

**APPROVED BY BOARD OF STUDIES OF AGRICULTURAL ENGINEERING DEPARTMENT  
IN ITS MEETING HELD ON 19.04.2018**

**APPROVED BY BOARD OF FACULTY OF AGRICULTURAL SCIENCES & TECHNOLOGY  
FACULTY IN ITS MEETING HELD ON 12.07.2018**

Department of Agricultural Engineering

# SCHEME OF STUDIES FOR MSc (Hons.) AGRICULTURAL ENGINEERING

With Effect from Winter Semester 2018-19 and onwards

**DEPARTMENT OF AGRICULTURAL ENGINEERING**  
Faculty of Agricultural Sciences & Technology  
Bahauddin Zakariaya University, Multan

**DEPARTMENT OF AGRICULTURAL ENGINEERING**  
**FACULTY OF AGRICULTURAL SCIENCES & TECHNOLOGY, B.Z.U. MULTAN**  
**(Scheme of Studies for MSc (Hons) Agricultural Engineering**  
**(Applicable w.e.f. Winter Semester 2018-19 & onwards)**

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MSc (Hons) Agricultural Engineering will be offered with following three specializations:

1. Irrigation & Drainage (I&D)
2. Farm Machinery & Energy (FME)
3. Structures and Environmental Engineering (SEE)

**1. IRRIGATION AND DRAINAGE (I&D)**

Sr. No.	Course No.	Name of Course	Credit Hours
1	I&D-501	Hydraulic Engineering	3(2-1)
2	I&D-502	Surface Water Hydrology	3(2-1)
3	I&D-503	Waterlogging and Salinity Control	3(2-1)
4	I&D-504	Design of Irrigation & Drainage Projects	3(2-1)
5	I&D-505	Modern Irrigation Systems	3(2-1)
6	I&D-506	Advanced Groundwater Hydrology	3(2-1)
7	I&D-507	Irrigation Engineering and Management	3(2-1)
8	I&D-508	Groundwater Modeling	3(2-1)
9	I&D-509	Flood estimation and its Control	3(2-1)
10	I&D-510	Irrigation Scheduling	3(2-1)
11	I&D-511	Water Resources Management	3(2-1)
12	I&D-521	Special Problem	1(1-0)
13	I&D-522	Seminar	1(1-0)
14	I&D-523	M.Sc. (Hons.) Thesis	6(0-6)

## 2. FARM MACHINRY AND ENERGY (FME)

Sr. No.	Course No.	Name of Course	Credit Hours
1	FME-501	Harvesting Machinery	3(2-1)
2	FME-502	Instrumentation and Data Acquisition	3(2-1)
3	FME-503	Manufacturing Processes	3(2-1)
4	FME-504	Product Design and Development	3(2-1)
5	FME-505	Agricultural Storage Engineering	3(2-1)
6	FME-506	Tillage and Traction Dynamics	3(2-1)
7	FME-507	Evaporative Cooling Engineering	3(2-1)
8	FME-508	Renewable Energy Engineering	3(2-1)
9	FME-509	Innovative Sorption Cooling Systems	3(2-1)
10	FME-510*	Plant Protection Equipment Engineering	3(2-1)
11	FME-511**	Advanced Engineering Technologies in Agriculture	3(2-1)
12	FME-512**	Energy-Efficient Systems for Agricultural Applications	3(2-1)
13	FME-521	Special Problem	1(1-0)
14	FME-522	Seminar	1(1-0)
15	FME-523	MSc (Hons.) Thesis	6(0-6)

\*FME-510 course added by BoS in its meeting held on 20-07-2020

\*\*FME-511 & FME-512 courses added by BoS in its meeting held on 26-05-2022

## 3. STRUCTURES AND ENVIRONMENTAL ENGINEERING (SEE)

Sr. No.	Course No.	Name of Course	Credit Hours
1	SEE-501	Pollution Control Systems	3(2-1)
2	SEE-502	Water Quality Engineering	3(2-1)
3	SEE-503	Wastewater Engineering	3(2-1)
4	SEE-504	Machine Evolution and Environment	3(2-1)
5	SEE-505	Water Supply and Sewerage	3(2-1)
6	SEE-506	Environmental Impact Assessment	3(2-1)
7	SEE-507	Farm Waste Disposal Systems	3(2-1)
8	SEE-508	Air and Noise Pollution Control	3(2-1)
9	SEE-509	Environment and Development	3(2-1)
10	SEE-510	Farm Management Systems	3(2-1)
11	SEE-511	Solute Transport Modeling	3(2-1)
12	SEE-512**	Environmental Modeling and Simulation	3(2-1)
13	SEE-521	Special Problem	1(1-0)
14	SEE-522	Seminar	1(1-0)
15	SEE-523	M.Sc. (Hons.) Thesis	6(0-6)

\*\*SEE-514 courses added by BoS in its meeting held on 26-05-2022

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7	I&D-507	Irrigation Engineering and Management	3(2-1)
8	I&D-508	Groundwater Modeling	3(2-1)
9	I&D-509	Flood estimation and its Control	3(2-1)
10	I&D-510	Irrigation Scheduling	3(2-1)
11	I&D-511	Water Resources Management	3(2-1)
12	I&D-520	Special Problem	1(1-0)
13	I&D-521	Seminar	1(1-0)
14	I&D-522	M.Sc. (Hons.) Thesis	6(0-6)

### **I&D- 501                      HYDRAULIC ENGINEERING                      3(2-1)**

*Basic concepts of fluid flow:* Basic principles, governing equations, classification of flow and definitions, velocity and pressure distribution.

*Energy and momentum principle:* Energy in open channel flow, critical flow and its occurrence, momentum in open channel flow, hydraulic jump.

*Flow resistance:* Chezy's coefficient, modified Moody diagram, Manning's coefficient.

*Steady Uniform flow:* Normal depth & velocity, normal and critical slope for steady uniform flow, discharge under uniform flow, steady Non uniform flow; longitudinal water surface backwater curve computation for irregular channels, backwater curve computation for regular channels, discharge problems.

*Unsteady flow:* Introduction, equation of motion, method of characteristics, positive and negative waves, surge formation, dam break problem.

Flood routing: Storage routing, kinematic routing, diffusion analogy, dynamic routing.

#### **PRACTICALS**

- 1 - Uniform flow channel: To establish uniform flow conditions and to obtain values of Chezy 'C' and Manning's 'n' for a rectangular glass channel.
- 2- Backwater curve computation for regular and irregular channels.
- 3- Study of surge formation.
- 4- Dynamic routing study.

#### **RECOMMENDED BOOKS**

1. Subramanya, k. 2009, Flow in Open Channels, Tata McGraw –Hill Publishing company Ltd .New Delhi, India.
2. Chaudhry, M.H 1999. Applied Hydraulic Transients. Van Nostrand Reinhold company, New York.
3. Chaudhry, M.H. 2007, Open Channel Flow. Springer Verlag Publisher

4. Chanson, H., 1999, *Hydraulics of Open Channel Flow: An Introduction*. Butterworth-Heinemann Publisher

**I&D- 502                      SURFACE WATER HYDROLOGY                      3(2-1)**

*Introduction to Hydrology:* Hydrologic cycle, genesis, measurements and sources of data, temporal and spatial variability, storm characteristics, rainfall frequency analysis, design storms, probable maximum precipitation.

*Surface Runoff and stream flow:* Measurements, rainfall-runoff relationships, hydrograph analysis, peak flow estimates, synthetic hydrographs, unit hydrographs, instantaneous unit hydrographs.

*Evaporation and Evapotranspiration & Infiltration:* Evaporation, factors affecting evaporation, estimation of evaporation, measurement of evaporation, reducing evaporation from water surfaces, transpiration, Evapotranspiration, Infiltration, factors affecting infiltration capacity, measurement of infiltration, infiltration equations, initial abstraction.

*Flood frequency Analysis:* Probability and risk in hydrology, statistical moments, probability distributions, reliability, synthetic hydrology.

*Flood routing/Hydrologic Routing:* Muskingum method, Modified Puls method, hydraulic routing, and kinematic wave, method of characteristics, hydrologic simulation, physically-based models, event and continuous simulation.

**PRACTICALS**

- 1-To develop unit hydrograph by different methods.
- 2-Runoff computation using computer model HEC-HMS
- 3-Hydrologic routing using local data.
- 4-computation of peak floods with inadequate hydrologic data.

**RECOMMENDED BOOK**

Chow, V.T., D.R. Maidment and L.W. Mays . 1998. *Applied hydrology*. McGraw –Hill Book company, New York.

**I&D-503                      WATERLOGGING AND SALINITY CONTROL                      3(2-1)**

*Introduction:* The extent of waterlogging and Salinity in Pakistan, present infrastructure to control waterlogging and salinity problem in Pakistan, Seepage from irrigation unlined and lined canals and rivers, theories of water flow in the sub soils.

*Management and Reclamation of water logged soils:* Use of tubewells for lowering of watertable, size and spacing of tubewells for lowering of water table, economics of reclamation of waterlogged soils by tubewells, interface of fresh and saline water under the Indus plain, skimming wells.

*The quality and quantity of salts in soil and irrigation water:* Origin of saline and sodic soils, concept of salt, leaching requirement, management and reclamation of salt affected soils, irrigation water analysis, classification and interpretation of water analysis, water quality criteria, treatment to improve water quality, gypsum requirements.

**PRACTICALS**

1. Soil and water analysis procedures and interpretation.
2. Problem solving related to design and spacing of drainage wells.

