Courses Related to

Farm Machinery and Power Engineering

for

Master Degree Programme

Dept. of Farm Machinery and Power Engineering

Faculty of Agricultural Engineering

Bidhan Chandra Krishi Viswavidyalaya

Mohanpur, Nadia, West Bengal

Course Credit Structure, Master Degree Program, BCKV

Sl. No.	Course Work	Master's Programme
I	Major Subject	20
II	Minor Subject	08
III	Supporting Subject	06
IV	Common Courses	05
V	Seminar	01
VI	Thesis	30
	TOTAL	**70**

Course Contents for

M.Tech. in Farm Machinery and Power Engineering

Semester – I		
Courses Code	**Course Title**	**Credit Hours (L + P)**
FMPE-501	Soil Dynamics in Tillage and Traction	2+1
FMPE-502	Testing and Evaluation of Agricultural Equipment	2+1
FMPE-505	Design of Farm Machinery- I	3+0
STAT-502	Statistical Methods for Applied Sciences	3+1
CC-502	Intellectual Property and its management in Agriculture	1+0

Semester – II		
Courses Code	**Course Title**	**Credit Hours (L + P)**
FMPE-503	Ergonomics and Safety in Farm Operations	2+1
FMPE-504	Design of Tractor Systems	2+1
FMPE-506	Design of Farm Machinery- II	1+1
CSE-501	Big Data Analytics	2+1
CSE-505	Database Management System	2+1
CC-502	Basic Concepts in Laboratory Techniques	0+1

Course Contents for

M.Tech. in Farm Machinery and Power Engineering

Semester – III		
Courses Code	**Course Title**	**Credit Hours (L + P)**
FMPE-507	Management of Farm Power and Machinery System	2+1
CSE-502	Artificial Intelligence	2+1
STAT-511	Experimental Designs	2+1
CC-503	Library and Information Services	0+1
CC-504	Technical Writing and Communication Skills	0+1
CC-505	Agricultural Research, Research Ethics and Rural Development Programmes	1+0

Semester – IV		
Courses Code	**Course Title**	**Credit Hours (L + P)**
FMPE-591	Master's Seminar	0+1
FMPE-599	Master's Research	0+30

Syllabus for

M.Tech. in Farm Machinery and Power Engineering

I. Course Title : Soil Dynamics in Tillage and Traction

II. Course Code : FMPE 501

III. Credit Hours : 2+1

IV. Aim of the course

To have an understanding of the principles of soil mechanics as applied to interaction of tillage tools and traction devices with soil in terms of soil forces and deformation during for soil cutting and generation of traction.

V. Theory

Unit I

Characterization of state of stress in a point: Derivation, representation by Mohr's Circle. Coulomb's law of friction and cohesion. Measurement of soil resistance properties: Direct shear box, torsion shear apparatus, tri-axial apparatus. Soil behaviour considerations: Soil water pressure and movement. Critical state soil mechanics: Soil stress-strain behaviour, shear rate effects.

Unit II

Soil cutting forces: The universal earthmoving equation, two dimensional cases, smooth vertical blade, smooth and rough raked blades in cohesive soil, unconstrained tool to soil adhesion. The shape of failure surfaces. Hettiaratchi's calculations, effect of soil weight. Soil cutting force by method of trial wedges.

Unit III

Extension of theory to three dimension: Hettiaratchi, Reece-Godwin and Spoor. Three dimensional wedges: McKyes and Ali, Grisso models. Dynamic effect: Inertial forces, change in soil strength. Concept of critical depth. Complex tool shapes: Curved tools-shank and foot tools-mould board plough. Soil Loosening and manipulation: Measurement of soil loosening and its efficiency. Draft force efficiency: Loosening and pulverization efficiency. Soil mixing and inversion: Soil properties, tool shape, tool speed and tool spacing.

Unit IV

Traction devices: Tyres, type, size, selection mechanics of traction devices. Maximum traction force: Soil deformation and slip, estimation of contact areas. Sinkage in soil: Rolling resistance, Bekker's formulae, McKyes formulae. Soil compaction by agricultural vehicles and machines.

VI. Practical

Measurements of soil shear strength by in-situ shear box apparatus and soil friction by friction plate. Measuring cone penetrometer resistance and working out tractive coefficients for tyres. Measurement of in-situ shear strength of soil by torsional vane shear apparatus. Solving problems on stress in soil. Solving problems on soil

properties. Solving problems of tool forces. Problems on tillage tool forces, wheel slippage, tyre deflection, design and performance of traction devices.

