JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA–533003, Andhra Pradesh, India
B.TECH AGRICULTURAL ENGINEERING
(R23 – III[rd] YEAR COURSE STRUCTURE & SYLLABUS)

COURSE STRUCTURE

III Year – I Semester

S. No.	Category	Subject	L	T	P	C
1	PC	Farm Machinery and Equipment - I	3	0	0	3
2	PC	Agricultural Process Engineering	3	0	0	3
3	PE-I	1. Engineering Properties of Agricultural Produce 2. Greenhouse Technology 3. Tractor Design and Testing	2	0	0	2
4	OE-I	OR Entrepreneurship Development & Venture Creation Civil Engineering Department (e.g. Theory of Structures)	3	0	0	3
5	OE-II	Mechanical Engineering Department (e.g. Kinematics of Machines)	3	0	0	3
6	PC	Farm Machinery and Equipment - I Lab	0	0	3	1.5
7	PC	Agricultural Process Engineering Lab	0	0	3	1.5
8	SEC	Structural Design with ANSYS	0	1	2	2
9	BS&H	Tinkering Lab	0	0	2	1
10		Evaluation of Community Service Internship	-	-	-	2
Total			**14**	**1**	**10**	**22**
MC	Minor Course (Student may select from the same specialized minors pool)		3	0	3	4.5
MC	Minor Course through SWAYAM / NPTEL (Minimum 12 Week, 3 credit course)		3	0	0	3
HC	Honors Course (Student may select from the same Honors pool)		3	0	0	3
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III Year – II Semester

S. No.	Category	Subject	L	T	P	Credits
1	PC	Surface Water Hydrology	3	0	0	3
2	PC	Farm Machinery and Equipment - II	3	0	0	3
3	PC	Post-Harvest Engineering of Cereals, Pulses and Oilseeds	3	0	0	3
4	PE-II	1. Food Packaging Technology 2. Watershed Management 3. Human Engineering and Safety	3	0	0	3
5	PE-III	1. Irrigation and Drainage Engineering 2. Production Technology of Agricultural Machinery 3. Dairy and Food Engineering	2	0	0	2
6	OE-III	Chemical Engineering Department (e.g. Bioprocessing and Downstream Process Engineering)	3	0	0	3
7	PC	Farm Machinery and Equipment - II Lab	0	0	2	1
8	PC	Post-Harvest Engineering of Cereals, Pulses and Oilseeds Lab	0	0	2	1
9	SEC	Computational Fluid Dynamics with FLUENT	0	1	2	2
10	AC	Technical Paper Writing and IPR	2	0	0	-
		Total	**19**	**1**	**6**	**21**
Mandatory Industry Internship of 8 Weeks Duration During Summer Vacation… To be evaluated in IV Year I Semester						
MC	Student may select from the same minors pool		3	0	3	4.5
MC	Minor Course (Student may select from the same specialized minors pool)		3	0	0	3
HC	Student may select from the same honors pool		3	0	0	3
HC	Honors Course (Student may select from the honors pool)		3	0	0	3

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HONORS PROGRAMMME

S. No.	Course Name*	L-T-P	Credits
POOL-1			
1	Management of Canal Irrigation System	3-1-0	4
2	Mechanics of Tillage and Traction	3-1-0	4
3	Post-Harvest Engineering of Horticultural Crops	3-1-0	4
POOL-2			
1	Information Technology for Land and Water Management	3-1-0	4
2	Theory of Machines	3-1-0	4
3	Food Plant Utilities and Sanitation	3-1-0	4
POOL-3			
1	Landscape Irrigation Design and Management	3-1-0	4
2	Tractor Systems and Controls	3-1-0	4
3	Food Quality and Control	3-1-0	4
POOL-4			
1	Floods and Control Measures	3-1-0	4
2	Bio-energy Systems: Design and Applications	3-1-0	4
3	Refrigeration Engineering and Cold Chain	3-1-0	4

*If S.No. 1 in Pool-1is selected first time, student has to take S.No. 1 only among Pool-2, Pool-3 and Pool-3 subsequently.

MOOCs programme will be notified by HoD at the beginning of the semester with 8/12 weeks in duration to earn 2 credits.

Professional electives which are not studied, in any form during the programme, can also be selected for Honors Program

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MINOR PROGRAM
GENERAL TRACK
for II Year II Semester

Course No.	S. No.	Subject	L	T	P	Credits
1	1	Precision Farming Techniques for Protected Cultivation	3	1	0	4
	2	Wasteland Development	3	1	0	4

MINOR PROGRAM
SPECIALIZED TRACKS

Course No.	S. No.	Subject	L	T	P	Credits
TRACK 1 Farm Machinery and Power Engineering						
2	1	Farm Machinery Design and Production	3	1	0	4
	2	Testing and Evaluation of Tractors and Farm Equipment	3	1	0	4
	3	Earth Moving Machines	3	1	0	4
TRACK 2 Soil and Water Engineering						
3	1	Sprinkler and Micro Irrigation Systems	3	1	0	4
	2	Minor Irrigation and Command Area Development	3	1	0	4
	3	Agricultural Structures and Environmental Control	3	1	0	4
TRACK 3 Processing and Food Engineering						
4	1	Seed Processing and Storage Engineering	3	1	0	4
	2	Development of Processed Food Products	3	1	0	4
	3	Food Waste and By-products Utilization	3	1	0	4
MOOCs programme will be notified by HoD at the beginning of the semester with 8/12 weeks in duration to earn 2 credits.						

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OPEN ELECTIVE COURSES FOR OTHER DEPARTMENT STUDENTS

Open Elective	S. No.	Subject	L	T	P	Credits
1	1	Principles of Soil Science and Agronomy	3	0	0	3
2	2	Farm Power and Tractor Systems	3	0	0	3
	3	Soil and Water Conservation Engineering	3	0	0	3
3	4	Ground Water Hydrology, Wells and Pumps	3	0	0	3
	5	Surface Water Hydrology	3	0	0	3
4	6	Post-Harvest Engineering of Cereals, Pulses and Oilseeds	3	0	0	3
	7	Agricultural Process Engineering	3	0	0	3

III Year I Semester	FARM MACHINERY AND EQUIPMENT - I	L	T	P	C
		3	0	0	3

Objective: To understand primary and secondary tillage implements along with earth moving machinery. Seeding and plant protection equipment will be discussed to get awareness on the mechanical area of the agricultural engineering.

UNIT-I

Objectives of farm mechanization, sources of farm power, classification of farm machines. Materials of construction and heat treatment. Principles of operation and selection of machines used for production of crops - Field capacities of different implements and their economics. Problems on field capacities and cost of cultivation.

UNIT-II

Classification and types of tillage. Primary tillage implements - Moldboard plough and its parts, disc plough, and other ploughs. Secondary tillage equipment - Disc harrows, implements - Cultivators, and intercultural implements. Forces acting on tillage tools. Problems on forces analysis, draft measurement of tillage equipment. Draft and unit draft related calculations and workout with exercises.

UNIT-III

Earth moving equipment - Terminology, earth moving equipment, construction and their working principles. Earth moving equipment - Shovels, bulldozers. Earth moving equipment - Trenches and elevators.

UNIT-IV

Seeding methods, different types of seed metering mechanism, different types of furrow openers. Calibration of seed drills. Adjustment of sed drills. Objectives and uses of plant protection equipment. Types of sprayers and dusters. Sprayers calibration and selection. Constructional features of different components of sprayers and dusters and their adjustments.

UNIT-V

Transplanting methods, different types of transplanting machinery and their working principle, adjustments in transplanting equipment. Fertilizer application equipment – Fertilizer meeting mechanism, calibration of fertilizer equipment.

TEXTBOOKS

1. Farm Machinery, Stone A A 1958. John Wiley and Sons, New York.

2. Farm Machinery and Equipment, Smith H P 1971. Tata McGraw-Hill Publishing Co. Ltd, New Delhi.

REFERENCE BOOKS

1. Principals of Agricultural Engineering, Michael A M and OJha T P 1985 Vol. I, Jain Brothers, New Delhi.
2. Principals of Farm Machinery, Kepner R A, Bainer R and Barger E L 1987. CBS Publishers and Distributors, Delhi.
3. Elements of Agricultural Engineering, Jagadeshwar Sahay 1992. Agro Book Agency, Patna.
4. Land Reclamation Machinery, Borshahov Mansurov Sergecv 1988. Mir Publishers, Moscow.

Course Outcome

CO1: Apply principles of farm mechanization to calculate field capacities and cost of cultivation
CO2: Calculate the forces acting on tillage tools, draft and unit draft
CO3: Explain earth moving equipment
CO4: Analyze seeding methods, plant protection equipment
CO5: Discuss the features of transplanting machinery and fertilizer application equipment

III Year I Semester	AGRICULTURAL PROCESS ENGINEERING	L	T	P	C
		3	0	0	3

Objective: To train students on unit operations of agricultural process engineering to acquaint with preliminary operations such as clearing, size reduction, mixing, separation, filtration and materials handling equipment.