3. Problem solving related to design, layout and installation of open ditches for reclaiming waterlogged soils.

### **RECOMMENDED BOOKS**

1. Michel, A.M. 1993. Irrigation: Theory and Practices. Tata Mc-Graa Hill Book Co.
2. Land Drainage; Principles, Methods and Applications by A.K. Bhattacharya 2003

### **I&D-504                      DESIGN OF IRRIGATION & DRAINAGE PROJECTS                      3(2-1)**

*Drainage Concepts:* Need and benefits of drainage consequences of water logging and drainage in agriculture, sources of excess water, historical developments of drainage problem and its solutions tried in Pakistan.

*Soil Water:* Soil Moisture, groundwater, soil moisture characteristics, soil water potential, soil water movement, saturated and unsaturated flow through soil.

*Drainage Investigations:* Purpose and scope of drainage investigations, based data collection (Topography, slope, soil profile, soil characteristics, salinity, water table, crops, climate, surface runoff, hydraulic conductivity, infiltration rate, diagnosis and nature of drainage problem, drainage coefficient, stage of project preparation-Identification, reconnaissance, feasibility and final Stage.

*Field Drainage System and Methods:* Surface drainage, vertical drainage, pipe drainage, layout patterns for groundwater drainage; organic, natural and synthetic drainage envelop materials, drain pipes, construction equipment, design, construction and operational problems.

*System Problems:* Back filling, installation below water table, blocking and clogging, sediment outflow and performance efficiency.

*Design Methods:* Pipe drainage-flow patterns, components of head loss, Homogenous and non Homogenous soils, Hooghoudt formula, Earnst formula and Glover-Dumm formulae.

*Application of drainage design methods to selected problems:* Use of nomographs for drainage design. Surface drainage factors affecting, design formula, safe velocity and grades.

*Performance Assessment of drainage systems:* Need, performance parameters and criteria.

### **PRACTIALS**

1. Hydraulic conductivity data collection and use.
2. Problems related to vertical and horizontal drainage system.
3. Evaluation of surface drainage system based on the given parameter.

### **RECOMMENDED BOOKS**

1. USBR, 1994, Drainage Manual-A water resources Technical Publication, Government Printing Office, Denver, Co. USA.
2. Smedema, L.K. and W.R. Dab, 1993. Land Drainage, Cornell University Press, Ithaca, New York

**I&D-505****MODERN IRRIGATION SYSTEMS****3(2-1)**

*Introduction:* Review of soil water relations, objective of irrigation, types of irrigation systems, selecting an irrigation system, irrigation system design variables and irrigation system performance.

*Volume Balance Design:* Concept of volume balance, system design objective, design of surface irrigation systems, limitations of volume balance design.

*Soil Conservation Service (SCS) Design:* Basics for SCS design procedures, designs of surface irrigation systems, limitation of volume design.

*Hydrodynamics and Zero-Inertia models based design:* Interpretation of dimensionless design variables, designs of surface irrigation systems, comparisons of irrigation systems design approaches.

*Adaptability of sprinkler and trickle irrigation systems:* Types of sprinkler irrigation systems: portable, semi-portable and permanent systems, hand-move, toe move, side-roll and rain gun sprinklers, centre-pivot and linear move systems.

*Components of a sprinkler system:* Pump, mainline and laterals, sprinkler heads, types of sprinkler heads and their characteristics, water application patterns by stationary sprinklers, effect of wind and drift losses, sprinkler discharge, water application depth and spacing.

*Evaluation of a sprinkler system:* water application uniformity and application efficiency, wind losses and pressure variation, layout of set sprinklers: Number of sprinkler heads & lateral positions, topographic effect, Main line layout, preliminary design: Pipe and hydraulic, pressure & friction losses, economical pipe size selection.

*Centre pivot sprinkler system:* Water application rates & patterns, irrigation depth and speed of the system, variation of discharge along the lateral and evaluation.

*Trickle irrigation system and its components:* Emitters and their types, criteria for selection of emitters, clogging of emitters and filtration, design of a trickle system.

**PRACTICALS**

Field design, layout and evaluation of surface, sprinkler and trickle irrigation systems.

**RECOMMENDED BOOKS**

1. Jack Keller. 2001. Sprinkler and Trickle irrigation, Utah State University Logan, Utah 84321-USA.
2. Hoffman, J., Robert, G., Evans, Jensen, M.E. 2007. Design and Operation of Farm Irrigation Systems. American Society of Agricultural Engineers Monograph, St. Joseph, Michigan, USA.

**I&D-506****ADVANCED GROUNDWATER HYDROLOGY****3(2-1)**

*Groundwater origin and Occurrence:* Geologic formation and groundwater distribution in Indus, Basin aquifer system Global distribution of groundwater. Groundwater extraction potential. Fluctuation of groundwater levels Hydrologic Budget Surface water, soil water and groundwater budget.

*Aquifer Characteristics:* Homogeneous and non-homogeneous aquifers. Isotropic and Anisotropic, aquifers, storage coefficient, Hydraulic conductivity, Transmissivity and their determination.

*Steady Well Hydraulics:* Dupuit-Forchheimer Assumptions, Boussinesq Equation, Differential, Equations for confined flow, Flow Equations with vertical accretion. One dimensional flow, radial flow, aquifer boundaries leaky aquifers, one dimensional flow and radial flow in leaky aquifers. Superposition of wells: Principle of superposition, Drawdown due to a well field, pumping near hydrologic boundaries. Fully penetrating and partially penetrating well considerations.

*Unsteady well Hydraulic:* Unsteady Radial flow towards a fully penetrating well, Radial flow in leaky aquifer, Drawdown with variable pumping rates. One dimensional flow with distributed recharge.

*Pumping test data analysis:* Methods, data collection, data analysis, Methods of determining aquifer, Characteristics using test data.

*Groundwater Quality:* Water analysis, Irrigation water quality criteria, groundwater pollution. Groundwater exploration: Surface and subsurface geophysical methods, analysis of aquifer test data, well drilling methods, well screens and methods of sediment size analysis, water well design, well development, water well pumps, water quality protection near wells. Salt water intrusion, water mining.

## **PRACTICALS**

1. Hydrological study of a watershed.
2. Determination of well characteristics from pumping test data.
3. Designing of pumping well for specific situations.

## **RECOMMENDED BOOKS**

1. M. Karamouz, A. Ahmadi and M. Akhbari. 2011. Groundwater Hydrology: Engineering, Planning, and Management. CRC press Taylor and Francis Group.
2. D. K. Todd and L. W. Mays. 2008. Groundwater Hydrology. John Wiley and Sons, New York.
3. R. J. Sterrett. 2007. Groundwater and Wells. Publisher: Smyth Co Inc, New York. ISBN-10: 0978779304
4. W. Brutsaert. 2005. Hydrology: An Introduction. Cambridge University Press.

## **I&D-507 IRRIGATION ENGINEERING AND MANAGEMENT 3(2-1)**

*Objectives of irrigation:* scope & major issues, irrigation and food security; Soil-water-plant relationships, soil moisture indicators, available soil moisture, management allowed deficit, soil moisture determination; Flow measurement, water losses and their determination

*Irrigation water requirements:* reference evapotranspiration (ET), measurement and estimation of ET, crop coefficients, water production functions. Irrigation scheduling, deficit irrigation water,

*Water distribution at farm:* on-demand, continuous and rotational schedules; Irrigation efficiencies, distribution uniformity and water productivities; Conjunctive use. Concepts of surface irrigation, surface irrigation process, infiltration and infiltration models, measurement of infiltration; Types of surface irrigation systems, their suitability and limitations, Volume balance theory and its application, evaluation of irrigation systems and their improvement, design fundamentals; Irrigation system layout and operations at division, circle and command level,

Water allocation and distribution at canal command, region, country and basin level, Water management at various levels.

### **PRACTICALS**

1. Study of characteristics of various irrigation structures in the nearby area.
2. Design and layout of a canal for a given command.
3. A field visit to canal irrigation system and structures.
4. Design of outlets.
5. Computer aided design of a watercourse for a command area.
6. Sampling and measurement of sediments in canal water.

### **RECOMMENDED BOOKS**

1. Irrigation Engineering & Hydraulic Structures by Santosh Kumar, Garg, 10<sup>th</sup> revised Edition, 1993
2. Irrigation & Water Power Engineering by Dr. B.C. Punmia, Dr. Pande B.B. Lal
3. Siddiqui, I. H. 2003. Irrigation and Drainage Engineering. Royal Book Company, BGRex Centre Fatima Jinnah Road, Karachi.
4. Iqbal Ali. 2001. Irrigation Engineering, Oxford University Press, London.
5. Withers, Bruce & Vipond, S. 1980. Irrigation Design and Practice, Batsford Academic and Education Limited London.
6. Aisenbrey, A.J., Hayes, R.B., Warren, H.J., and Young, R.B., 1983. Design of small canal structures, USBR, Denver Colorado, USA.
7. Ahmad, N. and Chaudhry, G.R. 1988. Irrigated Agriculture of Pakistan, Shahzad Nazir Publisher, Gulberg-III, Lahore.
  2. Ahmad, N. 1993. Water Resources of Pakistan, Shahzad Nazir Publisher, Gulberg-III, Lahore.
  3. Michal, A.M. 2003. Irrigation Theory and Practice, Vikas Publishing House (Pvt) New Delhi, India. Arora, R.K. Irrigation and Water Power Engineering.

### **I&D 508**

### **GROUNDWATER MODELING**

**3(2-1)**

*Groundwater Resources of Pakistan:* Distribution and development of groundwater, Aquifer

characteristics, Groundwater survey and data collection, Role of groundwater in water resources systems, Management of groundwater resources.

*Introduction to Modeling:* Modeling concepts, types of models, Need for aquifer models, Model calibration, Introduction to Modeling techniques i.e., Finite Difference Model, Finite Element Model.

