COURSE SYLLABUS
for
M. Tech. (Agril. Engg.)
in
Farm Machinery and Power Engineering

(Approved by Academic Council vide resolution No. 7644, dat. 07.12.2022)

ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY
BHUBANESWAR-751003

SEMESTER WISE COURSES TO BE TAKEN FOR THE M.TECH. (AG.ENGG.),
FARM MACHINERY AND POWER ENGINEERING (2022 onwards)

Course No.	Course Title	Credit hours		
		Major	Minor	Supporting
SEMESTER-I				
MATHS 502	**Numerical Methods for Engineers**		**3+0**	
REE 503	Biomass Energy Conversion Technologies		**2+1**	
PFE-504*	**Horticultural Crops process Engineering**		**2+1**	
EE 501	**Applied Instrumentation**			**2+1**
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	2+1		
PGS-501	***Library and Information Service***		***1+0 (NC)***	
PGS-504	***Basic concepts of laboratory Techniques***		***0+1 (NC)***	
SEMESTER-II				
STAT 501	**Statistical methods for Research Works**			**2+1**
ASCE 501	Dimensional Analysis and Similitude		2+1	
REE 513	Agro Energy Audit and Management		2+1	
FMPE 503*	Ergonomics and Safety in Farm Operations	2+1		
FMPE 506	Design of Farm Machinery-II	2+1		
FMPE 507*	Management of Farm Power and Machinery System	2+1		
PGS-502	***Technical writing and communication skills***		***0+1 (NC)***	
PGS-505	***Agricultural research, research ethics and rural development Programmes***		***1+0 (NC)***	
FMPE 599	**Research for thesis**		**0+5**	
SEMESTER-III				
FMPE 504	Design of Tractor systems	2+1		
FMPE 599	**Research for thesis**		**0+10**	
PGS-503	**Intellectual Property and its Management**		**1+0 (NC)**	
SEMESTER-IV				
FMPE 591	**Master's Seminar**	**0+1**		
FMPE 599	**Research for Thesis**		**0+15**	

***The courses are compulsory for the Master's and PhD programme respectively. NC: Noncredit course**
The students, M. Tech. (Ag. Engg.) course will have to take a minimum 65 credit hours as given below:

Type of course	Minimum credit hours
A. Course Work	
i) Major course	**20**
ii) Minor course	**08**
iii) Supporting course	**06**
iv) Non-credit compulsory course	**--**
v) Seminar	**01**
Sub-Total	35
B. Thesis	**30**
Grand Total	65

COURSE CONTENTS
M. Tech (Agril.Engg.) in Farm Machinery and Power Engineering

SOIL DYNAMICS IN TILLAGE AND TRACTION

1. Course Title: Soil Dynamics in Tillage and Traction

2. Course Code : FMPE 501

3. Credit Hours : 2+1

4. 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.

5. 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 behavior considerations: Soil water pressure and movement. Critical state soil mechanics: Soil stress-strain behavior, 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 dimensions: 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.

6. 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.

7. 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.

8. Lecture schedule

S. No.	Topic	No of Lectures
Unit I		
1	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 behavior considerations: Soil water pressure and movement.	**1**
5	Critical state soil mechanics: Soil stress-strain behavior, shear rate effect	**2**
Unit II		
6	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**
Unit III		
10	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**
Unit IV		
17	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**
	Total	**32**

9. List of Practical

S. No	Topic	No of Practical
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 de vices.	**1**
9	Practical Examination	**1**
	Total	**16**

10. 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.

TESTING AND EVALUATION OF AGRICULTURE EQUIPMENT

1. Course Title : Testing and Evaluation of Agriculture Equipment

2. Course Code : FMPE 502

3. Credit Hours : 2+1

4. 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.

5. 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 and rice transplanters

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 cutters.

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.

6. Practical

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

7. Learning outcome

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

8. 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/ transplanters	**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**

9. List of Practical

S. No	Topic	No. of Practical
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 planters and transplanters	**1**
4	Lab Testing and evaluation of knapsack Sprayers	**1**
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	**4**
	Total	**16**

10. Suggested Reading

- Barger E L, Liljedahl J B David W. Smith, and Makato Hoki, 2004. 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.

3. ERGONOMICS AND SAFETY IN FARM OPERATIONS

1. Course Title : Ergonomics and Safety in Farm Operations

2. Course Code : FMPE 503

3. Credit Hours : 2+1

4. 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**.**

5. **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, color-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.

6. 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 con

ditions. Case studies of agricultural accidents and safety measure.

7. Learning outcome

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

8. Lecture Schedule

S. No.	Topic	No of Lectures
Unit I		
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**
Unit II		
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 farm machinery design	**1**
9	First hourly examination	**1**
Unit III		
	Principles of applied anthropometry in ergonomics	**1**
10	Availability of anthropometric database for Indian agricultural workers	**1**
11	Definitions and possible applications of anthropometric dimensions	**1**
12	Workspace and equipment design	**2**
13	Different modes of force application	**1**
14	Design of manual handling tasks	**1**
15	Biomechanics aspects in machine design	**1**
16	Mid-semester examination	**1**
Unit IV		
17	Human posture, posture stresses and its role in design of agricultural machinery	**1**
18	Work place design for standing and seated workers	**2**
19	Human factors in tractor seat design	**1**
20	Entry system, controls, shape, colour coding, dial and indicators	**1**
21	Modern technology for safety and comfort in driving place	**1**
22	Physiological and psychological parameters for ergonomic evaluation	**1**

23	Physiological and psychological stresses and measurements techniques	**1**
24	Human work load assessment, human energy expenditure	**1**
25	Calibration of subjects – concept, importance and techniques	**1**
26	Accidents and safety in agriculture operations, general safety guidelines	**1**
27	Safety feeding systems for threshers and chaff cutters	**1**
29	Safety gadgets for tractors and trailers	**1**
30	Standard/ codes for agricultural machinery safety	**1**
	Total	**32**

9. List of Practical

S. No.	Topic	No of Practical
1	Identify role of ergonomics in design of agricultural equipment / machinery	**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.Vibration measurement in tractors	**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**

10. 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
- Kroemer K H E, Grandjean E, 2000 Fitting the task to human: Atext book of Ocupational Ergonomics, Taylor and Francis Ltd.
- 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.

