigation projects after institutional and legal aspects in the use of irrigation water. Technological changes and irrigation water use efficiency.Methods and approaches to water pricing. Indian agriculture, main problems, population, government policies, systems, organizing agriculture production, socio-economic survey, importance of such survey in planning, implementation and evaluation of project performance. Farm Management- definition, Importance, scope, relation with other sciences and its characteristics. Role of farm management principles in decision making for irrigated agriculture. Socio–economic survey:- Data set and data point. Statistics main division and nature of statistics, planning of socio-economic survey. Collection of data:- Primary and secondary data, questionnaires & schedules sampling, editing and scurting of secondary data, classification and tabulation and analysis of data

References:	James, Douglas and Lee. Rober R-Economics of Water Resource Planning. Tata Mcgraw-Hill Publication Company Ltd., Bombay, New Delhi. Sharma, V.K. (1985) Water Resource Planning and management. Himalaya Publication House, New Delhi. Management of Water Project-Decision making and investment appraisal. Oxford Publication Co. Heady, Early O.R. Hexem, Rogrew Water Production Functions for irrigated Agriculture. Agarwal, A. N. Indian Economic Problems of Development and Planning. Joshi, S.S. and T.R. Kapoor, (2001), Fundamentals of Farm Business management. Kalyani Publishers, Ludhiyana.
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze investment criteria for irrigation projects, applying cost-benefit analysis, pricing strategies, and project evaluation methods. Identify social benefits and address causes of under-utilization. **CO2:** Evaluate the impact of public policies on water regulation and allocation. Compare the economic efficiency of alternative irrigation models and implement optimization techniques for improved water use efficiency. **CO3:** Assess the economic and social benefits of irrigation projects, considering institutional and legal aspects of water use. Analyze technological changes and their impact on irrigation water use efficiency. **CO4:** Understand the economic and social context of Indian agriculture, including population trends, government policies, and agricultural production systems. Conduct socio-economic surveys to inform planning, implementation, and evaluation of irrigation projects. **CO5:** Apply farm management principles for decision-making in irrigated agriculture, considering data analysis, statistical

	methods, socio-economic surveys, and risk assessment to optimize production and profitability.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
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Course code	**IDE 509**
Course title	**WATER CONVEYANCE AND DISTRIBUTION**
Corse credit	**3 (2+1)**
Objective of Course	To develop the common understanding of different conveyance structure in canal irrigation network, able to infuse the knowledge about different types of channel flow and their behavior, able to gain the knowledge of appraisal of flow control and distribution structures.
Course Content	Channel characteristics, Prismatic and non-prismatic channel, Steady, unsteady, uniform and non-uniform flow Dimension-less representative parameters of flow behavior, Energy and momentum in open channel flow. Critical uniform, gradually varied rapidly varied and spatially varied flows and their computations Energy dissipation, Flow control structures, Flow measurement, Theories and methods of open channel design Water conveyance through pipes – Design & evaluation. Methods of Seepage estimation and control measures – Lining Material
References:	Chaudhry M.H. (1993). Open channel Flow. Prentice-Hall, NJ. Chow, Ven T. 1959. Open Channel Hydraulic, Mc-Graw Hill Book Co. New York. Kinori, B.Z. (1970). Manual of Surface Drainage Engineering. Elsevier Publ. Co. Amsterdam. Henderson, F.M. (1966). Open Channel Flow. Macmillan Co. New York. USBR. (1977). Water Measurement Manual. United States Bureau of Reclamation
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the characteristics of open channels, differentiating between prismatic and non-prismatic geometries, and understand the concepts of steady, unsteady, uniform, and non-uniform flow. **CO2:** Utilize dimensionless parameters to represent the behavior

	of open channel flow, apply energy and momentum principles for flow analysis, and distinguish between critical uniform, gradually varied, rapidly varied, and spatially varied flows. **CO3:** Understand energy dissipation in open channels and the role of flow control structures in managing flow behavior. Utilize appropriate methods for open channel flow measurement and apply various theories and techniques for effective open channel design. **CO4:** Design and evaluate water conveyance systems through pipes, considering hydraulic principles and material characteristics. Analyze seepage problems in water conveyance systems and implement appropriate control measures, including lining materials. **CO5:** Integrate knowledge of open channel hydraulics and pipelines to solve real-world water management problems. Design and optimize water conveyance systems, taking into account hydraulic efficiency, environmental concerns, and cost-effectiveness.
Mapping between COs with POs and PSOs	

Mapping between Cos, POs and PSOs

CO	PO												PSO		
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CO4															
CO5															

Course code	**IDE 510**
Course title	**DESIGN OF SPRINKLER AND MICRO IRRIGATION SYSTEM**
Corse credit	**3 (2+1)**
Objective of Course	Able to hydraulic design of drip as well as sprinkler irrigation system for particular area and crop based on water requirement, able to calculate uniform distribution of water and pressure distribution through entire system, able to compute the size of pipe for conveying the flow of water in drip as well as sprinkler irrigation system.
Course Content	Suitability of sprinkler and micro irrigation systems under Indian conditions. Basic hydraulics of sprinkler and micro irrigation

	system Pipe flow analysis. Friction losses and pressure variation. Flow in nozzles and emitters Design & evaluation of sprinkler and micro irrigation systems in relation to source, soil , climate and topographical conditions. Selection of pipe size, pumps and power units, layout distribution, efficiency and economics Fertigation/ chemigation through sprinkler and micro irrigation systems.
References:	Michael, A.M. 2006. Irrigation Theory and Practice. Vikas Publ. New Delhi. Jensen, M.E. (Editor). (1983). Design and Operation of Farm Irrigation Systems, ASAE, Monograph No. 3. USA James. L.G. (1988). Principles of Farm Irrigation System Design. John Wiley and Sons, New York, USA. Withers, Bruce and Vipond, Stanley. (1974). Irrigation : Design and Practice. B.T. Batsford Ltd., London. Sivanappan, R.K. (1987). Sprinkler Irrigation. Oxford and IBH Publishing Co. New Delhi. Sivanappn, R.K. Padmakumari,O. and Kumar V.(1987). Drip Irrigation. Keeerthy Publishing House Coimbature. Keller, J. and Karmeli, D. (1975). Trickle Irrigation Design. Rainbird Sprinkler Manufacturing Corporation. Glendora, California, USA Karmeli, D., Peri, G. and Todes, M. (1985). Irrigation Systems: Design and Operation. Oxford University Press. Captown.
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the suitability of sprinkler and micro irrigation systems under Indian conditions, considering factors like climate, soil type, topography, and water availability. **CO2:** Understand the basic hydraulic principles governing sprinkler and micro irrigation systems, including pipe flow analysis, friction losses, pressure variations, flow through nozzles and emitters, and pump selection. **CO3:** Design and evaluate sprinkler and micro irrigation systems based on source water characteristics, soil properties, climate

	conditions, and topographical features. Optimize system layout and distribution for efficient water delivery. **CO4:** Select appropriate pipe sizes, pumps, and power units based on hydraulic calculations and system requirements. Analyze the efficiency and economics of different sprinkler and micro irrigation options. **CO5:** Implement fertigation/chemigation techniques through sprinkler and micro irrigation systems, ensuring effective fertilizer and chemical application for improved crop yield and nutrient management.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
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CO2															
CO3															
CO4															
CO5															

Course code	**IDE 511**
Course title	**CROP ENVIRONMENTAL ENGINEERING**
Corse credit	**2 (2+0)**
Objective of Course	To develop the common understanding aerial and edaphic environments for plant growth, energy and mass transfer which help to maximizing the crop yield, to understanding the basic interface of soil and root and its characteristics, able to identify climatic changes on plant and how plan are response to environmental stresses, evapotranspiration.
Course Content	Aerial and edaphic environments for plant growth, energy and mass transfer in and above crop canopies. Climatic changes and plant response to environmental stresses, evapotranspiration models. Instrumentation and techniques for monitoring plant environments. Processes and aspects of growth and development, soil-root interface, root sink functions. Water movement in soil-plant atmosphere continuum, artificial environments and plant behavior. Water requirement of crops in controlled environment. Design and operation of controlled environment facilities and their instrumentation. Crop growth and yield modelling. Remote sensing based modelling.
References:	Ghildyal BP and Tripathy RP. 1987. Fundamental of Soil Physics. Wiley Eastern. Slatyor OP. 1967. Plant Water relationship. Academic Press. Gomtia N.K. & Tiwari K.N. 2008. Irrigation Scheduling & Crop water Stress using Remote sensing & GIS, Lamber Publication
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the interactions between aerial and edaphic environments, including energy and mass transfer processes in and above plant canopies. Analyze the impact of climatic changes and environmental stresses on plant growth and development. **CO2:** Apply evapotranspiration models for accurate water management in controlled environments. Utilize appropriate instrumentation and techniques to monitor various environmental parameters affecting plant growth.