*Analytical Solution Techniques:* Laplace's equation, Isotropic and anisotropic aquifers, Solution of Laplace equation,

*Finite difference model:* Theoretical consideration of one dimensional flow, Grid system, Explicit and implicit solution techniques, Crank Nicholson approximation, Two dimensional flow case, Application of finite difference model to the solution of groundwater problems.

*Finite Element Model:* Theoretical considerations, Mesh generation, Solution techniques, Application of finite element model to groundwater flow problem.

### **PRACTICALS**

1. Case studies for application of Finite Difference Model.

2. Case studies for application of Finite Element Model.

### **RECOMMENDED BOOKS**

1. Jacob Bear, 2007. Hydraulics of Groundwater, McGraw-Hill Book Company, New York. ISBN-10: 9780486453552
2. W. H. Chiang. 2005. 3D-Groundwater Modeling with PMWIN. A Simulation System for
3. Modeling Groundwater Flow and Transport Processes. Springer-verlag Berlin Heidelberg, Netherlands
4. Pinder. G. F. 2002. Groundwater Modeling Using Geographical Information Systems. Publisher: John Wiley & Sons, Ltd.

### **I&D-509**

### **FLOOD ESTIMATION AND ITS CONTROL**

**3(2-1)**

*General:* Definitions, classification of floods, Introduction to flood estimation and design, philosophy, meaning of frequency.

*Flood Estimation:* Peak Flow determination, flood determination for ungauged catchments, flood determination for ungauged catchments with frequency relationship, flood estimation for gauged watersheds, probable maximum flood, flood hydrograph of a given frequency, prediction of the runoff hydrograph from a design storm, flood estimation from catchment characteristics, flood estimation by statistical methods, regional flood frequency analysis, flood hydrograph estimation using SCS method, estimation of flood using routing techniques, choice of estimation techniques.

*Flood Control:* General, classification of floods, estimation of peak flood, methods of flood control, flood control by reservoirs, retarding basins, construction of 10scill, channel improvement, soil conservation measures, combination of flood control measures, flood forecasting and warning, results of controlling floods, flood control economics.

*Disaster management/Adjustments:* Emergency evacuation and rescheduling, structural adjustment, land use change, insurance.

### **PRACTICALS**

1. Study of characteristics of various irrigation structures in the nearby area.
2. Design and layout of a canal for a given command.
3. A field visit to canal irrigation system and structures.
4. Design of outlets.
5. Sampling and measurement of sediments in river Irrigation System.

### **RECOMMENDED BOOKS**

1. Irrigation Engineering & Hydraulic Structures by Santosh Kumar, Garg, 10<sup>th</sup> revised Edition, 1993
2. Ahmad, N. and Chaudhry, G.R. 1988. Irrigated Agriculture of Pakistan, Shahzad Nazir Publisher, Gulberg-III, Lahore.
3. Ahmad, N. 1993. Water Resources of Pakistan, Shahzad Nazir Publisher, Gulberg-III, Lahore.
4. Ward, R.C., Robinson, M. 1990. Principles of Hydrology, McGraw Hill, Book Co., London.

### **I&D-510**

### **IRRIGATION SCHEDULING**

**3(2-1)**

*Soil-Plant-Atmospheric Relationships:* Physical properties of water and water vapor, water vapor expressions, soil-water systems, energy state of soil water, soil-water characteristic curves, water

potential in plants, osmotic potential, flow of water in plants. Energy Balance: Heat energy balance, sensible heat and latent heat. Evapotranspiration:

*Definitions:* estimating reference/potential evapotranspiration by BlaneyCriddle, Radiation, penman and Pan evaporation methods, crop coefficients and crop evapotranspiration.

*Irrigation Water Requirements:* seasonal ET, annual ET, leaching requirements, miscellaneous requirements, effective rainfall, net irrigation requirements, allowances for non-uniform distribution, storage and distribution system losses, irrigation efficiency, system capacity.

*Irrigation Scheduling:* Irrigation scheduling concept, factors to be considered in irrigation scheduling, schools of thought on irrigation scheduling, types of irrigation scheduling, application of irrigation scheduling. Crop Production Models: Yield response to water, seasonal water use-yield models, additive multigrowth stage and multiplicative multigrowth stage yield models, calibration and application of yield-water models.

### **PRACTICALS**

1. Development of soil moisture characteristics curve.
2. Estimation of water requirements from local climatic data.
3. Preparation of irrigation schedules for various crops.
4. Application of crop yield model in irrigation scheduling.

### **RECOMMENDED BOOKS**

1. M. A. Burton. 2010. Irrigation Management. CABI, Publisher UK, ISBN-10: 1845935160
2. S. K. SINGH. 2010. Irrigation Water Requirement Of Paddy, Wheat And Sugarcane
3. Irrigation Scheduling and Crop Planning. Lap Lambert Academic Publishing, India. ISBN-10: 3843379653.
4. G. J. Hoffman, R. G. Evans, M. E. Jensen, D. L. Martin and R. L. Elliott. 2007. Design And Operation OF Farm Irrigation Systems. Publisher: American Society of Agricultural, USA.

### **I&D-511 WATER RESOURCES MANAGEMENT 3(2-1)**

*Water Resources Potential:* Surface water potential in the Indus Basin; surface water potential outside Indus Basin; groundwater development potential; potential water savings from irrigation system; water application efficiencies. Surface Water Development in the Indus Basin; History of development of irrigation system, Indus Water Treaty 1960; IBP works and their role in water management; present integrated surface water management. Bank storage and negotiation; Water Apportionment Accord. Groundwater Development in the Indus Basin: Public & Private sector development; evaluation of SCARP program. Groundwater mining, watertable control, artificial recharge. Water Supply Constraints: Increasing dimension capacity of the canal system; conversion to demand based system and surface storages; system inefficiencies; Conjunctive use of surface and groundwater.

### **RECOMMENDED BOOKS**

1. Soncini; Sessa, R., 2007. Integrated and Participatory Water Resource Management Theory, Elsevier Publisher.
2. Mollinga, PP., 2006. Integrated Water Resources Management, SAGE Publications Pvt. Ltd
3. Stephen, D., 2003. Water Resources Management. The Print Force, Meppel, the Netherlands.

**I&D-521****SPECIAL PROBLEM****1(1-0)**

A special problem in Irrigation & Drainage will be selected by the student in consultation with his major supervisor. A careful study of the problem will be made and report will be submitted by the student.

**I&D-522****SEMINAR****1(1-0)**

A special problem in Irrigation & Drainage will be selected by the student in consultation with his major supervisor. A careful study of the problem will be made and report will be submitted by the student.

## 2. FARM MACHINERY AND ENERGY (FME)

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6	FME-506	Tillage and Traction Dynamics	3(2-1)
7	FME-507	Evaporative Cooling Engineering	3(2-1)
8	FME-508	Renewable Energy Engineering	3(2-1)
9	FME-509	Innovative Sorption Cooling Systems	3(2-1)
10	FME-510*	Plant Protection Equipment Engineering	3(2-1)
11	FME-511**	Advanced Engineering Technologies in Agriculture	3(2-1)
12	FME-512**	Energy-Efficient Systems for Agricultural Applications	3(2-1)
13	FME-521	Special Problem	1(1-0)
14	FME-522	Seminar	1(1-0)
15	FME-523	MSc (Hons.) Thesis	6(0-6)

\*FME-510 course added by BoS in its meeting held on 20-07-2020

\*\*FME-511 & FME-512 courses added by BoS in its meeting held on 26-05-2022

### **FME- 501** **HARVESTING MACHINERY** **3(2-1)**

*Introduction:* Mechanism of separation, cutting-threshing and traction mechanism, loss of grain, settings for various crops, regulations for movement of combines and maintenance.

*Threshing:* History, methods of threshing (tangential axial, radial, combined), power requirements for threshing, factors effecting grain damage and threshing, methods of evaluating grain damage, new approaches and concepts in grain threshing.

*Shelling:* Historical development of shelling, concave studies, forces acting on the concave, ear orientation studies, damage evaluation, time of relaxation.

*Combine Header:* History, characteristics, header component analysis and evaluation.

*Cutterbars:* Fundamentals of cutting, cutting forces, influences of cutterbar speed on header losses, impact cutting.

*Conveyers:* Critical speeds of conveyers, grain damage.

Harvesting machines for wheat, rice.

### **RECOMMENDED BOOKS**

1. CIGR Handbook of Agricultural Engineering: Information Technology, Jan 30, 2006.

2. Cigr Handbook of Agricultural Engineering, April 1998.
3. Important Research Papers.

**FME-502      INSTRUMENTATION AND DATA ACQUISITION      3(2-1)**

*Basic Concepts:* Calibrations, system's response distortion, planning of experiments.

*Analysis of Experimental Data:* Cause and types of experimental errors, uncertainly analysis, statistical analysis of experimental data, probability distribution, the Gaussian distribution, Chi-square test of 14scillog of fit, method of least squares, propagation of error.

*Nomograms:* Transformation of concurrency charts to alignment charts.

*Basic Electrical Measurement and Sensing Devices:* Input circuit, amplifiers, filters circuits, oscilloscope, 14scillography, transducers and electrical sensing devices.

*Displacements and Area Measurement:* Dimensional Measurements gauge blocks, optical methods, pneumatic displacement gauge, area measurements-planimeter, graphical and numerical methods for area measurements.

*Pressure Measurement:* Dead Weight tester, Bounden tube, pressure gauge, diaphragm and bellows gauge, low pressure measurement-Pirani thermal conductivity gauge, The ionization gauge.

*Flow Measurement:* Positive displacement method, flow obstruction method, flow measurements by drag effects, magnetic flow meter.