VII. Learning outcome

The student will be able to understand the principles that govern manipulation of soil by tillage tools.

The student will be able to apply the principles of soil mechanics to theoretically calculate the forces on tillage tools during soil cutting and forces generated by tractor wheels.

VIII. Lecture schedule

S.No.	Topic	No of Lectures
1.	**Unit I** Characterization of state of stress in a point: Derivation, representation by Mohr's Circle.	2
2.	Coulomb's law of friction and cohesion.	**1**
3.	Measurement of soil resistance properties: Direct shear box, torsion shear apparatus, tri-axial apparatus.	2
4.	Soil behaviour considerations: Soil water pressure and movement.	1
5.	Critical state soil mechanics: Soil stress-strain behaviour, shear rate effects	2
6.	**Unit II** Soil cutting forces: The universal earthmoving equation, two dimensional cases, smooth vertical blade, smooth and rough raked blades in cohesive soil, unconstrained tool to soil adhesion.	3
7.	The shape of failure surfaces.	2
8.	Hettiaratchi's calculations, effect of soil weight.	2
9.	Soil cutting force by method of trial wedges.	2
10.	**Unit III** Extension of theory to three dimensions: Hettiaratchi, Reece-Godwin and Spoor.	2
11.	Three dimensional wedges: McKyes and Ali, Grisso models. Dynamic effect: Inertial forces, change in soil strength.	2
12.	Concept of critical depth.	1
13.	Complex tool shapes: Curved tools-shank and foot tools-mould board plough.	1
14.	Soil Loosening and manipulation: Measurement of soil loosening and its efficiency.	1
15.	Draft force efficiency: Loosening and pulverization efficiency.	1
16.	Soil mixing and inversion: Soil properties, tool shape, tool speed and tool spacing.	2
17.	**Unit IV** Traction devices: Tyres, type, size, selection mechanics of traction devices.	1
18.	Maximum traction force: Soil deformation and slip, estimation of contact areas.	1
19.	Sinkage in soil: Rolling resistance, Bekker's formulae, McKyes formulae.	2
20.	Soil compaction by agricultural vehicles and machines.	1
		32

IX. List of Practicals

S.No.	Topic	No of Practicals
1.	Measurements of soil shear strength by *in-situ* shear box apparatus and soil friction by friction plate.	3
2.	Measuring cone penetrometer resistance and working out tractive coefficients for tyres.	2
3.	Measurement of *in-situ* shear strength of soil by torsional vane shear apparatus.	1
4.	Solving problems on stress in soil.	2
5.	Solving problems on soil properties.	2
6.	Solving problems of tillage tool forces.	1
7.	Problems on wheel slippage and tyre deflection.	3
8.	Problems on design and performance of traction devices.	1
9.	Practical examination	1
	Total	**16**

X. Suggested Reading

- Gill WR and Van den Berg GE. 1968. *Soil Dynamics in Tillage and Traction.*
- Handbook 316, *Agricultural Research Service*, US Department of Agriculture, Washington DC, 1968.
- John BL, Paul KT, David WS and Makoto H. 2012. *Tractors and their Power Units.* 4th Edition. Springer Science & Business Media, ISBN: 81-239-0501-7, ASAE ISBN: 0-929355-72-5.
- Koolen AJ and Kuipers H. 1983. *Agricultural Soil Mechanics.* Springer-Verlag ISBN 13:978-3-642-69012-9.
- McKyes E. 1989. *Agricultural Engineering Soil Mechanics*, Elsevier science publishers B.V., P.O. Box 211, 1000 AE Amsterdam, the Netherlands.
- McKyes E. 2016. *Soil Cutting and Tillage: Vol 7.* Developments in Agricultural Engineering Elsevier R Science Publisher SBV.

I. Course Title : Testing and Evaluation of Agriculture Equipment

II. Course Code : FMPE 502

III. Credit Hours : 2+1

IV. Aim of the course

To enable the student to learn the procedure for testing of different farm machinery and the concept behind evaluation of different performance parameters of farm machinery and the standards adopted therein.

V. Theory

Unit I

Importance and significance of testing and types of testing. Test equipment, usage and limitations. Test procedures and various test codes: National and International.

Unit II

Laboratory and field testing of tillage and sowing machinery: Sub-soiler, laser land leveler, mould board Plough, disc plough, rotavator, cultivator, disc harrow, seed cum fertilizer drill and planter.