UNIT-I

Scope and importance of material handling devices, study of different material handling systems – Classification, principles of operation, conveyor systems selection/design. Belt Conveyor – Inclined belt conveyors, idler spacing, belt tension, drive tension, belt tripper. Chain conveyor –Principle of operation, advantages, disadvantages, capacity and speed, conveying chain. Screw conveyor – Principle of operation, capacity, power, troughs, loading and discharge, inclined and vertical screw conveyors. Bucket elevator – Principle, classification, operation, advantages, disadvantages, capacity, speed, bucket discharge, relationship between belt speed, pickup and bucket discharge, bucket types. Pneumatic conveying system - Capacity and power requirement, types, selection of pneumatic conveying system. Gravity conveyor - Design considerations, capacity and power requirement. Size reduction – Principle of comminution/size reduction, mechanisms of comminution of food, particle shape, average particle size, characteristics of comminuted products, crushing efficiency. Determination and designation of the fineness of ground material, screen analysis, empirical relationships (Rittinger's, Kick's and Bond's equations), work index, energy utilization. Methods of operation of crushers, classification based on particle size, nature of the material to be crushed. Size reduction equipment: Principal types, crushers (jaw crushers, gyratory, smooth roll), hammer mills and impactors, attrition mills, burr mill, tumbling mills, action in tumbling mills. Size reduction equipment – Ultra fine grinders (classifying hammer mills, fluid energy mill, micronizer fluid jet pulverizer, colloid mill), cutting machines (slicing, dicing, shredding, pulping), energy requirement of size deduction, energy requirement of cutting operation, maintenance of cutting edges.

UNIT-II

Mixing – Introduction, theory of solids mixing, criteria of mixer effectiveness and mixing index for granular solids, mixing indices, mixing of widely different quantities, criteria of mixer effectiveness and mixing index for pastes and semi- solid masses, mixing index at zero-time, rate of mixing, theory of liquid mixing, power requirement for liquids mixing. Mixing equipment – Mixers for low or medium viscosity liquids (paddle agitators, impeller agitators, powder-liquid contacting devices, other mixers), mixers for high viscosity liquids and pastes, mixers for dry powders and particulate solids.

UNIT-III

Theory of separation, types of separators, cyclone separators, size of screens and applications, separator based on length, width, and shape of the grains, specific gravity, density. Air-screen grain cleaner - Principle and types, design considerations of air-screen grain cleaners, sieve analysis, particle size determination, ideal screen and actual screen, effectiveness of separation and related problems. Pneumatic separator, threshing, winnowing, cleaning and separation equipment.

UNIT-IV

Moisture content and methods for determination in grains, moisture content representation, wet basis, dry basis, direct and indirect methods of moisture content determination, calculations and workout with exercises. Importance of EMC and method of determination, static-dynamic methods, EMC curve and EMC models, hysteresis effect, bound, unbound and free moisture. Principles of drying, theory of diffusion, mechanism of drying, falling rate, constant rate period. Thin-layer, deep bed dying methods. Effect of different factors on the drying process, different types of dryers, LSU dryer, flat bed batch dryer, fluidized bed dryer, rotary dryer, solar dryer.

UNIT-V

Theory of filtration, rate of filtration, pressure drop during filtration, applications, Constant-rate filtration and constant-pressure filtration derivation of equation, Filtration equipment - Plate and frame filter press, rotary filters, centrifugal filters and air filters.

TEXTBOOKS

1. Transport Processes and separation Process Principle, Geankoplis C J 2003 Prentice-Hall Inc., New Jersey.
2. Unit operations in Food processing, Earle R L 1983. Pergamon Press, New York

REFERENCE BOOKS

1. Post-Harvest Technology of Cereals, Pulses and oil seeds, Chakraverty A 1988. Oxford and IBH Publishing Co. Ltd, Calcutta.
2. Unit Operations of Chemical Engineering, McCabe W L, Smith J C and Harriott P 1993 McGraw-Hill Book Co., Boston.

Course Outcome

Upon successful completion of this course, learner will be able to

CO1: Discuss different types of material handling devices

CO2: Analyze the effectiveness and mixing index for granular solids, mixing indices

CO3: Explain aerodynamics of agricultural product

CO4: Estimate moisture content in wet basis and dry basis for different types of grains

III Year I Semester	ENGINEERING PROPERTIES OF AGRICULTURAL PRODUCE	L	T	P	C
		2	0	0	2

Objective: To enable the students to understand the basic concepts of application of engineering properties of biological material, rheology, basic concepts, classification of rheology, flow behavior of biological materials, measurement of viscosity using viscometer, types of viscometer, workout exercises on viscometer, rolling resistance, angle of internal friction and angle of repose, applications of frictional properties in design of processing equipment, specific heat, thermal conductivity, thermal diffusivity, latent heat of vaporization, latent heat of fusion, sensible heat, enthalpy and heat energy calculation.

UNIT-I

Physical properties - Introduction and application of engineering properties of biological material. Physical properties of different food commodities and aided products – importance. Shape and size – Criteria for describing shape and size. Roundness and sphericity, volume and density, specific gravity, bulk density, porosity, surface area and measurement of these properties.

UNIT-II

Rheology - Introduction to rheology, basic concepts, classification of rheology, ASTM standard definition of terms. Rheological properties, flow behavior of biological materials, force deformation curve, linear elastic limit, yield point, bio-yield point and rupture point. Stress relaxation and creep behavior. Visco-elasticity and visco-plasticity.

UNIT-III

Rheological models - Introduction to mechanical models, Kelvin and maxwell models. Electrical equivalence of mechanical models. Rheological equations of maxwell model, generalized Maxwell model, Kelvin model and generalized Kelvin model. Difference between Kelvin and Maxwell model. Viscosity - Measurement of viscosity using viscometer, types of viscometers, workout exercises on viscometer.

UNIT-IV

Frictional Properties - Basic concepts, effect of load sliding velocity. Friction in agricultural materials, measurement. Rolling resistance, angle of internal friction and angle of repose. Applications of frictional properties in design of processing equipment. Aerodynamic properties - Importance of aerodynamic properties in agricultural processing equipment with examples. Terminal velocity and drag coefficient, frictional drag and profile drag or pressure drag. Terminal velocity of different grains, working of pneumatic conveyor based on aerodynamic properties.

UNIT-V

Electrical properties – Di-electrical properties, dielectric loss factor and dielectric constant. Applications and role of electrical properties in food processing. Thermal Properties - Introduction to thermal properties, specific heat, thermal conductivity, thermal diffusivity, latent heat of vaporization, latent heat of fusion, sensible heat, enthalpy and heat energy calculation.

TEXTBOOKS

1. Physical properties of plant and animal materials, Mohsenin N N, Gordon and Breach Science Publishers, New York, 2nd Edition, 1986.
2. Engineering Properties of Foods, Rao M A, Syed S H Rizvi and Ashim K Datta, CRC Press – Taylor & Francis Group, Boca Raton, FL, 4th Edition, 2014

REFERENCE BOOKS

1. Food and Process Engineering Technology, Wilhelm LR, Suler W A and Brusewitz, G H, American Society of Agricultural Engineers (ASAE), St. Joseph, Ml.
2. Engineering Properties of Biological Materials, O.P. Singhal and D.V.K. Samuel, Saroj Prakashan, Allahabad, 1st Edition, 2003.

Course Outcome

At the end of the course, student will be able to

CO1: Calculate the basic engineering properties of a biological material
CO2: Analyze the flow behavior of biological materials and force deformation
CO3: Analyze the Maxwell and Kelvin model equations in the rheology for important biologicalmaterials
CO4: Explain the applications of frictional and aerodynamic properties in the design of processing equipment
CO5: Explain the applications of electrical and thermal properties in the design of processing equipment

III Year - I Semester	GREENHOUSE TECHNOLOGY (Professional Elective - I)	L	T	P	C
		2	0	0	2

Objective: Constructional and operational details of greenhouses will lead the students to grow crops with profits and also to use the greenhouses for off-season usage and also to manage them commercially.

UNIT-I

Greenhouses – Introduction, history, definition, greenhouse effect, advantages of greenhouses. Classification of greenhouses – Greenhouse types based on shape, utility, construction and covering material. Plant response to greenhouse environment – Light, temperature, relative humidity, ventilation and carbon dioxide.

UNIT-II

Environmental requirement for crops – Temperature requirement of horticultural crops, light requirement of crops and lighting control methods. Greenhouse shading methods, greenhouse supplemental lighting systems. Environmental control inside greenhouse – Manual controlling, thermostats, microprocessors and computerized control systems.

UNIT-III

Natural and forced ventilation summer and winter cooling systems, carbon dioxide enrichment method. Planning of greenhouse facility – Site selection and orientation, structural design. Materials used for construction of greenhouses – Wood, galvanized iron pipe and glass. Greenhouse covering materials – Polyethylene film, PVC, polyester, Tefzel T2 film, polyvinyl chloride rigid panel, fiber glass reinforced plastic rigid panel, acrylic and polycarbonate rigid panel. Design criteria and construction details of glass and pipe framed greenhouses, material requirement and procedure for erection.