	CO3: Analyze the processes and aspects of plant growth and development, focusing on the soil-root interface and root sink functions. Understand the water movement within the soil-plant-atmosphere continuum. **CO4:** Design and operate controlled environment facilities, including instrumentation and technology for optimal environmental control. Evaluate the water requirements of different crops under controlled conditions. **CO5:** Develop and utilize crop growth and yield models, including those based on remote sensing data, for predicting plant performance and optimizing production in controlled environments. Analyze the advantages and limitations of various modeling approaches.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
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CO4															
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Course code	**IDE 512**
Course title	**DESIGN OF PUMPS FOR IRRIGATION AND DRAINAGE**
Corse credit	**3 (2+1)**
Objective of Course	Able to select the pump for desired discharge to be pumped from particular water source by developing pump characteristics curve, able to analyze the flow in different types of pump, able to design the pumping station for managing the irrigation and drainage system.
Course Content	Design principles of the common types of pumps and well lifts, Influence of design parameters on the pump performance Matching of pumps with prime movers, Matching of pumps and prime movers with water source Non-conventional energy sources for pumping, Assessment of wind energy and design of wind mill, Assessment of solar insolation and selection of photovoltaic pump Hydraulic ram and its design, Energy loss in pressurized conveyance of pumped water

	Design of pumping plant for irrigation and drainage.
References:	Church, A. H. and Jagdish Lal. (1973). Centrifugal Pumps and Blowers, Metropolitan Book Co. Pvt. Ltd. Delhi. Bansal, R. K. (1990). A Text Book of Fluid Mechanics and Hydraulic Machines. Laxmi Publications, New Delhi. Luthine, J N. (1966). Drainage Engineering, Wiley and Sons. New York, USA. Michael, A. M. and Khepar, S. D. (1989). Water Wells and Pump Engineering. Tata McGraw Hill Publishing Co., New Delhi.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the design principles of various types of pumps and well lifts, including the influence of design parameters on their performance. **CO2:** Analyze and perform the matching of pumps with prime movers (electric motors, diesel engines, etc.) and optimize their selection based on water source characteristics. **CO3:** Evaluate the potential of non-conventional energy sources (wind, solar) for pumping applications. Design windmills and select photovoltaic pumps based on available wind energy and solar insolation data. **CO4:** Understand the working principle of hydraulic rams and design them for efficient water lifting. Analyze energy losses in pressurized water conveyance systems and implement strategies for minimizing them. **CO5:** Design pumping plants for both irrigation and drainage applications, considering factors like water source, discharge requirements, energy efficiency, and cost-effectiveness. Integrate knowledge of pumps, prime movers, and hydraulic principles for optimal design and operation.
Mapping between COs with POs and PSOs	

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 513**
Course title	**GROUND WATER ENGINEERING**
Corse credit	**3 (2+1)**
Objective of Course	After completion of course student will be able to analyze storage, movement and flow characteristics of different aquifers, able to model ground water and plan for ground water recharge.
Course Content	Properties affecting groundwater storage and movement, groundwater balance studies. Well hydraulics, two dimensional flow, steady and unsteady state flow in confined, unconfined and semi-confined aquifers, steady flow in sloping aquifers, partial penetrating wells. Analysis of multi-aquifers. Flow analysis in interfering wells. Pumping tests and determination of aquifer parameters. Groundwater modeling for water resources planning. Techniques for groundwater recharge.
References:	Boonstra J & de Ridder NA.1981. Numerical Modelling of Groundwater Basins. ILRI. Demenico PA 1972. Concept and Models in Groundwater Hydrology. Mc Graw Hill. Jat, M.L. and SR Bhakar 2008. Ground Water Hydrology. Agrotech Publishing Academy, Udaipur. Huisman L.1972. Ground Water Recovery, Mac Millan. Polubarinova Kochina P Ya 1962. Theory of Ground Water Movement. Princeton Univ. Press. Raghunath HM. 1992. Ground Water. Wiley Eastern. Todd DK 1997. Ground Water Hydrology. Wiley Eastern.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the properties of aquifers affecting groundwater storage and movement, including porosity, hydraulic conductivity, specific yield, and specific storage. Analyze groundwater balance studies for sustainable management. **CO2:** Analyze well hydraulics, including two-dimensional flow, steady and unsteady state flow in confined, unconfined, and semi-confined aquifers, steady flow in sloping aquifers, and

	partial penetrating wells. Apply appropriate analytical solutions for different aquifer types and well configurations. **CO3:** Analyze flow in interfering wells and the impact of pumping on neighboring wells. Design and conduct pumping tests and interpret data to determine key aquifer parameters like hydraulic conductivity and transmissivity. **CO4:** Utilize groundwater modeling tools for water resources planning and management. Develop and apply models to simulate groundwater flow, predict aquifer response to pumping and recharge, and inform decision-making for sustainable water resource utilization. **CO5:** Evaluate and implement techniques for groundwater recharge, including artificial recharge basins, injection wells, and managed aquifer recharge (MAR) methods. Analyze the effectiveness of different recharge strategies in enhancing groundwater resources.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 514**
Course title	**SOIL-WATER-PLANT RELATIONSHIP**
Corse credit	**3 (2+1)**
Objective of Course	After completion of course student will be able to analyze factors responsible for water movement in soil, plant and evaporative demand of plant, student will be able to estimate the evapotranspiration using meteorological data.
Course Content	Aerial and edaphic environment for plant growth, Energy and Mass transfer in and above crop canopies, Plant response to environmental stresses, Evapo-transpiration models, Instrumentation techniques for monitoring plant environment, Processes and aspects of growth and development, Soil root interface, Root sink functions, Well hydraulics, two dimensional flow, steady and unsteady state flow in confined, unconfined and semi-confined aquifers, steady flow in sloping aquifers, partial penetrating wells. Analysis of multi-aquifers. Flow analysis in interfering wells. Pumping tests and determination of aquifer parameters. Water movement in soil-plant-atmosphere continuum, Artificial environment and plant behavior Design and operation of controlled environment facilities and their instrumentation.
References:	
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the interactions between aerial and edaphic environments, including energy and mass transfer processes in and above plant canopies. Understand plant responses to environmental stresses and utilize appropriate evapotranspiration models for water management. **CO2:** Apply instrumentation techniques to monitor plant environment and its impact on growth. Analyze the processes and aspects of plant growth and development, focusing on soil-root interface and root sink functions. **CO3:** Understand the principles of well hydraulics, including

	two-dimensional flow, steady and unsteady state flow in various aquifer types (confined, unconfined, semi-confined), and flow in sloping aquifers and partial penetrating wells. Analyze multi-aquifer systems and flow interactions between wells. **CO4:** Analyze flow patterns in interfering wells and interpret pumping test data to determine aquifer parameters like hydraulic conductivity and transmissivity. Apply this knowledge to assess groundwater resources and manage well operations. **CO5:** Understand the movement of water within the soil-plant-atmosphere continuum and the effects of artificial environments on plant behavior. Design and operate controlled environment facilities with appropriate instrumentation for optimal plant growth conditions.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 515**
Course title	**Water Supply and Treatment**
Corse credit	**3 (3+0)**
Objective of Course	Understanding importance and necessity of water Supply scheme, water quality, water treatment objectives and water conveyance system and able to estimate water demand for population of target area.

Course Content	Water Quantity: Importance and necessity of water supply scheme. Water demands and its variations. Estimation of total quantity of water requirement. Population forecasting. Quality and quantity of surface and ground water sources. Selection of a source of water supply. Types of intakes. Water Quality: Impurities in water and their sanitary significance. Physical, chemical and bacteriological analysis of water, water borne diseases, water quality standards. Water Treatment: Objectives, treatment processes and their sequence in conventional treatment plant, sedimentation – plain and aided with coagulation. Types, features and design aspects. Mixing basins and Flocculation units. Filtration – mechanism involved, types of filters, slow and rapid sand filtration units (features and design aspects), Disinfection principles and aeration. Other water treatment processes: Purification processes in natural systems, water softening, removal of taste and odour, advanced methods of water treatment, deflouridation, dissolved solids removal. Water Conveyance System: Conveyance of water, Intake structures, Rising and Gravity system, Dual systems, Pumping Systems and pumping stations, valves and appurtenances, pipe materials and pipe fitting, O&M and trouble shooting for conveyance system. Water Distribution System: Layout of Distribution system – Dead End system, Grid Iron system, Ring system, Radial system, their merits and demerits, Distribution Reservoir- functions and determination of storage capacity, Water Distribution Network, analysis of distribution network, layout, capacity and pressure requirements, leak detection, Maintenance, Water supply in buildings and plumbing.
References:	Steel, E.W. Water Supply and Sewerage Terence, J. Mc Ghee Water Supply and Sewage by J. Mc Ghee. Kshirsagar, S.R. Water Supply Engineering Garg, S. K. Water Supply Engineering Punmia, B.C., Jain, Ashok & Jain, Arun. Water Supply Engineering: B.C. Punmia, Ashok Jain & Arun Jain. Manual on Water Supply and Treatment: Ministry of Urban Dev., New Delhi. Chatterjee, A. K. Water Supply Waste

