

PAKISTAN ENGINEERING COUNCIL

Syllabus for Engineering Practice Examination (EPE)

Agricultural Engineering

Total Marks: 60

PART-II

This is an open book breadth and depth examination, comprising 60 Multiple Choice Questions (MCQs) of one mark each (total 60 marks) with a duration of three hours. There shall be two sections of Part-II for each major discipline of EPE. Qualifying Marks for this part shall be **sixty per cent**.

SECTION-A / BREADTH

This section will generally confirm to latest (updated) B.E./equivalent qualification of Agricultural Engineering. The examination of this section shall comprise 25 MCQs (total 25 marks).

1. **MATHEMATICS AND STATISTICS FOR ENGINEERS** **10%**
 - i. **Derivates:** ordinary derivatives, general theorems, derivatives of functions, practical derivatives, geometrics meaning and practical derivatives of higher order
 - ii. **Anti-derivatives:** indefinite integration by substitution and by parts and by reduction formula
 - iii. **The Definite Integration:** the definite integral as limit of sum, evaluation of limit of sum, evaluation of definite integrals, improper integrals, reduction formulae, application of the definite integration
 - iv. **Numerical Integration:** discrete time differences, difference equations, solving 1st order differential equations
 - v. **Vector Spaces:** fundamentals, components of a vector, addition of vectors, multiplication by scalars, linear dependence and independence of vectors, inner product, vector product, curves, arc length, transformation of coordinate systems and vector component
 - vi. **Matrices and Determinates:** fundamental concepts, transpose of matrices, special matrices, matrix addition and multiplication, system of linear equations

- vii. **Differential Equations:** basic definitions of differential equations and classification of differential equations, formation of differential equations, initial value and boundary value conditions, 1st order differential equations and their solutions
- viii. **Probability and Statistics:** graphic representation of statistical data, measures of central tendency and dispersion, introduction to probability, addition and multiplication theorems of probability, the binomial, Poisson's and normal distribution, sampling theory, sampling distribution of means, and the difference between two means, applications of F, T and Chi-Square distributions, regression analysis, simple, partial and multiple correlation, applications of analysis of variance.

Suggested Books:

- Yousaf, S.M. and M. Amin. 1985. Calculus with Analytical Geometry
- Yousaf, S.M. 1998. Mathematical Methods, Ilmi Kitab Khana Kabir Street, Urdu Bazar, Lahore.
- Muhammad F. 1999. Statistical Methods and data analysis; Kitab Markaz, Bhowana Bazar, Faisalabad, Pakistan.
- Choudhry, S.M. and S. Kamal. 1998. Introduction to Statistical Theory Part I & II; Ilmi Kitab Khana, Kabir Street, Urdu bazaar, Lahore.

2. COMPUTER APPLICATIONS FOR ENGINEERS

8%

- i. **Computer Hardware:** type and features of computer, classification of computers, parts of computer, inputs and output from the computer, Central Processing Unit (CPU), processor, control unit, memory
- ii. **Software:** types of software, Operating System (OS), computer network, types of computer networks, data communication
- iii. **Data Processing:** data and information, data types, data processing, data representation, and flowchart
- iv. **Windows Operating Systems:** elements of Windows Operating Systems, display properties, control panel, keyboard setting, and task bar
- v. **Microsoft Office:** features of Microsoft Word, parts of word interface, managing documents, spreadsheet, Microsoft Excel, creating a workbook, rows and columns, formulas, formatting toolbar, Microsoft Power Point, Power Point screen, working with slides, adding content, working with text, color schemes, slides effects, master slides, saving and printing
- vi. **Introduction to the Internet:** services of internet, internet concepts, World Wide Web (WWW), web services, electronic mail, search engines, HTML, building links to HTML files, HTML levels.
- vii. **Computer Programming:** Basic concept of programming languages.

Suggested Books:

- Perry, G. and M. Johnsons. 1992. Turbo C++ by Examples. Prentice Hall Computer Publishing, New York.
- Shelly and Cashman. 1996. Using Computer, a Gateway to Information. Boyd and Fraser Publishing Company, USA.