*Temperature Measurement:* The ideal gas thermometer, temperature measurements by mechanical effect. Temperature measurement by electrical effects, thermocouple compensation.

*Force, Torque and Drain Measurement:* Mass balance measurement, elastic elements for force measurements, torque measurements, strain measurement-Electrical resistance strain gauges, measurement of resistance, strain gauge output.

Standard for measuring and recording time, humidity, color, deformation and length.

**RECOMMENDED BOOKS**

1. Instrumentation by Kirk W. Franklyn, Jun 30, 2005
2. Experimental Methods for Engineers by J.P. Holman, Dec 1, 2000

**FME-503      MANUFACTURING PROCESSES      3(2-1)**

*Mechanical Properties of Materials:* Definitions of Tensile properties, the strain-hardening equation, generalized strain hardening equation, stress strain relationships, natural strain and nominal strain true stress and engineering stress and strain, lineal strain and a real strain, yield strength and percent cold work, tensile strength versus percent cold-work etc.

*Metallurgical control of Mechanical Properties:* Principles of mechanical strength, sub-recrystallization plastic deformation, alloying, application of the concepts of alloying to the heat treatment, heat treatment of alloys, ferrous alloys, unsaturated alloying, saturated alloying & super-saturated alloying, ferrous micro-structure and their predictions.

*The casting Process:* Molding theory, patterns, molds and melting equipment, pouring of molten metal, cooling and solidification.

*The Welding Process:* Definition of welding, the fundamental welding problems, welding processes, are welding characteristics curves, weld-penetration, and the strength of weldments.

*The Forming Process:* Definition, forming operations, forces and power for forming, deformation, directionality of strain hardening.

*The Machining Processes:* Definition, machining operations, cutting tools – theory and life, surface, finish, cost analysis machinability, definition and equation, automatic and numerical control.

### **RECOMMENDED BOOKS**

1. Manufacturing Processes & Materials by George F. Schrader and Ahmad K. Elshennawy, Jul 2000
2. Manufacturing Engineering Processes (Manufacturing Engineering and Materials Processing, Volume 40) by Leo Alting, Nov 23, 1993
3. Class Notes.

### **FME-504                      PRODUCT DESIGN AND DEVELOPMENT                      3(2-1)**

*Overview:* Basic Procedure of Machine Design, Design of Machine Element, Sources of Design Data, Economic Considerations of Design, Manufacturing consideration in design

*Properties of Engineering Material:* Stress-Strain Diagram, Mechanical Properties of Engineering Materials, Creep, Stress Concentration, Static and Dynamic Loads, Fatigue Failure

*Design of Machine Parts:* Factor of Safety, Tensile and Compressive Stresses, Stresses due to Bending Moment, Stresses due to Torsional Moment, Design of Shafts, Shaft Design on Strength Basis, Shaft Design on Torsion Rigidity Basis, Design of Hollow Shaft on Strength and Torsional Rigidity Basis.

*Product Development Process Tools:* Modern Product Development Process, Product Development Teams, Strategies, Team Structures, Team Buildings, Product Development Planning, Planning Process, Basic Planning and Scheduling Tools

*Scoping Product Development: Technical and Business Concern:* Determining what to do, S-Curves and New Product Development, Technical Questioning, Advanced Method, Business Case Analysis, Product Development Economic Analysis, Design Drivers

*Product Tear down and Experimentation:* Teardown Process, Teardown Methods, SOP Examples, Force Flow Diagrams, Post Teardown Reporting, Actual Product Function Structure, Applications of Product Teardown

*Physical Prototypes:* Prototyping Essentials, Types of Prototype, Prototyping Processes, Rapid Prototyping Techniques, Scale and Dimension Analysis and Similitude, Physical Prototype Design and Planning

*Introduction to Finite Element Modeling of Machine Element* Application of FEA in Agricultural Engineering, Procedure for FEA. Meshing and Stress analysis

### **PRACTICALS**

1. Designing of Parts of Agricultural Machinery using 3D Model
2. Create assembly model in Solidworks , ProE. Perform actual Assembly.
3. Create the complete Drawing folder of a prototype of silage baler for the BOM
4. Create Request for quote (RFQ) package for local vendors
5. Perform finite element analysis for simple machine part

### RECOMMENDED BOOKS

1. V B Bhandari, Introduction to Machine Design, Tata McGraw-Hill Publishing Company Ltd. New Delhi, India .
2. Kevin Otto and Kristin Wood, Product Design, Techniques in Reverse Engineering and New Product Development, Pearson Education Inc. India.
3. Richard G Bunnynas and J. Keith Nisbett, Shingley's Mechanical Engineering Design (SI Units). Ninth Edition. Tata-McGraw Hill Publications Inc. India.

### **FME-505                      AGRICULTURAL STORAGE ENGINEERING                      3(2-1)**

*Storage Requirements of Agricultural Produce: Fresh and Dried Fruits, Vegetables, Grains and Cereal Crops*

*Processed Food and Agricultural Produce: Temperature, Humidity, Enthalpy Solar Radiation, Oxidation Level, Carbon Dioxide Level, Respiration, Transpiration, Fermentation.*

*Storage Quality Parameters: Definitions, Limitations, and Scope of: Taste, Appearance, Texture, Order, and Decay etc.*

*Role/Minimization of Living Organism: Viable grain kernels, Insects, Fungi, Micro-organisms (Bacteria, moulds, and yeasts), Mites, Rodents and birds etc. Factors affecting Micro-organisms survival. Reasons of deterioration.*

*Basic Preservation Methods: Drying, Mechanical isolation, Refrigeration, Chemical treatment, Ionizing Radiations, Vacuum. Effectiveness of preservation:*

*Strategic Preservation Methods: Vapor Compression Air-Conditioning, Desiccant Air-Conditioning, Maisotsenko Cycle, Direct and Indirect Evaporative Cooling, and allied technologies.*

*Moisture in Grains: Measurements, Psychrometric Analysis, Moisture Content Relationships, Dry and Wet Basis Moisture and Conversion, Bushel.*

*Determination of Moisture: (1) Direct methods: (i) Air Oven Method (one and two stage), (ii) Water Oven Method; and (2) Indirect methods: (i) Resistance method, (ii) Capacitance method, (iii) Chemical method. Drying rate.*

*Equilibrium Moisture Contents and Psychrometrics: Fundamentals and applications in storage engineering. Dryers, Fans, Pumps, Power and energy.*

*Heating and Cooling Processes: Sensible heating or cooling, Heating with humidifying, Cooling with dehumidifying*

*Storage building and structures: Design, Assessment, Ceiling Designs. Modern and Cold storage structures. Scope and limitation of cold storages*

### PRACTICALS

1. Determination of moisture contents by: 1. Direct method, and 2. Indirect method



*Direct Evaporative Cooling:* Fundamentals, applications, and scope in agriculture and livestock industry

*Indirect Evaporative Cooling:* Fundamentals, applications, scope and thermodynamic limitations

*Maisotsenko Cycle (M-Cycle) Air-Conditioning:* Fundamentals, applications, scope and limitations according to Pakistan's climatic conditions

Displacement Ventilation: Fundamentals, applications, scope animal housing as well as farm structures

*Heat Exchangers:* Advantages over conventional air-conditioning techniques, limitations, scope in farm air-conditioning

*Associated Components:* Condensers; Cooling Towers; Hybrid Systems; Ejector Air-Conditioning; Solar Thermal Energy Utilization; Waste Heat Utilization; Energy Storage Processes

### **PRACTICALS:**

1. Determination of sensible and latent load of air-conditioning for the storage of various agricultural products using psychrometric analysis for various climatic cities
2. Optimization of evaporative cooling option for precision air-conditioning at agricultural farms
3. Thermodynamic limitation of existing farm air-conditioning technologies and corresponding latest solutions
4. Thermodynamic assessment of Maisotsenko Cycle for agriculture sector of Pakistan
5. Thermodynamic limitation of Maisotsenko Cycle in various applications and regions
6. Technological overview and thermodynamic judgements on existing Energy projects of Pakistan
7. Thermodynamic limitation of existing farm air-conditioning technologies and corresponding latest solutions
8. Simple cost analysis for potential and sustainable energy options for Pakistan

### **RECOMMENDED BOOKS:**

1. Solar Energy Engineering : Processes and Systems (1<sup>st</sup> Edition) 2009 by Soteris Kalogirou
2. Encyclopedia of Energy: Glass and Energy (Volume 3) 2004 by Christopher W. Sinton
3. Handbook of Energy Engineering (Sixth Edition) by Albert Thumann and D. Paul Mehta
4. Renewable Energy: Sources and Methods (2010) by Anne Maczulak
5. ASHRAE (2005) –Fundamentals
6. ASHRAE (2006)- Refrigeration
7. ASHRAE (2007)- HVAC applications
8. ASHRAE (2008)- HVAC Systems and Equipment

*Energy:* History of energy usage, forms of energy, present energy consumption, and associated environmental problems. Conventional energy sources, energy and power, fossil fuels, nuclear and clean energy.

*Solar thermal energy:* Solar radiation resource, passive and active solar heating, solar concentrators. Fundamental concepts and thermodynamic operations.

*Solar photovoltaic:* Basic PV operation, PV technologies, electrical characteristics

*Biomass:* Definitions, biomass resource, extracting biomass energy, fuel crops, anaerobic digestion, landfill gas, waste to energy, energy balances and economics.

*Hydroelectricity:* Resource, hydropower power equation, turbines, large and small scale systems, pumped storage.

*Tidal Power:* The tides, tidal resource, system operation, and environmental factors.

*Wind energy:* Generation of the winds, wind resource, basic aerodynamics (lift versus drag) and the fundamental power equation; fundamental design concepts.

