

Courses Related to
Farm Machinery and Power Engineering
for
Doctoral Degree Programme



Dept. of Farm Machinery and Power Engineering
Faculty of Agricultural Engineering
Bidhan Chandra Krishi Viswavidyalaya
Mohanpur, Nadia, West Bengal

Course Credit Structure, Doctoral Degree Program, BCKV

Sl. No.	Course Work	Doctoral Programme
I	Major Subject	12
II	Minor Subject	06
III	Supporting Subject	05
IV	Seminar	02
V	Thesis	75
	TOTAL	100

Course Contents for
Ph.D. in Farm Machinery and Power Engineering

Major Courses:

Courses Code	Course Title	Credit Hours (L + P)
FMPE-601	Advances in Farm Machinery and Power Engineering	2+1
FMPE-602	Advances in Machinery for Precision Agriculture	2+1
FMPE-603	Energy Conservation and Management in Production Agriculture	3+0
FMPE-612	Farm Machinery Management and Systems Engineering	2+1

Minor Courses:

Courses Code	Course Title	Credit Hours (L + P)
RE-602	Thermo-Chemical Conversion of Biomass	2+1
RE-615	Energy Planning Management and Economics	3+0
ME-507	Fatigue Design	2+1
ME-515	Computer Aided Design	2+1
CSE-506	Digital Image Processing	2+1

Supporting Courses:

STAT-513	Computer Fundamentals and Programming	2+1
AGM-601	Climate Change and Sustainable Development	2+1
CC-601	Research and Publication Ethics	2+0

Other Essential Requirements:

FMPE-691	Doctoral Seminar-I	0+1
FMPE-692	Doctoral Seminar-II	0+1
FMPE-699	Doctoral Research	0+75

Syllabus for

Ph.D. in Farm Machinery and Power Engineering

- I. Course Title** : **Advances in Farm Machinery and Power Engineering**
II. Course Code : **FMPE 601**
III. Credit Hours : **2+1**

IV. Aim of the course

To familiarize the students about modern developments in construction, design and analysis of farm machinery systems as applied in different areas of agriculture.

V. Theory

Unit I

Advances in mechanization as applicable to Indian context. Future outlook for improving agricultural productivity and reducing cost. Mechanization: Review of the applications of some of the advanced mechanization technologies and constraints in adaptability. Levels of mechanization and transition between levels.

Unit II

Sustainable mechanization management: Management of compaction of agricultural fields. Strategies to develop machinery and systems that reduce compaction. Concept of Controlled Traffic Farming (CTF) systems. Introduction of wide span mechanization to vegetable production systems to enhance productivity and sustainability.

Unit III

Optimization of production processes to minimize energy loss in agriculture. The rationale for the use of photovoltaic systems in farming. The Energy Returned on Energy Invested (EROEI) ratio as an indicator for evaluating the efficiency of renewable energy sources.

Unit IV

board sensors, computing hardware, algorithms and software. Manipulator type ag-robots: Use in food processing, dairy, horticulture, and orchard industries.

Unit V

Precision Livestock Farming (PLF): Individual identification and monitoring of animals, tractability of livestock products. Developments in livestock and building control: Radio telemetry systems to remotely monitor and record physiological parameters. Silage process and their variants. Coordination of machinery system to enhance quality of silage and forage conditioners.

VI. Practical

Case studies and presentations on: Mechanization in India-analysis of machinery data- mechanization index and relation between productivity and mechanization. Levels of mechanization in different crops. Design of traffic lanes-field geometry and generating guideline lanes for operation of machinery. Planning use of multiple

machinery-sugarcane harvesting system. Measurement of soil compaction due to heavy machinery using cone penetrometer. Machine vision system design–case studies. Challenges in development of robotic machinery in agricultural operations–case studies.

VII. Learning outcome

The students will be able to design, operate and maintain surface irrigation systems, surface and sub-surface pressurized irrigation systems, and managing crop productivity with poor quality of waters without deteriorating soil conditions.