3. ENGINEERING MECHANICS

7%

- i. Concept of measurement of mass, force, time and space (3-D), systems of units, fundamentals and derived units, required accuracy of results
- ii. General principles of statistics, vector addition, subtraction and products, resultant of distributed (linear and non-linear) force systems
- iii. General condition of equilibrium of co-planer forces, laws of triangle, parallelogram and polygon forces
- iv. Types of beams, supports and loads, simple cases of axial forces, shear forces and bending momentum diagrams
- v. Problem involving friction on flat forces, geometrical properties of plane areas
- vi. Work, energy, power, impulse, momentum, conservation of momentum and energy
- vii. Rectilinear and curvilinear motion, tangential and normal components of acceleration, simple harmonic motion.

Suggested Books:

- Meriam, J.L. and L.G. Kraige, "Engineering Mechanics". Vol. I Statics. John Willy and Sons, 1993, New York.
- Higdon, A. and W.B. Stile, "Statics and Dynamics", Prentice-Hall, Inc. Englewood Cliffs, N.J. 1986, USA.
- Riley, W. & Struges, C.d. "Engineering Mechanics, Static's and Dynamites", John Wiley & Sons, 1996, New York.

4. STRENGTH OF MATERIALS

7%

- i. **Simple Stresses and Strains:** stress at a point, components of stress, analysis of plane stress, principle stresses, maximum shear stress, Mohr's circle
- ii. **Axial Loading:** stress due to axial forces, strain, properties of material under axial loading
- iii. **Bending Loading:** bending stresses in beams, shear and bending moment diagrams
- iv. **Torsion:** shearing stress and angle of twist, hollow and circular shafts
- v. **Combined loading:** stresses due to axial, bending and torsional loading

- vi. **Columns:** introduction, stability of structures, Euler's formula for pin-ended columns, extension of Euler's formula to columns with other end conditions, design of columns under a centric load, design of columns under an eccentric load.

Suggested Books:

- Singer, F.L., "Engineering Mechanics", Harper and Row Publishers, 2000, New York
- Muvdi, B.B. and W. McNab, "Engineering Mechanics of Materials" McMillan Publishing Co., 2001, New York.
- Shigley, J.E. and C. R. Mischke, "Mechanical Engineering Design", Fifth Edition. 2000, McGraw Hill Publications Inc. USA.
- Higdon. A, E.H. Ohsen, W.B. Stiles, J.A, Weese and W.F. Riley, Mechanics of Materials. John Wiley & N.Y. 1985

5. ENGINEERING MATERIALS 9%

- Stone:** Classification, characteristics of good building stone & their uses, examination and testing of stone, stones availability in Pakistan
- Tiles and Bricks:** Preparation and burning of bricks, tests and characteristic of good bricks, tiles and terra cotta.

Suggested Books:

- Haider, S.Z. "Materials of Construction" (2nd edition), Oxford University Press, 1985, Pakistan.
- Kulkarni, G.J. "Text Book of Engineering Materials", Union Book Stall, 1980, M.A. Jinnah Road, Karachi.

6. FLUID MECHANICS 9%

- Fundamentals and Properties of Fluid:** fundamentals of fluid mechanics, properties of fluids
- Fluid Statics and Kinematics:** pressure variations in a fluid, pressure measuring devices, buoyancy and stability of submerged and floating bodies, forces on plane and curved surfaces, center of pressure, flow pattern, continuity equation
- Energy Consideration in Steady Flow:** general equations of steady flow, Bernoulli's equation, hydraulic and energy grade lines, power consideration in fluid flow, cavitation, head losses
- Momentum and Forces in Fluid Flow:** impulse momentum principle and application, force exerted on a stationary and moving bodies, relation between absolute and relative velocities, reaction and propulsion of a jet, torque in rotating machines

- v. **Flow in Open Channels and Closed Conduits:** basic hydraulics, flow types, energy losses in pipes, branching pipes, pipes in series, pipes in parallel and pipe network analysis
- vi. **Measuring Devices for Fluid Flow:** discharge through orifices, weirs, notches and venture meter, and pitot tube.