*Wave energy:* The wave resource, the fundamental power equation; onshore and off-shore wave energy extraction systems.

*Geothermal Energy:* Introduction, nature of fields, classification of geothermal resources, introduction to geothermal steam electric plants, liquid dominated system: flashed steam system, total flow concept.

*Geothermal exploration Fuel Cell:* Introduction and Classification, Reactions and Configurations, Phosphoric Acid Fuel Cell, Molten Carbonate Fuel cell (Construction, Working, Advantages and Disadvantages), Solid Oxide Fuel Cell (Construction, Combined Cycle Schematics, Advantages, Limitations), Solid Polymer Fuel Cell (Construction, Applications, Membrane Properties)

*Nuclear Physics Review:* Nuclear structure; nuclear stability; Binding energy and mass-energy equivalence; Radioactivity (natural and artificial); Decay rate; Mean-life and half-life; radioactive equilibrium;

*Nuclear Reactions:* Fission reaction; Elastic and inelastic scattering reactions. Neutron reaction; Neutron flux; Cross section for scattering, absorption and fission Reactor Theory: Nuclear chain reactors; Criticality; The four factor formula; One group critical equation; The critical size, Reactor Kinetics:

*Types of Nuclear Reactors:* Introduction, Pressurized Water Reactor (PWR), and Primary Loop, Pressurize Chemical Shim Control.

## **PRACTICALS**

1. Measurement of beam diffuse and total solar radiations using Pyrometers.
2. Performance evaluation of biomass boilers by direct and indirect methods.
3. Optimization of sustainable energy options for Pakistan.
4. Scope Estimation and optimization of sustainable renewable energy options for Pakistan.
5. Thermodynamic limitations of prime energy options of Pakistan.
6. Determining hydropower equations using impulse turbines.
7. Determining the physical basics of wind energy transformation.

## **RECOMMENDED BOOKS**

1. Boyle, G. 2004. Renewable Energy: Power for a Sustainable Future, 2<sup>nd</sup> Ed. OUP and Open University.
2. Boyle, G., B. Everett, and J. Ramage. 2004. Energy Systems and Sustainability, 2<sup>nd</sup> Ed. OUP and Open University.
3. Scheer, H. 2004. A Solar Manifesto. 2<sup>nd</sup> Ed. Hermann Scheer.
4. Kalogirou, S.A. 2009. Solar Energy Engineering: Processes and Systems. 1<sup>st</sup> Ed. British Library Printed in USA.
5. Viswanathan, B. and M.A. Scibioh. 2007. Fuel Cells: Principles and Applications. Taylor & Francis Group. USA
6. Solar Engineering of Thermal Processes (1991) by John A. Duffie and William A. Beckman
7. Fundamentals of Thermo-photovoltaic Energy Conversion (2007) by Donald L. Chubb
8. Handbook of Energy Engineering (Sixth Edition) by Albert Thumann and D. Paul Mehta

**FME-509**

**INNOVATIVE SORPTION COOLING SYSTEMS**

**3(2-1)**

**OBJECTIVE:** To understand the fundamentals of sorption based Heating, Ventilation, and Air-conditioning (HVAC) systems and to apply the adsorption/absorption conceptions for the development of low-cost and energy-efficient HVAC systems for agricultural applications

**CONTENTS:**

**Fundamentals:** Definitions of HVAC terminologies, Psychrometric processes and conceptions, Adsorption, Absorption and Sorption Phenomena, Sorbents-Refrigerant interactions, Environmental Safety, Agricultural Applications

**Scope and Limitations of Sorption HVAC Systems:** Significance of absolute and relative humidity in HVAC systems, Latent and Sensible load of HVAC, Role of Sorption HVAC systems in latent load control, Thermodynamics limitations from the prospective of temporal and spatial variations

**Adsorption based HVAC Systems:** Fundamentals of HVAC systems and integration of Sorption technology, Thermal and Electric Compressors, Sorption heat pump cycles

- Single and multi-stage adsorption HVAC cycles
- Solid desiccant air-conditioning Systems
- Adsorption cooling Systems
- Renewable energy utilization systems
- Desiccants and adsorbents utilizations

**Absorption based HVAC Systems:** Scope of absorptions system in close cycle applications, Comparison of absorption and adsorption systems, Thermodynamic merits and demerits, Solar and biogas energy utilization, Duhrium diagram

- Single and multi-bed Liquid desiccant air-conditioning Systems
- Absorption cooling Systems
- Renewable energy utilization systems

### **Hybrid Systems:**

- Compressor based hybrid Systems
- Evaporative cooling based Systems
- Renewable energy utilization systems

### **PRACTICALS:**

- Design of close and open cycle based adsorption cooling systems for Cold storage of tomatoes and potatoes
- Analysis of absorption cooling ideal cycle on Duhrium diagram for any agricultural application
- Field visits and tours

### **Recommended Books:**

1. Principles of Adsorption and Adsorption Processes (1984) by Douglas M. Ruthven.
2. Refrigeration (2017) Edited by Orhan Ekren, ISBN 978-953-51-3498-5, Print ISBN 978-953-51-3497-8, 152 pages, Publisher: InTech Open, DOI: 10.5772/65998.
3. Handbook of Thermal Science and Engineering (2017) by F.A. Kulacki (ed.), Springer International Publishing AG, DOI 10.1007/978-3-319-32003-8\_22-1
4. Modern Refrigeration and Air Conditioning, 19<sup>th</sup> Edition (2013) 1488 pages, Goodheart-Willcox Publisher. ISBN-10: 1619601990, ISBN-13: 978-1619601994.
5. ASHRAE (2005) -Fundamentals
6. ASHRAE (2006)- Refrigeration
7. ASHRAE (2007)- HVAC applications
8. ASHRAE (2008)- HVAC Systems and Equipment

**FME-510**

**Plant Protection Equipment Engineering**

**3(2-1)**

Course objective:

- Develop skill to evaluate agricultural spraying equipment.
- Develop the design capacity of spraying equipment.
- Create the capability to design a research project in the area of plant protection engineering

### **Content:**

**Overview:** Role of plant protection engineering in crop protection, spaying equipment, an overview of drift management approaches, Recent development of unmanned aerial vehicle for plant protection

**Design of Spraying Equipment:** Design of ground sprayers, Aerial spraying and assessment, Unmanned Aerial Vehicle sprayer design, application and evaluation, Vortex and droplet trajectory, relationship of downwash and vortex.

**Nozzle Selection and Design**, Type of nozzle, Nozzle performance, Nozzle design equation and flow measurement, Kinetics and Evaporation of Water Drops in Air, Variable flow control for pressure atomization nozzles. Effect of droplet size and carrier volume on performance of foliage-applied herbicides, Effects of formulation on spray nozzle performance for applications

**Speyer Evaluation Procedure**: ISO, 2005. ISO/FDIS 22866, fluorescent tracer, UV and fluorescent spectrophotometer application for quantitative measurement of spray, Spray sampling approaches, Visual and image system measurement of spray deposits using water sensitive paper, DepositScan, Comparison between indirect and direct spray drift assessment methods

**Numerical and computer models**: Eulerian Lagrangian approach, AGDISP model, AGDrift Model, GDS models, SAAS Model CFD simulation.

**Metrological factors and spray drift**: Emission of pesticides to the air during sprayer application, wind, humidity, temperature effect on sprayer airflow

**Assessment of human and environmental risk**: Estimation of drift amount, Risk assessment (Human exposure, Aquatic organisms, Earthworms, Bees, Adult bystanders, Child bystanders, Residents)

### **Practical:**

1. Maintenance and handling of plant protection equipment.
2. Study the droplet trajectory and kinematics under various operation and climatic factors
3. Field testing of ground sprayers using ISO 22866 standard.
4. Study the evaluation approaches aerial sprayers and UAV sprayers
5. Design a testing plant form and equipment for the testing of ground and aerial sprayers.
6. Field and industrial visit related to plant protection equipment manufacturing and testing industry

### **Reference Books:**

1. Baggio, A. 2005. Wireless sensor networks in precision agriculture. ACM Workshop on Real-World Wireless Sensor Networks (REALWSN 2005), Stockholm, Sweden, 20:1567-1576.
2. Pimentel, D. 2009. Pesticides and pest control. In: R. Peshin and A.K. Dhawan (eds.), Integrated Pest Management: Innovation-development process. Springer, Dordrecht. The Netherlands.
3. Peshin, R., R.S. Bandral, W. Zhang, L. Wilson and A.K. Dhawan. 2009. Integrated pest management: A global overview of history, programs and adoption. In: R. Peshin and A.K. Dhawan (eds.), Integrated Pest Management: Innovation-Development Process. Springer, Dordrecht. Netherlands.
4. ISO, 2005. ISO/FDIS 22866, Equipment for Crop Protection e Methods for Field Measurement of Spray Drift. ISO, Geneva.

