LITHUANIAN UNIVERSITY OF AGRICULTURE

FACULTY OF AGRICULTURE ENGINEERING

Department of Mechanics

STUDY SUBJECT DESCRIPTION

MECHANISM AND MACHINE THEORY

Study cycle: …BSc…… (BSc, MSc, PhD) Number of ECTS credit points: 4,5

Prerequisites and purpose:

Basic knowledge of mathematics, mechanics, physics, engineering graphics, informatics is required. This lecture is suitable for students of machines elements, computer design, agriculture machines branches.

Learning outcomes:

After completing the course students should obtain the knowledge of theoretical fundamentals and practical methods for solving engineering problems of the firm:

- have a clear overall picture about the machines and mechanisms structure and principles of motion;
- have good knowledge about the kinematics and dynamic analysis of mechanisms using Mathcad software;
- have enough knowledge about the synhthesis of linkages;
- have good knowledge about the vibration;
- have good knowledge about robotics.

Syllabus

- **Theory** (32 hours):

The world of mechanisms. Position and displacement. Velocity. Acceleration. Slider-crank, crank-rocker mechanisms. Cam design. Spur gears, helical gears. Synthesis of linkages. Spatial mechanisms. Dynamics of machines: static and dynamic force analysis. Vibration analysis. Robotics.

- **Practice classes** (48 hours)

1. Calculations of the slider-crank, crank-rocker mechanisms (22 hours)

2. Kinematics and dynamic analysis of the cam (24 hours)

3. Workshop (2 hours)

- **Private study** (80 hours)

1. Preparation for practical *16 hours*
2. Work on course project *32 hours*
3. Examination *32 hours*

Course project:

Themes of project taken from separate list. It should include description of the theme, the calculation examples using Mathcad software, conclusions and list of references. Size of project: 15-20 pages (format A4), font ≤ 12 pt with the pictures.

Teaching and learning methods:

Lectures, supported by PowerPoint presentation and slides. Scripts referring to the actual topics are distributed during lectures.

Registration for course:

Two weeks before the beginning of the course.

Methods and timing of assessment:

The structure of achievements assessment	Importance coefficient
Course project	0,40
Laboratories	0,10
Examination	0,50

Exam in written form. Registration for examination should be made with lecturer personally or by phone.

READING REFERENCES

MAIN LIST

1. Theory of machines and mechanisms. John J. Uicker, Gordon R. Pennokc, Joseph E. Shigley. Oxford University Press, 2003, p.734.????ess,
2. Mabie Hamilton H., Ocvirk F. W. Mechanisms and dynamics of machinery.-New York: John&Sons,1978.- p.610.
3. J. L. Meriam, L. G. Kraige. Engineering mechanics dynamics.-John Wiley&Sons, INC, 2001, p. 710

SUPPLEMENTARY LIST

1. Theory and practice of robot and manipulators. Ed. A. Morecki, G. Bianchi, K. Jaworek.-New York:Springer-Verlag,1995, p. 427.
2. Hibbeler R.C. Engineering mechanics: dynamics.- Singapore [etc.]: - Prentice Hall, 2004.- p.688.
3. Bedford A., Fowler W. Engineering mechanics: dynamics.- New Jersey. - Prentice Hall,

2002.- p.580.

4. Tongue B. H. Principles of vibration. - New York: Oxford University Press,2002.- p.518.

Study programme designed by
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ANNEX

CONTENT DESCRIPTION

Lessons (32 hours)

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1. The world of mechanisms (10 %).

- Classification of mechanisms
- The science of mechanics.
- Analysis and synthesis.
- Terminology, definitions, and assumptions.
- Mobility.
- Classification of mechanisms.
- Mechanical advantage.

2. Position and displacement (15 %).

- Locus of a moving point.
- Position of a point.
- Position difference between two points.
- Apparent position of a point
- Absolute position of a point.
- The loop-closure equation.
- Graphic position analysis.
- Algebraic position analysis.
- Complex-algebra solution of planar vector equations.
- Displacement of a moving point.
- Displacement difference between two points.
- Rotation.

3. Velocity (10 %).

- Definition of velocity.
- Rotation of a rigid body.
- Velocity difference between points of a rigid body.
- Velocity polygons.
- Velocity in a moving coordinate system.
- Angular velocity.
- Velocity analysis.

4. Acceleration (10 %).

- Definition of acceleration
- Acceleration difference between points of a rigid body.

- Acceleration polygons.
- Acceleration in a moving coordinate system.
- Angular acceleration.
- Acceleration analysis.

5. Slider-crank, crank-rocker mechanisms (10 %).

- Kinematics analysis.
    - Displacement diagrams.
    - Velocity diagrams.
    - Acceleration analysis.
- Dynamic analysis.
    - Gas force.
    - Equivalent masses.
    - Inertia forces.
    - Bearing loads in a single-cylinder engine.

6. Cam design (10 %).

- Kinematics analysis.
    - Displacement diagrams.
    - Velocity diagrams.
    - Acceleration analysis.
- Dynamic analysis.
    - Analysis of an eccentric cam.
    - Effect of sliding friction.
    - Analysis of disk cam with reciprocating roller follower.

7. Spur gears, helical gears (10 %).

- Terminology and definitions.
- Fundamental law of toothed gearing.
- Involute properties.
- Interchangeable gears.
- Fundamentals of gear-tooth action.
- Manufacture of gear teeth.
- Interference and undercuting.
- Contact ratio.
- Nonstandard gear teeth.
- Helical gears.

8. Synthesis of linkages (5 %).

- Type, number, and dimensional synthesis.
- Two position synthesis of slider-crank mechanisms.
- Three-position synthesis.
- Four-position synthesis; point-position reduction.

9. Dynamics of machines: static and dynamic force analysis (15 %).

- Static force analysis.
    - Newton's laws.
    - Applied and constraint forces.
    - Conditions for equilibrium.
    - Friction-force models.
    - Effect of sliding friction.
- Dynamic force analysis.
    - Centroid and center of mass.
    - Mass moments and products of inertia.
    - The principle of superposition.
    - Equation of motion.

10. Vibration analysis (3%).

- Differential equations of motion.
- Vertical model.
- Solution of the differential equation.

11. Robotics (2 %).

- Topological arrangements of robotic arms.
- Forward kinematics.

Practice classes (48 hours)

1. Calculations of the slider-crank, crank-rocker mechanisms (46 %)

Introduction to mechanisms design. Formulation of task for slider-crank design. Kinematics analysis: Displacement diagrams. Velocity diagrams. Acceleration analysis. Dynamic analysis: Gas force. Equivalent masses. Inertia forces.

Formulation of task for crank-rocker design. Kinematics analysis: Displacement diagrams. Velocity diagrams. Acceleration. Dynamic analysis: Equivalent masses. Inertia forces.

2. Kinematics and dynamic analysis of the cam (50 %)

Introduction. Formulation of task for the cam design. Kinematics analysis: Displacement diagrams. Velocity diagrams. Acceleration analysis. Analysis of an eccentric cam. Dynamic analysis.

3. Workshop (4 %)

Discussion and presentation of practical calculation and graphic exemples of slider-crank, crank-rocker and cam mechanisms.