UNIT-IV

Greenhouse heating and energy storage – Type of heat loss, heating systems, heat distribution systems, water and rock storage, heat conservation practice. Greenhouse irrigation systems – Rules of watering, hand watering, perimeter watering, overhead sprinklers, boom watering, dripirrigation.

UNIT-V

Greenhouse utilization in off-season – Drying of agricultural produce. Protected agriculture techniques – Row covers. Economics of greenhouse production – Capital requirements. Economics of production and conditions influencing returns.

TEXTBOOKS

1. Greenhouse technology and Application, Vilas M. Salone and Ajay K. Sharma Agrotech Publishers, New Delhi, 2012
2. Greenhouse Technology for controlled Environment, Tiwari, G.N. Narsoa Publishing House Pvt. Ltd.
3. Greenhouse Technology- Management, Operation and Maintenance, N.N Patil, UniversalPrakashan Publisher.

REFERENCE BOOKS

1. Greenhouse Technology and Management, Radha Manohar K and Igathinathane C 2nd Edition, BS Publication.
2. Advances in Protected Cultivation, Singh Brahma and Balraj Singh, New India PublishingCompany, 2014.
3. Greenhouse Management of Horticulture Crops, S Prasad and U Kumar, Second Edition, Agrobios, New Delhi, 2012.
4. Greenhouse: Advanced Technology for Protected Horticulture, J Hanan, CRC Press, LLC,Florida, 1998.

Course Outcome

At the end of the course, student will be able to

CO1: Classify the greenhouses based on different parameters

CO2: Identify the required environmental factors for crop growth

CO3: Analyze the natural and forced ventilation, summer and winter cooling systems

CO4: Explain greenhouse irrigation systems

CO5: Describe protected agricultural techniques

III Year - I Semester	TRACTOR DESIGN AND TESTING (Professional Elective - I)	L	T	P	C
		2	0	0	2

Objects: To enable the students to know the development of agricultural tractors and different operations performed by the tractors. To know the different trouble shootings and remedies, design of different parts. To get knowledge on different tests performed on tractors.

UNIT-I

Procedure for design and development of agricultural tractor, classification, selection. Study of parameters for balanced design of tractor for stability and weight distribution, traction theory, hydraulic lift and hitch systems design.

UNIT-II

Complete drive train, transmission. Design of mechanical power transmission in agricultural tractors - Single disc, multi disc and cone clutches. Rolling friction and anti-friction bearings.

UNIT-III

Design of Ackerman steering and tractor hydraulic steering. Study of special design features of tractor engines and their selection viz. cylinder, piston, piston pin, crankshaft, etc. Design of seat and controls of an agricultural tractor. Tractor testing.

UNIT-IV

Design calculation exercises on tractor clutch – (Single/multiple disc clutch). Design of gear box (synchromesh/constant mesh), variable speed constant mesh drive. Selection of tractor tyres –Calculation exercises. Calculation exercises on design of governor. Design and selection of hydraulic pump. Engine testing as per BIS code.

UNIT-V

Drawbar performance in the lab. PTO test and measure the tractor power in the lab/field. Determining the turning space, turning radius and brake test, hydraulic pump performance test and air cleaner and noise measurement test. Visit to tractor testing Centre/industry.

TEXTBOOKS

1. Maleev V L, 1964. Internal Combustion Engines, Tata McGraw-Hill, USA
2. Richey C B, 1991. Agricultural Engineering Handbook. McGraw-Hill, USA

REFERENCE BOOKS

1. Liljedahl J B, Carleton W M, Turnquist P K and Smith D W, 1984. Tractors and their Power Units. AVI Publishing Co. Inc., Westport, Connecticut.
2. Raymond N, Yong E A and Nicolas S, 1984. Vehicle Traction Mechanics, Elsevier Scientific Publications, USA.

3. Kirpal Singh. 2012. Automobile Engineering – Vol I and Vol II. Standard Publishers, Delhi.
4. Mehta M L, Verma S R, Mishra S K, Sharma V K, 2005. Testing and Evaluation of Agricultural Machinery, Daya Publishing House, New Delhi.

Course Outcome

At the end of the course, student will be able to

CO1: Analyze parameters for balanced design of a tractor

CO2: Explain the elements of mechanical power transmission in agricultural tractor

CO3: Design seat controls of an agricultural tractor

CO4: Design gear box

CO5: Determine turning space, turning radius and other parameters associated

II Year - I Semester	FARM MACHINERY AND EQUIPMENT - I LAB	L	T	P	C
		0	0	3	1.5

Objective: To enable the student to get the practical knowledge on various operation in agricultural field for crop production.

Practical

1. Study of various farm machinery and equipment
2. Visit to machinery production industry and ICAR, SAU research station
3. Determination of field capacity and field efficiency of primary tillage implements
4. Draft and fuel consumption measurement for different implements
5. Study of different types of plough bottoms and shares of M.B. Plough
6. Determination of disc angle, tilt angle, concavity of a disc plough
7. Calculation of draft and horse power
8. Study of seed-cum-ferti drill and seed metering mechanisms
9. Calibration of seed drill and calculation exercises
10. Study of sprayers, dusters and measurement of nozzle discharge and field capacity
11. Study of earth moving equipment through exposure visit
12. Construction and working of rotovators and weeding equipment

TEXTBOOKS

1. Principles of Farm Machinery. Kepner R.A., Bainer, R and Barger E.L., 1987. CBS Publishersand Distributors, Delhi.
2. Elements of Agricultural Engineering. Jagadeshwar Sahay. 1992. Agro Book Agency, Patna.

REFERENCE BOOKS

1. Farm Machinery. Stone A.A. 1958. John Wiley and Sons. New York.
2. Farm Machinery and Equipment. Smith H.P. 1971. Tata Mc Graw-Hills. Publishing Co. Ltd.,New Delhi.
3. Principals of Agricultural Engineering, Vol. I. Michael A.M. and Ohja T.P. 1985. Jain Brothers,New Delhi.
4. Land Reclamation Machinery. Borshahov Mansurov Sergecv 1988 Mir Publishers, Moscow.

Course Outcome

CO1: Study various implements and functional element
CO2: Evaluate field efficiencies and fuel efficiencies
CO3: Evaluate performance of various agricultural implements and machines
CO4: Design and calibrate seed drills and matching mechanism

III Year - I Semester	AGRICULTURAL PROCESS ENGINEERING LAB	L	T	P	C
		0	0	3	1.5

Objective: To train the students on how to conduct experiments and evaluate performance of various agriculturalfood process

Practical

1. Preparation of flow charts and layout of a food processing plant
2. Determination of fineness modulus and uniformity index
3. Determination of mixing index of a feed mixer
4. Determination of the efficiency of cyclone separator
5. Tutorial on extraction by McCabe and Thiele plot
6. Tutorial on use of psychrometry chart
7. Tutorial Problems on distillation
8. Tutorial on power requirement in size reduction of grain using Rittinger's law, Kick's law and Bond's law
9. Performance evaluation of hammer mill and attribution mill
10. Separation behavior in pneumatic separation
11. Evaluation of performance of indented cylinder and screen pre cleaner
12. Mixing index and study of mixers

TEXTBOOKS

1. Transport Processes and separation Process Principle, Geankoplis C J 2003 Prentice-Hall Inc., New Jersey.
2. Unit operations in Food processing, Earle R L 1983. Pergamon Press, New York

REFERENCE BOOKS

1. Post Harvest Technology of Cereals, Pulses and oil seeds, Chakraverty A 1988. Oxford and IBHPublishing Co. Ltd., Calcutta.
2. Unit Operations of Chemical Engineering, McCabe W L, Smith J C and Harriott P 1993 McGraw-Hill Book Co., Boston.

Course Outcome

CO1: Calculate uniformity and milling index

CO2: Design the procedural calculation of cyclone and pneumatic separation

CO3: Solve the calculation exercises on psychometric chart and on site reduction

CO4: Conduct the performance evaluation of hammer and attribution mills

III Year - I Semester	STRUCTURAL DESIGN WITH ANSYS	L	T	P	C
		0	1	2	2

Objective: To enable the students to understand the concepts of loads and use of BIS codes, design of singly and doubly reinforced sections, reinforced concrete cantilever and counter fort retaining walls, RC solid slab bridge, design of eccentric shear and moment resisting connections, method of IS code and structural steel framing

UNIT-I

Loads and use of BIS Codes. Design of connections. Design of structural steel members in tension,compression and bending. Design of steel roof truss.

UNIT-II

Analysis and design of singly and doubly reinforced sections, shear, bond and torsion. Design of flanged beams, slabs, columns, foundations, retaining walls and silos.

UNIT-III

Retaining walls - Reinforced concrete cantilever and counter fort retaining walls. Horizontal backfill with surcharge – Design of shear key - Design and drawing.