DESIGN OF TRACTOR SYSTEMS

1**. Course Title : Design of Tractor Systems**

2. Course Code : FMPE 504

3. Credit Hours : 2+1

4. 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.

5. 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, differential. Differential lock, final drive, 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.

6. Practical

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

7. Learning outcome

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

8. 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, Differential. Differential lock	**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**

9. List of Practical

S. No.	Topic	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**

10. Suggested Readings

- 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.

DESIGN OF FARM MACHINERY - I

1. Course Title : Design of Farm Machinery - I

2. Course Code : FMPE 505

3. Credit Hours : 2+1

4. 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 to learn how the systems of planting machinery are designed.

5. 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.

6. 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.

7. 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.

8. 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**
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**

9. List of Practical

S. No.	Practical	No of Practical
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**
16	Visit to local manufacturer	**1**
	Total	**16**

10. 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.

DESIGN OF FARM MACHINERY-II

1. Course Title : Design of Farm Machinery-II

2. Course Code : FMPE 506

3. Credit Hours : 2+1

4. 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.

5. 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.

6. 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.

7. Learning outcome

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

8. 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**
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	**1**
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**

9. List of Practical

S. No.	Practical	No of Practical
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	**1**

	Conveyors.	
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**
16	Visit to local manufacturer	**1**
	Total	**16**

10. Suggested Readings

- 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. Construction 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.

MANAGEMENT OF FARM POWER AND MACHINERY SYSTEM

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

2. Course Code : FMPE 507

3. Credit Hours : 2+1

4. Aim of the course

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

5. 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, and 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.

6. 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.

7. Learning outcome

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

8. 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**

9. List of Practical:

S. No.	Topic	No of Lectures
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**

10. Suggested Readings

- 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.
- Singh S and Verma SR. Farm Machinery Maintenance and Management. DIPA, IC KAB-I, New Delhi

PRINCIPLES OF AUTOMATION AND CONTROL

1. Course Title : Principles of Automation and Control

2. Course Code : FMPE 511

3. Credit Hours : 2+1

4. Aim of the course

- To learn the principles behind systems for industrial automation and control especially with respect to electronically implemented systems.

5. Theory

Unit I

Introduction to industrial automation and control: Architecture of industrial automation systems, review of sensors and measurement systems. Introduction to process control: PID control, controller tuning, implementation of PID controllers, special control structures, feed forward and ratio control, predictive control, control of systems with inverse response, cascade control, overriding control, selective control and split range control.

Unit II

Introduction to sequence control: PLCs and relay ladder logic, sequence control, scan cycle, RLL syntax, sequence control structured design approach, advanced RLL programming, the hardware environment, Introduction to CNC machines.

Unit III

Control of machine tools: Analysis of a control loop, introduction to actuators. Flow control valves, hydraulic actuator systems, principles, components and symbols, pumps and motors. Proportional and servo valves. Pneumatic control systems, system components, controllers and integrated control.

Unit IV

Control systems: Electric drives, introduction, and energy saving with adjustable speed drives stepper motors, principles, construction and drives. DC motor drives: Introduction to DC-DC converters, adjustable speed drives. Induction motor drives: Introduction, characteristics, adjustable speed drives. Synchronous motor drive- motor principles, adjustable speed and servo drives.

Unit V

Networking of sensors, actuators and controllers, the fieldbus, the fieldbus communication protocol, introduction to production control systems.

6. Practical

Control system practical: Characteristics of DC servomotor, AC/DC position control system.

ON/OFF temperature control system. Step response of second order system, temperature control system using PID level control system. Automation: Introduction to ladder logic, writing logic and implementation in ladder. PLC programming, water level controller using programmable logic controller. Batch process reactor using programmable logic controller. Speed control of AC servomotor using programmable logic controller.

7. Learning outcome

- Understanding of the principles behind implementation of systems for automation and control.

8. Lecture Schedule:

S. No.	Topic	No of Lectures
1	Introduction to industrial automation and control	**1**
2	Architecture of industrial automation systems	**1**
3	Review of sensors and measurement systems-I	**1**
4	Review of sensors and measurement systems-II	**1**
5	Introduction to process control	**1**
6	PID control, controller tuning and implementation of PID controllers	**1**
7	Special control structures, feed forward and ratio control	**1**
8	Predictive control and control of systems with inverse response	**1**
9	Cascade control, overriding control	**1**
10	Selective control and split range control.	**1**
11	Introduction to sequence control	**1**
12	PLCs and relay ladder logic, sequence control and scan cycle	**1**
13	RLL syntax, sequence control structured design approach	**1**
14	Advanced RLL programming and the hardware environment	**1**
15	Introduction to CNC machines	**1**
16	Control of machine tools	**1**
17	Analysis of a control loop	**1**
18	Introduction to actuators	**1**
19	Introduction to flow control valves,	**1**
20	Hydraulic actuator systems, principles, components and symbols	**1**
21	Introduction to hydraulic pumps and motors	**1**
22	Introduction about proportional and servo valves	**1**
23	Pneumatic control systems, system components and controllers and integrated control	**1**
24	Introduction about electric control systems	**1**
25	Electric drives, energy saving with adjustable speed drives	**1**
26	Stepper motors, principles, construction and drives	**1**

27	DC motor drives: Introduction to DC-DC converters, adjustable speed drives.	**1**
28	Induction motor drives: Introduction, characteristics, adjustable speed drives	**1**
29	Synchronous motor drive-motor principles, adjustable speed and servo drives	**1**
30	Networking of sensors, actuators and controllers	**1**
31	The field bus, the field bus communication protocol,	**1**
32	Introduction to production control systems.	**1**
	Total	**32**

9. List of Practical

S. No.	Practical	No of Practical
1	Control system including characteristics of DC servomotor	**2**
2	AC/DC position control system	**1**
3	Temperature control system	**1**
4	Step response of second order system	**2**
5	Temperature control system using PID level control system	**1**
6	Introduction to ladder logic, writing logic and implementation in ladder.	**2**
7	PLC programming	**2**
8	Water level controller using programmable logic controller	**1**
9	Batch process reactor using programmable logic controller	**1**
10	Speed control of AC servo motor using programmable logic controller	**1**
	Total	**14**

10. Suggested Readings

- https://nptel.ac.in/downloads/108105063/
- Manesis S and Nikolakopoulos G. 2018. Introduction to Industrial Automation. 1st Edition, CRC Press. Textbook-ISBN 9781498705400-CAT#K24766

PRINCIPLES OF HYDRAULIC AND PNEUMATIC SYSTEMS

1. Course Title : Principles of Hydraulic and Pneumatic Systems

2. Course Code : FMPE 512

3. Credit Hours : 2+1

4. Aim of the course

To understand the principles behind operation of hydraulic and pneumatic systems and their components and design simple hydraulic and pneumatic circuits and select components for the same.