Suggested Books:

- Finnemore, E.J. & Franzini, J.B., 10th Edition. Fluid Mechanics with Engineering Application. McGraw Hill Book Co. Singapore.
- Jain, A.K. "Fluid Mechanics". Khanna Publishers, 1990, New Delhi, India.
- S.S. Rattan, "Fluid Machines" Khanna Publishers, 1994, New Delhi, India.

7. FARM STRUCTURES 10%

- i. **Farm Stead:** fundamentals, site selection, planning and development
- ii. **Dairy Building:** functional planning, environment, sanitation, space requirements for animals and traffic, arrangement of space, other considerations
- iii. **Poultry Structures:** functional planning, production practices, environment, space requirements, arrangement of space, insulation and ventilation, other considerations
- iv. **Storage of Fruits and Vegetable Crops:** condition for storage, refrigerated and common storage design, management and other characteristics, economic aspects
- v. **Storage of Grains:** parameters affecting the grain storage, functional requirements and grain conditioning, storage structure and equipment for grain handling and processing.

Suggested Books

- Barre, H.J., and Sommet, L.L. Farm Structure. John Walley and Sons., Inc., New York, USA.
- Gray Horrold, E. , "Farm Service Building", McGraw Hill Book Company, 1985, New York.
- Naubauer, L.W. and Walker H.B., "Farm Building Design", Prentice Hall inc., 1981, Englewood Cliffs, N.J.

8. THERMODYNAMICS 7%

- i. **Properties of Gases and Fundamental Laws:** fundamentals, P-V diagram, Laws of thermodynamics, methods of heating, expansion of gases
- ii. **Air Cycles:** cycles of operation, air standard efficiency of a cycle, carnot cycle, otto cycle, diesel cycle, mean effective pressure

- iii. **Entropy of Gases:** entropy and heat, T-S diagrams, carnot, otto, diesel and dual combustion cycles on T-S diagrams
- iv. **Air Compressors:** compressor types and functions, cylinder clearance, work done, compressor efficiency
- v. **Fuels:** properties and combustion of fuels, conversion of volumetric analysis, weight analysis, air fuel ratio for I.C. Engine
- vi. **Refrigeration:** co-efficient of performance, characteristics of refrigeration, rating, quality of refrigerant and general considerations, components of refrigeration system, heat pumps.

Suggested Books:

- Jones, J.B and Hawkais, G.A., “Engineering Thermodynamics”,2002, John Willy & Sons Inc. N.Y. USA.
- Khurmi, R.S. and J.K. Gupta, “Thermal Engineering”, 2000, S. Chand & Co. Ltd New Dehli, India.
- Nastop, T.D. and McConkey, “Applied Thermodynamics for Engineers and Technologists”, 5th Ed. 1992, Willis Clowes and Sons Ltd., London.

9. SOIL AND WATER CONSERVATION

10%

- i. **Soil Properties:** soil texture, structure, classifications and profile, physical and hydraulic properties
- ii. **Soil-Water-Plant Relationships:** water holding characteristics, soil water movement, retention curve and measurement, crop water requirement
- iii. **Soil Erosion and its Control:** causes of soil erosion, erodibility factors, erosion control measures (conservation tillage, soil and water conservation structures, vegetative cover etc), watershed management
- iv. **Rainwater Harvesting:** in situ and runoff harvesting methods, small and mini dams, ponds
- v. **Water Application Methods:** types and classification of irrigation methods advantages and disadvantages of irrigation methods, Components of sprinkler, trickle/drip, and sub-surface irrigation methods issues of rainfed agriculture, water conservation in rainfed areas, improvement in water application efficiency
- vi. **Conveyance System:** canals, distributaries, minors, and water courses, required canal capacity, conveyance losses, optimum channel sections design of conveyance systems, improvement in conveyance efficiency.

Suggested Books:

- Schwab, G. O., Fervert, R.K., Edminster, T.W. and Baren. K.K., “Soil and Water Conservation Engineering”, John Wiley & Sons, 1993, New York.