UNIT-IV

Flat slab and bridges - Design of flat slabs with and without drops by direct design method of IS code - Design and drawing - IRC Specifications and loading – RC Solid Slab Bridge – Steel Foot over Bridge - Design and Drawing. Liquid storage structures - RCC water tanks - On ground, elevated circular, underground rectangular tanks. Hemispherical bottomed steel water tank –- Design and Drawing

UNIT-V

Industrial structures - Structural steel framing - Steel roof trusses – Roofing elements – Beam columns – Codal provisions - Design and drawing. Girders and connections: Plate girders – Behaviour of components - Design of welded plate girder - Design of industrial gantry girders – Design of eccentric shear and moment resisting connections.

Practical

Design and drawing of single reinforced beam, double reinforced beam. Design and drawing of teel roof truss. Design and drawing of one-way, two-way slabs. Design and drawing of RCC building. Design and drawing of retaining wall. To measure workability of cement by slump test

TEXTBOOKS

1. Junarkar, S.B. 2001. Mechanics of Structures Vol. I Charotar Publishing Home, Anand.

REFERENCE BOOKS

1. Kumar Sushil 2003. Treasure of R.C.C. Design. R.K. Jain. 1705-A, Nai Sarak, Delhi-110006, P.B.1074.
2. Khurmi R S, 2001. Strength of materials. S. Chand & Company Ltd, 7361, Ram Nagar,New Delhi – 110055.

Course Outcome

At the end of the course, student will be able to

CO1: Design of connections, structural steel members in tension, and compression and bending

CO2: Analyze singly and doubly reinforced sections, shear, bond and torsion

CO3: Design of reinforced concrete cantilever and counter fort retaining walls

CO4: Design of flat slabs with and without drops by direct design method of IS code

CO5: Design of eccentric shear and moment resisting connections

III Year - II Semester	SURFACE WATER HYDROLOGY	L	T	P	C
		3	0	0	3

Objective: To enable the students to acquire knowledge and skills on hydrological (rainfall and runoff) measurements in watersheds, hydrological design of structures, prediction of volume and rates of runoff with tools like hydrographs and unit hydrographs, reservoir planning with flood routing techniques for application in natural resources management.

UNIT-I

Hydrology - Definition, hydrology cycle and its components. Forms of precipitation rainfall, characteristics of rainfall in India (types of monsoons). Measurement of rainfall – Recording and non-recording rain gauges, rain gauge network density for different topographic conditions, point rainfall analysis. Presentation of rainfall data mass curve and hyetograph, mean precipitation over an area – Arithmetic mean, Thiessen polygon, isohyetal methods, DAD relationships and curves. Probability analysis of rainfall – Return period, plotting position by Weibull's method, rainfall events at different probability levels (20%, 40%, 60%, 80%).

UNIT-II

Intensity-duration-frequency relationship, determination of net effective rainfall, infiltration indices, Phi index. Runoff – Definition, components of runoff, direct runoff and base flow, overload flow and interflows, pictorial representation of different routes of runoff. Runoff characteristics of streams – Perennial, intermittent and ephemeral streams, measurement of stream flows. Measurement of stage and velocities, staff gauge, wire gauge, automatic stage recorders, current meters (horizontal and vertical axis meters), calibration (V= a Ns + b). Rainfall-runoff relations (R=a P + b), curve fitting and determination of 'a' and 'b' and (correlation coefficient), factors affecting runoff. Definition and estimation of peak runoff and design peak runoff rate, rational method and curve number techniques.

UNIT-III

Hydrographs - Definitions and components, factors affecting flood hydrographs, hydrograph separation for simple and complex storms – Method I (straight line method, N=b A0.2), other Methods II and III. Unit hydrographs - Concept and the three implications of the definitions and the two basic assumptions (linear response and time invariance). Effects of the characteristics of storms (duration of rain, time- intensity pattern, areal distribution of runoff and amount of runoff) on the shape of the resulting hydrographs. Derivation of unit hydrographs, average unit hydrographs from several storms of the same duration (proper procedure of computing average perk flow and time to peak). Derivation of unit hydrographs for complex storms.

UNIT-IV

Conversion of unit hydrograph duration, methods for unit hydrographs of different durations, method of superposition and S-curve. S-curve method, explanation of concept and application. Conversion of unit graph duration by S-curve method, determination of lower duration graph from the given higher duration graph and vice-versa. Synthetic unit hydrograph, concept, Snyder' synthetic unit hydrograph, formulas relating hydrograph features (basin lag, peak flow and time base of the unit hydrograph). Instantaneous unit hydrograph, concept and application, SCS triangular hydrograph, application of hydrology, flood control and regulation, flood mitigation, floodplain mapping, retards.

UNIT V

Flood routing - Introduction, two broad categories of flood routing and channel routing, hydrologic routing and hydraulic routing, basic equations. Hydrologic storage routing, schematic representation of storage routing, modified Pul's method (semi-graphical method). Explanation of the features of the modified Pul's method. Flood routing through a reservoir by modified Pul's method. Applications of hydrology in land and water management, watershed management.

TEXTBOOKS

1. Engineering Hydrology. Raghunath H M, 1986. Willey Eastern Limited, New Delhi.
2. Watershed Hydrology, Suresh R, 1997. Standard Publisher and Distributors, New Delhi.

REFERENCE BOOKS

1. Engineering Hydrology. Subramanyam K, 1984. Tata McGraw-Hill Publishing Co. Limited, New Delhi.
2. Hydrology for Engineers, Linsley R K, Kholer A and Paul Hus J L H, 1988, McGraw-Hill Book Co., New Delhi.
3. Watershed Management. Dhruvanarayana, V V, 1990. ICAR Publication, New Delhi.

Course Outcome

CO1: Analyze probability of rainfall, return period, plotting position
CO2: Determine net effective rainfall, peak runoff and peak runoff rate
CO3: Discuss the factors affecting flood hydrographs, hydrograph Separation for simple and complex storms
CO4: Describe method of superposition, S-curve and determine duration graphs
CO5: Use the concepts of flood raining

III Year - II Semester	**FARM MACHINERY AND EQUIPEMNT - II**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Objective: To enable the students to understand the basic principles of cutting mechanisms and to know the various available harvesting machines. To know the working principle and functions of various machine parts of mowers, reapers, windrowers, forage harvesters, threshers, combine harvesters, cotton strippers, cotton pickers, groundnut and potato and sugarcane harvesters. Students can also understand the importance of testing and evaluation of agricultural machines and different standard codes (BIS) available in India for testing of machinery.

UNIT-I

Harvesting – Crop harvesting machinery, history of development, manual harvesting and its classification. Principles and types of cutting mechanisms – Principle of cutting mechanism, impact cutting, types of impact cutting, shear cutting Construction and adjustments of shear and impact type cutting mechanisms. Mowers – History and development, tractor mounted mowers, trail behind tractor mower, integral rear mounted mowers, side or central mounted tractor mower, semi-mounted mowers, safety precautions in operation and adjustments of mowers, knife drives, cutter bar and its parts – inside and outside shoes. Cutter bar – Guards, ledger plates, wearing plates, knife clips, grass board and various parts of cutter bar assembly, alignment and registration of cutter bar. Windrowing – Methods of windrowing, Self-propelled windrows, effects on yields and quality of reapers, animal drawn reaper, tractor mounted vertical conveyer reaper. Repairs and maintenance of harvesting equipment.

UNIT-II

Power operated vertical conveyer reapers – Reaper binders, care and maintenance, types. Forage harvesting equipment – Row forage harvesting equipment, field forage harvesters, types offield forage harvesters. Field chopper harvesters, forage wagons and boxes, field flail forage harvesters, self-propelled forage harvester, silo forage blowers, silo unloaders.

UNIT-III

Threshing – Principal of threshing, threshing methods, threshing by manual, threshing by animals, threshing by machines, Olpad threshers. Power thresher – Types of power threshers, hammer mill type, rasp bar, spike tooth, syndicator. Classification threshers based on feeding type, components of power thresher. Cleaning unit - Aspirator, blower, winnower, winnowing fan, cylinder adjustment. Wheat thresher, groundnut thresher, and terminology connected with power thresher. Development of the binder and development of the combine.

UNIT-IV

Harvesters, advantages and disadvantages of combines. Types of combines – Tractor drawn and self-propelled combines. Functions performed by a combine, cutting mechanism.

Threshing harvesting equipment - Types of corn pickers, snappers, picker husker, Picker Sheller, power transmission, gathering and snapping mechanism, conveying and elevating mechanism. Husking mechanism, shelling mechanism, factors affecting performance of corn pickers, safety rules for operating corn pickers. Root crop harvesting equipment – Groundnut harvester, groundnut diggers, digger operation and adjustments, groundnut shakers, groundnut threshers and pickers, groundnut combines different units and its operation. Potato harvesters – Harvesting methods and equipment, one-row harvester, two-row harvester, digging and soil separation, vine removal by harvesters, separation of stones and clods.

UNIT-V

Cotton harvesting equipment – Cotton stripper, types of cotton strippers, factors affecting the performance of the cotton strippers, plant characteristics (thickness of plants), conveying system. Cotton pickers – Types of pickers, drum type and chain belt spindle arrangements in cotton pickers, methods of mounting spindles, doffing of the cotton, conveying systems, working, factors affecting performance of cotton pickers. Sugarcane harvesters – Self-propelled sugarcane harvester, cleaning, conveying and special sugarcane wagon. Principles of fruit harvesting tools and machines – Harvesting methods, manual harvesters, hold on and twist type, horticultural tools and gadgets. Testing of farm machine - Introduction, standardization efforts, testing programme and procedure, type of testing systems, national testing, prototype testing, testing for quality marketing.