5. Theory

Unit I

Hydraulic power, its advantages, applications, properties of hydraulic fluids, viscosity, bulk modulus, density. Concepts of energy of hydraulic systems, laws of fluid flow.

Unit II

Hydraulic pump and motors, principle, capacity, classifications, working, performance. Design of various types of pumps and motors.

Unit III

Actuators, types, design of linear actuator and rotary actuators. Hydraulic rams, gear motors, piston motors and their performance characteristics. Hose, filters, reservoirs, types of circuits, intensifier, accumulator, valves. Valve types: Direction control, deceleration, flow, pressure control, check valve and their working etc.

Unit IV

Hydraulic circuit design. Applications in farm power and machinery: Tractor, combine, farm machinery systems, hydrostatic system etc.

Unit V

Power pack, pneumatic circuits, properties of air. Compressors, types. Design of pneumatic circuits.

6. Practical

Study of various hydraulic pumps, motors, valves, directional control valves, cylinder piston arrangements, engineering properties of hydraulic fluids, hydraulic system of tractor, power steering system.

7. Learning outcome

- Ability to design simple hydraulic and pneumatic circuits and to select the components for the same. To design hydraulic and pneumatic systems of farm Machinery.

8. Lecture Schedule

S. No.	Topic	No of Lectures
1	Introduction to hydraulic power, its advantages, applications	**1**
2	Properties of hydraulic fluids, viscosity, bulk modulus, density	**2**
3	Concepts of energy of hydraulic systems, laws of fluid flow	**1**
4	Introduction to hydraulic pump and motor	**1**
5	Principle of hydraulic pump and motor, capacity, classifications, working, performance	**1**
6	Design of various types of hydraulic pumps	**1**
7	Design of various types of hydraulic motors	**1**
8	Actuators, types, design of linear actuator and rotary actuators	**3**
9	Hydraulic rams, gear motors, piston, motors and their performance characteristics	**3**
10	Hose, filters, reservoirs, types of circuits, intensifier, accumulator, valves.	**3**
11	Valve types: Direction control, deceleration, flow, pressure control, check valve and their working etc.	**4**
12	Hydraulic circuit design	**2**
13	Applications in farm power and machinery: Tractor, combine, farm machinery systems, hydrostatic system etc	**3**
14	Power pack, pneumatic circuits, components of pneumatic systems, properties of air.	**3**
15	Compressors, types. Design of pneumatic circuits	**3**
	Total	**32**

9. List of Practical

S. No.	Practical	No of Practical
1	Study of various hydraulic pumps	**1**
2	Study of various hydraulic motors	**1**
3	Study of various hydraulic valves	**2**
4	Study of various hydraulic directional control valves	**2**
5	Study of various hydraulic cylinder piston arrangements	**1**
6	Engineering properties of hydraulic fluids	**2**
7	Study of hydraulic system of tractor	**2**
8	Study of power steering system	**2**
9	Study of power pack, pneumatic circuits, components of pneumatic systems	**2**
10	Practical examination	**1**
	Total	**16**

10. Suggested Readings

- Anthony E. 2003. Fluid Power with Applications. Pearsons Education (Singapore) Pvt. Ltd.
- Krutz G. 1984. Design of Agricultural Machines. John Wiley and Sons.
- Majumdar S R. 2003. Oil Hydraulics Systems: Principles and Maintenance. Tata McGraw Hill Co.
- Merritt HE. 1991. Hydraulic Control System. John Wiley and Sons Inc.

APPLIED INSTRUMENTATION IN FARM MACHINERY

1. Course Title : Applied Instrumentation in Farm Machinery

2. Course Code : FMPE 513

3. Credit Hours : 2+1

4. Aim of the course

- To understand the operation of instruments that is used in design and evaluation of farm machinery and their application.

5. Theory

Unit I

Strain gauges, types and applications in two and three dimensional force measurement in farm machinery. Various methods of determining strain/stresses experimentally. Design, selection and analysis of strain gauges.

Unit II

Introduction to transducers (sensors). Active and passive transducers, analog and digital modes, null and deflection methods. Performance characteristics of instruments including static and dynamic characteristics.

Unit III

Load cells, torque meters, flow meters types and principles of working. Devices for measurement of temperature, relative humidity, pressure, sound, vibration, displacement (LVDT) etc. Recording devices and their types. Measuring instruments for calorific value of solid, liquid, and gaseous fuels.

Unit IV

Basic signal conditioning devices, data acquisition system. Microcomputers for measurement and data acquisition. Data storage and their application including wireless communication. Application of sensors in farm machinery and power: Tractor and selected farm machinery.

6. Practical

Calibration of load cells, torque meters, flow meters etc. Experiment on LVDT, strain gauge transducer, speed measurement using optical devices, vibration measurement, making of thermocouples etc, application of sensors in farm machinery like wheel hand hoe, etc.

7. Learning outcome

- The student will be able to select and implement suitable systems for measurement of different parameters like force, torque, speed and pressure etc, that are used in design and evaluation of Farm machinery.