	Disposal and Environmental Pollution Engineering. Duggal, K. N. Elements of Public Health Engineering. Birdie, G. S. and Birdie J. S. Water Supply and Sanitary Engineering Peavy, S., Donald, R. Rowe and George Tchobanologlous Environmental Engineering Mark, T. Hammer, Water and Waste Water Technology
Course Outcomes	At the end of the course, learners will be able **CO1:** Assess the importance of water supply schemes and estimate water demands for various purposes, considering population forecasting and source availability. Analyze the quantity and quality of surface and groundwater resources and select suitable water sources for specific needs. Design appropriate intake structures for water withdrawal. **CO2:** Understand the types and significance of impurities in water, their impact on human health, and waterborne diseases. Analyze water quality through physical, chemical, and bacteriological testing and evaluate compliance with relevant standards. **CO3:** Explain the objectives and sequence of water treatment processes in conventional treatment plants. Design and analyze sedimentation (plain and aided with coagulation), mixing basins, flocculation units, and filtration systems (slow and rapid sand filters). Implement disinfection principles and understand the role of aeration in water treatment. **CO4:** Design and analyze water conveyance systems, including intake structures, rising and gravity systems, dual systems, pumping stations, and pipe networks. Select appropriate pipe materials and fittings, and develop operation and maintenance (O&M) strategies for the conveyance system. **CO5:** Analyze and design water distribution systems, considering various layout options (dead-end, grid-iron, ring, and radial systems) and their merits and demerits. Determine storage capacity of distribution reservoirs, analyze network connectivity and pressure requirements, and implement leak detection and maintenance strategies. Design water supply systems for buildings, considering plumbing principles and regulations.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 516**
Course title	**Climate Change and Water Resources**
Corse credit	**3 (3+0)**
Objective of Course	To acquaint and equip the students with the concepts of weather and climate, to make them familiars with climate changes and there impacts on different resources on the earth. How to tackle the problem the climate change. Forecasting methods for prediction of water resources for effective under future under climate change.
Course Content	Climate and weather: Basic concept of climate, Climate and weather, climatic classification, drivers of climate change, over view of changing climate, analysis of climate change, climate forecasting. Hydrologic system overview with drought and floods: Hydrologic system overview, global and national water budget, rainfall and temperature variability, an overview of climate change effects on water (runoff, ET, Soil Moisture, GW), and soil (sediment) resources, climate change and droughts & floods. Climate forecast: GCM and RCM. An overview of future climate scenarios, Assessment of future water resources (surface/GW/SM) status and vulnerability. Application of hydrologic models in present and future resources assessment, probabilistic methods of results interpretation of future water resources. Adaptation and mitigation under climate change: Climate change adaptation capacity & methods analysis, Sensitivity of the changing climate on WR, Application of CC forecasts on water resources management (reservoirs, surface water, GW). Impact on climate change on water resources and agriculture: Impact on climate change case studies, agriculture, waters resources in India and around the globe. Case studies based on different river basin of India and globe. Application of hydrological modelling to assess the impact the climate change in future.
References:	Cowie Johathan (2013). Climate change Biological and Human Aspects, Cambridge University Press. Lal, D. S (2012). Climatology, Sharda Pustak Bhawan.

	Singh, B. K (2012). Specifications of Sustainable development and climate change, Surendra Publications Pipe, Jim (2011). Specifications of Planet Earth: Weather and Climate, Octopus Publishing Group. Sutcliffe, R. C, 1967. Weather and Climate: The Advancement of Science Series, W. W. Norton & amp; Company.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the fundamental concepts of climate and weather, including climate classification, drivers of change, and current and future trends. Analyze climate change data and utilize climate forecasts for informed decision-making. **CO2:** Gain a comprehensive understanding of the hydrologic system, including the global and national water budget, rainfall-temperature interactions, and the impact of climate change on water resources (runoff, evapotranspiration, soil moisture, groundwater) and soil resources (sediment). Analyze the relationship between climate change and droughts and floods. **CO3:** Familiarize yourself with global climate models (GCMs) and regional climate models (RCMs). Analyze future climate scenarios and assess potential impacts on water resources (surface water, groundwater, soil moisture). Apply hydrologic models to evaluate future water resources availability and vulnerability under changing climatic conditions. **CO4:** Understand climate change adaptation and mitigation strategies in the context of water resources management. Analyze the sensitivity of water resources to changing climate and apply climate forecasts for efficient reservoir and surface water management, including groundwater management. **CO5:** Evaluate the impact of climate change on water resources and agriculture through case studies from India and around the globe. Apply hydrological modeling techniques to assess the future impact of climate change on specific river basins and develop appropriate adaptation and mitigation strategies for sustainable water management.
Mapping between COs with POs and PSOs	

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**

CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 601**
Course title	**DESIGN, OPERATION & EVALUATION OF PRESSURIZED IRRIGATION SYSTEM**
Corse credit	**3 (2+1)**
Objective of Course	Developing competency for hydraulic design of drip as well as sprinkler irrigation system for particular area and crop based on site situation, to develop the common understanding of filtration unit in drip and sprinkler irrigation and able to estimate the fertilizer requirement for particular crop, able to assess the cost effective drip and sprinkler irrigation system for particular area and crop.
Course Content	Filtration units, drip fertigation, Distribution uniformity of water, Pressure distribution in the system, Cost economics of different systems, Evaluation of micro and sprinkler irrigation system Basic hydraulics of sprinkler and drip system, Pipe flow analysis, Friction losses and pressure variation Flow in nozzles and emitters, 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. Pressurized irrigation networks system (PINs)
References:	Sivanappan, R.K. (1987). Sprinkler Irrigation. Oxford and IBH Publishing Co. New Delhi. Finkel, H.J. (1983). Handbook of Irrigation Technology Vol. I CRC Press, Florida, USA. Karmeli, D., Peri, G. and Todes, M. (1985). Irrigation Systems: Design and Operation. Oxford University Press. Captown. Sivanappn, R.K. Padmakumari, O. and Kumar V. (1987). Drip Irrigation. Keerthy Publishing House Coimbature. Pillsbury, A.F. (1972). Sprinkler Irrigation, FAO Agricultural Development Paper No. 88, FAO, Rome.

	Mane & B. L. Ayare, Design Operation of Drip Irrigation, Jain Publications. Mane & B. L. Ayare, Design Operation of Sprinkler Irrigation, Jain Publications.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the fundamental hydraulic principles of both sprinkler and drip irrigation systems, including pipe flow analysis, friction losses, pressure variation, and flow characteristics of nozzles and emitters. **CO2:** Design and evaluate micro and sprinkler irrigation systems based on source water characteristics, soil properties, climate conditions, and topographical features. Optimize layout and distribution for efficient water and nutrient delivery. **CO3:** Analyze the uniformity of water distribution and pressure within the irrigation system, ensuring optimal crop growth and resource utilization. Evaluate the cost-effectiveness of different irrigation options and select the most suitable system based on specific needs and constraints. **CO4:** Design and operate Pressurized Irrigation Networks (PINs) for efficient water conveyance and distribution. Select appropriate pipe sizes, pumps, and power units based on hydraulic calculations and system requirements. **CO5:** Implement fertigation techniques through sprinkler and drip systems, ensuring effective application of fertilizers and nutrients for improved crop yield and nutrient management. Analyze the efficiency and economics of fertigation compared to traditional fertilization methods.
Mapping between COs with POs and PSOs	

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 602**
Course title	**ADVANCES IN IRRIGATION AND DRAINAGE**
Corse credit	**3 (3+0)**
Objective of Course	After completion of course student will be familiar about Advance methods of Irrigation and Drainage, drainage material and various sources of agricultural pollution, able to develop and apply simulation model for management of drainage system for particular area.
Course Content	Advances in surface irrigation systems-surge irrigation : effect of surging on surface flow hydraulics, cablegation: water supply management. Atomization in sprinkler and micro irrigation systems; multipurpose and special uses of micro irrigation. Synthetic materials for drainage systems. Environmental issues related to drainage. Socio-economic impacts of drainage systems. Controlled drainage for reducing agricultural non point pollution. Application of simulation models for drainage systems.
References:	FAO. 1082. Mechanized Sprinkler Irrigation. FAO Irrigation and Drainage Paper 35. FAO. 1989. Guidelines for Designing and Evaluating Surface Irrigation System.FAO Irrigation and Drainage paper 45. Keller J and Bliesner RD. 1990. Sprinkler land Trickle Irrigation. Chapman & Hall. Ritzema HP. (Ed.) 1994. Drainage Principles and Applications. ILRI. Walker WR & Skogerboe GV. 1987. Surface Irrigation: Theory and Practice, Prentice Hall.
Course Outcomes	At the end of the course, learners will be able **CO1:** Analyze the concept of surge irrigation and its impact on surface flow hydraulics. Evaluate the effectiveness of surge irrigation systems compared to traditional surface irrigation methods. **CO2:** Understand the principles of atomization in sprinkler and micro irrigation systems and its role in improving water application efficiency. Explore the multipurpose and special applications of micro irrigation systems for various agricultural and non-agricultural purposes. **CO3:** Evaluate the advantages and disadvantages of using synthetic materials for drainage systems compared to traditional