Unit III

Laboratory and field testing of manual and power operated intercultural machinery and plant protection machine.

Unit IV

Laboratory and field testing of reaper, thresher and chaff cutter.

Unit V

Laboratory and field testing of straw combine and combine harvester. Review and interpretation of test reports. Importance and need of standardization of components of agricultural equipment.

VI. Practical

Laboratory and field testing of selected farm equipment: Tillage, sowing and planting. Material testing of critical components. Accelerated testing of fast wearing components.

VII. Learning outcome

The student will be able to test farm machinery, prepare performance reports and also analyze the performance reports to find the suitability of a machinery for a given farm operation.

VIII. Lecture Schedule

S.No	Topic	No. of Lectures
1.	Introduction, various test codes, Test programs, testing terminology, procedures and type of testing systems	2
2.	Study of different types of Dynamometer	2
3.	Stationary diesel engine performance testing	2
4.	Tractor Test Codes and Data Interpretation Estimation of error	2
5.	Testing and evaluation of tillage machinery	2
6.	Testing and evaluation of seed-cum-fertilizers drills/planters	3
7.	Testing and evaluation of manually and power operated Sprayers	3
8.	Testing and evaluation of reapers and straw combines	1
9.	Testing and evaluation of combine harvester and threshers	3
10.	Testing and evaluation of manually and power operated chaff cutters	2
11.	Testing and evaluation of advanced machinery	2
12.	Reliability in Engineering with emphasis on agricultural machinery	2
13.	Discussion on Farm machinery codes	2
14.	Interpretations of the information given in different codes on farm machinery	1
15.	Formulation of test-code for machines that do not have any code.	2
16.	Current topics/discussion	1
	Total	**32**

IX. List of Practicals

S.No.	Topic	No of Practicals
1.	Lab testing of Stationary diesel engine for full load, variable load and governor test	2
2.	Lab Testing and evaluation of seed-cum-fertilizers drills	1
3.	Lab Testing and evaluation of seed-cum-fertilizers planters	1
4.	Lab Testing and evaluation of knapsack Sprayers	1

S.No.	Topic	No of Practicals
5.	Lab Testing and evaluation of nozzles	1
6.	Field testing of rotavators	1
7.	Lab testing of rotavators for soil sample analysis	1
8.	Testing and evaluation of reapers	1
9.	Testing and evaluation of combine harvester and threshers	1
10.	Testing and evaluation of chaff cutters	1
11.	Testing and evaluation of laser land leveler	1
12.	Case study of test reports of different agricultural implements	3
	Total	**15**

X. Suggested Reading

- Barger E L, Liljedahl J B and McKibben E C. 1967. *Tractors and their Power Units*. Eastern Wiley 4th Edition.
- *Indian Standard Codes for Agricultural Implements*. Published by BIS, New Delhi.
- Inns F M. 1986. *Selection, Testing and Evaluation of Agricultural Machines and Equipment*. FAO Service Bull. No.115.
- Mehta M L, Verma S R, Rajan P and Singh S K 2019. *Testing and Evaluation of Agricultural Machinery*. Daya Publishing House, Delhi.
- *Nebraska Tractor Test Code for Testing Tractor*, Nebraska, USA.
- Smith D W, Sims B G and O'Neill D H 2001. *Testing and Evaluation of Agricultural Machinery and Equipment -Principle and Practice*. FAO Agricultural Services Bull. 110.

I. Course Title : Ergonomics and Safety in Farm Operations

II. Course Code : FMPE 503

III. Credit Hours : 2+1

IV. Aim of the course

To understand the principles of the science of Ergonomics and its application to farm machinery in order to reduce drudgery in the use of tools and equipment and also make them safe and comfortable to operate.

V. Theory

Unit I

Description of human-machine systems. Ergonomics and its areas of application in the work system. History of ergonomics. Modern ergonomics.

Unit II

Anthropometry: Its role in daily life, principles in workspace and equipment design, design of manual handling tasks and application in equipment design. Human postures: Postural stress and its role in design of farm machinery.

Unit III

Human factors in tractor seat design: Entry system, controls, shape, colour coding, dial and indicators. Modern technology for comfort in driving places.

Unit IV

Physiological parameters: Psychological and mental stresses and their measurement techniques. Human energy expenditure: Calibration of subjects, human workload and its assessment.

Unit V

Safety considerations and operators protective gadgets in farm operations. Standards/codes for tractors and agricultural machinery safety.