8. Lecturer Schedule

S. No.	Topic	No of Lectures
Unit I		
1	Strain gauges and its types; working principle, wheatstone bridge measurement, commercial available strain gauges	**2**
2	Applications of strain gauges in two and three dimensional force measurement in farm machinery	**2**
3	Various methods of determining strain/stresses experimentally	**2**
4	Design, selection and analysis of strain gauges	**2**
Unit II		
5	Introduction to transducers (sensors).	**1**
6	Active and passive transducers, analog and digital modes, null and deflection methods	**2**
7	Performance characteristics of instruments including static and dynamic characteristics	**2**
Unit III		
8	Load cells, torque meters, flow meters types and principles of working	**3**
9	Devices for measurement of temperature and relative humidity	**2**
10	Devices for measurement of pressure and sound	**2**
11	Devices for measurement of vibration and displacement (LVDT)	**2**
12	Recording devices and their types	**1**
13	Measuring instruments for calorific value of solid, liquid, and gaseous fuels	**2**
Unit IV		
14	Basic signal conditioning devices and data acquisition system	**1**
15	Micro computers for measurement and data acquisition; general purpose microcontrollers and microprocessors	**2**
16	Data storage and their application including wireless communication	**2**
17	Application of sensors in farm machinery and power: Tractor and selected farm machinery	**2**
	Total	**32**

9. List of Practical

S. No.	Practical	No of Practical
1	Calibration of Load Cells	**2**
2	Calibration of Torque Meters	**1**
3	Calibration of Flow Meters	**1**
4	Experiment on LVDT	**2**
5	Experiment on Strain Gauge	**1**
6	Speed measurement using optical devices	**2**
7	Vibration Measurement	**2**
8	Making of Thermocouples	**2**
9	Application of Sensors in Farm Machinery like wheel hand hoe etc	**3**
	Total	**16**

10. Suggested Readings

- Ambrosius EE. 1966. Mechanical Measurement and Instruments. The Ronald Press Company.
- Doeblin EO. 2004. Measurement System- Application and Design. Tata McGrawHill
- Nakra BC and Choudhary KK. 1985. Instrumentation, Measurement and Analysis.2nd Edition Tata McGraw Hill.
- Nachtigal CL (Editor). 1990. Instrumentation and Control. Fundamentals and Application. Wiley Series in Mechanical Engineering.
- Oliver FJ. 1971. Practical Instrumentation Transducers. Hayden book company Inc.Course

SYSTEMS SIMULATION AND COMPUTER AIDED PROBLEM SOLVING IN ENGINEERING

1. Course Title : Systems Simulation and Computer Aided Problem Solving in Engineering

2. Course Code : FMPE 514

3. Credit Hours : 1+1

4. Aim of the course

- To give the student orientation in simulation of continuous and discrete systems especially using computer programme and software.

5. Theory

Unit I

Mathematical modeling and engineering problem solving: Conservation laws and engineering. Computers and software: Software development, structured programming, logical representation. Modular programming. Approximation: Round off errors, truncation errors, significant figures, accuracy and precision.

Unit II

Nature of simulation: Systems models and simulation, discreet event simulation, time advance mechanisms, components of discrete event simulation model, simulation of single server queuing system. Program organization and logic, development of algorithm. Simulation of an inventory system.

Unit III

Solving roots of equation using computers. Application in: Ideal and non-ideal gas laws, open channel flows, design of an electric circuit, vibration analysis. Solving linear algebraic equation on computers: Naïve Gauss Elimination, techniques for improving solutions, LU decomposition and matrix inversion. Application in: Steady state analysis of chemical reactors, statically determinate truss, current and voltage in circuits, spring mass systems.

Unit IV

Optimization techniques. Search techniques: Golden Sections, quadratic interpolation. Application: Optimum design of tank, least cost treatment of waste water, power transfer for circuits. Solving ordinary differential equation on computers: Modeling engineering systems with ordinary differential equation, solution techniques using computers.

6. Practical

Comparison of analytical and numerical solutions using Spread sheet. Generation of random variables. Generation of discreet and continuous random variate coding. Implementation of

single server queue on computer. Exercises with software packages for roots of equation: Solving linear algebraic equation, curve fitting and optimization. Solving simultaneous equation through Gauss elimination, solving steady state analysis of chemical reactors, statically determinate truss, current and voltage in circuits, spring mass systems on computers. Application of ordinary differential equation to solve mixed reactor problems, predator prey models and chaos.

7. Learning outcome

- Ability to analyze problems from a systems perspective and apply the principles to simulation of continuous and discrete engineering systems

8. Lecture Schedule

S. No.	Topic	No of Lectures
1	Introduction to mathematical modeling in engineering problem solving, comparison of analytical and numerical approaches	**1**
2	Conservation laws applied to engineering, modeling simple system	**1**
3	Computer modeling, computing environments software development process.	**1**
4	Modular design, top down design, structured programming, algorithm design	**1**
5	Program composition, quality control- testing and documentation software strategy	**1**
6	Approximation- round off errors- accuracy and precision definitions, number system in the computer- truncation errors.	**1**
7	Nature of simulation, systems models and simulation.	**1**
8	Discreet event simulation, time advance mechanisms, components of discreet event simulation model	**1**
9	Principles of simulation of singular server queuing system	**1**
10	Programme organization and logic for single server queuing system	**1**
11	Development of algorithm, single server queuing system	**1**
12	Solving roots of equation in computers, graphical method	**1**

13	Developing algorithm for bisection method, false position method	**1**
14	Application of roots of equation to gas laws, open channel flows	**1**
15	Application of roots of equation to electric circuits, vibration analysis	**1**
16	Solving linear algebraic equation in engineering practices	**1**
17	Developing algorithm for Gaussian elimination.	**1**
18	Pitfalls of elimination methods and remedies	**1**
19	Overview of LU decomposition	**1**
20	LU decomposition algorithms, calculating inverse of matrix	**1**
21	Application of linear algebraic equation to statically determinate truss	**1**
22	Application of linear algebraic equation to Circuit analysis	**1**
23	Application of linear algebraic equation to spring mass system	**1**
24	Introduction to optimization in engineering, Formulation of Problems.	**1**
25	One dimensional unconstrained optimization, development of algorithm for golden sections	**1**
26	One dimensional unconstrained optimization quadratic interpolation	**1**
27	Application of optimization to design of tank	**1**
28	Application of optimization to waste water treatment problem	**1**
29	Application of optimization to power transfer circuits	**1**
30	Formulating engineering problems using ordinary differential equation	**1**
31	Solving ordinary differential equation using computers, Euler's method.	**1**
32	Solving ordinary differential equation using modeling engineering Systems, computers, Runge-kutta method	**1**
	Total	**32**