- Siddiqui, I.H., "Irrigation and Drainage Engineering", Royal Boom Company, 2003, BG-Rex Centre Fatima Jinnah Road, Karachi.
- Withers, Bruce & Vipond, S., "Irrigation Design and Practice", 1980, Batsford Academic and Education Limited London.
- Ahmad, N. and Chaudhry, G.R., "Irrigated Agriculture of Pakistan", Shahzad Nazir Publisher, 1988, Gulberg-III, Lahore.
- Frederick, R.T. and J. A. Hobbs., "Soil and Water Conservation", Prentice Hall, 1991, Englewood Cliffs, New Jersey, USA.
- Richey, C.B., Pal Facobson and C.w. Hall, "Agricultural Engineers Hand Book", 1961, McGraw-Hill Book Co. Inc. N.Y.

10. WATER RESOURCES ENGINEERING:

13%

- Surface Hydrology:** hydrologic cycle, precipitation, stream flow, evaporation, transpiration, runoff hydrograph and its analysis, frequency analysis
- Basic Concepts of Flow:** state and regimes, channel geometry, measurement of velocity in channels, velocity distribution in channel and its coefficient, pressure distribution in channel and effect of slope, silt theories, seepage analysis
- Discharge Measurement:** types of hydraulic structures, discharge measuring devices and formulae
- Water Supply Systems:** hydraulic structures, reservoir operations, water uses and quantities, water characteristics and quality, treatment, distribution system
- Hydro Power:** hydel power, system and load, project arrangement, hydraulic machinery, electrical equipment, operation
- Flood Damage Mitigation:** flood, hazards, peak flood, design and flood mitigation, reservoirs, levees, river training, cross drainage works and flood protection walls, floodways, evacuation and flood proofing, flood plain management, economics of flood mitigation.

Suggested Books:

- Ray K. Linsley and Joseph B. Franzini, "Water Resources Engineering", International Student Edition, 1979.
- Ray K Linsley, Paulhus, Kohler, "Hydrology for Engineers", 2nd ed. McGraw-Hill, 1974.
- Ven T Chow, "Open Channel Hydraulics", 2004, McGraw-Hill International Book Company, N.Y.

11. FARM POWER AND MACHINERY

12%

- Engine Fundamentals:** functions, construction, cylinder and heads, liner, crank case, piston, connecting rod, crank shaft, firing order, clutch, flywheel, valves and their operation, valve mechanism

- ii. **Engine Systems:** fuel (petrol/diesel), cooling, ignition, combustion, lubrication, electrical, intake and exhaust system of I.C. Engines
- iii. **Power Transmission System:** types (transmission, hydraulic and traction), principle of operation, working of single and multiple disk clutch, clutch adjustment, gear types, gear train, brakes, crown gear, pinions, working, components, types of hydraulic system and weight transfer, implement hitching and control
- iv. **Implement Classification:** tillage, sowing/planting, inter-culture, chemical and fertilizer applicators, harvesting, specialized equipment; types, uses and principles of operations
- v. **Precision Farming:** Introduction, precision farming methods, precision equipment-laser land leveling, sensors, variable rate application, role of GIS and GPS in precision farming
- vi. **Machine Performance:** machines capacities, time efficiency, machine maneuverability, field patterns, factors effecting machine performance
- vii. **Power Performance:** tractor power, drawbar power, PTO power, hydraulic power, power measurement, tractor tests, Nebraska Tractor Tests (NTT)
- viii. **Machinery Management:** machinery costs, ownership costs, operating costs, and timeliness costs, machinery selection and replacement.

Suggested Books:

- Kepner, R.A., R. Brainer, and E.L. Barger, “Principles of Farm Machinery”, John Willey and Sons, 2000, New York.
- Hunt, D., “Farm Power and Machinery Management” 2003, Iowa State University Press, Ames, Iowa, USA.
- Liljedahl, J.B.; Carleton, W.M., Turnquist, P.K., and, D.W. Smith, “Tractor and Their Power Units”, 1994, John Wiley and Sons, New York.
- Smith H.P. and L.H. Wilkes, “Farm Machinery and Equipment”, 6th Ed.1976, McGraw Hill, Inc. USA.
- Richey, C.B., Paul Jacobson and C.W. Hall, “Agricultural Engineers Hand Book”, McGraw-Hill Book Co. Inc. 1961, N.Y.