VI. Practical

Identifying role of ergonomics in our daily life. Measurement of anthropometric dimensions of agricultural workers and establishing relationship between them. Determination of human requirements for field operation with manually operated equipment. Assessment of psychological/general load for specific agricultural operations. Calibration of human subject on bicycle ergometer and/ or treadmill for its energy output and physiological parameters like heart rate, oxygen consumption rate under laboratory conditions. Case studies of agricultural accidents and safety measure.

VII. Learning outcome

The student will be able to apply the concepts of ergonomics in the design of agricultural tools and equipment and also evaluate the ergonomic suitability of such equipment.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Introduction to ergonomics, definition of ergonomics	1
2.	Operator- machine-environment system approach	1
3.	Relative advantages of man and machine, ergonomics in daily life	1
4.	Importance of ergonomics in agriculture and farm machinery	1
5.	History of ergonomics, modern ergonomics	1
6.	Man machine environment components, broad objectives of ergonomics	1
7.	Basic issues and processes under ergonomics for design and development of machine	1
8.	Anthropometry and its uses in daily life	1
9.	First hourly examination	1
10.	Principles of applied anthropometry in ergonomics	1
11.	Availability of anthropometric database for Indian agricultural workers	1
12.	Definitions and possible applications of anthropometric dimensions	2
13.	Workspace and equipment design	1
14.	Different modes of force application	1
15.	Design of manual handling tasks	1
16.	Biomechanics aspects in machine design	1
17.	Mid-semester examination	1
18.	Human posture, posture stresses and its role in design of agricultural machinery	1
19.	Work place design for standing and seated workers	2
20.	Human factors in tractor seat design	1
21.	Entry system, controls, shape, colour coding, dial and indicators	1
22.	Modern technology for safety and comfort in driving place	1
23.	Physiological and psychological parameters for ergonomic evaluation	1
24.	Physiological and psychological stresses and measurements techniques	1
25.	Human work load assessment, human energy expenditure	1
26.	Calibration of subjects – concept, importance and techniques	1
27.	Accidents and safety in agriculture operations, general safety guidelines	1
28.	Safety feeding systems for threshers and chaff cutters	1

S.No.	Topic	No. of Lectures
29.	Safety gadgets for tractors and trailers	1
30.	Standard/ codes for agricultural machinery safety	1
	Total	**32**

IX. List of Practicals

S.No.	Topic	No of Practicals
1.	Identify role of ergonomics in our daily life	1
2.	Measurement of anthropometric dimensions of agriculture workers and establishing relation between them	2
3.	Measurement of strength parameters	1
4.	Determination of human requirements of field operation with manual operated equipment	2
5.	Assessment of psychological/ general load for agricultural operations	1
6.	Assessment of stress on eyes by specific agricultural operation	1
7.	Noise measurement in tractors	1
8.	Calibration of human subject on bicycle ergometer	1
9.	Calibration of human subject on treadmill	1
10.	Measurement of physiological parameter, viz. heart/ pulse rate	1
11.	Measurement of oxygen consumption under laboratory conditions	1
12.	Case study of accidents and safety on tractors and trailers	1
13.	Case study of accidents and safety on chaff cutters and threshers	1
14.	Practical examination	1
	Total	**16**

X. Suggested Reading

- Bridger R S 2009. *Introduction to Ergonomics*. CRC Press, Boca Rotan, USA
- Sanders M S and McCormick E J 2000. *Human Factors in Engineering and Design*. McGraw Hill. 7th edition
- Astrand P, Rodahl K, Dahl H A and Stromme S B 2003. *Textbook of Work Physiology - Physiological Basis of Exercise*. McGraw Hill.
- Gite L P 2009. *Anthropometric and Strength Data of Indian Agricultural Workers for Farm Equipment Design*. Central Institute of Agricultural Engineering, Bhopal.
- Gite L P, Agrawal K N, Mehta C R, Potdar R R and Narwariya B S. 2019. *Handbook of Ergonomical Design of Agricultural Tools, Equipment and work Places*. Jain Brothers, New Delhi.

I. Course Title : Design of Tractor Systems

II. Course Code : FMPE 504

III. Credit Hours : 2+1

IV. Aim of the course

To introduce the student to the principles that direct the design of a tractor and its subsystems and enable the student to apply the concept of machine design in designing the subsystems and critical components.

V. Theory

Unit I

Design and types, research, development, design procedure, technical specifications

of tractors, modern trends in tractor design and development, special design features of tractors in relation to Indian agriculture.