VIII. Lecture schedule

S.No.	Topic	No. of Lectures
1.	Advances in mechanization as applicable to Indian context.	2
2.	Mechanization in large scale agricultural fields	1
3.	Mechanization in small scale agricultural fields	1
4.	Future outlook for improving agricultural productivity and reducing cost.	1
5.	Requirements of energy and fuels for machinery operations	2
6.	Case studies of the applications of some of the advanced mechanization technologies and constraints in adaptability.	2
7.	Case studies of Technology transfer mechanisms in India	1
8.	Levels of mechanization and transition between levels.	1
9.	Sustainable mechanization management.	1
10.	Management of compaction of agricultural fields.	1
11.	Strategies to develop machinery and systems that reduce compaction.	1
12.	Concept of Controlled Traffic Farming (CTF) systems.	1
13.	Introduction of wide span mechanization to vegetable production systems to enhance productivity and sustainability.	2
14.	Optimization of production processes to minimize energy loss in agriculture.	2
15.	The rationale for the use of photovoltaic systems in farming.	1
16.	The Energy Returned on Energy Invested (EROEI) ratio as an indicator for evaluating the efficiency of renewable energy sources.	2
17.	Machine vision system-hardware and software technologies, and machine learning and image analysis techniques.	1
18.	Unmanned agricultural ground vehicles (UAGVs)	1
19.	UAGVs instrumented mobile platform, on board sensors, computing hardware, algorithms and software.	1
20.	Manipulator type ag-robots: Use in food processing, dairy, horticulture, and orchard industries.	2
21.	Precision Livestock Farming (PLF): Individual identification and monitoring of animals, tractability of livestock products.	1
22.	Developments in livestock and building control: Radio telemetry systems to remotely monitor and record physiological parameters.	2
23.	Silage process and their variants. Coordination of machinery system to enhance quality of silage and forage conditioners.	1
24.	Silage and forage conditioners.	1
	Total	32

IX. List of Practicals

S.No.	Topic	No of Practicals
1.	Case studies of Mechanization in India	1
2.	Case studies of Mechanization in SAARC countries	1
3.	To find mechanization index.	1
4.	Relation between productivity and mechanization in India and Punjab.	1
5.	Relation between productivity and mechanization in developed countries.	1
6.	Levels of mechanization in cereal crops like paddy, Wheat etc.	1
7.	Levels of mechanization in Horticulture crops	1
8.	Levels of mechanization in cotton crop and pulses and oilseed crops	1
9.	Design of traffic lanes-field geometry and generating guideline lanes for operation of machinery.	1
10.	Planning use of multiple machinery-sugarcane harvesting system.	1
11.	Measurement of soil compaction due to heavy machinery using cone penetrometer.	1
12.	Machine vision system design–case studies.	1
13.	Machine vision system design–case studies.	1
14.	Unmanned agricultural ground vehicles (UAGVs) for different applications like spraying, imaging etc.	1
15.	Challenges in development of robotic machinery in agricultural operations-case studies.	1
16.	Developments in livestock and building control: Radio telemetry systems to remotely monitor and record physiological parameters.	1
	Total	16

X. Suggested Reading

- Chen G. (ed). 2018. *Advances in Agricultural Machinery and Technologies*. Boca Raton: CRC Press, <https://doi.org/10.1201/9781351132398>.
- Edwards GTC, Hinge G, Skou-Nielsen N and Villa-Henriksen A. 2017. *Route Planning Evaluation of a Prototype Optimized in Field Route Planner for Neutral Material Flow Agricultural Operations*. *Biosystems Engineering* **153**: 149-157. <https://www.sciencedirect.com/science/article/pii/S1537511016303713>.
- Seyyedhasani H. 2017. *Using the Vehicle Routing Problem (VRP) to Provide Logistic Solutions in Agriculture*. Ph.D. dissertation. University of Kentucky, Kentucky, USA. [https://www.researchgate.net/publication/264791116_Advances in Agricultural Machinery Management A Review](https://www.researchgate.net/publication/264791116_Advances_in_Agricultural_Machinery_Management_A_Review).
- Srivastava A K. 2006. *Engineering Principles of Agricultural Machines*. 2nd Edition American Society of Agricultural and Biological Engineers (ISBN) 1-892769-50-6 ASAE Publication 801M0206.

I. Course Title : Advances in Machinery for Precision Agriculture

II. Course Code : FMPE 602

III. Credit Hours : 2+1

IV. Aim of the course

Detailed study of the hardware system used in precision agriculture (PA) and techniques of using them in precision agriculture.

V. Theory

Unit I

Global navigation satellite system (GNSS). Satellite ranging: Accuracy, standards,

components of GIS, data layers, map component, attribute table component, function of a GIS, resolution. Data formats: Vector or raster. GIS for precision farming, data analysis, field calculator, convert to grid, interpolation, reclassification, image classification, band math, interpretation of analysis, farm management information systems, and crop intelligence.