TEXTBOOKS

1. Principals of Farm Machinery. Kepner R.A., Bainer R and Barger E.L, 1987. CBS Publishers and Distributors, Delhi.
2. Engineering principles of Agricultural machines, Ajith K Srivatsava, Carrol E. Goering, Roger P Rohrbach, 1993, ASAE Publishers.

REFERENCE BOOKS

1. Pesticide Application Equipment. Bindra O S and Hari Charansingh, 1971. Oxford and IBH Publishing Co. Ltd, New Delhi.
2. Farm Machinery and Equipment. Smith H P, 1971. Tata McGraw-Hills Publishing Co., Ltd.,New Delhi.
3. Testing and Evaluation of Agricultural Machinery. Mehta M L, Verma S R, Misra S K and Sharma V K, Daya Publishing House, New Delhi.

Course Outcome

Upon successful completion of this course, learner will be able to

CO1: Describe crop harvesting machinery
CO2: Analyze the power operated vertical conveyer reapers
CO3: Apply the threshing principles for all types of threshers
CO4: Analyze the factors affecting the harvesters
CO5: Explain the features of cotton harvesting equipment

III Year - II Semester	POST-HARVEST ENGINEERING OF CEREALS, PULSES AND OILSEEDS	L	T	P	C
		3	0	0	3

Objective: To enable the students to acquire knowledge and skills on cleaning and grading, aspiration, scalping, size separators, screens, sieve analysis, capacity and effectiveness of screens, milling of rice, milling of wheat, unit operations and equipment, milling of pulses - traditional milling methods, commercial methods, pre-conditioning, dry milling and wet milling methods, CFTRI and Pantnagar methods.

UNIT-I

Cleaning and grading, aspiration, scalping. Cleaning and separation – Definition, objectives, requirements, contaminants in raw materials, characteristics for separation, screening, screen openings, aperture, screening equipment classification, screen interval, screen series, comparison of actual and ideal screens, material balance over screens, sieve analysis, capacity and effectiveness of screens. Cleaning and separation equipment – Separation based on size (fixed aperture and variable aperture), shape, pneumatic separation, specific gravity separation, separation based on surface texture, cyclone, shape graders, colour sorting. Air screen cleaner – Design considerations of air screen cleaner.

UNIT-II

Rice milling – Definition, terminology related to rice. Rice processing – modern rice milling flowchart, layout of modern rice mill. Parboiling of paddy – Introduction, advantages, disadvantages, process variables, changes in chemical constituents. Parboiling – Starch gelatinization methods, parboiling operations, parboiling methods (traditional and modern), drying equipment. Rice husk and rice bran utilization – Commercial products and food products processing, uses of bran, instability of bran, stabilization of rice bran, factors affection rate of formation of FFA. Rice milling – Terminology. Milling equipment – Engelberg huller, centrifugal sheller, under-runner disk husker, rubber roll sheller, husking action of rubber rolls, paddy separator (Satake type, Schule type), whiteners (Schele type, Satake type), rice grader. Rice processed food products – Introduction, manufacture process of rice noodles, puffed rice, oven puffed rice and pressure puffed rice, flaked and extruded products. Stabilization of rice bran.

UNIT-III

Maize shelling and milling – Maize shellers (spring type, cylinder type). Dry milling – Cleaning, conditioning, degerming, reduction, classifying. Wet milling – Flow chart, cleaning, steeping, degerming, germ separation, germ oil, refining of oils, separation of hulls and fiber, gluten-starch separation. Extrusion cooking - Principle, factors affecting, single and twin-screw extruders.

UNIT-IV

Wheat milling – Introduction, dry milling, unit operations (selection, blending, cleaning, conditioning/tempering, grinding/milling), Flour grades. Wet milling – Process.

UNIT-V

Milling of pulses – Introduction, composition and structure, important unit operations in pulse milling – cleaning, conditioning, dehusking and splitting, polishing of dhal and grading of dhal. Dry milling and wet milling methods - CFTRI and Pantnagar methods. Red gram – Process technology (methods) flow charts, equipment. Black gram and green gram process technology, flowcharts, equipment. Oilseed processing – Importance, concepts, oil expression and oil extraction, mechanical expression devices, hydraulic press, flow chart, screw press expeller configuration, radial and axial pressure in a barrel. Solvent extraction methods, batch immersion type, percolation type, continuous solvent extraction system, counter current extractor both mechanical and by solvent extraction. Refining of oil.

TEXTBOOKS

1. Chakraverty, A, Post Harvest Technology of cereals, pulses and oilseeds. Oxford & IBH Publishing Co. Ltd, New Delhi.
2. Dash S K, Bebartta J P and Kar A, Rice Processing and Allied Operations. Kalyani Publishers, New Delhi.

REFERENCE BOOKS

1. Earle R L, 2003. Unit Operations in Food Processing. Pergamon Press. Oxford, U.K.
2. Henderson S M, and Perry R L, Agricultural Process Engineering, Chapman and hall, London.
3. McCabe, W L, Smith J C and Harriott P, Unit Operations of Chemical Engineering. McGraw-Hill.
4. Singh R Paul and Heldman R Dennis, 2004. Introduction to Food Engineering, 3rd Edition. Academic Press, London.

Course Outcome

CO1: Apply principles of separation of agricultural product
CO2: Explain the processing of rice, wheat and maize
CO3: Apply the principles of milling pulses and oilseeds
CO4: Use CFTRI and Jadavpur methods for parboiling practices

III Year - II Semester	**FOOD PACKAGING TECHNOLOGY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Objective: To provide knowledge on factors influencing spoilage of foods, packaging systems, different packaging materials, packaging equipment and packaging technology.

UNIT-I

Introduction to food packaging – Packaging situation in world and in India, definition of packaging - package, packaging, packing - need of packaging food, logistics, merchandising outlets, handling, transportation, packaging machinery, technology upgradation, public distribution, cost effective packaging, levels of packaging, functions of packaging, packaging environments, functions/environment grid.

UNIT-II

Shelf-life of processed foods: Factors influencing shelf-life of food products, package environment, hazards of distribution – mechanical, climatic and other hazards - and general principles of control of spoilage agents, packaging laws and regulations, FSSAI packaging and labeling regulations.

UNIT-III

Packaging materials – Classification of packages. Paper as packaging material - Types of paper, kraft paper, bleached paper, grease proof paper, glassine paper, vegetable parchment waxed paper, paper boards, paper board grades, folding cartons, kinds of carton boxes, beverage cartons, molded pulp containers, printing and varnishing, die cutting and creasing, gluing and sealing. Glass as package material - Composition of glass, parts of glass container closures, parts of closures, types of closures, properties of glass, internal pressure resistance, vertical load Strength, resistance to impact, resistance to scratches and abrasions. Glass manufacture - Press and blow, narrow neck press and blow, shape of glass container. Improvements in glass manufacturing - Hot and cold end treatment of surface. Inspection of glass bottles, advantages and disadvantages. Metal as packaging material – Introduction, manufacture of tin plate, tin plating manufacture of ECCS, manufacture of aluminium, advantages and disadvantages.

UNIT-IV

Packaging of milk and milk products - Packaging of fruits and vegetables, meat, fish and poultry, bakery and confectionary products, protein rich foods, packaging of edible starches and starch products, oils and fats, food grains and food grain products, sugar and honey, stimulant foods, alcoholic drinks and carbonated beverages, spices and condiments. Packaging of biscuits, milk powder, coffee, carbonated soft drink, fried snack foods. Package testing – Thickness, paper density, basis weight, grammage, burst strength, tear resistance, tensile strength, grease resistance, gas transmission rate, water vapour transmission rate.

UNIT-V

Container making processes - End manufacture, three piece can manufacture, welded side seams, soldered side seams, double seaming, two piece can manufacture, D&I cans, DRD cans, protective and decorative coatings. Aluminium foils and containers – Tube, retort pouch. Plastic consumption in India and world. Plastic packaging material - Classification of plastics, advantages and disadvantages polyethylene, low density polyethylene, linear low-density polyethylene, high density polyethylene, polypropylene, polystyrene, polycarbonate, polyvinyl chloride, polyvinylidene chloride, ethylene vinyl alcohol. Polyethylene terephthalate coating – Laminating and coating process.

TEXTBOOKS

1. Food Packing Technology by Richard Coles and Mark J Kirwan, Wiley Blackwell Publishing. 2nd Edition. 2011
2. In-pack Processed Food by P Richardson, Woolhead Publishing, 1st Edition, 2008.