Unit II

Engine related terminology. Selection of stroke-bore ratio. Design of engine components; Piston, connecting rod, cylinder, cylinder head, crank shaft etc.

Unit III

Design of tractor systems like clutch, gearbox, steering, steering geometry, turning force, hydraulic system & hitching, chassis, operator's seat, work-place area and controls. Tire selection, aspect ratio etc.

Unit IV

Mechanics of tractor stability. Computer aided design and its application in farm tractors.

VI. Practical

Engine design calculations, transmission component design calculations. Extensive practices on the computer aided design packages.

VII. Learning outcome

The student will have an overview of the philosophy guiding the design of a tractor and also design tractor systems and components.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
	Unit I	
1.	Design and types, research, development, design procedure, technical specifications of tractors, modern trends in tractor design and development, special design features of tractors in relation to Indian agriculture.	3
	Unit II	
2.	Engine related terminology. Selection of stroke-bore ratio.	1
3.	Design of engine components: Piston, connecting rod, cylinder, cylinder head, crank shaft etc.	3
	Unit III	
4.	Design of tractor clutch	2
5.	Design of tractor gearbox	3
6.	Tractor steering system, functional requirements, steering geometry, turning force	2
7.	Steering system design parameters and design procedure	2
8.	Hydraulic system & hitching – principles of operation	2
9.	Hydraulic system - Design parameters and design procedures including design of pump, cylinder etc.	2
10.	Design of chassis	2
11.	Human factors in tractor design. Design of operator's seat	2
12.	Work-place area and controls	2
13.	Tire selection, aspect ratio etc.	1
	Unit IV	
14.	Mechanics of tractor stability. Dynamic and static analysis of forces acting on farm tractor, case studies.	3
15.	Computer aided design and its application in farm tractors	2
	Total	**32**

IX. List of Practicals

S.No.	Practical	No. of Practical
1.	Engine design calculations - Stroke-bore ratio determination - Design of radiator - Balancing of crankshaft	2
2.	Engine design calculations - Calculation of volumetric/thermal efficiencies	1
3.	Transmission component design calculations - Design of clutch	1
4.	Transmission component design calculations - Design of gear box and calculation of speed ratios	2
5.	Design of Ackerman steering. Calculation of turning radius.	1
6.	Design of brakes (mechanical and hydraulic)	2
7.	Design of hydraulic system	2
8.	Calculation for determination of centre of gravity of tractor, moment of inertia and stability	3
9.	Practice on the Computer Aided Design (CAD) packages for design of various components	2
	Total	**16**

X. Suggested Reading

- Barger EL Liljedahl JB and McKibben EC. 1967. *Tractors and their Power Units*. Wiley Eastern Pvt. Ltd.
- Macmillan RH. 2002. *The Mechanics of Tractor – Implement Performance and Worked Example*. University of Melbourne, Australia.
- Sharma PC and Agarwal DK. 2000. *Machine Design*. S K Kataria and Sons, Delhi.

I. Course Title : Design of Farm Machinery I

II. Course Code : FMPE 505

III. Credit Hours : 2+1

IV. Aim of the course

To understand the interaction of tillage tools with soil and design the components of the tillage tools based on their requirement and also to learn how the systems of planting machinery are designed.

V. Theory

Unit I

Farm machinery design: Modern trends, tasks and requirements, economic considerations of durability, reliability and rigidity. Physico-mechanical properties of soils. Technological process of ploughing. Wedge. Working process of mould board plough, determination of basic parameters. Design of coulters, shares, mould boards.

Unit II

Constructing of mould board working surface. Design of landside, frog, jointer. Forces acting on plough bottom and their effect on plough balance: Trailed, semi mounted and mounted plough. Draft on ploughs, resistance during ploughing. Design disk ploughs: Concave disk working tools, forces acting.

Unit III

Machines and implements for surface and inter row tillage; Peg toothed harrow,

disk harrows, rotary hoes, graders, rollers, cultivators. Design of V shaped sweeps. Rigidity of working tools. Rotary machines: Trajectory of motion of rotary tiller tynes, forces acting, power requirement. Machines with working tools executing an oscillatory motion.

Unit IV

Methods of sowing and planting: Machines, agronomic specifications. Sowing inter-tilled crop. Grain hoppers: Seed metering mechanism, furrow openers and seed tubes. Machines for fertilizer application: Discs type broadcasters. Organic fertilizer application: Properties of organic manure, spreading machines. Liquid fertilizer distributors. Planting and transplanting: Paddy transplanters, potato planters.