PART-II

SECTION-B / DEPTH

This section shall be based on practical concepts framed to judge the practical experience and field based knowledge of Registered Engineers (REs). The examination of this section shall comprise 35 MCQs. Each candidate may attempt the only opted area of practice, among the followings.

1. ENVIRONMENTAL ENGINEERING

- i. **Basic Concepts:** Environment & ecosystems, environmental engineering & science, contaminants & pollutants, types & sources of pollutants, potable & palatable water (W), Waste-Water (WW), solid waste, hazardous waste, atmospheric (Air) pollutants, noise pollution & aesthetics, environmental justice & ethics, sustainability, materials & energy balance approaches, unit operations & processes for W&WW treatment, agricultural pollution & impacts, environmental pollution control systems & role of professional (Env.) engineer, Environmental Quality Standards (EQS), Environmental Monitoring & Management (EMM)
- ii. **Water & Wastewater Quality Management: Water & Wastewater Characteristics:** Water supply sub-systems & main components, water treatment works, simple filtration, coagulation & softening plants, wastewater collection & treatment sub-Systems, preliminary, primary, advanced primary, secondary, secondary with nutrient removal, tertiary & advanced wastewater treatment
- iii. **Agricultural Practices and Water Pollution:** surface & subsoil nutrient & chemical contamination and pollutant migration in ground water, river & ground water quality management, best practices to avoid nutrient leaching, land & water management for water pollution control
- iv. **Solid Waste Management:** municipal, commercial, industrial, hospital, radioactive and hazardous solid waste, generation, collection, processing and disposal, waste reduction, recycle & reuse
- v. **Air Quality Management:** types & sources of air pollution, global warming, ozone depletion, photochemical smog, acid rain, carbon cycle, horizontal & vertical dispersion and good stack design considerations, measurement & control of particulate & gaseous air pollutants
- vi. **Noise Pollution:** concept of sound, sound pressure level, frequency and propagation, acoustic environment and health effects, measuring & control.

Suggested Books:

- Davis, Mackenzie L. and Susan J. Masten, "Principles of Environmental Engineering and Science", MacGraw Hill, 2004, International NY

- Vesilind, P.A. J.J. Peirce and R.T. Weiner, “Environmental Pollution and Control”, Butterworth-Heinemann, 1990, London
- Pandey, G.N. and G.C. Carney, “Environmental Engineering”, Tata McGraw Hill Publishing Company Limited, 1992, New Delhi.
- Wall, J.D., “Environmental Management Hand Book”, Welf Publishing Co., 1980, London, Tokyo.
- Henry J. Glynn & Gary W. Heinke, “Environmental Science and Engineering”, 2nd Ed. Pearson Education (Singapore) Ltd. 2004, Indian Branch, Delhi, India.

2. MACHINE SYSTEMS ENGINEERING

- Farm Machinery Management:** field capacities, factors affecting field capacity, cost analysis, tillage implements, planters, fertilizers, sprayers, reapers, material handling systems, manure handling systems
- Specialized Equipment:** sunflower harvester, vegetable harvester, sugarcane harvester, mango picker, maize sheller, combine harvester, earth moving and land development machinery, precision farming techniques
- Machine System Design:** phases of design, structural elements, functional elements, fasteners, connections, materials properties and strength, weight, elasticity, corrosion resistance, cost, material strength, deflection analysis, power transmission systems and drive trains, frames
- Stability Analysis:** vehicular, overturning, stability of structural elements
- Power Systems:** energy values, products of combustion, emissions, storage, efficiency, thermodynamic principles, power curves, specific fuel consumption, power density, combustion cycles, power requirements of electrical, hydraulic and mechanical systems
- Power Transmission Systems:** hydraulic pumps, actuators, valves, conduits, logic controls, mechanical chains, v-belts, clutches, shafts, gears, universal joints
- Optimization:** optimum use of machine, estimation of power for a machine, part load operation, break-even point, linear programming.