5. Holterman, H.J., 2003a. Kinetics and Evaporation of Water Drops in Air. IMAG Report 2003e12, Wageningen UR.

## **FME-511 Advanced Engineering Technologies in Agriculture 3(2-2)**

<b>Contact Hours</b> Theory = 30 Practical = 30 Total = 60	<b>Advanced Engineering Technologies in Agriculture</b>  <b>FME-511</b> <b>MSc (Hons) Agricultural Engineering</b>	<b>Credit Hours</b> <b>3(2-1)</b> Theory = 2.0 Practical = 1.0 Total = 3.0
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### **Course Objectives:**

- To introduce the latest engineering technologies used in agriculture
- To study the application and advancement of in engineering technologies in agriculture for local requirement

### **Course Outline:**

#### **New Paradigm in the Delivery of Modernizing Agricultural Technologies:**

Technology approaches, enabling environment, regional technology delivery infrastructure technology delivery strategy, relationship to resilience and climate action technology deployment, larger outcomes and impacts, pandemic disruption and adjustments, technologies and agricultural transformation

#### **Artificial intelligent system for Smart Framing**

Introduction to artificial intelligence, introduction to Python's application in artificial intelligence efficient irrigation, automatic weeding, automatic harvesting, soil health monitoring, ariel surveying and imaging

#### **Precision Vegetable Farming Technologies**

Application global positioning system (GPS) in precision vegetable farming, Sensor technologies in precision vegetable farming, Geographic information system (GIS) in precision vegetable farming, Variable-rate technology (VRT) application in precision vegetable farming, recent developments and tools in precision vegetable farming

#### **Precision in Agriculture Decision Making Based on Machine Learning**

Introduction to technology in agriculture decision making, agriculture decision making, existing decision-making system, machine learning methods and applications for decision making, Role of machine learning in agriculture decision making

#### **Solar Technology in Agriculture**

Impact of solar energy, solar technology adoption, application of solar technologies in agriculture farm operations, role of solar technology in post-harvesting, solar greenhouse, solar powered tractors, solar fertilization

#### **Advancements of Spraying Technology in Agriculture**

Variate-rate spraying technologies, sensor based spraying machine, IOT used for spraying machine, machine learning role in spray application, drift management strategies, environment pollution control

#### **Practical:**

1. Study the current agriculture technology delivery system in Pakistan and regional countries.
2. Study the detection models for Artificial intelligence.

3. Design of a solar PV system for the agricultural implement
4. Study the various models and equipment in decision making based on machine learning
5. Study the variate rate spraying system
6. Visit to smart agricultural farm

**Reference Books**

- 1- Fiaz, A., Sultan, M., ed. (2021) “*Technology in Agriculture*” DOI10.5772/intechopen.92469 ISBN978-1-83881-922-4. Published by London: Intechopen
- 2- [Chen](#), G., ed. (2021) “*Advances in agriculture machinery and technology*”. ISBN 9781032095677. Published by CRC Press
- 3- Choudhury, A., Biswas, A., Singh, T.P., Ghosh. S.K. ed. (2021) “*Smart agriculture automation using advance Technologies*”. ISBN-978-981-16-6124-2. Publish by New York: Springer

**FME-512 Energy-Efficient Systems for Agricultural Applications 3(2-2)**

<b>Contact Hours</b> Theory = 30 Practical = 30 Total = 60	<b>Energy-Efficient Systems for Agricultural Applications</b>  <b>FME-512</b> <b>MSc (Hons) Agricultural Engineering</b>	<b>Credit Hours</b> <b>3(2-1)</b> Theory = 2.0 Practical = 1.0 Total = 3.0
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**OBJECTIVES:**

- To identify the energy-efficient options for various agricultural applications
- To develop concepts and skills of energy-efficient systems for agricultural applications.

**COURSE OUTLINE**

**AGRICULTURAL PRODUCT STORAGE**

Introduction and background, development of temperature and relative humidity storage zones, batch type desiccant air-conditioning system, effects of regeneration temperature on supply air, effect of climatic conditions on dehumidification performance, effect of regeneration temperature on coefficient of performance, effect of regeneration temperature on dew point and wet bulb effectiveness, psychrometric evaluation of for agricultural product storage.

**POULTRY HOUSES**

Introduction and background, thermal comfort of poultry birds, development of temperature and relative humidity zones, concepts of heat and mass transfer, performance evaluation of system, heat load calculations, effect of ambient temperature on surface temperature of birds, effect of live body weight on surface area of birds, heat loss determination by convection and radiation, effect of temperature on sensible heat loss by birds, effect of temperature on evaporative heat loss by birds, effect of temperature on total heat loss by birds, dehumidification capacity, cooling capacity, coefficient of performance, temperature humidity index calculations, feasibility analysis of desiccant system.

**LIVESTOCK THERMAL COMFORT**

Introduction and background, heat stress in dairy cattle, direct evaporative cooling, indirect evaporative cooling, Maisotsenko Cycle evaporative cooling, integration of desiccant system with evaporative cooling, heat and mass transfer calculations, performance evaluation of systems, temperature-humidity index calculations, psychrometric evaluation, feasibility analysis of systems.

## STORAGE OF FRUITS AND VEGETABLES

Introduction and background, insights of fruits and vegetables optimum growth, development of ideal storage zones of fruits and vegetables, performance evaluation of systems, psychrometric evaluation, feasibility analysis of system.

## ZERO-ENERGY COOL CHAMBER FOR VEGETABLE STORAGE

Introduction and background, performance evaluation, determination of cooling efficiency, physico-chemical analyses, physiological weight loss, total solid content variation, titratable acidity variation, pH variation.

## WET MARKETS

Introduction and background, effect of climatic conditions on survival of virus and microorganisms, psychrometric evaluation of human thermal comfort zone and virus minimum activity zone, evaporative and desiccant system configurations, performance evaluation, psychrometric evaluation, wet bulb effectiveness, dew point effectiveness, coefficient of performance, heat supplied for regeneration.

## PRACTICALS:

- 1) Psychrometric development of optimum temperature and humidity requirements for agricultural product storage, livestock thermal comfort, and greenhouse air conditioning.
- 2) Design and analyses of direct and indirect evaporative cooling system for poultry sheds.
- 3) Design and analyses Maisotsenko cycle evaporative cooling for greenhouse dehumidification.
- 4) Design and analyses for the zero-energy cool chamber for tomato storage application

## RECOMMENDED BOOKS:

- Book Title: Energy-Efficient Systems for Agricultural Applications. Springer book series: Green Energy and Technology (GREEN). Number of Pages V, 121. ISBN: 978-3-030-86394-4. Published by Springer Nature (2022). <https://doi.org/10.1007/978-3-030-86394-4>
- Book Title: Low-temperature Technologies. ISBN 978-1-83880-667-5. Number of Pages 280. Published by IntechOpen (2020). DOI 10.5772/intechopen.78524.

## FME-521

## SPECIAL PROBLEM

1(1-0)

A special problem in Fam Machinery and Energy will be selected by the student in consultation with his major supervisor. A careful study of the problem will be made and report will be submitted by the student.

## FME-522

## SEMINAR

1(1-0)

A special problem in Fam Machinery and Energy will be selected by the student in consultation with his major supervisor. A careful study of the problem will be made and report will be submitted by the student.

### 3. STRUCTURES AND ENVIRONMENTAL ENGINEERING (SEE)

Sr. No.	Course No.	Name of Course	Credit Hours
1	SEE-501	Pollution Control Systems	3(2-1)
2	SEE-502	Water Quality Engineering	3(2-1)
3	SEE-503	Wastewater Engineering	3(2-1)
4	SEE-504	Machine Evolution and Environment	3(2-1)
5	SEE-505	Water Supply and Sewerage	3(2-1)
6	SEE-506	Environmental Impact Assessment	3(2-1)
7	SEE-507	Farm Waste Disposal Systems	3(2-1)
8	SEE-508	Air and Noise Pollution Control	3(2-1)
9	SEE-509	Environment and Development	3(2-1)
10	SEE-510	Farm Management Systems	3(2-1)
11	SEE-511	Solute Transport Modeling	3(2-1)
12	SEE-512**	Environmental Modeling & Simulation	3(2-1)
13	SEE-521	Special Problem	1(1-0)
14	SEE-522	Seminar	1(1-0)
15	SEE-523	M.Sc. (Hons.) Thesis	6(0-6)

\*\*SEE-512 course added by BoS in its meeting held on 26-05-2022

#### **SEE-501 WATER POLLUTION CONTROL 3(2-1)**

*Types of water pollutants:* Organic and inorganic pollutants; nutrients, pesticides, heavy metals, toxic chemicals, salt, silt, and thermal pollution.

*Sources and causes of water pollution:* point and non-point sources, contribution of domestic, industrial, agricultural, transport, and mining effluents to water pollution.

*Impacts of water pollution:* Water pollution and human and ecological health, impacts through food chain.

*Water quality:* Water quality criteria and requirements, water quality standards for various uses including drinking water, irrigation, recreation etc.

*Water quality management:* Water quality management in rivers, lakes and groundwater. Streeter-Phelps model to manage river water quality model. Differences in water quality from surface and subsurface sources.

*Groundwater:* groundwater contamination with leaking underground reservoirs.

*Water pollution control:* Source reduction versus end of pipe treatment, water pollution prevention practices and techniques, water treatment

*Legislation and instruments for water pollution control:* Legislation, regulation and instruments for water pollution control with particular reference to Pakistan.

#### **PRACTICALS**

Principles of titration, filtration, distillation, paper chromatography, spectroscopy, atomic absorption, determination of pH, DO, Eh, EC, water hardness, turbidity, BOD and COD.

## RECOMMENDED BOOKS

1. Water pollution control: A guide to the use of water quality management principles, edited by R. Helmer and I. Hespanhol, published on behalf of UNESCO, WHO and UNEP by E&FN Spon2-6 Boundary Row, London SE1 8HN, UK ISBN 0419229108. Rhonda Lucas Donald, Water Pollution.
2. Vigil, K. M. Clean Water: An Introduction to Water Quality and Pollution Control.
3. Viessman Jr. W. and Hammer M. J. Water Supply and Pollution Control.
4. Desai B. Water Pollution in India: Law and Enforcement.