VI. Practical

Design of mould board working surface; Coulter, frog, share, jointer, mould board plough. Trailed, semi mounted and mounted ploughs. Design of disc plough, disc harrow, peg tooth harrow, cultivators, sweeps. Design of rotary tiller. Design of traction and transport devices.

Design of seed drills; Metering mechanism, hopper, furrow opener. Fertilizer spreader, liquid fertilizer applicators and design of its sub systems. Design of paddy transplanters and potato planters.

VII. Learning outcome

The student will be able to appreciate the principles behind the design of tillage tools and planting machinery. He will be able to arrive at design configurations for such machines.

VIII. Lecture Schedule

S.No.	Topic	No of Lectures
1.	Farm machinery design: Modern trends, tasks and requirements, economic considerations of durability, reliability and rigidity.	3
2.	Farm machinery design: economic considerations of durability, reliability and rigidity.	2
3.	Physio-mechanical properties of soils.	1
4.	Technological process of ploughing. Wedge. Working process of mould board plough, determination of basic parameters.	2
5.	Design of coulters, shares, mould boards.	2
6.	Constructing of mould board working surface.	1
7.	Design of landside, frog, jointer.	1
8.	Forces acting on plough bottom and their effect on plough balance: Trailed, semi mounted and mounted plough.Draft on ploughs, resistance during ploughing.	2
9.	Design disk ploughs: Concave disk working tools, forces acting.	2
10.	Machines and implements for surface and inter row tillage: Peg toothed harrow, disk harrows, rotary hoes, graders, rollers, cultivators.	2
11.	Design of V shaped sweeps. Rigidity of working tools.	1
12.	Rotary machines: Trajectory of motion of rotary tiller tynes, forces acting, power requirement.	2
13.	Machines with working tools executing an oscillatory motion.	1
14.	Methods of sowing and planting: Machines' agronomic specifications. Sowing inter-tilled crop, Grain hoppers Seed metering mechanism Furrow openers and seed tubes.	2

S.No.	Practical	No. of Lectures
15.	Machines for fertilizer application: Discs type broadcasters.	1
16.	Organic fertilizer application: Properties of organic manure spreading machines. Liquid fertilizer distributors.	2
17.	Planting and transplanting: Paddy transplanters, potato planters.	1
18.	Case studies	2
	Total	**30**

IX. List of Practicals

S.No.	Practical	No of Practicals
1.	Design of mould board: Coulter, frog, share	1
2.	Design of mould board: mould board plough working surface, jointer.	1
3.	Trailed, semi mounted and mounted ploughs.	1
4.	Design of disc plough	1
5.	Design of disc harrow	1
6.	Design of peg tooth harrow	1
7.	Design of cultivators and sweep.	1
8.	Design of rotary tiller.	1
9.	Design of traction and transport devices.	1
10.	Design of seed drills: Metering mechanisms	1
11.	Design of seed drills: hopper and furrow opener.	1
12.	Design of Fertilizer application equipment: fertilizer spreaders	1
13.	Design of Fertilizer application equipment: liquid fertilizer applicators and design of its sub systems	1
14.	Design of paddy transplanters	1
15.	Design of potato planters.	1
	Total	**15**

X. Suggested Reading

- Bernacki C, Haman J and Kanafajski Cz. 1972. *Agricultural Machines Theory and Construction.* Vol.I. U.S. Dept. of Commerce, National Technical Information Service, Springfield, Virginia 22151.
- Bosoi ES, Verniaev OV, Smirnov II and Sultan-Shakh EG. 1990. *Theory, Construction and Calculations of Agricultural Machinery - Vol. I.* Oxonian Press Pvt. Ltd. No.56, Connaught Circle, New Delhi.
- Gill R and Vanden Berg GE. 2013. *Soil Dynamics in Tillage and Traction*. Scientific Publishers (India) ISBN-10: 8172338031.
- Yatsuk EP 1981. *Rotary Soil Working Machines Construction, Calculation and Design*. American Publishing Co. Pvt. Ltd, New Delhi.

I. Course Title : Design of Farm Machinery-II

II. Course Code : FMPE 506

III. Credit Hours : 1+1

IV. Aim of the course

To learn the engineering principles behind application of pesticides and the systems that implements the same. To learn the concepts behind design of crop harvesting and threshing equipment.

V. Theory

Unit I

Pesticide calculation examples. Multidisciplinary nature of pesticide application. Overview of chemical control integrated pest management. Targets for pesticide deposition. Formulation of pesticides.