Suggested Books:

- Kepner, R.A., R. Bainer, and E.L. Barger, “Principles of Farm Machinery”, John Willey and sons, 2000, N.Y.
- Shigley, J.E., C.R. Mischke and R.G. Budynas, “Mechanical Engineering design”, 7th ed. McGraw Hill Co., 2004, New York.
- Liljedahl, J.B., P.K. Turnquist, D.W. Smith and M. Hoki, “Tractors and their Power Units”, 4th edition. Van Nostrand Reinhold, 1989, New York.
- Smith H.P. and L.W. Wikes, “Farm Machinery and Equipment”, 6th Ed. McGraw-Hill, Inc. 1976, USA.

- Hunt, D., “Farm Power and Machinery Management”, Iowa State University Press, 2003, Ames, Iowa, USA.

3. IRRIGATION AND DRAINAGE ENGINEERING

- i. **Irrigation:** basic concept, multi-purpose projects, irrigation schemes, development of irrigation in Pakistan, planning for irrigation projects, administrative arrangements, economics of irrigation projects, measurements of irrigation water
- ii. **Soils and Crops:** major soil series, properties and classification, soil fertility, principal crops, crop zoning
- iii. **Soil-Water-Plant Relationship:** soil water, evapotranspiration, crop water requirements, irrigation scheduling, crop rotation
- iv. **Surface Irrigation:** source of water, suitability of irrigation water, methods of irrigation (basin, border, furrow), assessment of irrigation water
- v. **Pressurized Irrigation:** lift irrigation, drip irrigation, sprinkler irrigation, design and operation of pressurized irrigation systems
- vi. **Groundwater:** occurrence and availability, wells, tubewell, pumping technology
- vii. **Irrigation System:** canals, minor/distributaries, watercourses, unlined and lined channels, survey and design of irrigation channels, management of irrigation water
- viii. **Water logging:** basic concepts, causes and effects of water logging, control measures, optimum water-table depth
- ix. **Drainage:** drainage requirements, surface and sub-surface drains and design, disposal of effluent, maintenance of drainage systems, socio-economic of drainage, environmental impacts of drainage, legal aspects of drainage, drainage machinery, reuse of drainage water, biological drainage
- x. **Land Reclamation:** scope and significance of soil salinity, types and causes of soil salinity, methods of land reclamation, management of salt-affected soils, salt tolerant crops, biological and engineering reclamation of salt-affected soils.

Suggested Books:

- A.M. Michael, “Irrigation theory and practice”, Vikas Publishing House, 1996, New Delhi.
- M.E. Jensen, “Design and operation of farm irrigation systems” 1983, American Society of Agricultural Engineers.
- L. K. Smedema, “Modern Land Drainage: Planning, Design and Management of Agricultural Drainage Systems”, Taylor and Francis Routledge, 2004.

- Siddiqui, I.H, "Irrigation and Drainage Engineering", 2003 Royal Book Co. GG-5 Rex Centre, Fatima Jinnah Road, GPO, Box 7737, Karachi
- Richey, C.B., Paul Jacobson and C.W. Hall, "Agricultural Engineers Hand Book", McGraw-Hill Book Co. Inc. 1961, N.Y.

4. WATER RESOURCES DEVELOPMENT AND MANAGEMENT

- Planning for Water Resources Development:** level, phases, objectives, data requirements, project formulation, environmental consideration, system analysis, multipurpose projects, and engineering economics of water resources
- Surface Water:** dams and reservoirs, reservoirs physical characteristics, yield, capacity and sedimentation, canals, distributaries and watercourses
- Groundwater:** occurrence and potential, hydraulics, yield, water quality monitoring, skimming wells, tubewells, radius of influence, pumps and their power requirements
- Water Management:** institutional arrangements, legal framework and constitutional provisions, water availability and water sharing among stakeholders, infrastructure management and water regulation, flow measurements, water losses, on farm water management, water application methods, higher efficiency irrigation systems
- Environmentally Sustainable Use of Land and Water Resources:** salt and water balance, salt affected soils and their reclamation, drainage requirements, on-farm drainage projects (surface and pipe drainage), disposal of drainage effluent, pollution of water ways and water bodies, protection of water quality
- Water Resource Information Database:** hydrological data, climatological data, organizations, hydro-meteorological networks, data processing and reporting, data banks.