	materials. Analyze environmental issues related to drainage, including potential impacts on water quality and soil health. **CO4:** Understand the concept of controlled drainage and its role in reducing agricultural non-point pollution. Apply simulation models to design and optimize drainage systems for specific agricultural landscapes. **CO5:** Analyze the socio-economic impacts of drainage systems, considering both benefits and potential drawbacks. Develop strategies to mitigate negative impacts and ensure sustainable drainage practices for improved water resource management.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 603**
Course title	**HYDRO-CHEMICAL MODELLING AND POLLUTANT MANAGEMENT**
Corse credit	**3 (3+0)**
Objective of Course	Demonstrate understanding of hydrodynamics of fluid and pollutant transport through modelling, capable to do water quality analysis of lakes and reservoir based physical and chemical characteristics, develop water reclamation and water reuse plans for irrigation and industries.
Course Content	Hydrodynamics in flow through porous media, Hydrodynamic dispersion, diffusion, convection equation. Analytical and numerical models of contaminant transport in unsaturated soil profile and ground water. Water quality management in lakes and reservoirs; physical characteristics; hydrologic and chemical budgets; bio geochemical processes of pollutants, assessment methods. Classical wastewater problems; water reclamation, reuse, water quality constraints and considerations for reuse in irrigation and industry; Biological wastewater treatment. Modern stream pollution problem. Quality of groundwater and sources of contaminants. Cost economics-environment impact assessment.
References:	Larry W Mays 1996. Water Resources Handbook. Mc Graw Hill. Metcalf and Eddey 1994. Wastewater Treatment Engineering and Reuse. John Wiley. Soli J Arceivala 1998. Wastewater Treatment for Pollution Control. Tata Mc Graw- Hill.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the principles of hydrodynamics in flow through porous media, including hydrodynamic dispersion, diffusion, and the convection equation. Apply analytical and numerical models to simulate contaminant transport in unsaturated soil profiles and groundwater systems. **CO2:** Analyze water quality management strategies for lakes and reservoirs, considering physical characteristics, hydrologic and chemical budgets, biogeochemical processes of pollutants,

	and assessment methods. Develop and implement remediation strategies for polluted water bodies. **CO3:** Understand the challenges and opportunities associated with water reclamation and reuse. Evaluate water quality constraints and considerations for reuse in irrigation and industrial applications. Design and analyze biological wastewater treatment systems for efficient removal of pollutants. **CO4:** Analyze modern stream pollution problems and their impact on aquatic ecosystems. Identify sources of groundwater contamination and develop strategies for groundwater quality protection. Assess the cost-effectiveness of different pollution control measures and conduct environmental impact assessments. **CO5:** Integrate knowledge of hydraulics, contaminant transport, and water quality management to solve complex environmental problems. Design and implement sustainable solutions for water pollution control and environmental protection.
Mapping between COs with POs and PSOs	
Mapping between Cos, POs and PSOs	

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 604**
Course title	**PLANT GROWTH MODELLING & SIMULATION**
Corse credit	**3 (2+1)**
Objective of Course	After completion of course student will be able to know various plant growth models and their application based on input environmental parameters, student will acquainted with generalized agricultural simulator.
Course Content	Introduction to plant growth modelling, Simulation and simulation language Types of models and modelling approaches, Relational diagram of principle process Structure of a generalized agricultural simulator, Input environment and techniques for monitoring plant environment, Process and aspects of growth and development, Input yield

	models Quantitative analysis of photosynthesis, respiration, growth, water and nutrient uptake, Yield functions. Remote sensing based modelling.
References:	Nobel, P.S. (1991). Physicochemical and Environment Plant Phsiology. Academic Press Inc. San Diego, CA, USA. Goudriaan, J and Van Laar, H.H. (1994). Modelling Potential Crop Growth Process. Kluweer Academic Publisher, Dordrecht, Netherlands. Levitt, J. (1972). Responses of Plants to Environment Stress. Academic Press, New York. USA. Evans, L.T. (1963). Environmental Control of Plant Growth. Academic Press, New Yor, USA. Charls-Edwards, D.A. (1981). The Mathematics of Photosysnthesis and Productivity Academic Press, London Jones, J.W. and Ritchie, J.T. (1990). Crop Growth Models. In: ASAE Monograph on Management of Farm Irrigation Systems, Editted by:G.J. Hoffman, T.A. Howell and K.H. Solomon, ASAE, St. Joseph, Michigan, USA
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the basic concepts of plant growth modeling, including simulation techniques and commonly used simulation languages. Analyze different types of models and their underlying approaches to understanding plant growth processes. **CO2:** Construct relational diagrams to represent the key processes involved in plant growth and development. Design and develop a generalized agricultural simulator based on these principles. **CO3:** Define the input parameters required for plant growth models, including environmental data and techniques for monitoring the plant environment. Analyze the processes and aspects of growth and development, considering factors like photosynthesis, respiration, water and nutrient uptake, and yield functions. **CO4:** Develop quantitative models for photosynthesis,

	respiration, growth, water and nutrient uptake, and yield functions. Apply these models to analyze and predict plant growth under different environmental conditions. **CO5:** Integrate remote sensing data into plant growth models for improved accuracy and real-time monitoring. Analyze the advantages and limitations of remote sensing-based modeling compared to traditional methods.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 605**
Course title	**FLOW THROUGH POROUS MEDIA**
Corse credit	**2 (2+0)**
Objective of Course	To acquaint and equip with the hydraulics and process of water flow in the water bearing formation under saturated as well as unsaturated conditions.
Course Content	Aquifer and fluid properties, forces holding water in soils, hydrodynamics in porous media and limitations of governing laws. Differential equations of saturated flow, initial and boundary conditions. Dupuit and Business approximations and linearization techniques. Stream functions, potential functions and flow net theory. Analysis of seepage from canals and ditches. Unsaturated flow theory, Infiltration and capillary rise flux dynamics. Hydro-dynamic dispersion in soil-aquifer system.
References:	Harr Milton E. 1962. Groundwater and Seepage. McGraw-Hill. Jacob Beer 1972. Dynamics of Fluid Flow in Porous Media. Elsevier. Muskat M & Wyckoff RD. 1946. The Flow of Homogeneous Fluids through Porous Media. JW Edwards. Patrick A Domenico & Schwartz FW. 1998. Physical and Chemical Hydrogeology. John Wiley & Sons. Remson I, Hornberger GM & Moiz Fred J. 1971. Numerical Methods in Subsurface Hydrology. Wiley Interscience.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the properties of aquifers and fluids, including porosity, permeability, hydraulic conductivity, specific yield, and specific storage. Analyze the forces holding water in soils and the principles of hydrodynamics in porous media. **CO2:** Solve differential equations governing saturated flow in porous media, considering initial and boundary conditions. Apply Dupuit and Business approximations and linearization

	techniques to simplify complex flow problems. **CO3:** Utilize stream functions, potential functions, and flow net theory to analyze groundwater flow patterns and solve seepage problems. Analyze seepage from canals and ditches and design appropriate drainage systems. **CO4:** Understand the principles of unsaturated flow theory, including infiltration and capillary rise dynamics. Analyze the impact of hydrodynamic dispersion on contaminant transport in the soil-aquifer system. **CO5:** Integrate knowledge of aquifer properties, flow equations, and analytical techniques to solve various groundwater management and engineering problems. Design and implement sustainable solutions for water resource conservation, groundwater pollution control, and aquifer recharge.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 606**
Course title	**ADVANCED HYDO-MECHANICS IN SOIL AQUIFER SYSTEMS**
Corse credit	**3 (3+0)**
Objective of Course	To acquaint and equip the students with the advance soil-aquifer-water mechanics and various techniques for the analysis of the system.
Course Content	Soil aquifer system. Flow of water in partially saturated soils. Partial differential equation of flow. Determination of unsaturated hydraulic conductivity and models for its estimation. Infiltration and exfiltration from soils in absence and presence of water table. Movement of groundwater in fractured and swelling porous media. Spatial variability. Theory of krigging. Statistical approaches in soil water dynamics.
References:	Kirkham & Powers.1972. Advanced Soil Physics. John Wiley & Sons. Muskut M.1937. The Flow of Homogeneous Fluid through Porous Media. McGraw Hill.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the concept of the soil-aquifer system and the principles governing water flow in partially saturated soils. Analyze the partial differential equation of flow and its application to various soil water dynamics problems. **CO2:** Determine unsaturated hydraulic conductivity, a critical parameter for predicting water movement in unsaturated soils. Evaluate different models for estimating this parameter based on experimental data. **CO3:** Analyze infiltration and exfiltration processes in soils, accounting for the presence or absence of a water table. Develop solutions for infiltration and exfiltration problems under different soil and boundary conditions. **CO4:** Understand the unique characteristics of groundwater

	movement in fractured and swelling porous media. Develop analytical or numerical models to analyze flow patterns and contaminant transport in these complex systems. **CO5:** Apply statistical approaches to analyze spatial variability in soil properties and water content. Use geostatistics, particularly kriging, to estimate unknown soil properties at unsampled locations and improve the accuracy of soil water dynamics predictions.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**IDE 607**
Course title	**COMMAND AREA DEVELOPMENT**
Corse credit	**3 (2+1)**
Objective of Course	Able to understand the concept of command area and its development, able to analyze problem diagnostics and remedies of command area, able to understand the performance evaluation procedure if command area.
Course Content	Concept of command area development as an integrated approach Command area project formulation, Major, medium and minor projects, various clearances involved for project approval Command areas in India, Command area activities and their prioritization, Source of budget for CAD works, Structure of command area development organization, legal aspects of natural resource development Partnership among developers, managers and users of natural resources in a command area, Diagnostic analysis and perform appraisal of command area projects
References:	Kumar, P. (1977). Economics of Water Management. Heritage Publishers, New Delhi. Garg, S.K. (1987). Hydraology and water resources engineering, Khanna Publishers, Delhi. Michael, A.M. (2006). Irrigation theory and practice. Vikas Publications, New Delhi. Sharma, R.K. (1987). Hydrology and water resources engineering, Dhanpat Rai & Sons, New Delhi.
Course Outcomes	At the end of the course, learners will be able **CO1:** Understand the concept of command area development (CAD) as an integrated approach to optimize water resource utilization and improve agricultural productivity within a specific irrigation project area. **CO2:** Analyze the process of command area project formulation, including project types (major, medium, minor) and the various clearances required for project approval. Gain an overview of existing command areas in India. **CO3:** Identify and prioritize key command area activities, such

	as on-farm development, irrigation system improvement, and drainage management. Understand the sources of budget for CAD works and the structure of command area development organizations. **CO4:** Analyze the legal aspects of natural resource development within command areas, considering water rights, land acquisition, and environmental regulations. Develop strategies for promoting partnership among developers, managers, and users of natural resources for sustainable management. **CO5:** Conduct diagnostic analysis and perform an appraisal of command area projects, evaluating their technical feasibility, financial viability, and socio-economic impacts. Recommend appropriate interventions and strategies for improving project performance and achieving desired outcomes.