Unit II

Spray droplets. Hydraulic nozzles. Power operated hydraulic sprayer design principles. Air assisted hydraulic sprayer design principles. Controlled droplet application. Electrostatically charged sprayers. Spray drift and its mitigation. Aerial spraying systems. Use of drones for spraying: Design of spray generation and application issues.

Unit III

Introduction to combine harvesters: Construction, equipment subsystems, power sub systems. Crop harvesting: Plant properties, physical and mechanical properties of plant stem, plant bending modelling. Properties of plant grain: Physical, mechanical, grain damage. Properties of MOG; Mechanical and aerodynamic.

Unit IV

Design of grain header; Orienting and supporting reel. Plant cutting cutter bar: Working process, cutter bar drive. Knife cutting speed pattern area. Design of auger for plant collection. Corn header: Working elements, snapping roll design, stalk grasping and drawing process. Corn ear detachment: Stalk cutting and chopping.

Unit V

Cereal threshing and separation; Design of tangential and axial threshing units. Performance indices of threshing units. Modelling material kinematics in different threshing units. Factors influencing the threshing process and power requirement. Separation process and design of straw walker. Cleaning Unit process and operation. Grain pan; Chaffer and bottom sieve. Blower design and flow orientation. Design of conveying system for grain. Straw choppers and shredders.

VI. Practical

Measurement of spray characters for different nozzles. Problems on sizing of sprayer components. Design of sprayer for special purpose: Orchard and tall trees. Harvesting machine. Problems on design of cutterbars, reels, platform auger, conveyors. Design of threshing drum: Radial and axial flow type. Design of cleaning and grading systems. Design of blowers.

VII. Learning outcome

The student will know the principles behind the design of crop spraying equipments and harvesting and threshing machinery.

VIII. Lecture Schedule

S.No.	Topic	No of Lectures
1.	Overview of chemical control integrated pest management.	1
2.	Targets for pesticide deposition. Formulation of pesticides.	1
3.	Multidisciplinary nature of pesticide application.	1
4.	Pesticide calculation examples.	2

S.No.	Topic	No of Lectures
5.	Spray droplets. Hydraulic nozzles. Power operated hydraulic sprayer design principles.	2
6.	Controlled droplet application. Spray drift and its mitigation.	1
7.	Air assisted hydraulic sprayer design principles. Electrostatically charged sprayers.	2
8.	Aerial spraying systems. Use of drones for spraying:	1
9.	Design of spray generation and application issues.	1
10.	Introduction to combine harvesters; Construction, equipment subsystems, power sub systems.	1
11.	Crop harvesting: Plant properties, physical and mechanical properties of plant stem, plant bending modelling.	1
12.	Properties of plant grain: Physical, mechanical, grain damage.	2
13.	Properties of MOG; Mechanical and aerodynamic.	2
14.	Design of grain header; Orienting and supporting reel. Plant cutting cutter bar.	2
15.	Working process, cutter bar drive. Knife cutting speed pattern area.	1
16.	Design of auger for plant collection.	1
17.	Corn header: Working elements, snapping roll design, stalk grasping and drawing process. Corn ear detachment: Stalk cutting and chopping.	2
18.	Cereal threshing and separation, Design of tangential and axial threshing units. Performance indices of threshing units.	2
19.	Modelling material kinematics in different threshing units. Factors influencing the threshing process and power requirement.	1
20.	Separation process and design of straw walker.	1
21.	Cleaning Unit process and operation. Grain pan: Chaffer and bottom sieve. Blower design and flow orientation.	2
22.	Design of conveying system for grain. Straw choppers and shredders.	2
	Total	**32**

IX. List of Practicals

S.No.	Practical	No of Practicals
1.	Measurement of spray characters for different nozzles.	1
2.	Problems on sizing of sprayer components.	1
3.	Design of spraying units – manual	1
4.	Design of spraying units – powered	1
5.	Design of sprayer for special purpose: Orchard and tall trees.	1
6.	Design of agitation units – mechanical and hydraulic	1
7.	Harvesting machines: Problems on design of shear type cutting mechanism	1
8.	Harvesting machines: Problems on design of impact type harvesting mechanism	1
9.	Harvesting machines: Problems on design of platform auger and conveyors.	1
10.	Harvesting machines: Problems on design of reels	1
11.	Design of threshing drum: Radial flow type.	1
12.	Design of threshing drum: Axial flow type.	1
13.	Design of cleaning systems.	1
14.	Design of grading systems.	1
15.	Design of blowers.	1
	Total	**15**

