S.No.	Topic	No. of Practicals
5.	Measurement of energy required for soil breakup by different methods.	2
6.	Field study of crop root development in relation to soil compaction and hard pan.	2
7.	Measurement of moisture movement in different surface configuration: Ridges, furrows, raised bed and flat bed.	2
8.	Field evaluation of plant establishment in relation to planting parameters.	1
	Total	**14**

X. Suggested Reading

- Birkas M. 2014. *Book of Soil Tillage*. Szent Istvan University Press, Godollo, Hungary. ISBN-978-963-269-447-4 (Unit III & IV).
- Koolen AJ and Kuipers H. 1983. *Agricultural Soil Mechanics*. Springer-Verlag. New York, USA. ISBN 13:978-3-642-69012-9 (Unit I, II, V).

I. Course Title : Mechanics of Traction and its Application

II. Course Code : FMPE 611

III. Credit Hours : 2+1

IV. Aim of the course

Learning techniques of modelling soil traction device interaction under different states of wheel and under different soil conditions by analytical and empirical method.

V. Theory

Unit I

Tractor performance in soft soils, operational states of wheel: Wismer and Luth. Path traced by point on tyre periphery. Rolling resistance, conditions of wheel soil interaction, theoretical prediction, work on soil deformation, Bekke's model, derivation of resistance offered by flat rigid plate on soft soil. Measurement of sinkage parameters. Soft wheel on soft surface and rigid wheel on soft surface. Empirical prediction of tractive force: Bekker's model, stress deformation relation in soil, analysis of tractive performance of tracks.

Unit II

Empirical modelling of tractor performance, tractive performance modelling and mobility number. Empirical models for rolling resistance and traction by Gee-Clough. Derivation of equations for drawbar pull and drawbar power.

Unit III

Rigid wheel systems. Rigid wheel at rest: Soil bearing capacity, contact pressure and sinkage. Rigid wheel at driving state: Ground reaction on rigid wheel during driving action, force balance in soil reaction to driving wheel, determination of driving force, compaction resistance and effective driving force. Energy equilibrium under driving wheel.

Unit IV

Wheel under braking state: Slip velocity and amount of slippage under braked

wheel. Soil deformation under braked wheel. Distribution of shear stresses and normal stress under driving wheel.

Unit V

Tyre wheel system-deformation of tyre and area of contact. Deformation of tyre and its measurement. Tyre deformation as function of inflation pressure. Ground reaction during pure rolling of tyre on hard surface. Trafficability in soft terrain, concept of wheel mobility number-cornering characteristic of wheel forces on a steered wheel under driving and braking conditions. Relation between cornering force and self-aligning torque.

VI. Practical

Measurement of soil parameters for modelling traction-simulation of the different traction models to obtain the tractive performance. Calculating the performance of tractor drive wheels, Braking performance of trailer wheels on road, Planter metering drive wheels, Tractor front wheel. Measurement of performance of tyres under soil bin condition/field condition for driving and braking. Measurement of variation in contact patch of tractor tyres under different inflation pressures. Design of lugged wheels for wet puddle soil condition. Field experiment with tractive performance of tractor.

VII. Learning outcome

Ability to model vehicle traction mechanics and provide insight into behavior of vehicles under different soil conditions.

VIII. Lecture Schedule

S.No.	Topic	No. of Lecture
1.	Tractor performance in soft soils, operational states of wheel: Wismer and Luth.	2
2.	Path traced by point on tyre periphery.	1
3.	Rolling resistance, conditions of wheel soil interaction, theoretical prediction, work on soil deformation, Bekke's model, derivation of resistance offered by flat rigid plate on soft soil.	4
4.	Measurement of sinkage parameters.	1
5.	Soft wheel on soft surface and rigid wheel on soft surface.	1
6.	Empirical prediction of tractive force: Bekker's model, stress deformation relation in soil, analysis of tractive performance of tracks	2
7.	Empirical modelling of tractor performance, tractive performance modelling and mobility number.	2
8.	Empirical models for rolling resistance and traction by Gee-Clough.	1
9.	Derivation of equations for drawbar pull and drawbar power.	1
10.	Rigid wheel systems. Rigid wheel at rest: Soil bearing capacity, contact pressure and sinkage.	2
11.	Rigid wheel at driving state: Ground reaction on rigid wheel during driving action.	2
12.	Force balance in soil reaction to driving wheel, determination of driving force, compaction resistance and effective driving force.	2
13.	Energy equilibrium under driving wheel.	1
14.	Wheel under braking state: Slip velocity and amount of slippage under braked wheel.	2
15.	Soil deformation under braked wheel.	1
16.	Distribution of shear stresses and normal stress under driving wheel.	1

S.No.	Topic	No of Lectures
17.	Tyre wheel system-deformation of tyre and area of contact.	1
18.	Deformation of tyre and its measurement. Tyre deformation as function of inflation pressure.	1
19.	Ground reaction during pure rolling of tyre on hard surface.	1
20.	Trafficability in soft terrain, concept of wheel mobility number-cornering characteristic of wheel forces on a steered wheel under driving and braking conditions.	2
21.	Relation between cornering force and self-aligning torque.	1
	Total	**32**

IX. List of Practicals

S.No.	Topic	No of Practicals
1.	Measurement of soil parameters for modelling traction-simulation of the different traction models to obtain the tractive performance.	3
2.	Calculating the performance of tractor drive wheels, Braking performance of trailer wheels on road, Planter metering drive wheels, Tractor front wheel.	4
3.	Measurement of performance of tyres under soil bin condition/ field condition for driving and braking.	2
4.	Measurement of variation in contact patch of tractor tyres under different inflation pressures.	1
5.	Design of lugged wheels for wet puddle soil condition.	2
6.	Field experiment with tractive performance of tractor.	2
7.	Revision	1
8.	Revision	1
	Total	**16**

X. Suggested Reading

- Muro T and O'Brien J. 2004. *Terramechanics: Land Locomotion Mechanics*. Lisse, Netherlands. ISBN 90 5809 572 X (Unit III, IV, V).
- Macmillan RH. 2010. *The Mechanics of Tractor-Implement Performance: Theory and Worked Examples: A Textbook for Students and Engineers*. Custom Book Centre, University of Melbourne, Australia. http://hdl.handle.net/11343/33718 (Unit I, II).

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