Mapping between COs with POs and PSOs

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**CE 501**
Course title	**OPEN CHANNEL FLOW**
Course credit	**3+0**
Objective of Course	4. Understanding of Open Channel Principles and Computations 5. Application of Uniform Flow Concepts in Hydraulic Engineering 6. Proficiency in Analyzing Flow Characteristics and Instabilities 7. Mastery in Analyzing Varied Flow Scenarios.
Course Content	**Course content:** Theory **UNIT I** Open channel and their properties. Energy and momentum principles. Critical flow computations and applications. **UNIT II** Uniform flow. Its development. Formula and design computation. **UNIT III** Boundary layer concept. Surface roughness. Velocity distribution and instability of uniform flow. **UNIT IV** Gradually varied flow theory and analysis. Method of computations. **UNIT V** Hydraulic jump and its use as levelling energy dissipation. **UNIT VI** Spatially varied flow. Unsteady flow. Rapidly varied flow.
References:	Suggested Readings • Henderson FM.1966. Open Channel Flow. Macmillan. • Subramaninum 1960. Open Channel Flow. McGraw Hill. Ven T Chow. 1959. Open Channel Flow. McGraw Hill
	At the end of the course, learners will be able **CO1:** Mastery in Computational Methods for Open Channel Critical Flow **CO2:** Application of Uniform Flow Formulas and Design Computations **CO3:** Proficiency in Analyzing Boundary Layer Effects and Flow Instability **CO4:** Competency in Gradually Varied Flow Analysis and Rapidly Varied Flow Computation

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1						-	-	-	-	-	-				
CO2						-	-	-	-	-	-				
CO3				-	-	-	-	-	-	-	-				
CO4					-	-	-	-	-	-	-				

Course code	**CE 502**
Course title	**DAMS & RESERVOIR OPERATIONS**
Course credit	**3+1**
Objective of Course	1. Comprehensive Understanding of Dam Construction and Design Principles 2. Proficiency in Analyzing Stability and Seepage Aspects of Dams 3. Competency in Planning and Assessing Reservoirs and Spillways 4. Mastery in Economic Evaluation and Flood Management of Storage Projects
Course Content	**Theory** UNIT I Dams classification. Suitable site selection for dams & reservoirs. Survey & planning of storage projects. UNIT II Type of concrete dams. Forces acting on concrete dams. Stability analysis. Methods of design of gravity dams. Temperature control for dams. UNIT III Earth dams and their types. Methods of construction. Causes of failure & remedial measures. Seepage and stability analysis of earth dams. UNIT IV Foundation treatment. Abutment grunting. Instrumentation in dams. UNIT V Spill way and spillway capacities and spillway gates. UNIT VI Reservoir planning, Storage, sedimentation, Losses, Economics. Flood routing. **Practical** Exercises on above topics
References:	Suggested Readings • Bharat Singh. 2002. Earthen Dams. New Chand & Bros., Roorkee. • Creager WP, Justin JD, Hinds J. 1945. Engineering for Dams. Vols. I-III. • John Wiley & Sons. Sharma HD. 1981. Concrete Dams. Metropolitan
Course Outcomes	At the end of the course, learners will be able **CO1:** Mastery in Design Principles and Stability Analysis of Concrete Dams **CO2**: Proficiency in Construction Techniques and Seepage Analysis of Earth Dams **CO3:** Competency in Reservoir Planning, Sedimentation, and Flood Routing **CO4:** Comprehensive Understanding of Site Selection, Surveying, and Instrumentation in Dam Projects

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3

CO1							-	-	-	-	-	-			
CO2	-		-				-	-	-	-	-	-			
CO3	-	-		-		-	-	-	-	-	-	-			
CO4		-	-			-	-	-	-	-	-	-			

Course code	**CE 503**
Course title	**WATER QUALITY AND POLLUTION CONTROL**
Course credit	**3+1**
Objective of Course	1. Understanding the spectrum of impurities and contaminants in water, and mastering diverse analysis methods for assessing water quality comprehensively. 2. : Acquiring skills in effective purification techniques and treatments to ensure the delivery of potable and safe water for domestic and industrial use. 3. Proficiency in characterizing wastewater, exploring various disposal methods, and implementing efficient treatment techniques for responsible environmental impact. 4. Understanding and application of local and international environmental laws and regulations concerning water pollution, integrating legal knowledge into effective pollution control strategies.
Course Content	**Course content:** **Theory** UNIT I Impurities in water. Water analysis (Physical, Chemical and Bacteriological). UNIT II Indices of water quality for domestic and industrial uses. Monitoring of water quality from various sources of water pollution. UNIT III Purification of water supplies. UNIT IV Waste water characteristics and disposal methods. UNIT V Waste water treatment. UNIT VI Mathematical modeling on pollution control. Environmental legislation on water pollution in India and abroad. **Practical** Determination of pH, dissolved and suspended solids, Chlorides, Sulphates, turbidity, dissolved oxygen hardness, BOD, COD, Nitrogen (Ammonical, nitrate, nitrite), MPN, Total count of bacteria in water/sewage samples
References:	**Suggested Reading** • Garg SK. 2004. Environmental Engineering. Vol. II. Khanna Publ. • Garg SK. 2004. Environmental Engineering. Vol. I. Khanna Publ. • Howard S Peavey, Donald R Rod & Tchobanglous G.

	1985. Environmental Engineering. McGraw Hill. • Manual of Water Supply and Treatment. 1999 Ministry of Urban Development, New Delhi. • Metcalf and Eddy. 2003. Waste Water Engineering Treatment and Reuse. Tata McGraw Hill
Course Outcomes	At the end of the course, learners will be able **CO1:** Master diverse analysis methods for water quality assessment. **CO2:** Apply various purification methods for safe water delivery. **CO3:** Proficiently manage wastewater and apply effective treatment techniques. **CO4:** Comprehend and apply environmental laws for pollution control

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1			-	-			-								
CO2			-	-			-								
CO3			-	-			-								
CO4			-	-		-	-								

Course code	**CE 504**
Course title	**FLUVIAL HYDRAULICS**
Course credit	**2+1**
Objective of Course	1. Grasp the fundamental properties of sediment and various mechanisms governing its transport in different flow regimes. 2. Attain skills in analyzing alluvial streams, including their hydraulic geometry, bed level variations, and transport characteristics of sediment loads. 3. Acquire proficiency in sediment sampling methods, river modeling, and understanding the transport of sediment through pipes. 4. Develop expertise in practical problem-solving related to sediment properties, flow regimes, resistance, and transport in real-world scenarios.
Course Content	**Theory** UNIT I Sediment properties, Sediment problems. Incipient motion of sediment particles. UNIT II Regimes of flow. Resistance to flow. UNIT III Bed load. Suspended load. Total load transport. UNIT IV Alluvial streams and their hydraulic geometry. Bed level variations in alluvial streams. UNIT V Sediment samples and sampling. Alluvial river models.

	Sediment transport through pipes. Bed level variations in alluvial streams. River **Practical** Problems on determination of sediment properties, regimes of flow, resistance to flow, incipient motion, bed load, suspended load, total load transport and sediment transport
References:	Suggested Readings • Garde RJ & Ranga Rajan KG. 2001. Mechanics of Sediment Transport and Alluvial Stream Problems. • Howard H Chang. 1988. Fluvial Process in River Engineering. John Wiley & Sons. • Raudkivi AJ. 1990. Loose Boundary Hydraulics. Pergamon Press
Course Outcomes	**CO1:** Demonstrate an advanced understanding of sediment properties and the factors influencing sediment transport in diverse flow conditions. **CO2:** Competently analyze alluvial streams, interpret their hydraulic geometry, and predict variations in bed levels along with sediment transport. **CO3:** Apply efficient sampling methods, engage in river modeling, and assess sediment transport through pipes with accuracy**.** **CO4:** Effectively apply theoretical knowledge to solve practical problems related to sediment properties, flow regimes, and transport scenarios.