REFERENCE BOOKS

1. Food Packaging Principles and Practices by Gordon L. Robertson, CRC Press, 3rd Edition, 2013.
2. Recent Innovation in Barrier Technology for Plastic Packaging, A Review by Jacob L. Packaging Technology and Sciences, 2003.
3. New Concept in Dairy Packaging by Varghes S and Goyal G K, Beverages

Course Outcome

Upon successful completion of this course, learner will be able to

CO1: Apply principles of packaging for cost effective packaging
CO2: Estimate the Shelf-life of processed foods
CO3: Describe different types of packaging materials
CO4: Analyze the different techniques used for packaging of milk, fruits and meat.
CO5: Explain various container making processes

III Year - II Semester	WATERSHED MANAGEMENT	L	T	P	C
		3	0	0	3

Objectives: To train the students in the multi-disciplinary subject of watershed management for effective conservation of land, using engineering and agronomic practices, control of soil loss in watershed participatory management teams in small as well as large watersheds for increasing the productivity and preparation of necessary proposals.

UNIT-I

Watershed – Introduction and characteristics. Watershed development – Problems and prospects, investigation, topographical survey, soil characteristics, vegetative cover, present land use practices and socio-economic factors.

UNIT-II

Watershed management – Concept, objectives, factors affecting, watershed planning based on land capability classes, hydrologic data for watershed planning, watershed codification, delineation and prioritization of watersheds, sediment yield index. Water budgeting in a watershed.

UNIT-III

Management measures – Rainwater conservation technologies, in-situ and ex-situ storage, water harvesting and recycling. Dry farming techniques – Inter-terrace and inter-bund land management.

Integrated watershed management – Concept, components, arable lands – agriculture and horticulture, non-arable lands – forestry, fishery and animal husbandry.

UNIT-IV

Effect of cropping systems, land management and cultural practices on watershed hydrology. Watershed programme – Execution, follow-up practices, maintenance, monitoring and evaluation.

UNIT-V

Participatory watershed management – Role of watershed associations, user groups and self-help groups. Planning and formulation of project proposal for watershed management programme including cost-benefit analysis.

TEXTBOOKS

1. Ghanshyam Das. 2008. Hydrology and Soil Conservation Engineering: Including Watershed Management. 2nd Edition, Prentice-Hall of India Learning Pvt. Ltd., New Delhi.
2. Katyal J C, R P Singh, Shriniwas Sharma, S K Das, M V Padmanabhan and

P K Mishra. Field 1995.

REFERENCE BOOKS

1. Singh G D and T C Poonia. 2003. Fundamentals of Watershed Management Technology. Yash Publishing House, Bikaner.
2. Singh P K, 2000. Watershed Management: Design and Practices. E-media Publications, Udaipur.
3. Singh, R.V. 2000. Watershed Planning and Management. Yash Publishing House, Bikaner.
4. Tideman, E.M. 1999. Watershed Management: Guidelines for Indian Conditions. OmegaScientific Publishers, New Delhi.

Course Outcome

Upon successful completion of this course, learner will be able to

CO1: Plan for watershed development

CO2: Analyze the factors affecting the watershed management

CO3: Explain rainwater conservation technologies

CO4: Estimate the effect of cropping systems, land management and cultural practices on watershed hydrology

CO5: Prepare project proposal for watershed management programme including cost-benefit analysis

III Year - II Semester	**HUMAN ENGINEERING AND SAFETY**	**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**

Objective: To enable the students to study of human relation with environmental factors, study of anthropometry study of safety gadgets for spraying, chaff cutting and tractor and trailer operator.

UNIT-I

Introduction to human engineering and safety - Human factors, machine factors, environmental factors,relationship between the three; study of human machine model, human performance, effectors and senses, importance of FMJ (Fitting Man Job) and FJM (Fitting Job Man). Study of anthropometrics in designs - Workspace design for standing and seated workers. Tasks requirements – Visual requirements and postural requirements.

UNIT-II

Functions of the skeletal and muscular systems - Conditions for the static equilibrium for the human body, the muscle function and types of muscle fatigue and discomfort. Factors influencing the work posture.

UNIT-III

Design of hand tools - Biometrics and energy for muscle contraction, oxygen dependent and oxygen independent system, CO_2 consumption, importance of cardio muscular system and respiratory system in physical work handling, difference between static and dynamic works.

UNIT-IV

Physical work capacity - Factors affecting the work capacity, introduction, work capacity personal factors - age and sex. Environmental factors - Light and climate. Indirect measures of energy expenditure, calculation of rest periods in manual work. Safety - Different machines and measures taken for the protection, vision - importance of vision, measures taken for the protection of the vision, guidelines for using colour combinations.

UNIT-V

Noise and vibration - Measurement of sound, the nature of sound, damages due to noise, preventive measures, displacer, types of displace, visual displace, audio signals, communication, noise communication, audio warning cues. Advance effects of air pollution - Safety regulation acts during field operations, safety measures. Rehabilitation and compensation to accident victims, human information processing, skill and performance, general model of human information processing, memory storage, short-term and long-term storages, feedback information, design of hand tools for agricultural operations.

TEXTBOOKS

1. Work Study and Ergonomics, Dalela S and Saurabh 1995, Standard Publishers and Distributors, New Delhi.
2. New Horizons I - Human Factor Design, Huckingson 1992. McGraw-Hill Book Co., New Delhi.
3. Human Factors Engineering, McCormick E J 1992. McGraw-Hill Book Co., New Delhi.

REFERENCE BOOKS

1. Human Factors in Engineering and Design, Sanders M S and McCormick E J, 1992. McGraw-Hill Book Co., New Delhi.
2. Anthropometric Methods: Designing to Fit the Human Body by John A. Roebuck Jr. 1996. HFES Publications.
3. Anthropometric Sourcebook (1978). NASA Reference Publication No. 1024, Houston TX: NASA (NTIS, Springfield, VA 22161, Order No. 79 11734).

Course Outcome

Upon successful completion of this course, learner will be able to

CO1: Design workspace for standing and seated workers

CO2: Interpret the functions of the skeletal and muscular systems

CO3: Apply biometrics and energy for muscle contraction for the design of hand tools

CO4: Estimate the physical work capacity

CO5: Calculate sound, the nature of sound, damages due to noise

III Year - II Semester	IRRIGATION AND DRAINAGE ENGINEERING	L	T	P	C
		2	0	0	2

Objective: To impose skills to students on surface and sub-surface drainage system, their concepts of design and keynotes for problem soils in irrigated agriculture.

UNIT-I

Introduction irrigation engineering, advantages of irrigation, necessity and development of irrigation in India and AP and classification of irrigation projects. Irrigation terminology - GCA, CCA, Base period, crop period, delta, duty, relationship between duty and delta. Introduction to soil-water plant relationships, soil physical properties such as soil texture, soil structure, capillary conductivity, soil consistency-volume-mass relationships of soil constituents. Water relations with soil - Kinds of soil water-hygroscopic, capillary and gravitational movement of water into soils. Infiltration - Factors affecting infiltration, procedure for measurement of infiltration rate and development of infiltration equations (Kostia-Kov equations, Huston equations, curve fitting). Soil moisture characteristic curves, difference between soil moisture stress and soil moisture tension, soil moisture constants such as saturation capacity, field capacity moisture equivalent and permanent wilting point. Terminology related with movement of water within soils-water intake, percolation, interflow, seepage, permeability, hydraulic conductivity and hydraulic gradient- Measurement of soil moisture by different methods, evaporation, transpiration and evapo-transpiration- Estimation by Blaney-Criddle, Thornthwaite, Penman and modified Penman equations only- Potential ET. Water requirements of crops importance of water in plant growth, procedures net irrigation requirement (depth of irrigation), gross irrigation requirement, irrigation frequency and Irrigation efficiency (conveyance, application, storage, distribution, water use efficiency) with few numerical examples,

UNIT-II

Gravity water application methods - Classification, border irrigation, components of border irrigation - width, length and slope for different soils for different soils. Hydraulics of border irrigation (advance curve, recession curve and opportunity time through time and distance curve), design of border irrigation. Derivation of Israelson's equation for the width of the border furrow irrigation system, advantages and disadvantages, determination of infiltration depth in furrows by inflow-outflow method (steam size, distance advance time, CS area and wetted perimeter data problem on computation of infiltration depth). Check basin irrigation – Advantages and disadvantages, estimation of infiltration under check basin conditions, adaptability and design considerations. Surge irrigation - Concepts, parameters, infiltration, hydraulics, efficiency anddistribution uniformity.

UNIT-III

Conveyance of irrigation water - Methods assessment of design capacity of irrigation channels. Design of irrigation canals using Lacey's and Kennedy's theories and problems. Measurement of irrigation water-units of measurements, methods of measurement, direct and indirect methods, measurement of velocity using current meter-indirect methods such as area velocity method and coordinate method for measuring discharges form pipes, dethridge meter, tracer method. Direct methods of measurement of discharges - Different devices such as weirs, flumes and notches and their installation procedures, equations for rectangular triangular and trapezoidal notches, explanation on RBC flumes (critical flow flumes). Underground pipe lines for irrigation water distribution, types of pipes used for underground pipe lines, testing of pipes for its water absorption and pressure requirements, estimating the discharge capacity of pipe lines, installation procedures of underground pipe lines and study of different structuresassociated with underground pipe lines.