9. List of Practical

S. No.	**Practical**	No of Practical
1	Exercises in developing simple programmes in C	1

2	Demonstration of solutions using analytical and numerical methods for simple problems.	1
3	Solving simple engineering problems using roots of equation	1
4	Development of programmes for generation of random variables	**1**
5	Writing programme for generating random variates	**1**
6	Writing programme for event advance mechanism of single server queuing system	**1**
7	Writing programme for arrival module of single server queuing System.	**1**
8	Writing programme for departure module of single server queuing system and statistical performance	**1**
9	Writing programme for solution of roots of equation	**1**
10	Development of algorithm for Gaussian elimination	**1**
11	Application of Gaussian elimination to mass balance problems and statically determinate truss	**1**
12	Application of Gaussian elimination to analysis of electrical circuits	**1**
13	Development of algorithm for Golden Sections and application	**1**
14	Application of optimization technique to design of tank	**1**
15	Application of optimization technique to waste water treatment	**1**
16	Predator prey models and chaos	**1**
	Total	**16**

10. Suggested Readings

- Balagurusamy E. 2000. Numerical Methods. Tata McGraw Hill Publishing Company limited, New Delhi.
- Chapra SC and Canale RP. 1994. Introduction to Computing for Engineers. 2nd Edition McGraw Hill International Edition, New York.
- Dent JB and Blackie MJ. 1979. System Simulation in Agriculture. Applied Science Publishers Ltd., London.
- Law AM. 2015. Simulation Modeling and Analysis. McGraw Hill International Edition, New York.
- Schilling RJ and Harries SL. 2002. Applied Numerical Methods for Engineers Using MATLAB and C.Thomson Asia Pvt. Ltd. Singapore.

- Veerarajan T and Ramachnadran T. 2004. Numerical Methods with Programmes in C and C++. Tata McGraw Hill Publishing Company limited, New Delhi.

COMPUTER AIDED DESIGN OF MACHINERY

1. Course Title : Computer Aided Design of Machinery

2. Course Code : FMPE 515

3. Credit Hours : 0+2

4. Aim of the course

To learn the practice of designing components and assemblies based on computer aided drafting technique.

5. Practical

Learning 2D drafting: Controlling display settings, setting up units, drawing limits and dimension styles. Drawing and dimensioning simple 2D drawings, keyboard shortcuts. Working with blocks, block commands. Exercise in simple assembly in orthographic. Exercise in measuring and drawing simple farm machinery parts. Learning 3D Drafting: Advantages of virtual prototyping-starting the 3D drafting environment, self-learning tools, help and tutorials. Familiarizing with user interface, creating files and file organization, structuring and streamlining. Features of document window. Concept of coordinate system: Working coordinate system, model coordinate system, screen coordinate system, graphics exchange standards and database management system. Working with feature manager and customizing the environment. Planning and capturing design intent. Documentation of design. Using design journal and design binder. Preliminary design review and layout. Practice in drawing 2D sketches with sketcher and modifying sketch entries. Adding Reference geometry: Planes and axes. Adding relations and working with relations. Dimensioning a sketch. Exercises.

Parts and features: Sketched features and applied features, pattern and mirror features. Documenting design. Assembly: Creating and organizing assemblies, connecting parts and subassemblies with mates. Organizing the assembly by using layouts.

Exercise in creating drawing: Setting up and working with drawing formats, creating drawing views from the 3D model, making changes and modifying dimensions. Case studies: Measuring and drawing assemblies of farm implements and their components.

6. Learning outcome

- The student will be able to conceptualize spatial concepts and design components and assemblies of Farm machinery and make graphic models using commercial CAD software like Solid Works, Catia and AutoCAD.

7. List of Practical:

S. No.	Practical	No of Practical
1	Learning 2D drafting: Controlling display settings, setting up units, drawing limits and dimension styles	**2**
2	Drawing and dimensioning simple 2D drawings, keyboard shortcuts	**1**
3	Working with blocks, block commands. Exercise in simple assembly in orthographic	**1**
4	Exercise in measuring and drawing simple farm machinery parts	**2**
5	Learning 3D Drafting: Advantages of virtual prototyping-starting the 3D drafting environment, self-learning tools, help and tutorials. Familiarizing with user interface, creating files and file organization, structuring and streamlining. Features of document window	**2**
6	Concept of coordinate system: Working coordinate system, model coordinate system, screen coordinate system, graphics exchange standards and database management system.	**2**
7	Working with feature manager and customizing the environment. Planning and capturing design intent	**2**
8	Documentation of design. Using design journal and design binder. Preliminary design review and layout	**1**
9	Practice in drawing 2D sketches with sketcher and modifying sketch entries	**2**
10	Adding Reference geometry: Planes and axes. Adding relations and working with relations. Dimensioning a sketch. Exercises	**2**
11	Parts and features: Sketched features and applied features, pattern and mirror features. Documenting design	**2**
12	Assembly: Creating and organizing assemblies, connecting parts and subassemblies with mates	**2**
13	Organizing the assembly by using layouts	**1**
14	Exercise in creating drawing: Setting up and working with drawing formats, creating drawing views from the 3D model, making changes and modifying dimensions.	**2**
15	Case studies: Measuring and drawing assemblies of farm implements and their components.	**5**
	Total	**32**

8. Suggested Readings

- Jankowski G and Doyle R. 2007. SolidWorks® For Dummies®, 2nd Edition, Published

by Wiley Publishing, Inc. ISBN: 978-0-470-12978-4

- Shih R H. 2014. AutoCAD 2014 Tutorial-First Level: 2D Fundamentals. SDC Publications

ADVANCED MANUFACTURING TECHNOLOGIES

1. Course Title : Advanced Manufacturing Technologies

2. Course Code : FMPE 516

3. Credit Hours : 2+0

4. Aim of the course

- To learn the modern manufacturing techniques and their application to manufacture of different components and assemblies.

5. Theory

Unit I

Material and their characteristics, structure and properties of materials, wood, ferrous, Non-ferrous, alloys, plastic, elastomers, ceramics and composites. Material selection and metallurgy: Equilibrium diagram, time temperature transformation curves, heat treatments, surface treatment: Roughness and finishing.

Unit II

Measurement and quality assurance: Quality control, tolerance, limits and clearance. Automated 3-D coordinate measurements. Advance casting processes and powder metallurgy. Forming process: Fundamentals of metal forming, hot and cold rolling, forging processes, extrusion and drawing.