Course code	**CE 505**
Course title	**EXPERIMENTAL STRESS ANALYSIS**
Course credit	**2+1**
Objective of Course	1. Develop a thorough comprehension of strain, stress, and their interrelationships, and recognize various strain gauge types. 2. Acquire proficiency in using different strain measurement techniques, including mechanical, optical, electrical, and semiconductor strain gauges.
Course Content	**Theory** UNIT I Strain and stress, Strain relationship, Strain gauges mechanical, optical, electrical, acoustical and pneumatic etc and their use. Different types of electric strain gauges, Semiconductor gauges. **Practical** Measurement of strain with strain gauge. Photo elastic methods and Moire's apparatus
References:	Suggested Readings • Srinath LS.1984. Experimental Stress Analysis. Tata

	McGraw Hill. • Singh Sadhu. 1982. Experimental Stress Analysis. Khanna Publ. • Dally J.W. & W.F. Riley, 1990. Experimental Stress Analysis. Tata McGraw Hill
Course Outcomes	**1. CO1:** Demonstrate mastery in understanding strain and stress relationships, and identify various strain gauge types. **2. CO2:** Exhibit proficiency in utilizing diverse strain measurement methods, encompassing mechanical, optical, electrical, and semiconductor strain gauges.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1				-			-		-	-					
CO2				-			-		-	-					

Course code	**CE 506**
Course title	**SIMILITUDE IN ENGINEERING**
Course credit	**2+1**
Objective of Course	1. Develop a thorough understanding of dimensions, units, dimensional analysis, and similarity analysis, with a focus on theory and practical applications. 2. Attain proficiency in the theory of models, distinguishing true, distorted, and dissimilar models, and applying them to diverse systems including structural and fluid flow systems. 3. Acquire practical skills in conducting experiments related to pendulum periods, cantilever beams, spring-mass systems, deflection analysis, and model-based predictions. 4. Develop expertise in utilizing analogical reasoning and analogue model experiments for addressing and solving complex engineering problems.
Course Content	**Theory** UNIT I Dimensions and units. UNIT II Dimensional and similarity analysis. Theory of models. UNIT III True, distorted and dissimilar models. UNIT IV Application to different systems with special reference to Structural and fluid flow systems, Analogues. Practical Equations for the period of simple pendulum. Uniform rectangular cantilever beam. Spring mass level system. Investigation of extrapolation. Deflection of a cantilever beam. Prediction of the deflection of a beam using a model. Analogue model experiments
References:	Suggested Readings

	• Green Murphy.1950. Similitude in Engineering. Ronald Press. • Huntley HE. 1974. Dimensional Analysis. Dover Publ. • Stephen J Klin.1965. Similitude and Approximation Theory. McGraw Hill
Course Outcomes	At the end of the course, learners will be able **CO1:** Demonstrate mastery in comprehending dimensions, units, dimensional analysis, and similarity analysis, and apply them proficiently. **CO2:** Exhibit proficiency in understanding model theory and its application to various systems, distinguishing between true, distorted, and dissimilar models. **CO3:** Demonstrate practical skills in conducting experiments related to pendulum periods, cantilever beams, spring-mass systems, deflection analysis, and model-based predictions. **CO4:** Develop expertise in utilizing analogical reasoning and conducting analogue model experiments for effective problem-solving in engineering scenarios.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1				-		-					-				
CO2				-		-					-				
CO3				-		-					-				
CO4				-		-					-				

Course code	**CE 507**
Course title	**CONTROL OF POLLUTION FROM SOLID WASTES**
Course credit	**2+0**
Objective of Course	1. Develop a comprehensive understanding of solid waste, encompassing its sources, characteristics, collection, handling, and reduction strategies. 2. Attain proficiency in various waste disposal methods, their merits, demerits, and the processing of solid waste to derive value such as fertilizers, fuel, and food. 3. Acquire practical skills in handling, collecting, storing, transporting solid waste, and applying techniques for recycling, reusing materials, and energy recovery. 4. Apply sustainable waste management practices by integrating knowledge of waste reduction, recycling, and efficient disposal methods.
Course Content	**Course content:** **Theory** UNIT I Definition. Sources. Quality, Classification and characteristics of solid waste collection, Transport and reduction at source.

	UNIT II Handling, Collection , Storage, transport of Solid wastes. UNIT III Disposal methods and their merits and demerits. UNIT IV Processing of solid wastes. Fertilizers, fuel and food values. UNIT V Recycling and reuse materials and energy recovery operations
References:	Suggested Readings • Kreith F & Tchobanoglous G. 2002.Handbook of Solid Waste Management. McGraw Hill. • Ramachandra TV. 2006. Management of Municipal Solid Waste. Capital Publ. Co
Course Outcomes	At the end of the course, learners will be able **CO1:** Demonstrate mastery in understanding the principles of solid waste management, including its sources, classification, and reduction strategies. **CO2:** Exhibit proficiency in evaluating and applying various waste disposal methods and processing solid waste to derive valuable products. **CO3:** Demonstrate practical skills in effectively handling, collecting, storing, and transporting solid waste, and applying recycling and reuse techniques. **CO4:** Apply sustainable waste management practices by integrating knowledge of waste reduction, recycling, and efficient disposal methods for environmental conservation.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1				-		-	-		-	-	-				
CO2				-		-	-		-	-	-				
CO3				-		-	-		-	-	-				
CO4				-		-	-		-	-	-				

Course code	**CE 601**
Course title	**PROBABILISTIC APPROACH IN DESIGN**
Course credit	**2+0**
Objective of Course	1. Gain an in-depth understanding of various engineering design methodologies alongside an introduction to the probabilistic approach. 2. Attain expertise in manipulating random variables, probability distributions, expected values, and conditional probabilities within engineering contexts. 3. Apply the concepts of stationary, ergodic, and non-stationary processes to engineering scenarios involving functions of random variables.

	4. Develop practical skills in performing auto-correlation, cross-correlation, covariance functions, and spectral density functions for experimental data analysis.
Course Content	**Course content:** **Theory:** UNIT I Review of various approaches in engineering design and introduction of probabilistic approach. UNIT II Random variables. Probability distribution and density functions. Expected values, Mean. Variance, Conditional probability. Characteristic functions. UNIT III Function of random variable. Concepts of stationary, ergodic and non- stationary processes. UNIT IV Auto correlation. Cross-correlation. Covariance functions. Power spectral and cross spectral density functions and their determination from experimental data. UNIT V Broad-band and Narrow band random processes. White noise. Application in various disciplines of engineering
References:	Suggested Readings • Benjamin JR & Allen C. 1975. Probability Statistics and Decision for Civil Engineers.MGH New York. • Evan DH.1992. Probability and its Applications for Engineers. ASQC Press & Marcel Dekker
Course Outcomes	At the end of the course, learners will be able CO1: Demonstrate mastery in comprehending diverse engineering design methodologies and adeptly applying probabilistic approaches within engineering problem-solving. CO2: Exhibit proficiency in applying probability theory and manipulating random variables effectively in engineering contexts. CO3: Apply the concepts of stationary, ergodic, and non-stationary processes, integrating functions of random variables into practical engineering scenarios. CO4: Demonstrate practical expertise in conducting correlation and spectral analyses, specifically auto-correlation, cross-correlation, covariance functions, and spectral density functions for experimental data analysis in engineering applications.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1							-		-	-	-	-			
CO2							-		-	-	-	-			
CO3							-		-	-	-	-			
CO4							-		-	-	-	-			

Course code	**CE 602**

Course title	**RANDOM VIBRATIONS**
Course credit	**2+0**
Objective of Course	1. Gain a holistic understanding of how both single and multi-degree linear systems respond to stationary and non-stationary random excitations. 2. Develop expertise in employing the normal mode method to analyze continuous systems, predicting their responses to random excitations in diverse engineering applications. 3. Apply sophisticated non-linear random vibration concepts like level crossing, peak statistics, and fatigue failures in different engineering systems. 4. Apply and integrate random vibration analysis practically across mechanical, aerospace, civil, oceanic, and agricultural engineering, addressing real-world challenges.
Course Content	**Course content:** **Theory:** UNIT I Response to linear single and multi-degree of freedom system to stationary and nonstationary random excitation. UNIT II Response of continuous systems. Normal mode method. UNIT III Non-linear random vibration. Level crossing. Peak and envelope statistics. First excursion land fatigue failures. UNIT IV Applications to mechanical, aero, civil, ocean and agricultural engineering systems
References:	Suggested Readings • Benjamin JR & Allen C. 1975. Probability Statistics and Decision for Civil Engineers. MGH New York. • Lipson C & Shets NJ. 1973. Statistical Design and Analysis of Engineering Experiments. McGraw Hill. • Subra Suresh. 1998. Fatigue of Materials. Cambridge Univ. Press
Course Outcomes	At the end of the course, learners will be able CO1: Demonstrate mastery in predicting linear system responses to diverse random excitations, considering varying degrees of freedom. CO2: Showcase expertise in utilizing the normal mode method to analyze continuous systems' responses to random excitations, effectively characterizing their behavior. CO3: Apply sophisticated non-linear vibration concepts to engineering scenarios, interpreting statistical measures, predicting failures, and their implications in engineering systems. CO4: Demonstrate practical application of random vibration analysis techniques across diverse engineering domains, tackling real-world complexities and engineering problems.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**