UNIT-IV

Drainage - Definition, objective and types, familiarization with the drainage problems (twin problems of water logging and salinity) and extent of areas in irrigated areas in the state. Surface drainage - Effects of poor drainage, areas requiring drainage, factors affecting drainage requirement, drainage coefficient, determination of drainage coefficient based on different criteria. Types of surface drainage - Random field drain system, bedding system, parallel field drain, parallel lateral open ditch, cross slope drain system interception system, design of open drainage channels using Manning's equation and alignment of open ditches (radius of curvature), investigations on design parameters, hydraulic conductivity, drainable porosity fluctuations of depths to water table in the areas, methods of determining hydraulic conductivity - single auger hole method and inverse auger hole. Sub-surface drainage systems, purpose and benefits, types of sub surface systems, tile drains, mole drains, drainage wells, deep open drains and combinations and their suitability for different conditions and limitations.

UNIT-V

Components of sub-surface drainage system. Layouts and types – Random type herring bone, grid iron cutoff or interceptor drains, depth and spacing of drains, size of the pipe drains using Manning's equation, drain materials of burnt clay. Perforated corrugated and solid PVC and cement concrete, slope/grade for the drains, Envelope materials for sub-surface drains and selection criteria for uniform soils and graded soils, geo-textile and nylon mesh, outlets for sub surface drainage, gravity and pumped outlets. Design of sub surface drains under steady state (equilibrium) conditions and derivation of Hooghoudt's equation for spacing, the Ernst's derivation for drain spacing, Glover-Dumm equation (only) for spacing under non-steady state conditions of water table, drainage structures, loads on conduits, ditch conduit conditions and projecting conduit conditions, construction and installation of drains, bio-drainage, vertical drainage and drainage of irrigated and humid areas, salt balance, classification and reclamation of saline and alkaline soils, soil amendments, leaching requirement-leaching ratio. Economic aspects of drainage with a typical example for total

cost estimation of SSD system and benefit-cost ratio.

TEXTBOOKS

1. Irrigation Engineering, Muzumdar S K, 1983, Tata - McGraw-Hill Publishing. Co. Ltd, NewDelhi.
2. Irrigation Theory and Practice, Michael A M, 2008, Vikas Publishing House, New Delhi.

REFERENCE BOOKS

1. Drainage Engineering, Luthin J M, 1970, Wiley Eastern Ltd, New Delhi.
2. Soil and Water Conservation Engineering, Schwab G O, Frevert R K, Edminister T W and Barner K K, 1981, John-Wiley and Sons, New Delhi.
3. Land and Water management Engineering, Murthy V V N, 2004, Kalyani Publishers, New Delhi.

Course Outcome

At the end of the course, student will be able to

CO1: Explain the terminology related to Irrigation and calculate soil moisture by different methods

CO2: Determine infiltration under check basin conditions and adaptability

CO3: Design irrigation canals using Lacey's and Kennedy's theories

CO4: Describe the factors affecting drainage requirement, drainage coefficient based on the given criteria

CO5: Design subsurface drains under steady state conditions

III Year - II Semester	PRODUCTION TECHNOLOGY OF AGRICULTURAL MACHINERY	L	T	P	C
		2	0	0	2

Objective: To enable the students to understand the different processes and machinery involved in manufacturing the agricultural machines and to acquire knowledge on CNC tooling, turning tools, milling tools, drilling tools, finishing tools. To know the industrial lay out, planning, organization, administration and management.

UNIT-I

Critical appraisal in production of agricultural machinery - Stresses in machine elements working stresses-stress analysis of machine parts by using standard software. Cutting tools including CNC tools and finishing tools-High speed steel cutting tools, cemented carbides, coated carbides, ceramics, drillingtools, types of drill bits, milling cutters.

UNIT-II

CNC tooling - Turning tools, milling tools, drilling tools, finishing tools associated with tool turrets, different types of tools used in CNC machining centers – vertical anis machining centers – twin turret tuning centre. CNC turning centers – Multiple spindles turning centers, integrated material handling.

UNIT-III

Powder metallurgy - Introduction, powder metallurgy process, preparation of metal powders. Characteristics of metal powders – Mixing compacting, sintering, hot pressing, applications of powder metallurgy. Limits fits and tolerances – Limits and fits compound tolerances, conditions for the success of any system of limits and fits, terms and definitions.

UNIT-IV

Jigs and fixtures – Jigs, fixtures, differences between jigs and fixtures, advantages of jigs and fixtures, essential features of jigs and fixtures. General rules for designing jigs and fixtures. Different types of jigs and types of fixtures. Controllers – CNC controlling for machine tools – motion control systems, pointto point control system, continuous path control system. CNC controlling for machine tools absolute incremental control system – open loop and closed loop system.

UNIT-V

Machine control unit – Introduction, configuration of machine control unit. Distributed numerical control, introduction and configuration. CNC part programming – Part programming fundamentals, manual part programming methods. CNC part programming – Interpretation of G codes, computer assisted part programming types, quality of good

industrial management. Advantages of good organization – Economic order quantity, site selection of a factory, general location of a factory, plant lay out. Selection of stander and critical components for manufacturing agricultural machines. Case studies of manufacturing of agricultural machinery.

TEXTBOOKS

1. CAD/CAM: Principles and Applications, Rao P N, 2004, McGraw-Hill Education India, New Delhi.
2. Engineering Metrology, Jain R K, Khanna Publishers, New Delhi.

REFERENCEBOOKS

1. Industrial Organization and Engineering, Banga T.R. and Sharam S C, 2004, Khanna Publishers, New Delhi.
2. Mechanisms and Machine Theory, Rao J.S. and Dukkipatti R.V., 1990, Wiley Astern Ltd, New Delhi.
3. Theory of Mechanisms and Machines, Jagdish Lal, 191, Metropolitan Book Co. Pvt. Ltd, New Delhi.

Course Outcome

At the end of the course, student will be able to

CO1: Choose appropriate cutting tool material for a given application
CO2: Explain CNC tooling
CO3: Calculate limits, fits and tolerances
CO4: Apply the relevant motion control system of CNC machine for a given application
CO5: Develop part programme for a given product

III Year - II Semester	DAIRY AND FOOD ENGINEERING	L	T	P	C
		2	0	0	2

Objective: The student knowledge on milk processing and unit operations in dairy processing including offer strength to students to handle pasteurization, sterilization, packaging, etc. of dairy products and control spoilage through process operations such as evaporation, freezing, membrane processing, etc.

UNIT-I

Dairy development in India - Indian dairy industry. Products concentrated whole milk products – Composition, physic-chemical properties of milk, water content, acidity, pH, developed acidity, natural acidity, total acidity, density, specific gravity, freezing point colour and flavor of milk. Unit operations of various diary and food processing systems - Centrifugation, separation, separation by cyclone (application of separation in the dairy industry, velocity of particles in a gravitational field, distribution of fat globule diameters in milk, velocity of particles in a centrifugal field, strength of centrifugal bowl, disc bowl centrifuge, design of centrifuges and methods of application, decanting centrifuge for lactose and casein, cyclones for separation from gas phase).

UNIT-II

Milk receiving – Quantity determination, quality evaluation, clearing and disinfection of transport facilities, milk returns, procedures for reception and returns. Process flow charts for product manufacture – Pasteurized milk, process steps, person method and mass balance method for making balance of cream and fat in making whole milk, butter, cheese, ice cream manufacture, process steps, over run. Pasteurization - Purpose, microorganisms and enzymes and their reaction to temperature and other influences, bacteria in milk, effect of temperature. Pasteurization –Methods of heating, design and mode of operation heating equipment (vat, tubular heat exchanger, plate heat exchanger). Sterilization - UHT method (direct and indirect heating), sterilization in the package (temperature and pressure patterns), equipment for sterilizing goods in the package (batch autoclaves, continuously operating sterilizers). Freezing – Introduction, freezing point curve for food and water, freezing points of common food materials, freezing time calculation by using Plank's equation, types of freezing equipment types of equipment of leaching. Filtration – Ultra-filtration, processing variables, applications or ultra-filtration in milk processing. Reverse osmosis. Membrane separation – Membrane separation methods, gel filtration and on exchange. Thermal processing.

UNIT-III

Homogenization – Emulsifying, types of emulsions, emulsifiers, homogenizing (application, mode of operation, technical execution, effect of the product). Filling and packaging – Packaging of milk, cultured milk, cheese, butter, concentrated milk, products, dried milk

products and packaging materials, filling and metering, packaging methods. Butter manufacture – Principle, treatment of cream, churning, overrun, factors affecting churn ability, methods (butter churn, continuous butter making), butter oil and special butter products (composition, methods of manufacturing, direct evaporation method, decantation, centrifugal separation, vacuum method). Thermal death time curve, reaction kinetics of the heat treatment of milk and its use for the assessment of UHT treatment methods, change in milk produced by heating, Plant utilities requirement – Electricity, water, power. Dairy plant design and layout – Factors in planning, importance of site selection, location of building, size and type of dairy building, advantages of good plant layout, functional design, operating schedule and layout, process selection, floor space, walls and ceiling ventilation, doors, windows, lighting, flooring and drainage.