Unit II

Yield Monitors: Components, Differential GPS Receiver, GNSS Receiver, mass flow sensors. Impact plates, measuring volume with a photoelectric sensor. Using microwave radiation, and Gamma rays to estimate volume, volumetric flow sensing and alternatives. Grain moisture sensor, fan speed sensor, elevator speed sensor, header position, yield monitor data, cotton yield monitors.

Unit III

Sources of soil variability, general soil sampling basics, systematic variability, selecting a soil sampling strategy. Parameters: Electrical conductivity, electromagnetic sensors, sensing mechanical impedance. Proximal plant sensing systems, crops canopy reflectance and fluorescence. Machine vision thermal sensors, mechanical sensors, acoustic sensors.

Unit IV

Remote sensing platforms: Aircraft or satellite. Sensors: Imaging or non imaging, active or passive. Making use of reflected energy or emitted energy. The spectral signature of vegetation, vegetation indices, application to agriculture, nutrient management, weed management, disease and insect management, water management.

VI. Practical

Simple programming for automating precision farming calculations. Mathematics of longitude and latitude. Spatial statistics, soil sampling and understanding soil testing results for precision farming, calculations. Supporting management zones, understanding soil, water and yield variability in precision farming. Developing prescriptive soil nutrient maps, essential plant nutrients, fertilizer sources, and application rates calculations. Deriving and using an equation to calculate economic optimum fertilizer and seeding rates cost of crop production.

VII. Learning outcome

Ability to understand design and operate PA systems.

VIII. Lecture schedule

S.No.	Topic	No. of Lectures
1.	Introduction about Global navigation satellite system (GNSS	1
2.	Satellite ranging including accuracy, standards etc.	1
3.	Differential GNSS Receiver, RTK etc.	1
4.	Components of GIS, data layers, map component,	1
5.	Attribute table component, function of a GIS, resolution.	1
6.	Data formats: Vector or raster.	1
7.	GIS for precision farming, data analysis, field calculator, convert to grid,	1
8.	Interpolation, reclassification, image classification, band math and interpretation of analysis.	1

S.No.	Topic	No. of Lectures
9.	Farm management information systems, and crop intelligence.	1
10.	Introduction about Yield monitors and its components	1
11.	Mass flow and impact plate sensors, measuring volume with a photoelectric sensor. Lecture 12: Microwave radiation and Gamma rays to estimate volume,	1
12.	Different types of grain moisture sens	1
13.	Fan speed sensor, elevator speed sensor, header position, yield monitor data,	1
14.	Yield monitors for non-grain crops	1
15.	Sources of soil variability, general soil sampling basics, systematic variability Lecture 17: Selecting a soil sampling strategy.	1
16.	Proximal and remote sensing based soil sensors	1
17.	Electromagnetic based sensors for soil electrical conductivity measurement	1
18.	Sensing mechanical impedance based sensors for soil compaction	1
19.	Spectroscopy for determination of soil properties	1
20.	Introduction about proximal plant sensing systems	1
21.	Remote sensing platforms: Aircraft or satellite.	1
22.	Type of plant sensors: Imaging or non imaging, active or passive.	1
23.	Use of reflected or emitted energy for vegetation detection	1
24.	The spectral signature of vegetation, vegetation indices, application to agriculture	1
25.	Sensing system for nutrient management,	1
26.	Crops canopy reflectance and fluorescence.	1
27.	Machine vision thermal sensors, mechanical sensors, acoustic sensors	1
28.	Sensors for weed detection and management	1
29.	Sensing Techniques for disease and insect management,	1
30.	Different type of sensors/devices for water management.	1
	Total	30

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Simple programming for automating precision farming calculations	1
2.	Mathematics of longitude and latitude	1
3.	Spatial and temporal statistics using GIS	1
4.	Soil sampling strategies, understanding and results for precision farming	1
5.	Creation of management zones	1
6.	Measurement of yield variability in the field	1
7.	Measurement of soil Compaction in the field	1
8.	Measurement of soil EC in the field	1
9.	Measurement of soil pH in the field	1
10.	Developing and understanding prescriptive soil nutrient maps	1
11.	Measurement of essential plant nutrients in the field	1
12.	Fertilizer sources, and application rates calculations	1
13.	Deriving and using an equation to calculate economic optimum fertilizer	1
14.	Calculation of optimum seeding rates for optimized returns	1
15.	Cost of crop production using precision technologies.	1
	Total	15