CO1			-	-			-			-	-	-			
CO2			-	-			-			-	-	-			
CO3			-	-			-			-	-	-			
CO4			-	-			-			-	-	-			

Course code	**CE 603**
Course title	**DESIGN OF BINS AND SILOS**
Course credit	**2+1**
Objective of Course	1. Attain a comprehensive understanding of various theories like Rankine's, Coulomb's, Janssen's, Airy's, and Reimbert's theories related to silo design. 2. Compare and contrast design criteria from different standards (e.g., Australian AS and Indian BIS standards) applicable to bins and silos for better understanding and application. 3. Develop proficiency in using computer-aided design tools and software for the analysis and design of silos, integrating theories and standard codes. 4. Gain practical skills in developing flowcharts and design programs for silos of varying capacities using different standard codes and theories.
Course Content	Theory UNIT I Computer aided design manuals. Rankine's and Coloumb's theories of active and passive pressures. UNIT II Janssen's and Airy's theories grain pressure theories for design of deep and shallow silos. Reimbert's theory of silo design. UNIT III Comparison of Australian (AS) and Indian (BIS) design criteria for bins and silos. UNIT IV Computer aided design of grain silos by developing flowcharts and programs for underground and over ground silos. Practical Analysis and design of silos of various capacities using available software. Use of different standard codes and theories in the development of flowcharts and design program for various capacity silos.
References:	**Suggested readings** • AS-3774.1990. Loads on Bulk Solid Containers. • BS-5061.1974. Specifications for Cylindrical Storage Tower Silos and Recommendations for their use. • BIS Relevant Standards. • Rajgopalan K. 1989. Storage Structure. Oxford & IBH. • Reimbert M & Reimbert A.1956. Design of Bins
Course Outcomes	**CO1:** Demonstrate mastery in various silo design theories including Rankine's, Coulomb's, Janssen's, Airy's, and Reimbert's theories. **CO2:** Apply knowledge acquired from comparing international

	design criteria (AS and BIS) for bins and silos to engineering problems. **CO3:** Exhibit proficiency in using computer-aided design software for analysis and design of silos, incorporating diverse theories and standards. **CO4:** Demonstrate practical expertise in developing flowcharts and design programs for silos using various capacity specifications and incorporating standard codes.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1						-	-	-	-	-	-	-			
CO2						-	-	-	-	-	-	-			
CO3						-	-	-	-	-	-	-			
CO4						-	-	-	-	-	-	-			

Course code	**CSE 501**
Course title	**COMPUTER GRAPHICS**
Corse credit	**3 (2+1)**
Objective of Course	1. To learn the basic concept of computer graphics 2. To understand the generating various geometrical shapes and various operations. 3. To understand applications of computer graphics.
Course Content	UNIT I Graphic display devices, Interactive devices, Line and circle plotting techniques by using Bresenham's algorithm, Windowing and clipping, Sutherland Cophen algorithm, Cyrus and Beck method UNIT II Curve drawing using Hermite Polynomial, Bezier curve, B Splines, Picture Transformation, translation, rotation, Scaling and Mirroring UNIT III 3D Graphics, 3D transformation rotation about an arbitrary axis. Curved surface generation, Hidden surface removal. UNIT IV Orthogonal Projection and multiple views, Isometric projection, Perspective projection, 3D Clipping UNIT V Generation of solids, Sweep method, Interpolation, Graphic Standards, CGS Modeling, Applications of Computer Graphics **Practical** Practical problems on above topics
References:	▪ Hearn Donald.1996. Computer Graphics. PHI. ▪ Schaum. Series. 2004. Computer Graphics. TMH
Course Outcomes	At the end of the course, learners will be able **CO1**: The students have the basic concept of computer graphics **CO2**: The students learn to generate various geometrical shapes

	and apply various operations. **CO3**: The students will also learn about various computer graphics applications

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															

Course code	**CSE 502**
Course title	**NEURAL NETWORK AND ITS APPLICATIONS**
Corse credit	**3 (2+1)**
Objective of Course	1. To learn the basic concept of neural network models 2. To learn the neural network applications for solving engineering problems
Course Content	**Theory** UNIT I Introduction to neural network and its comparison with biological system. Perceptron and linear separable functions, multi-layers perceptrons. UNIT II Back propagation, one basic learning algorithm for feed-forward neural network, variation and improvement for back-propagation algorithm, Generalisation of learning algorithm. UNIT III Recurrent Networks: Hopefield networks and Boltzmann Machine. UNIT IV Unsupervised learning and self organized features maps UNIT V Application of neural network in function approximation, time series predictions, pattern recognition, control systems and optimization in engineering problems **Practical** Development of neural network by back-propagation learning algorithm using MATLAB for function approximation, time series predictions, pattern recognition, control systems and optimization in engineering problems
References:	▪ Haykins S.1999. Neural Network- Comprehensive Study. PHI. ▪ Hertz J, Krogh A & Palmer RG. 1991. Introduction to Theory of Neural Computation. Addison-Wesley
Course Outcomes	At the end of the course, learners will be able

	CO1: The students will be able to have the basic concept of neural network **CO2**: The students learn to develop different types of neural network models for solving agricultural engineering problems.

Mapping between Cos, POs and PSOs

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														

Course code	**EE 501**
Course title	APPLIED INSTRUMENTATION
Corse credit	**3 (2+1)**
Objective of Course	1. To acquaint and equip the students with various types of transducers 2. study and analysis of various variables
Course Content	Theory UNIT I Basic instrumentation systems and transducer principles. Displacement Transducers:Potentiometer, LVDT, Piezoelectric and capacitive transducers. Digital Transducers. Velocity transducers – Analog and Digital UNIT II Acceleration and absolute motion measurement. Force transducer -Strain Gauge, Hydraulic load cell, Cantilever type and Probing ring. Method of separation of force – Torque, Power and Energy measuring techniques. UNIT III Temperature measurement using Bi-metals, PTRs, Thermistors, Thermocouples, Electronic IC sensors and Pyrometers. Heat flux measurement. Humidity measurement – Dry and Wet bulb, Hair hygrometer and Humister. Soil and Grain moisture transducers, pressure measurement – Manometers, Bourdon Tube, Diaphragm type transducer. High pressure and vacuum sensing techniques. UNIT IV Flow transducers, Positive displacement, venturimeter, Rotameter, Drag force, Ultrasonic, Electromagnetic, Hot wire anemometers. Time and frequency measurement. UNIT V Level measurement, OD and pH measurement, PCO2 and grain quality measurement. Biomedical measurement – BP, ECG etc., Ultrasonic flaw detection, Spectroscopy

	Practical Study the characteristics of various transducers : Potentiometer, LVDT, Proximity sensors and Photo pickups, Load cell, Thermistor and Thermocouple, LM 335/AD 590se of various Analog interfacing blocks: Attenuators, Amplifiers, A/D converters, Filters, digital interfaces using Wave shapers and level shifters. Practice of using interfaces and developing suitable software for data acquisition through PC/Microcomputer: Use of Microcomputer kit, Study the use of 8255 I/O IC, Study the use of printer port in a PC. Data acquisition thr**ough PC/Kit**
References:	• Doebelin EO.1990. Measurement Systems Applications and Design. Tata McGraw Hill. Nakra BC &Chaudhary KK. 2004. Instrumentation Measurement and Analysis. Tata McGraw Hill. • Sawhney AK. 2008. Electrical and Electronics Measurement and Instrumentation. Dhanpat Rai & Sons
Course Outcomes	At the end of the course, learners will be able **CO1:** Obtain the performance characteristics of various transducers and infer the reasons for the behavior. **CO2:** Analyse the characteristics of sensors and transducers. **CO3:** Summarize the measurement application and suggest suitable measurement methods. **CO4:** Perform experiment to Calibrate the instruments.

Mapping between Cos, POs and PSOs

CO	PO												PSO	
	1	2	3	4	5	6	7	8	9	10	11	12	1	2
CO1														
CO2														
CO3														
CO4														

Course code	**EE 502**
Course title	PROCESS CONTROL SYSTEM
Corse credit	**3 (2+1)**
Objective of Course	1. To acquaint and equip the students about the concepts involved in process control system

	2. To control variables at the desired level
Course Content	Theory UNIT I Introduction to Process Control - Controlled Variable, Control strategy, Single Variable and multi variable control systems, Process Control loop, Open loop and closed loop control system, Linear and non linear control system, Transfer function and procedurefor determining the Transfer function of Complex Control System, Representation of a Control System by block diagram and its Reduction UNIT II Characteristics of real Process - Process Equation, Controlling & Controlled Variable, Transient & steady state response, Self Regulation Property, Control System Parameters, Evaluation of Control System. UNIT III Improved Control through Complex Control of process - Controller Modes or actions, On/OFF Mode, Proportional Mode, Integral Mode, Derivative Mode, Composite Control Mode (PD, PI, PID, Modes). UNIT IV Analysis of Common loop, involving - Flow control (Solid, liquid and gaseous flow), Pressure regulation (Pressure Transducers), Liquid level (Mechanical & Electrical Systems), Temperature Control (Thermistor and thermocouple). UNIT V Introduction to Computer Control of Process Application and design - Signal Conditioning, Design of OP AMPS circuits used to implement Proportional Integral, Derivative and Composite Modes. Study of various computer Controlled Electrical and Mechanical Systems. **Practical** Study of various controllers by using Op-Amps, Use of microprocessors in process control.
References:	• Johnson CD.1977. Process Control Instrumentation Technology. PPH. • Manke BS.2006. Linear Control System. Khanna Publishers
Course Outcomes	At the end of the course, learners will be able **CO1:** Comprehend the process system design. **CO2:** List controlled and controlling variables, and to describe the criteria to evaluate the performance of a process-control loop. .**CO3:** Design a controller operating in the proportional-integral-derivative mode combination with three-mode controller. **CO4:** Design the application of different sensors, for temperature, fluid, liquid and pressure.
Mapping between Cos, POs and PSOs	