UNIT-IV

Composition and proximate analysis of food products - Carbohydrates, protein, lipids, minerals, vitamins. Deterioration in products and their controls – Food as a substitute to microorganisms, food preservation methods, principles of food preservation, causes of food spoilage and classification of food with respect to spoilage and consumption. Principles of food preservation, effects of pH and water content on growth of microorganisms, methods of controlling water content, effect of water activity, methods of measuring a oxidation-reduction potential effect on microorganisms, effect of nutrient content and effect of inhibitory substances, biological structures, physical, chemical, and biological methods of food preservation. Change undergone by food components during processing – Changes during heating, evaporation, drying, freezing, juice extraction, filtration and separation.

UNIT-V

Evaporation – Applications, functions, factors affecting rate of evaporation, basic evaporator construction, factors affecting liquid boiling point, thermodynamics of evaporation (phase change, boiling point elevation, Duhring plot, factor influencing the overall heat transfer coefficient, influence of feed liquor properties on evaporation, factors influencing the economy of evaporation, types of evaporation equipment. Natural circulation evaporators – Batch type, horizontal short-tube, vertical short tube, natural circulation with external calendria, long tube, forced circulation (general forced circulation, plate, expanding flow, mechanical/agitated thin film). Drying – Drying methods (radiation, dielectric, spray, foam, spray, roller, fluidized bed, freeze).

TEXTBOOKS

1. Food Engineering and Dairy Technology, Kessler H G 1981. Verlag A. Kessler, Freising.
2. Outlines of Dairy Technology, Sukumar De 2005. Oxford University Press, New Delhi

REFERENCE BOOKS

1. Principles of Food Science, Fennema O R 2006. Marcel Dekkar Inc., New York.

2. Food Science, Chemistry and Experimental Foods, Swaminathan M, 2006. The Bangalore Printing & Publishing Co., Ltd, Bangalore

Course Outcome

At the end of the course, student will be able to

CO1: Estimate the physical and chemical properties of milk, water content, acidity, pH, developedacidity

CO2: Analyze the parameters that influence pasteurization

CO3: Describe emulsification and types of emulsions

CO4: Estimate the carbohydrates, protein, lipids, minerals, vitamins in food product

CO5: Analyze the factors influencing rate of evaporation, thermodynamics of evaporation, circulationin evaporators

III Year - II Semester	**FARM MACHINERY AND EQUIPMENT - II LAB**	**L**	**T**	**P**	**C**
		0	**0**	**2**	**1**

Objective: To enable the student to get the practical knowledge on various operation in agricultural field for crop production.

Practical

1. Introduction to different systems of CI engines
2. Engine parts and functions, working principles etc.
3. Valve system – study, construction and adjustments
4. Oil & Fuel – determination of physical properties
5. Air cleaning system; Fuel supply system of SI engine
6. Diesel injection system & timing;
7. Cooling system, and fan performance, thermostat and radiator performance evaluation
8. Part load efficiencies and governing
9. Lubricating system and adjustments
10. Starting and electrical system; Ignition system
11. Tractor engine heat balance and engine performance curves
12. Visit to engine manufacturer/ assembler/ spare parts agency

TEXTBOOKS

1. Principles of Farm Machinery. Kepner R.A., Bainer, R and Barger E.L., 1987. CBS Publishers and Distributors, Delhi.
2. Elements of Agricultural Engineering. Jagadeshwar Sahay. 1992. Agro Book Agency, Patna.

REFERENCE BOOKS

1. Farm Machinery. Stone A A, 1958. John Wiley and Sons. New York.
2. Farm Machinery and Equipment. Smith H P, 1971. Tata Mc Graw-Hills. Publishing Co. Ltd, New Delhi.
3. Principals of Agricultural Engineering, Vol. I. Michael A M and Ohja T P 1985. Jain Brothers, New Delhi.
4. Land Reclamation Machinery. Borshahov Mansurov Sergecv 1988 Mir Publishers, Moscow.

Course Outcome

1. Study various implements and functional element
2. Evaluate field efficiencies and fuel efficiencies
3. Evaluate performance of various agricultural implements and machines
4. Design and calibrate seed drills and matching mechanism

III Year - II Semester	POST-HARVEST ENGINEERING FOR CEREALS, PULSES AND OILSEEDS LAB	L	T	P	C
		0		2	1

Objective: To enable the students to acquire knowledge and skills on cleaning and grading, aspiration, scalping, size separators, screens, sieve analysis, capacity and effectiveness of screens, drying, different methods of drying, batch-continuous; mixing, non-mixing, sun, mechanical, conduction, convection, radiation, superheated steam, tempering during drying.

Practical

1. Performance evaluation of different types of cleaners and separators
2. Determination of separation efficiency
3. Study of different size reduction machines and performance evaluation
4. Determination of fineness modulus and uniformity index
5. Study of different types of conveying and elevating equipment
6. Study of different types of mixers
7. Measurement of moisture content: dry basis and wet basis
8. Study on drying characteristics of grains and determination of drying constant
9. Determination of EMC (Static and dynamic method)
10. Study of various types of dryers
11. Study of different equipment in rice mills and their performance evaluation
12. Study of different equipment in pulse mills and their performance evaluation
13. Study of different equipment in oil mills and their performance evaluation,
14. Type of process flow charts with examples relating to processing of cereals pulses and oilseeds
15. Visit to grain processing industries.

TEXTBOOKS

1. Chakraverty A Post Harvest Technology of cereals, pulses and oilseeds. Oxford & IBH Publishing Co. Ltd., New Delhi.
2. Dash, S.K., Bebartta, J.P. and Kar, A. Rice Processing and Allied Operations. KalyaniPublishers, New Delhi.

REFERENCE BOOKS

1. Earle R L, 2003. Unit Operations in Food Processing. Pergamon Press. Oxford. U.K.
2. Henderson S M, and Perry R L, Agricultural Process Engineering, Chapman and Hall, London
3. McCabe W L, Smith J C and Harriott P, Unit Operations of Chemical Engineering. McGraw-Hill.
4. Singh R Paul and Heldman R Dennis. 2004. Introduction to Food Engineering. 3rd Edition, Academic Press, London.

III Year - II Semester	COMPUTATIONAL FLUID DYNAMICS WITH FLUENT	L	T	P	C
		0	1	2	2

Objective:

1. To explain elementary details and numerical techniques for solving various engineering problemsinvolving fluid flow
2. To study about finite difference applications in heat conduction and convection
3. To use finite difference for flow modeling
4. To understand the concepts of finite volume method
5. To understand the concepts of finite element method applied to heat transfer problems

UNIT-I

Review of equations governing fluid flow and heat transfer - Introduction, conservation of mass, Newton's second law of motion, expanded forms of Navier-Stokes equations (Derivation), conservation of energy principle, and special forms of the Navier-Stokes equations.

Applied numerical methods. Solution of a system of simultaneous linear algebraic equations, iterative schemes of matrix inversion, direct methods for matrix inversion, direct methods for banded matrices, TDMA – Algorithms.

UNIT-II

Finite difference applications - Steady flow, dimensionless form of momentum and energy equations, stokes equation, conservative body force fields, stream function, vorticity formulation. Finite difference applications in heat conduction and convection – Heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer, closure.

UNIT-III

Finite difference for flow modeling - Discretization, consistency, stability and fundamentals of fluid flow modelling: introduction, elementary finite difference quotients, implementation aspects of finite-difference equations, consistency, explicit and implicit methods.

UNIT-IV

Fluid flow modeling - Introduction to first order wave equation, stability of hyperbolic and elliptic equations, fundamentals of fluid flow modelling, conservative property, the upwind scheme. Finite volume method - Approximation of surface integrals, volume integrals, interpolation and differentiation practices, upwind interpolation, linear interpolation and quadratic interpolation.

UNIT-V

Finite element methods – Introduction, weighted residual and variational formulations, Rayleigh-Ritz method, interpolation, One-dimensional and two-dimensional regions, Error control, applications of FEM to one dimensional problems (steady and transient), two dimensional problems.

TEXTBOOKS

1. Numerical Heat Transfer and Fluid Flow, Suhas V Patankar, Butter-Worth Publishers
2. Computational Fluid Dynamics - Basics with Applications, John D Anderson, McGraw-Hill.

REFERENCE BOOKS

1. Computational Fluid Flow and Heat Transfer, Niyogi, Pearson Publications
2. Introduction to CFD: Finite Volume Method, H Versteeg and W Malalasekahara
3. Fundamentals of Computational Fluid Dynamics, Tapan K Sengupta, Universities Press.
4. Computational Fluid Dynamics: An Introduction, 3rd Edition, John F Wendt, Springer publishers

Course Outcome

At the end of the course, student will be able to

CO1: Explain elementary details and numerical techniques for solving various engineering problems involving fluid flow

CO2: Study about finite difference applications in heat conduction and convection

CO3: Apply finite difference for flow modeling

CO4: Understand the concepts of finite volume method

CO5: Understand the concepts of finite element method applied to heat transfer problems