Unit III

Workshop practices applied in prototype production, jigs and fixtures. Traditional machining processes: Cutting tools, turning, boring, drilling, milling and related processes. Nontraditional machining processes fuzzy c-mean (FCM), electric discharge machining (EDM), laser beam machining (LBM), Abrasive jet machining (AJM), and Wire-electro-discharge machining (EDM).

Unit IV

Joining processes: Gas flame processes, arc processes, brazing and soldering, adhesive and bonding.

Unit V

Numerical control: Command system codes, programme, cutter position X and Y, incremental movements, linear contouring, Z movements and commands. Manufacturing systems and automation. Robotics and robot arms. 3-D printing. Integrated manufacturing production system.

6. Practical

Identification of material and their application. Study of heat treatment processes and their suitability with respect to materials. Tool and equipment for measurements: Tolerance limits, clearance and surface finish. Site visits for study of advanced manufacturing techniques. Case studies.

7. Learning outcome

- The students will be able to select suitable manufacturing technique to fabricate different components used in Farm machinery.

8. Lecture Schedule

S. No.	Topic	No of Lectures
1	Material and their characteristics	**1**
2	Structure and properties of materials wood, ferrous, Non-ferrous, alloys, plastic, elastomers, ceramics and composites	**2**
3	Material selection and metallurgy: Equilibrium diagram, time temperature transformation curves	**1**
4	Heat treatments, surface treatment: Roughness and finishing	**2**
5	Measurement and quality assurance: Quality control, tolerance, limits and clearance.	**1**
6	Automated 3-D coordinate measurements and practice	**2**
7	Advance casting processes and powder metallurgy	**1**
8	Forming process: Fundamentals of metal forming, hot and cold rolling, forging processes, extrusion and drawing	**2**
9	Forging processes, extrusion and drawing	**1**
10	Workshop practices applied in prototype production, jigs and fixtures	**1**
11	Traditional machining processes: Cutting tools, turning, boring, drilling, milling and related processes	**2**
12	Nontraditional machining processes fuzzy c-mean (FCM), electric discharge machining (EDM), laser beam machining (LBM).	**2**
13	Electric discharge machining (EDM), laser beam machining (LBM).	**1**
14	Abrasive jet machining (AJM) and wire-electro-discharge Machining (EDM).	**2**
15	Joining processes: Gas flame processes, arc processes	**2**

16	Brazing and soldering processes	**1**
17	Adhesive and bonding processes	**1**
18	Numerical control: Command system codes	**1**
19	NC Programme, Robotics and robot arms.	**2**
20	Cutter position X and Y, incremental movements, linear contouring, Z movements and commands	**2**
21	Manufacturing systems and automation.	**1**
22	3-D printing and integrated manufacturing production system	**2**
	Total	**32**

9. List of Practical

S. No.	Practical	No of Practical
1	Identification of material and their application	**2**
2	Study of heat treatment processes and their suitability with respect to materials.	**5**
3	Tool and equipment for measurements: Tolerance limits, clearance and surface finish	**4**
4	Site visits for study of advanced manufacturing techniques	**2**
5	Case studies.	**2**
6	Practical examination	**1**
	Total	**16**

10. Suggested Readings

- Begeman ML, Ostwald PF and Amstead BH. 1979. Manufacturing Processes: SI Version. John Wiley and Sons. 7th Edition.
- Chapman PAJ. 1996. Workshop Technology, Part III. CBS Publisher and distributors Pvt Ltd. 3rd Edition international Edition.
- Gupta RB. 2017. Production Technology, Vol I - Production Process. Satya Prakashan, New Delhi.
- Hoyos L. 2010. Fundamentals of Tool Design. American Society of Tool and Manufacturer Engineers. Sixth Edition.
- Jain RK. 1994. Production Technology: A Textbook for Engineering Students. Khanna Publishers, New Delhi.

- Polukin P, Gringerg B, Kantenik S, Zhadan V and Vasilye D. Metal Process Engineering,
- MIR Publishers Moscow.

MACHINERY FOR PRECISION AGRICULTURE

1. Course Title : Machinery for Precision Agriculture

2. Course Code : FMPE 517

3. Credit Hours : 2+1

4. Aim of the course

To learn the principles behind precision agriculture and the systems for implanting the same.

5. Theory

Unit I

Importance of precision agriculture. Mapping in farming for decision making. Geographical concepts of PA. Understanding and identifying variability

Unit II

Geographical Position System (GPS) Basics (Space Segment, Receiver Segment, Control Segment), Error and correction, Function and usage of GPS. Introduction to Geographic Information system (GIS), function of GIS, use of GIS for decisions. IDI devices usage in Precision Agriculture Yield monitor, variable rate applicator for fertilizers, seed, chemicals etc. Remote sensing Aerial and satellite imagery. Above ground (non-contact) sensors.

Unit III

Data analysis, concepts of data analysis, resolution, Surface analysis. Analysis application interpretive products (map, charts, application map etc).

Unit IV

Electronics and Control Systems for Variable rate applications, Precision Variable Equipment, Tractor-Implement interface technology, Environmental Implications of Precision Agriculture.

Unit V

Goals based on end results of Precision Agriculture, Recordkeeping, Spatial Analysis, Variable Rate Application, Reducing of negative environmental impact, Crop/ technology cost optimization. Economic of precision agriculture and determining equipment and software, review of Cost/Benefit of Precision Agriculture, System vs. Parcels. Making a selection.