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															1
CO2															3
CO3															
CO4															

Course code	**ME 501**
Course title	**MECHANISM ANALYSIS AND SYNTHESIS**
Corse credit	**3 (3+0)**
Objective of Course	**Objective** 1.To acquaint and equip the students with important area for analysis and design of Farm Machinery Mechanism 2.Compute velocity and acceleration in mechanisms. 3.To study Dimensional synthesis of linkages, analytical and graphical approach for mechanisms 4.To study various power transmission drives, gear trains, Cam design, and cam profile
Course Content	**UNIT I** Introduction to kinematics of mechanisms, kinematic analysis and synthesis, mobility, and degree of freedom of a mechanism, systematic of mechanisms deriving other mechanisms from linkages. **UNIT II** Relative motion, instantaneous centre method, Kennedy's theorem. Graphical and analytical methods of displacement, velocity and acceleration analysis, Computer – Aided analysis of mechanisms. **UNIT III** Dimensional synthesis of linkages for path generation, function generation and rigid-body guidance problems. Graphical techniques. Relative pole method and method of inversion etc. Analytical kinematics synthesis of linkages, Freudenstein's method, Loop closure equations based on complex. variable approach **UNIT IV** Kinematics of gears-Analysis of epicyclic gear trains. Synthesis of gear trains compound and epicyclic. Cam – follower system; standard follower motions and combinations, importance of follower acceleration in cam system dynamics, terms related to cam design- their importance. Cam synthesis – graphical cam profile layout for a desired follower motion. Analytical determination of cam profile co-ordinates for disc cam operating common types of follower.
References:	George N Sandor & Arthur G Erdman.1984. Advanced Mechanism Design - Analysis and Synthesis. Vols. I, II. Prentice Hall. Norton. 2003. Design of Machinery - An Introduction to the Synthesis and

	Analysis of Mechanisms and Machines. McGraw Hill. Shigley Vicker. 2007. Theory of Machines and Mechanisms. McGraw Hill. Soni AH. 1974. Mechanism Synthesis and Analysis. McGraw Hill.
Course Outcomes	At the end of the course, learners will be able **CO1:** To explain the principles of analysis and design of Farm Machinery Mechanism **CO2:** To do velocity and acceleration analysis. **CO3:** Apply the concept of Dimensional synthesis of linkages. **CO4:** Solve the problems of drives, gear trains, generation of cam profile.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															

Course code	**ME-502**
Course title	**Vibrations**
Corse credit	**3 + 0**
Objective of Course	1. To understand fundamental principles and theories essential for the analysis and operation of agricultural equipment. 2. Develop students' analytical skills in the field of farm machinery dynamics. 3. To develop the ability to effectively analyse, troubleshoot, and optimize the performance of agricultural equipment in real-world scenarios.
Course Content	**UNIT I:** Vibration motion and its terminology. Undamped free vibrations, equations of motion-natural frequency. Energy method, Rayleigh method; effective mass Principle of Virtual work. Equivalent spring stiffness in parallel and in series. Harmonic analysis and Fourier Series. Damping – viscous, solid, coulomb equivalent dampers. Viscosity damped free vibrations, Logarithmic decrement. Forced vibrations with harmonic excitation and rotating unbalance, Energy dissipated by damping. Forced vibration with damping, Vibration isolation and force and motion transmissibility. **UNIT II:** Two degree of freedom systems. Principal modes of vibration, co-ordinate coupling. Vibration absorbers, Free vibration equation of motion for multi- degree of freedom systems. Influence coefficients and Maxwell's reciprocal theorem, stiffness coefficients. Numerical methods for finding natural frequencies for multi degree of freedom systems. **UNIT III:** Vibration of lumped parameter systems and continuous systems. Lagrange equations. Vibration measuring instruments: Vibrometers, velocity pickups, Accelerometer, and frequency measuring instruments. Applications of vibrations.
References:	1. V.P. Singh.2014. Mechanical Vibrations. Dhanpat Rai

	and Company, New Delhi 2. Rao S S. 2010.Mechanical Vibrations. Pearson Education, Delhi 3. Srinivas P.1983. Mechanical Vibration Analysis. Tata McGraw Hill Company Limited,New Delhi 4. Daniel J Inman.2013. Engineering Vibration. Prentice Hall, New Jersey
Course Outcomes	At the end of the course, learners will be able **CO1**: **Foundational Understanding:** Graduates will possess a solid foundational understanding of significant concepts in farm machinery dynamics, enabling them to comprehend the intricacies of agricultural equipment and its dynamic behaviour. **CO2**: **Analytical Proficiency:** Students will demonstrate proficiency in analysing the dynamics of farm machinery, showcasing their ability to assess and address issues related to efficiency, safety, and overall performance in the agricultural context. **CO3: Applied Knowledge and Practical Skills:** Graduates will have the ability to apply theoretical knowledge in practical scenarios, showcasing hands-on skills in the study and analysis of farm machinery dynamics, ensuring they are well-prepared for real-world challenges in the agricultural industry.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															

Course code	**PGS 502**
Course title	**Technical Writing and Communication Skills**
Corse credit	**1 (0+1)**
Objective of Course	8. To equip the students/scholars with skills to write dissertations, research papers, etc. 9. To equip the students/ scholars with skills to communicate and articulate in English (verbal as well as writing).
Course Content	**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.
References:	Suggested Readings 1. Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India. 2. Collins' Cobuild English Dictionary. 1995. 3. Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed. 4. Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press. 5. James HS. 1994. Handbook for Technical Writing. NTC Business Books. 6. Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East- West Press. 7. Mohan K. 2005. Speaking English Effectively. MacMillan India. 8. Richard WS. 1969. Technical Writing. 9. Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language. 10. Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India. 11. Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.
Course Outcomes	At the end of the course, learners will be able **CO1**: to write dissertations, research papers, etc. **CO2:** to effectively communicate and articulate orally in English Communications **CO3:** to effectively communicate and articulate in written English Communications

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3

CO1															
CO2															
CO3															

Course code	**PGS-504**
Course title	BASIC CONCEPTS IN LABORATORYTECHNIQUES
Corse credit	**1(0+1)**
Objective of Course	1. To acquaint the students about the basics of commonly used techniques in laboratory. 2. To make them aware with the safety precautions to be taken in chemistry laboratory. 3. To learn the qualitative and quantitative aspects of common laboratory equipment. 4. To expose to the factors that affect the accuracy of an experiment. 5. To ensure experiments give the most accurate results.
Course Content	**Practical** Safety measures while in Lab; Handling of chemical substances; Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware; Drying of solvents/chemicals. Weighing and preparation of solutions of different strengths and their dilution; Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications; Preparation of solutions of acids; Neutralisation of acid and bases; Preparation of buffers of different strengths and pH values. Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath; Electric wiring and earthing. Preparation of media and methods of sterilization; Seed viability testing, testing of pollen viability; Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy
References:	Furr AK. 2000. *CRC Hand Book of Laboratory Safety*. CRC Press. Gabb MH & Latchem WE. 1968. *A Handbook of Laboratory Solutions*. Chemical Publ. Co
Course Outcomes	At the end of the course, learners will be able **CO1**: Understand the different types of apparatus to be used in laboratory and how to calibrate them. **CO2**: These skills play a significant role in order to perform various experiments and to run various tests. **CO3:** Basic laboratory skills are the techniques required for conducting experiments. These include pouring, measuring, filtration, and using gas burners and glassware. **CO4**:Prepare different media and solutions.

Mapping between Cos, POs and PSOs

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1															
CO2															
CO3															
CO4															
CO5															

Course code	**PGS-506(e-Course)**
Course title	**DISASTER MANAGEMENT**
Corse credit	**1(1+0)**
Objective of Course	1. To introduce learners to different types of manmade and natural disasters 2. To equip them to conduct thorough assessment of hazards, and risks vulnerability; and capacity building 3. To introduce learners to the key concepts and practices of natural disaster management. 4. To mitigate natural disasters at national and global levels.
Course Content	**Course content :** **Theory** UNIT I Natural Disasters- Meaning and nature of natural disasters, their types and effects. Floods, Drought, Cyclone, Earthquakes, Landslides, Avalanches, Volcanic eruptions, Heat and cold Waves, Climatic Change: Global warming, Sea Level rise, Ozone Depletion UNIT II Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire. Oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents. UNIT III Disaster Management- Efforts to mitigate natural disasters at national and global levels. International Strategy for Disaster reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, State, District and local Administration; Armed forces in Disaster response; Disaster response: Police and other organizations
References:	Gupta HK. 2003.*Disaster Management*. Indian National Science Academy. Orient Blackswan. Hodgkinson PE & Stewart M. 1991.*Coping with Catastrophe: A Handbook of Disaster Management*. Routledge. Sharma VK. 2001.*Disaster Management*. National Centre for

	Disaster Management, India.
Course Outcomes	At the end of the course, learners will be able **CO1**: Understand the different types of disasters and causes for disasters. **CO2**: Students will be equipped with various methods of risk reduction measures and risk mitigation. **CO3:** Gain knowledge on the impacts Disasters on environment and society. CO4: Understand the role of Information Technology in Disaster Management. CO5: Study and assess vulnerability of a geographical area.

Mapping between Cos, POs and PSOs

CO	**PO**												**PSO**		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1															
CO2															
CO3															
CO4															
CO5															