### SEE-502

### WATER QUALITY ENGINEERING

3 (2-2)

*Basic principles of public health; Communicable & non communicable water borne diseases, food borne, air borne and sanitation related diseases and control measures.*

*Introduction to safety: health and environment relationship, safety management, human and equipment safety, Industrial/nuclear hygiene and safety, Accident prevention and elimination plans, Fire protection techniques,*

*Occupational health and safety in Pakistan: Labor code of Pakistan (1986), Industrial-nuclear and occupational rules and regulations in Pakistan. Agricultural Pesticides Rules, 1973, Agricultural Pesticide Ordinance, 1971, OHSAS-18001, Pakistan Nuclear Regulatory Authority (PNRA) Regulations Pak/904 "Regulation on Radiation Protection-2004" Introduction to the principles of toxicology as applied to environmental engineering. Health hazards and toxic effects of chemicals Radioactivity; transport, storage & use of toxic chemicals-radio nuclides, occupational health programs*

### RECOMMENDED BOOKS

1. Mark A. Friend and James P. Kohn, 2010. Fundamentals of Occupational Safety and Health, 5th ed. Government Institutes, ISBN: 1605907065
2. Sandy Cairncross and Richard G. Feachem, 1993. Environmental Health Engineering in the Tropics: An Introductory Text, 2nd ed., John Wiley & Sons, ISBN: 0471938858.

### SEE-503

### WASTEWATER ENGINEERING

3(2-1)

Wastewater generation rates and characteristics of wastewater, Estimation of average and peak wastewater flows for a community, Concept of self-cleansing velocity for sanitary and storm sewers, Types of sewerage systems i.e. combined, separate and partially combined, Design criteria for the sanitary and storm sewer network, Hydraulic design of sewer and development of complete hydraulic statement for the sewer network for sanitary and storm sewer. Jointing of sewer. Inflow and infiltration problems into the waste water systems. Various materials for the sewer pipes and their characteristics, Loads coming on sewers. Different types of bedding to be provided under sewers, Various steps involved in the construction of sewers; especially how to shift levels to maintain correct gradient of sewers to allow flow under gravity. Various appurtenances in sewer system like manholes; drop manholes, etc. Design criteria for the sewage disposal station. Components of sewage disposal station including screens, wet



*Methods of Impact Analysis:* Purpose of environmental Impact assessment methods, comparative studies of methodologies, Warner and Preston study, Smith study, interaction matrices, networks, case studies exercise.

#### **RECOMMENDED BOOKS**

1. Environmental Impact Assessment: A Methodological Approach by Richard K. Morgan May 23, 2008
2. Morris and Peter. 1995. Methods of Environmental Impact Assessments. University College Press, London
3. Trivedi, P.R. 1992. Environmental Problems Impact Assessment. Ahasheep Publishing House, New Delhi.
4. Environmental Impact Assessment: Practice and Participation by Kevin S. Hanna Sep 8, 2005.

#### **SEE-507 FARM WASTE DISPOSAL SYSTEMS 3(2-1)**

*Farm Wastes:* Sources and Types, composition and generation rates, on site waste handling and storage methods, waste collection techniques, transfer and transportation means and methods, some typical wastes.

*Disposal Methods:* Introduction, technical and economic aspects, design consideration for composting, interaction, landfill, biogas and biomass systems, recent technological advancements in farm waste disposal methods.

#### **PRACTICALS**

Exercises related to waste storage, processing, collection, transfer and disposal of different types of farm wastes.

#### **RECOMMENDED BOOKS**

1. Environmental Friendly Management Of Farm Animal Waste By T. Matsunaka, 1997
2. Tehobanoglous G., H. Theisen and S. Vigil. 1992. Integrated Solid Waste management. McGraw Hill Book Company, New York.
3. Farm Management: Principles and Strategies by Kent D. Olson, Aug 15, 2003

#### **SEE-508 AIR AND NOISE POLLUTION CONTROL 3(2-1)**

*Resources of Nature:* Stationary, mobile and other sources of air and noise pollution.

*Dispersion of Airborne Effluents:* Wind Speed Correction, Wind Direction Standard Deviations, Plume Standard Deviations, Effective Stack Height, Maximum Ground-Level Concentration, Steady-State Dispersion Model (Crosswind Pollutant Concentrations), Centerline Pollutant Concentrations; Short & Long-Term Pollutant Concentrations, Stability and Environmental Conditions, Air Dispersion Applications)

*Noise Pollution:* Characteristics of Noise, Standards; Sources, Effects, Measurement, Control.

*Noise Control:* Physics of Sound (Sound; Speed of Sound; Sound Pressure; Frequency; Wavelength; rms Sound Pressure; Sound Level Meter; Sound Pressure Level; Loudness; Sound Power Level; Sound Energy Density), Noise and air standards and legislation in national and international level; Measurement and control strategies of noise and air pollution; Impact of noise pollution on human health and the general environment.

*Important air pollutants and their impacts on human health and the general environment:* Air quality standards and legislation in Pakistan & ISO (PAKERA); Health Concern and Indoor Pollution

Control, Health Effects and Standards; Indoor Air Quality, Pollution Control in Future Air Conditioned Environments, Management Practices for air borne emissions of gases, aerosols, particulate matter and organic vapors Air Quality Management, Air Quality Indices (US EPA Air Quality Index, The Mitre Air Quality Index (MAQI); Extreme Value Index (EVI); Oak Ridge Air Quality Index (ORAQI); Allowable Emission Rates; Effective Stack Height).

*Ventilation and Air Conditioning:* Air Ventilation and Circulation, General Discussion, Typical Applications, Ventilation Requirements, Ventilation Fans, Hood and Duct, Air Conditioning (General Discussion and Considerations, Typical Design Examples)

Radon Pollution Control, Units of Radioactivity; Growth of Radioactive Products in a Decay Series, Instrumental Methods of Radon Measurement; Radon Gas Measurement Methods, Radon Decay Product Measurement Methods, Health Effects of Radon.

*Noise Reduction,* Absorptive Materials, Nonacoustical Parameters of Absorptive Materials, Absorption Coefficients, Desulfurization and Emissions Control, Sulfur Oxides and Hydrogen Sulfide Emissions, SO<sub>x</sub> Emissions Control Technologies. Hydrogen Sulfide Reduction by Emerging Technologies, Innovative Wet Scrubbing Using a Nontoxic, Chelated Iron Catalyst, Conventional Wet Scrubbing Using Alkaline and Oxidative Scrubbing Solution, Scavenger Adsorption, Selective Oxidation of Hydrogen Sulfide in Gasifier Synthesis Gas, Biological Oxidation of Hydrogen Sulfide, Desulfurization Through Coal-Limestone Combustion; Fluidized-Bed Combustion; Lime-Coal Pellets.

*Advanced Coal Cleaning Technologies:* Innovative Hydrothermal Desulfurization for Coal Cleaning; Desulfurization Through Vehicular Fuel Cleaning, Emerging “Wet” Sulfur Oxide Reduction Technologies, Advanced Flue Gas Desulfurization Process, CT-121 FGD Process, Milliken Clean Coal Technology Demonstration Project, Control of NO<sub>x</sub> During Stationary Combustion, The 1990 Clean Air Act, NO<sub>x</sub> Control Technologies, In-Furnace NO<sub>x</sub> Control, Post combustion NO<sub>x</sub> Control.

*Hybrid Control Systems:* Simultaneous SO<sub>2</sub> and NO<sub>x</sub> Control, Future Regulation Considerations, Future Technology Developments in Multipollutant Control, Control of Heavy Metals in Emission Streams, Control of Metal Emissions, Control Device of Heavy Metals (Gravity Settling Chamber; Cyclone, Electrostatic Precipitator, Quench, Scrubber, Fabric Filters, Vitrification, Solidification; Chemical Stabilization and Fixation, Extraction, Fluidized-Bed Metal Capture)

*Indoor Air Pollution Control:* Indoor Air Quality: Increasing Public Health Concern, Indoor Air Pollution and Health Effects (Sources of Indoor Air Pollution; Health Effects of Indoor Air Pollutants.

*Indoor and out of door Sound:* Sound Buildup and Sound Decay, Diffuse Sound Field, Reverberation Time, Optimum Reverberation Time, Energy Density and Reverberation Time; Relationship Between Direct and Reflected Sound, Sound Isolation, Transmission Loss, Noise Reduction, Noise Isolation Class (NIC), Vibrations, Vibration Isolation

## **PRACTICALS**

1. Determination of PM<sub>10</sub> and PM<sub>2.5</sub>
2. Determination of oxides of carbon, nitrogen and sulfur
3. Determination of noise pollution (any site around university)
4. Determination of indoor pollution quality parameters and validation of NEQS values
5. Field visit to EP Department.

## RECOMMENDED BOOKS

1. Advanced Air and Noise Pollution Control; Lawrence K. Wang PhD, PE, DEE, Norman C. Pereira PhD, Yung-Tse Hung PhD, PE, DEE. Handbook of Environmental Engineering; Volume 2, 2005. ISBN: 978-1-58829-359-6 (Print) 978-1-59259-779-6.
2. Debi Prasad Tripathy, Noise Pollution, 2011, APH Publishing Corporation, ISBN: 8131303403
3. C. David Cooper and F. C. Alley, Air Pollution Control: A Design Approach, Fourth Edition,.2010, Waveland Pr Inc, ISBN: 157766678X
4. Environmental Noise Pollution, 1st Edition, Noise Mapping, Public Health, and Policy, Author(s) :Murphy & King, Release Date:05 May 2014, Imprint: Elsevier, eBook ISBN :9780124116146, Print Book ISBN :9780124115958, Pages:282
5. Bies DA and Hansen CH, Engineering Noise Control, E&FN Spon (ISBN 0-419-20430-X).