6. Practical

Calculation of the benefits of Data and Mapping, Determining Latitude/Longitude, UTM or

State Plane Position Navigation with Waypoints, Configuring a GPS System. Defining area of field for prescriptive treatment. Making the Grid, The Grid Sampling Process, generation of yield maps, Thematic or Spatial Resolution, Yield Map Example, Surface Analysis in Arc-View

7. Learning outcome

- Knowledge about the principles guiding the concept of precision agriculture and Farm Machinery and equipment systems that make muse of this principle

8. Lecture Schedule

S. No.	Topic	No of Lectures
1	Introduction to precision agriculture, its importance and applications	**1**
2	Mapping in farming for decision-making and geographical concept of PA.	**2**
3	Understanding and identifying variability	**1**
4	Introduction to Geographical Position System (GPS). Function and usage of GPS	**2**
5	Basics of GPS (Space Segment, Receiver Segment, Control Segment), Error and correction	**2**
6	Introduction to Geographic Information system (GIS), function of GIS,use of GIS for decisions	**2**
7	Remote sensing including aerial and satellite imagery	**2**
8	IDI devices usage in Precision Agriculture Yield monitor, variable rate applicator for fertilizers, seed, chemicals etc. Above ground (non-contact) sensors	**2**
9	Data analysis, concepts of data analysis	**3**
10	Surface analysis. Analysis application interpretive products (map, charts, application map etc)	**2**
11	Precision Variable Equipment	**2**
12	Electronics and Control Systems for variable rate applications	**2**
13	Tractor-Implement interface technology, Environmental Implications of Precision Agriculture	**2**
14	Recordkeeping, Spatial Analysis	**2**
15	Rate Application, reducing of negative environmental impact, Crop/technology cost optimization	**2**
16	Economic of precision agriculture and determining equipment	**2**
17	Review of Cost/Benefit of Precision Agriculture, Making a selection	**2**
	Total	**33**

9. List of Practical

S. No.	Practical	No of Practical
1	Calculation of the benefits of data and mapping	**1**
2	Determining Latitude/Longitude, UTM or State Plane Position Navigation with Waypoints	**2**
3	Configuring a GPS System	**1**
4	Defining area of field for prescriptive treatment	**1**
5	Making the grid and grid sampling process	**2**
6	Collection of tractor-implement interface data	**1**
7	Generation of yield maps	**2**
8	Example of spatial and temporal variability and resolution	**1**
9	Surface Analysis using software like Arc-View	**2**
10	Economic of precision agriculture and determining equipment	**2**
11	Cost/Benefit of Precision Agriculture for making a optimized selection	**2**
	Total	**17**

10. Suggested Readings

- Clay SA, Clay DE and Bruggeman SA, 2017. Practical Mathematics for Precision Farming American Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585 Gulford Rd, Madison, WI 53711
- Henten EJV, Goense D and Lokhorst C. 2009. Precision Agriculture. Wageningen Academic Publishers.
- Ram T, Lohan SK, Singh R and Singh P. 2014. Precision Farming: A New Approach. Astral International Pvt. Ltd., New Delhi, ISBN: ISBN 978-81-7035-827-5 (Hardbound) ISBN 978-93-5130-258-2 (International Edition).
- Shannon DK, Clay DE and Kitchen NR (editors). 2018. Precision Agriculture Basics American Society of Agronomy, Crop Science Society and Soil Science Society of America, 5585 Gulford Rd, Madison, WI 53711
- Singh AK and Chopra UK. 2007. Geoinformatics Applications in Agriculture. New India Publishing Agency, Pritam Pura, New Delhi.

MACHINERY FOR HORTICULTURE AND PROTECTED AGRICULTURE

1. Course Title : Machinery for Horticulture and Protected Agriculture

2. Course Code : FMPE 518

3. Credit Hours : 2+0

4. Aim of the course

- To learn about the different machinery used in cultivation of vegetable crops, orchard crops and also in protected agriculture.

5. Theory

Unit I

Vegetable cultivation, nursery machinery, tray seeders, grafting machines, vegetable trans-planters. Machinery for planting crops on raised beds, mulch laying and planting machines. Harvesting of vegetable crops: Harvesting platforms and pickers.

Unit II

Machinery for orchard crops: Pit diggers, inter-cultivators and basin forming equipment for orchards. Machinery for transplanting of trees. Harvesters for fruit crops: Shaker harvesters, types and principle of operation. Elevated platforms for orchard management and harvesting. Pruning machines.

Unit III

Machinery for orchards, vineyard machinery spraying machines, inter-cultivation machines. High clearance machines and special purpose machinery for crops on trellis. Machinery for special crops: Tea leaf harvesters, pruners and secateurs.

Unit IV

Machinery for lawn and garden: Grass cutters, special machinery for turf maintenance. Turf aerators and lime applicators.

Unit V

Protected agriculture: Principles, mechanical systems of greenhouse, ventilation systems, shading system, water logging system, irrigation system, sensors, electrical and electronic system. Intelligent Control system for greenhouses. Machinery for processing of growth media, tray filling machines-tray sowing machines, transplanting machines. Robotic grafting machines. Weeding and thinning equipment. Crop protection and harvest under protected agriculture.

6. Learning Outcome

- Knowledge about different principles of mechanizing cultivation of horticultural crops and in protected agriculture.

7. Lecture Schedule

S. No.	Topic	No of Lectures
1	History of vegetable cultivation in India and scope of mechanization in Horticulture	**1**
2	Methods of Nursery propagation techniques and machinery for nursery and tray seeders	**1**
3	Machinery for field preparation for vegetables (Disc harrows, Disc plough, offset rotavator, sub soiler, bed makers)	**1**
4	Principles of mulch laying and planting machines. Types of vegetable transplanters and their construction and working	**1**
5	Working and construction of subsurface drip laying machine. Types of planters for vegetable crops and its working	**1**
6	Principles of Pneumatic vegetable seeders and its working. Machinery for harvesting of vegetable crops like root crop harvester, its construction and working	**1**
7	Types of vegetable extraction machine, its working and construction	**1**
8	Types of pickers, their construction and working	**1**
9	Construction and working of different types of post hole diggers	**1**
10	Types of tractors and their uses in orchards	**1**
11	Types of inter cultivators and its construction and working.	**1**
12	Types of brush cutters and its working	**1**
13	Types of basin forming equipment for orchards. Machinery for transplanting of trees and their construction and working	**1**
14	Types of elevated platforms for orchard management. Types of Tree Pruners and principles and its working and construction	**1**
15	Types of fruit pluckers and its working and construction	**1**
16	Principles and working and construction of shaker harvesters	**1**
17	Types of vineyard machinery and its working and construction	**1**
18	Types of spraying machines and its working and construction. High clearance machines and special purpose machinery for crops on trellis.	**1**
19	Types of orchard sprayers, its working and construction	**1**
20	Types of Tea leaf harvesters, pruners and secateurs and its working and Construction	**1**