Suggested Books:

- Javed Saleem Qamar, "Pakistan Water Resources Development and Management", 2007.
- Nazir Ahmed, "Water Resources of Pakistan" 1993.
- Ray K. Linsley and Joseph B. Franzini, "Water Resources Engineering" 2nd Ed. McGraw-Hill.

5. PROCESS ENGINEERING:

- Fundamentals:** types of pumps used in the industries, pump laws and performance, pump selection, viscosity effects
- Fans:** classification as to the type and design of fans, fan theory, performance and factors affecting selection; general performance and laws, fans in series and parallel

- iii. **Size Reduction:** size characteristics, fineness modulai, value of ground feed, size relationships, energy requirements, mixing and types of mixers
- iv. **Cleaning and Sorting:** grade factors, washing types and methods of washing, sorting fruits and vegetables, types of sorters, cleaning, sorting, grading nuts and seeds, types of grain cleaners and sorters, aerodynamics of small particles, types of separators
- v. **Material handling Equipment:** belt and chain conveyors, bucket elevators, pneumatic conveyors, gravity conveyors, cranes, lifts and carrying trucks/carts
- vi. **Cold Storages:** need, type and design of cold storages, temperature and humidity controls, heat load, automation of cold storages, air condition aeration
- vii. **Drying and Refrigeration:** drying and dehydration methods, processes and types, moisture content determinations, equilibrium moisture content, constant and falling rate period, falling rate drying mechanism, effect of temperature upon the rate of drying, effect of air rate upon the rate of drying, heat and mass balance, limitation of the drying equipment
- viii. **Refrigeration:** natural and mechanical refrigeration, refrigeration cycle, rating, qualities of refrigerants and general consideration, components of refrigeration system, heat pumps.

Suggested Books:

- Henderson, S.M., “Agricultural Process Engineering”. The AVI Publishing Company, Inc. 2003, Westport, Connecticut, USA.
- Woodroof, J.G. and Luh. B.S., “Commercial fruit processing”, AVI Publishing Co., Inc. 2002, Westport Connecticut, USA.
- Hall, C.W. and Davis, D.C., “Processing equipment for agricultural products”. AVI Publishing Co., Inc. 1991, Westport Connecticut, USA.
- Brooker, D.B., F.W. Baker Akram and C.W. Hall., “Drying Cereal Grains”, The AVI Publishing Company Inc., 1989, Westport, Connecticut, USA.

6. ENERGY IN AGRICULTURE

- i. **Basics:** types of energy resources (renewable and non-renewable) and use
- ii. **Energy Production in Agriculture:** energy from biomass, various types of biogas plants, design, installation, operation and management of biogas plants, methods of energy production from woody biomass/agricultural waste
- iii. **Solar Energy:** solar radiation, solar panels and types, design of flat-plate solar collectors and their applications in agriculture; green house structures and their application in agriculture, solar stills – design and description, solar pumps, thermal heating and cooling.
- iv. **Wind Energy:** wind energy potential, vertical and horizontal axis for wind mills, wind operated pumps for water lifting, wind power and forces on blades (lift and dray forces)

- v. **Hydel Power:** water wheels, hydraulic rams, turbines, low head power production
- vi. **Biomass & Biofuel Energy:** biomass energy available in the country, Biomass gasification Ethanol production potential in the country, Ethanol production techniques, Biodiesel production potential from agricultural commodities, energy balance of a biomass combustion system, energy losses, and efficiency of the biomass combustion system
- vii. **Energy Management and Audit:** tubewell energy, tractor fuel, fertilizer (organic/inorganic), chemical control, irrigation, mechanization, post-harvest system and food consumption.

Suggested Books:

- Duffie, J.A. and W.A. Beckman, “Solar Engineering of Thermal Processes”, John Wiley & Sons, 1992, New York.
- Pimentel, D., Biofuels, “Solar and Wind as Renewable Energy Systems”. 2008, Springer.
- Parker, B.F., “Solar Energy in Agriculture”, Elsevier Amsterdam, 1991 New York.
- Board, N., “Hand Book on Biogas and its Application”, National Institute of Industrial Research, 2004, New Delhi, India.