### SEE-509

### ENVIRONMENT AND DEVELOPMENT

3(2-1)

*Introduction to environment and development:* Theory and approaches, Atmospheric environment, Aquatic environment, Soil environment, Urban environment, Energy environment, Extraterrestrial environment, Environmental management and developing countries

*Resource management issues:* Water, coastal and island resources, Agriculture, land degradation and food security, Biodiversity resources, Atmospheric issues, Urban environments and industrial pollution issues, Environmental threats

*Environmental tools and policies:* Environmental management methods, tools and techniques, Environmental accounting, green economics and business, Environmental management and development: the future

## RECOMMENDED BOOKS

Environment and Sustainable Development Editors: Fulekar, M.H., Pathak, Bhawana, Kale, R.K. (Eds.)

Environment and Development, 1st Edition Basic Principles, Human Activities, and Environmental Implications Editors [Poulopoulos](#) & [Inglezakis](#)

### SEE-510

### FARM MANAGEMENT SYSTEMS

3(2-1)

*Farm Management and Farm Types:* Economics as the framework for farm-system analysis, Alternative bases for farm-system analysis, Farm management fields, Farm management modes, Structure of small-farm systems

*Farm Waste and Types of Farm Wastes:* Laws, Regulations, Policy, and Water Quality Criteria, Federal laws, regulations and rules, State responsibilities, State laws and regulations, Owner/producer responsibilities, Safety, Water quality criteria and standards, Agricultural impacts on the use of water

*Farm Wastes and Environment:* Pollution versus contamination, Factors affecting the pollution process, Controlling the pollution process, Effects of Farm waste on the water, air and animal resources, Conservation practice physical effects

*Farm Waste Characteristics:* Definitions of waste characterization terms, Waste characteristics

*Planning Considerations for Farm Waste Management:* Planning for protection of natural resources, Conservation planning process, AWMS plan, Waste impoundment planning considerations

*Siting Agricultural Waste Management Systems:* Process, Design considerations

*Farm Waste Management Systems:* Total systems, Interface with other systems, Waste consistency, Waste management functions, Waste management systems design, Typical agricultural waste management systems

*Farm Waste Management Systems Component Design:* Production, Collection, Transfer, Storage, Treatment, Utilization, Mortality Management, Safety

*Role of Soils in Waste Management:* Soil-agricultural waste interaction, Soil-agricultural waste mineralization relationship, Soil characteristics

*Role of Plants in Waste Management:* Manure as a resource for plant growth, The plant soil system, Plant nutrient uptake, Balancing plant nutrient needs with waste application, Application of manure and sludge, Nutrient removal by harvesting of crops

*Waste Utilization :* Waste consistency, Land application, Salinity, Plant nutrients, Nutrient management

*Waste Management Equipment:* Selecting waste handling equipment, Waste production equipment, Waste collection equipment, Waste transfer equipment, Waste storage equipment, Waste utilization equipment, Other associated equipment

*Operation, Maintenance, and Safety,* Operation, Maintenance, Safety, Agricultural waste management system plans

*Computer Software and Models:* Planning software, Animal waste management design software, Site modeling software, Site assessment software

### **RECOMMENDED BOOKS:**

1. Agricultural Waste Management Field Hand Book

**SEE-511**

**SOLUTE TRANSPORT MODELING**

**3(2-1)**

Importance of Groundwater in Water Resources Systems, Characteristics of groundwater and aquifer, Functions of aquifers, Darcy's Law, subsurface contamination, Contaminant Fluxes, Measures of phase composition, Advective flux, Diffusive flux, Hydrodynamic dispersion, Dispersive flux, Dispersion coefficient and dispersivity, Total flux, Field-scale heterogeneity, Balance Equation for Single Species, Single cell model, Fundamental balance equation, Pumping and injection, Sources and Sinks, Conditions for chemical equilibrium, Equilibrium chemical reactions, Equilibrium adsorption, Ion exchange, Volatilization and dissolution, Non-equilibrium

reactions, Bio-transformations, Transport Without Dispersion, Transport by advection only, Velocity field, Travel time

**PRACTICALS**

1. Determination of saturated hydraulic conductivity and porosity
2. Collection and interpretation of sample data
3. Development of conceptual model
4. Solve model design example and model execution
5. Study the model’s calibration, sensitivity analysis and validation
6. To study the model’s results interpretation and analysis

**RECOMMENDED BOOKS**

1. Bear, J. and Cheng, A.H.-D. 2010. Modeling Groundwater Flow and Contaminant Transport. Springer XXII, 834 p. 250 illus, Hardcover, ISBN: 978-1-4020-6681-8.
2. Barnett B, Townley LR, Post V, Evans RE, Hunt RJ, Peeters L, Richardson S, Werner AD, Knapton A and Boronkay A. 2012. Australian groundwater modelling guidelines. Published by the National Water Commission, 95 Northbourne Avenue
3. M.U. Igboekwe and C. Amos-Uhegbu. 2011. Fundamental Approach in Groundwater Flow and Solute Transport Modelling Using the Finite Difference. Earth and Environmental Sciences, ISBN: 978-953-307-468-9.
4. MethodChiang, W.H and W. Kinzelbach. 1998. Processing Modflow: A Simulation System for Modeling Groundwater Flow and Pollution. User’s manual. U.S. Department of the Interior, U.S. Geological Survey. Pp. 1-343.
5. Bouwer, H. 1996. “Ground water Hydrology” Mc Graw Hill Inc. New York
6. Ahmad, N. 1985. “Ground water Resources of Pakistan” Shahzad Nazir Publisher, Gulberg-III, Lahore

**SEE-512                      Environmental Modeling and Simulation                      3(2-1)**

<b>Contact Hours</b> Theory = 30 Practical = 30 Total = 60	<b>Environmental Modeling and Simulation</b>  <b>SEE-512</b> <b>MSc (Hons) Agricultural Engineering</b>	<b>Credit Hours</b> <b>3(2-1)</b> Theory = 2.0 Practical = 1.0 Total = 3.0
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Course Learning Outcomes (CLOs)

Upon successful completion of the course, the student will be able to:

CLO	Statement
CLO1	<b>Understand</b> the basic concepts of water quality modeling in river, lakes, estuaries, water and wastewater treatment systems
CLO2	<b>Analyze</b> the different steps in the development of models (e.g. model specification, calibration and validation) and the methods used in each of these steps.

CLO3	Use models and multi-criteria decision analysis approaches to solve complex engineering problems
CLO4	Use computers and information technology effectively.

## Course Outline

### Mathematical modeling and analysis

- a) Mathematical models
- b) Kinetics
- c) Stoichiometry
- d) Mass balance
- e) Hydraulics
- f) Matrix notations
- g) Model selection
- h) Spatial and temporal resolution
- i) Statistical analysis
- j) Model calibration and validation
- k) Sensitivity analysis, parameter, and model structure uncertainty

### Environmental Models

- a) Basic concepts, Definitions and types
- b) Environmental systems modeling, objectives and choices
- c) Sensitivity analysis and sources of error
- d) Introduction to numerical methods, reaction type and orders of reactions
- e) Conservation of mass, energy and momentum
- f) River/stream quality
  - a) Contaminants transport models for groundwater and soil,
  - b) Air pollution dispersion models;
  - c) Noise pollution models in urban centers;
  - d) Environmental planning models

### Water quality modeling of rivers, lakes and reservoirs

- a) Characteristics of rivers and lakes
- b) Hydrodynamics processes in river/lakes
- c) Sediments and water quality processes in river/lakes
- d) River/lakes modeling
- e) General mathematical formulation of water quality models for streams and rivers, reservoirs, estuaries;
- f) Biological oxygen demand (BOD) Curves
- g) Dissolved oxygen (DO) Sag Curve

### Overview of activated sludge, clarifier and DO models and anaerobic digestion models

- a) Soluble and particulate organic modeling
- b) Clarifier and aeration models
- c) Nitrification modeling
- d) Total nitrogen process modeling
- e) P removal processes
- f) Process control
- g) ASM model

h) ASIM, AQUASIM, BioWin, GPS-X, SIMBA, STOAT, WEST, etc

Labs/Practical Work

1. Case studies - Scenario analysis with real-world modeling objectives and real datasets
2. The design of models and simulation are supported by dedicated software tools. Examples of some more recognized platforms for dynamic simulation of WWTP are for example ASIM, AQUASIM, BioWin, GPS-X, SIMBA, STOAT, WEST, etc.

Teaching Methodology

Lecturing, Written Assignments/Quizzes, Report Writing, Case studies

Assessment

Mid Term, Report writing/Presentation, Assignments, Quizzes, Final Term

Suggested Readings/Books

1. Bossel, H., 2018. "Modeling and simulation". AK Peters/CRC Press.
2. Mackenzie L., Davis, Susan J., Masten 2014. "Principles of Environmental Engineering and Science". McGraw Hill
3. Solon, K., Volcke, E.I., Spérandio, M. and Van Loosdrecht, M.C., 2019. "Resource recovery and wastewater treatment modelling". Environmental Science: Water Research & Technology, 5(4), pp.631-642.
4. Michael, L.D., Winebrake, J.J. 2000. "Dynamic Modelling of Environmental Systems". Springer-Verlag
5. Ji, Z. G. 2017. "Hydrodynamics and water quality: modeling rivers, lakes, and estuaries". John Wiley & Sons.

**SEE-521**

**Special Problem**

**1(1-0)**

A special problem in Structures and Environmental Engineering will be selected by the student in consultation with his major supervisor. A careful study of the problem will be made and report will be submitted by the student.

**SEE-522**

**Seminar**

**1(1-0)**

Each M.Sc. student in Structures and Environmental Engineering will take seminar of one credit during his program of studies on current issues or special topics. The topic of the seminar must be selected in consultation with his major supervisor.