21	Special purpose machinery for crops on trellis	
22	Types of lawn and garden mowers and its working	
23	Studies on special machinery for turf maintenance working and construction of Turf aerators and lime applicators	
24	Introduction to protected agriculture. Principles of protected agriculture	
25	Greenhouses - Mechanical systems, ventilation systems, shading system, water fogging system and irrigation system	**2**
26	Sensors, electrical and electronic system. Intelligent Control system for greenhouses	**1**
27	Machinery for processing of growth media, tray filling machines-tray sowing machines, transplanting machines	**1**
28	Robotic grafting machines. Weeding and thinning equipment	**1**
29	Crop protection and harvest under protected agriculture	**1**
	Total	**30**

8. Suggested Readings

- Bell B and Cousins S. 1997. Machinery for Horticulture. Old Pond Publishing Ltd ISBN-10: 0852363699,ISBN-13: 978-0852363690
- Good Agricultural Practices for Greenhouse Vegetable Production in the South East European countries FAO Rome 2017.
- Ponce P, Molina A, Cepeda P, Lugo E and MacCleery B. 2014. Greenhouse Design and Control. CRC Press, ISBN 9781138026292 - CAT K23481, 1st Edition.

APPLIED INSTRUMENTATION

1. Course Title : Applied Instrumentation

2. Course Code : EE-501

3. Credit Hours : 2+1

4. Aim of the course

- To understand the operation of instruments that is used in design and evaluation of agricultural machinery and their application.

5. Theory

UNIT I

Basic instrumentation systems. Transducers principles. Active and passive transducers, analog and digital transducers, Displacement transducers, Potential meters, LDVT, Piezoelectric and capacitive transducers, velocity transducers. Strain gauges, types and applications. Performance characteristics of instruments including static and dynamic characteristics. Power and energy measuring technique

UNIT II

Temperature measurement using bi-metals, thermistors, thermocouples, humidity measurement, manometers. Need for digital instruments, Advantages and requirements of digital instruments, Measurement of frequency, Ratio of two frequencies, Product of two frequencies, high, average and low-frequency measurement, Digital Tachometer.

UNIT III

Load cells, torque meters, flow meters types and principles of working. Measurement of recording devices and their types. Measuring instruments for calorific value of solid, liquid, and gaseous fuels.

UNIT IV

Basic signal conditioning devices - data acquisition system - micro computers for measurement and data acquisition. Data storage and their application including wireless communication. Function Generator, Pulse Generator, RF Signal Generator, Harmonic Distortion Analyzer, Spectrum Analyzer, Digital Storage CROs.

6. Practical

Experiment on resistive, inductive and capacitive transducer.

Experiment on LVDT and strain gauge transducer.

Speed measurement using optical devices.

Vibration measurement exercises.

Study of block wise construction of a Function Generator

Measure of Voltage, Frequency, Phase and Modulation Index (Trapezoidal Method) using CRO Demonstrate features of Digital Storage Oscilloscope

Simulation of digital clock using Matlab

Addition and product of different frequencies using Matlab

Simulation of digital voltmeter using Matlab.

Analysis and simulation of digital multi-meter.

7. Theory lecture outlines:

S. No.	Topic	No of Lectures
	UNIT-I	**1**
1	Basic instrumentation systems introduction.	1
2	Transducers principles and types.	1
3	Active and passive transducers with application	1
4	Analog and digital transducers with application,	1
5	Displacement transducers.	1
6	Piezoelectric and capacitive transducers.	1
7	Velocity transducers circuit.	1
8	Potential meters and LDVT	1
9	Strain gauges, types and applications.	1
10	Performance characteristics of instruments including static and dynamic characteristics.	1
11	Power and energy measuring technique	1
	UNIT-II	**1**
12	Basic Temperature measurement instruments and types.	1
13	Measurement of temperature using bi-metals.	1
14	Measurement of temperature using thermistors and thermocouples.	1
15	Humidity measurement, manometers.	1
16	Need for digital instruments, Advantages and requirements of digital instruments.	1
17	Measurement of frequency, Ratio of two frequencies.	1
18	Product of two frequencies, high, average and low frequency measurement.	1

19	Digital Tachometer.	1
	UNIT-III	**1**
20	Load cells types and principles of working.	1
21	Torque meters, and flow meters types and principles of working.	1
22	Measurement of recording devices and their types.	1
23	Measuring instruments for calorific value of solid, liquid, and gaseous fuels.	1
	UNIT-IV	**1**
24	Basic signal conditioning devices.	1
25	Data acquisition system and application	1
26	Microcomputers for measurement and data acquisition.	1
27	Data storage and their application including wireless communication.	1
28	Function Generator and application	1
29	Pulse Generator with application	1
30	RF Signal Generator with application	1
31	Harmonic Distortion Analyzer,	1
32	Spectrum Analyzer, Digital Storage CROs.	1

8. Practical Class Outline:

S. No.	Practical	No of Practical
1	Experiment on resistive, inductive and capacitive transducer.	1
2	Experiment on LVDT.	1
3	Experiment on strain gauge transducer.	1
4	Speed measurement using optical devices and tachometer.	1
5	Experiment on thermistor for temperature measurement	1
6	Experiment on thermocouple	1
7	Vibration measurement exercises.	1
8	Measurement of Voltage and Frequency using CRO.	1
9	Measurement of Phase and Modulation Index (Trapezoidal Method) using CRO Demonstrate features of Digital Storage Oscilloscope	1

10	Study of block wise construction of a Function Generator	1
11	Study of block wise construction of a DSO.	1
12	Simulation of digital clock using Matlab	1
13	Addition and product of different frequencies using Matlab	1
14	Simulation of digital voltmeter using Matlab.	1
15	Analysis and simulation of digital multi-meter.	1
16	Experiment on resistive, inductive and capacitive transducer.	1

9. Suggested readings:

- *David A. Bell - Electronic Instrumentation and Measurements, Oxford Univ. Press, 1997*
- Mechanical Measurements. Addison-Wesley. Doeblin EO. 1966.
- Shaney A. K. 1997.*Measurement of Electrical and Electronic Instrumentation*. Khanna Publications.
- Measurement System - Application and Design. McGraw Hill. Ernest O Doebelin.1995.
- Instrumentation and Control. Fundamentals and Application. John Wiley & Sons. Oliver FJ. 1971.