X. Suggested Reading

- Clay DE, Clay SA and Bruggeman SA. 2017. *Practical Mathematics for Precision Farming*. American Society of Agronomy, Madison, WI, USA.
- Ram T, Lohan SK, Singh R and Singh P. 2014. *Precision Farming: A New approach*. Astral International Pvt. Ltd., New Delhi, India. ISBN: ISBN 978-81-7035-827-5 (Hardbound) ISBN 978-93-5130-258-2 (International Edition).
- Shannon DK, Clay DE and Kitchen NR Newell. 2018. *Precision Agriculture Basics*. American Society of Agronomy, Inc., Madison, WI, USA.
- Singh AK and Chopra UK. 2007. *Geoinformatics Applications in Agriculture*. New India Publishing Agency, New Delhi, India.
- Van-Henten EJ, Goense D and Lokhorst C. (ed). 2009. *Precision Agriculture*. Wageningen Academic Publishers, Wageningen, Netherlands.

I. Course Title : Energy Conservation and Management in Production Agriculture

II. Course Code : FMPE 603

III. Credit Hours : 3+0

IV. Aim of the course

Detailed study of the hardware system used in precision agriculture (PA) and techniques of using them in precision agriculture.

V. Theory

Unit I

Global navigation satellite system (GNSS). Satellite ranging: Accuracy, standards, components of GIS, data layers, map component, attribute table component, function of a GIS, resolution. Data formats: Vector or raster. GIS for precision farming, data analysis, field calculator, convert to grid, interpolation, reclassification, image classification, band math, interpretation of analysis, farm management information systems, and crop intelligence.

Unit II

Yield Monitors: Components, Differential GPS Receiver, GNSS Receiver, mass flow sensors. Impact plates, measuring volume with a photoelectric sensor. Using microwave radiation, and Gamma rays to estimate volume, volumetric flow sensing and alternatives. Grain moisture sensor, fan speed sensor, elevator speed sensor, header position, yield monitor data, cotton yield monitors.

Unit III

Sources of soil variability, general soil sampling basics, systematic variability, selecting a soil sampling strategy. Parameters: Electrical conductivity, electromagnetic sensors, sensing mechanical impedance. Proximal plant sensing systems, crops canopy reflectance and fluorescence. Machine vision thermal sensors, mechanical sensors, acoustic sensors.

Unit IV

Remote sensing platforms: Aircraft or satellite. Sensors: Imaging or non imaging, active or passive. Making use of reflected energy or emitted energy. The spectral signature of vegetation, vegetation indices, application to agriculture, nutrient management, weed management, disease and insect management, water management.

VI. Practical

Simple programming for automating precision farming calculations. Mathematics of longitude and latitude. Spatial statistics, soil sampling and understanding soil testing results for precision farming, calculations. Supporting management zones, understanding soil, water and yield variability in precision farming. Developing prescriptive soil nutrient maps, essential plant nutrients, fertilizer sources, and application rates calculations. Deriving and using an equation to calculate economic optimum fertilizer and seeding rates cost of crop production.

VII. Learning outcome

Ability to understand design and operate PA systems.

VIII. Lecture Schedule

S.No.	Topic	No. of Lectures
1.	Introduction	1
2.	Classification of energy	2
3.	Energy coefficients	2
4.	Energy requirements for wheat production	2
5.	Energy requirements for paddy production	2
6.	Energy requirements for maize production	2
7.	Energy requirements for cotton production	2
8.	Energy requirements for oil seeds production	1
9.	Energy requirements for pulse production	2
10.	Energy requirements for production of other crops	2
11.	Energy requirements for vegetable production	2
12.	Energy requirements for fruit production	1
13.	Energy requirements for fish production	1
14.	Energy requirements for meat and milk production	2
15.	Limits of energy conservation	1
16.	Energy planning, management and forecasting in agriculture	3
17.	Design of integrated energy supply system	2
18.	Energy conservation and returns	2
19.	Assessment of energy conservation technology	2
20.	Case studies on application of various techniques of energy conservation and management	2
	Total	36

IX. Suggested Reading

- Mittal JP, Panesar BS, Singh S, Singh CP and Mannan KD. 1987. *Energy in Production Agriculture and Food Processing*. ISAE and School of Energy Studies for Agriculture, PAU Ludhiana, ISAE Publication.
- Pimental D. 1980. *Handbook of Energy Utilization in Agriculture*. CRC Press. Boca Rotan, USA.
- Singh S and Singh RS. 2014. *Energy for Production Agriculture*. DKMA, ICAR, New Delhi, India.