X. Suggested Reading

- Bernacki C, Haman J and Kanafajski Cz 1972. *Agricultural Machines Theory and Construction*. Vol-I. U.S. Department of Commerce, National Technical Information Service, Springfield, Virginia22151.
- Bindra, OS and Singh H. 1971. *Pesticides Application Equipments.* Oxford & IBH Publishing Co., New Delhi.
- Bosoi ES, Verniaev OV, Smirnov II and Sultan-Shakh EG. 1987. C*onstruction and Calculations of Agricultural Machinery - Vol.II*. Oxonian Press Pvt. Ltd. New Delhi.
- Miu P. 2016. *Combine Harvesters Modeling and Design.* CRC Press, Boca Raton, USA ISBN 13:978-1-4822-8237-5
- Thornhill EW and Matthews GA. 1995. *Pesticide Application Equipment for Use in Agriculture* Vol II. Mechanically powered equipment FAO Rome.

I. Course Title : Management of Farm Power and Machinery System

II. Course Code : FMPE 507

III. Credit Hours : 2+1

IV. Aim of the course

To understand how principles of management are applied to farm machinery systems to make them more effective and profitable.

V. Theory

Unit I

Importance and objectives of farm mechanization in Indian agriculture, its impact, strategies, myths and future needs. Estimation of operating cost of tractors and farm machinery. Management and performance of power, operator, labour. Economic performance of machinery, field capacity, field efficiency and factors affecting field efficiency.

Unit II

Tractor power performance in terms of PTO, drawbar and fuel consumption. Power requirement problems to PTO, DBHP.

Unit III

Selection of farm machinery, size selection, timeliness of operation, optimum width and problem related to its power selection. Reliability of agricultural machinery. Replacement of farm machinery and inventory control of spare parts.

Unit IV

Systems approach to farm machinery management and application of programming techniques to farm machinery selection and scheduling. Network Analysis: Transportation, CPM and PERT, dynamic programming, Markov chain.

VI. Practical

Study of latest development of different agricultural equipment and implements in India and other developing countries. Size selection of agricultural machinery. Experimental determination of field capacity of different farm machines. Study of farm mechanization in relation to crop yield. Determination of optimum machinery system for field crop and machine constraints. To develop computer program for the selection of power and machinery.

VII. Learning outcome

The student will be able to understand how farm machinery is selected and operated to make them economically viable.

VIII. Lecture Schedule

S.No.	Topic	No of Lectures
1.	Importance and scope of farm mechanization in Indian Agriculture	1
2.	Cost analysis of Farm Machinery and tractor, Breakdown analysis, Inflation.	2
3.	Measurement of power performance (PTO power, drawbar power and fuel consumption) of tractor and power tiller	3
4.	Study of field capacity and field efficiency of different farm machinery and factor affecting them	1
5.	Selection of Farm Machinery size wrt to power source and timeliness of operation	4
6.	Application of programming technique to problem of farm power and machinery selection.	4
7.	Replacement models, spare parts and inventory control	2
8.	Maintenance and scheduling of operations.	2
9.	Network analysis – transportation	2
10.	Network analysis – critical path method, PERT	2
11.	Network analysis – dynamic programming	3
12.	Network analysis – markov chain	3
13.	Linear programming, multivariable system, simplex algorithm. Theory of network.	3
	Total	**32**

IX. List of Practicals

S.No.	Topic	No of Practicals
1.	Introduction to latest development of advanced agricultural equipment's in India	3
2.	Experimental determination of field capacity of different farm machines	3
3.	Case studies on optimum size selection of agricultural machinery	3
4.	Determination of inventory of different farm machines for a farm of size 50 ha as per regional crop rotations	3
5.	To develop computer program regarding selection of farm machinery size and power requirement for a 10, 50 and 100 ha farm size	3
	Total	**15**

X. Suggested Reading

- Carveille LA. 1980. *Selecting Farm Machinery*. Louisiana Cooperative Extn. Services Publication.
- Culpin C. 1996. *Profitable Farm Mechanization.* Lock Wood and Sons, London.
- FAO. 1990. *Agricultural Engineering in Development: Selection of Mechanization Inputs.* FAO, Agri service Bulletin.
- Hunt D. 1979. *Farm Power and Machinery Management.* Iowa State University Press, USA.
- Kapoor VK. 2012. *Operation Research: Concepts, Problems and Solutions.* Sultan Chand and Sons, India.