I. Course Title : Farm Machinery Management and Systems Engineering

II. Course Code : FMPE 612

III. Credit Hours : 2+1

IV. Aim of the course

Understanding Farm Machinery from systems approach and ability to model the

Farm machinery system.

V. Theory

Unit I

Mathematical models of field machinery systems: Operational constraints, power constraints, weather constraints. Systems approach to field operations and models of: Tillage, seeding, chemical application, harvesting, storage and irrigation systems.

Unit II

Engineering economics: Concept of incremental and differential cost, economic efficiency, time value of money. Equipment investment cost: Operational cost, production cost, income cost and uncertainty cost. B.C. ratio, payback period, IRR machinery replacement policies.

Unit III

Uncertainty: Concepts of probability, probability functions, distributions, sampling. Statistics, confidence limits, significance, contingency tables, analysis of variance. Regression and correlation. Monte Carlo methods and applications to farm machinery.

Unit IV

System modeling in farm machinery: Numerical methods, analogs, models with uncertainty stochastic service system. Feasibility system design-stability. Deterministic systems and stochastic systems.

Unit V

Optimum Design: Trial and error, differential calculus, calculus of variations. Allocations: Linear programming, simplex technique. Transportation and assignment technique. Critical path scheduling, dynamic programming, game and its applications to farm machinery management.

VI. Practical

Solving problems of mathematical models of field machinery, constraints, power constraints, weather constraints. Problems relates to tillage seeding chemical application harvesting and storage and irrigation systems. Problem solving in Economics of Engineering, calculation of investment cost, operational cost, and uncertainty cost. Case studies in machine performance modelling, Economics of machine selection, Analog components, Analog modelling stochastic system modelling and critical path scheduling.

VII. Learning outcome

Ability to understand and develop model of any farm machinery system to help in selection, management and optimization.

VIII. Lecture Schedule

S.No.	Topic	No. of Lecture
1.	Understanding Farm Machinery from systems approach and ability to model the Farm machinery system.	2
2.	Mathematical models of field machinery systems: Operational constraints, power constraints, weather constraints.	2
3.	Systems approach to field operations and models of: Tillage, seeding, chemical application, harvesting, storage and irrigation systems. Engineering economics: Concept of incremental and differential	3

S.No.	Topic	No of Lectures
4.	Engineering economics: Concept of incremental and differential cost, economic efficiency, time value of money	1
5.	Equipment investment cost: Operational cost, production cost, income cost and uncertainty cost. B.C. ratio, payback period, IRR machinery replacement policies.	2
6.	Uncertainty: Concepts of probability, probability functions, distributions, sampling	2
7.	Statistics, confidence limits, significance, contingency tables, analysis of variance.	1
8.	Regression and correlation. Monte Carlo methods and applications to farm machinery.	3
9.	System modeling in farm machinery: Numerical methods, analogs, models with uncertainty stochastic service system.	3
10.	Feasibility system design-stability	1
11.	Deterministic systems and stochastic systems.	2
12.	Optimum Design: Trial and error, differential calculus, calculus of variations	2
13.	Allocations: Linear programming, simplex technique Transportation and assignment technique	2
14.	Critical path scheduling, dynamic programming, game and its applications to farm machinery management.	4
	Total	32

IX. List of Practicals

S.No.	Topic	No. of Practicals
1.	Problems solving of mathematical models of field machinery, constraints, power constraints, weather constraints	3
2.	Mathematical problems relates to tillage, seeding, chemical application harvesting and storage and irrigation systems	3
3.	Problem solving in Economics of Engineering, calculation of investment cost, operational cost, and uncertainty cost	3
4.	Case studies in machine performance modelling, Economics of machine selection	2
5.	Case studies in machine performance modelling	2
6.	Economics of Power and machine selection	2
	Total	15

X. Suggested Reading

- Hunt DR. 1986. *Engineering Models for Agricultural Production*. AVI Pub. Co., Westport, CT, USA.
- Hunt D and Wilson D. 2015. *Farm Power and Machinery Management*. Waveland Press, Illinois, USA.
- Singh S and Verma SR. 2009. *Farm Machinery Maintenance and Management*. DIPA, ICAR, New Delhi.