

Faculty of Mechanical Engineering

### SUBJECT CARD

Name in Polish: **Mechanika Analityczna**

Name in English: **Analytical Mechanics**

Main field of study (if applicable): **Mechanical Engineering and Machine Building**

Specialization (if applicable):

Level and form of studies: **II level, full-time**

Kind of subject: **obligatory**

Subject code: **MMM041005**

Group of courses: **no**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30	15			
Number of hours of total student workload (CNPS)	60	60			
Form of crediting	Examination	Crediting with grade			
Group of courses					
Number of ECTS points	2	2			
including number of ECTS points for practical (P) classes		2			
including number of ECTS points for direct teacher-student contact (BK) classes	1.2	1.4			

#### PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Mathematical analysis (differential and integral calculus)
2. Linear algebra (matrices, determinants), geometry, trigonometry
3. Mechanics I and mechanics II in range of study stage I

## SUBJECT OBJECTIVES

- C1. Knowledge of analytical methods for the application of Lagrangian mechanics in the dynamics of mechanical holonomic systems (for systems with constraints depending and not depending from time). Knowledge of vibration analysis of linear holonomic conservative systems with many degrees of freedom.
- C2. Knowledge of the dynamics of a rigid body in case of the spherical rotation about a fixed point. The using in to the gyroscope (in approximate theory range). Elementary knowledge of the theory of mass collisions (elastic and inelastic collision)
- C3. Ability to independently analyze complex mechanical systems with a holonomic constraints which are not depend on time to determine : differential equations of movement, natural vibration frequency spectrum, the modal matrix. The ability of dynamic analysis of rigid bodies in case of the spherical rotation about a fixed point and gyroscope.
- C4. The acquisition and consolidation of social skills including emotional intelligence relying ability to work in a group of students with a view to effective problem solving.  
Responsibility, honesty and fairness in conduct; observance of manners in the academic community and society

## SUBJECT EDUCATIONAL EFFECTS

### **I. Relating to knowledge:**

PEK\_W01 - He can define a discrete mechanical holonomic system and its possible and virtual displacements. He knows the fundamental problem of dynamics. He knows the classification of dynamical systems in respect of the constraint types. He knows the general equation of dynamics and the principle of virtual work.

PEK\_W02 - He knows the notion of generalized coordinates and configuration space of a dynamical system. He knows the concept of generalized forces (active and inertia). He knows the Lagrange's equations of the first and second kind.

PEK\_W03 - He knows the variational interpretation of virtual displacements, the central equation of the dynamics and the Hamilton's principle. He has an elementary knowledge of gyroscopic systems and collision theory.

### **II. Relating to skills:**

PEK\_U01 - He is able to apply the virtual work principle and d'Alembert's principle for holonomic systems

PEK\_U02 - He can derive the differential equations of motion of discrete dynamical systems by using Lagrange's equations and by using the energy conservation law for conservative holonomic systems.

PEK\_U03 - He can calculate the spectrum of natural frequencies and can determine the modal matrix for discrete conservative linear systems. He is able to analyze the dynamics of the gyro using the approximate theory (gyroscopic moment and reaction forces in the supports). He can calculate the collision coefficients in inelastic collision.

### **III. Relating to social competences:**

PEK\_K01 - He can search information and is able to critical review

PEK\_K02 - He can objectively evaluate the arguments and rationally explain and justify own point of view.

PEK\_K03 - He can observe the customs and rules of the academic community.

## PROGRAMME CONTENT

Form of classes – Lecture

Number of  
hours

Lec1	Curriculum. Requirements. Examples of dynamic systems. Constrains and their types, classification systems for the sake of the constrain types (holonomic systems), possible velocities and possible displacements.	2
Lec2	The fundamental problem of dynamics, virtual displacement, the notion of ideal constraints, the general equation of dynamics, the virtual work principle.	2
Lec3	The dynamic general equation for the rotational and planar motion of rigid body (examples)	2
Lec4	Generalized coordinates. Derivation of differential equations of motion by using the energy conservation law expressed in generalized coordinates (examples).	2
Lec5	Generalized forces. Configuration space. Lagrange's equations (of II type).	2
Lec6	Lagrange's equations (cont. examples, applications). Lagrangian.	2
Lec7	Linear systems with a finite number of degrees of freedom, matrix notation, conservative systems.	2
Lec8	Free vibrations of conservative systems: natural frequencies, modal matrices, mode shapes.	2
Lec9	Harmonically forced vibration, frequency characteristics, an example of oscillation analysis of two- degree- of- freedom system.	2
Lec10	The dynamics of a rigid body in general motion: the orientation, the recognition issue. Kinematics and dynamics of rigid body in case the spherical rotation about a fixed point (reminder of the course Mechanics II), the angular momentum in the general movement.	2
Lec11	The dynamic equations for general motion of rigid body (Euler's equation).	2
Lec12	Gyroscope (approximate theory).	2
Lec13	An outline of linear elastic particle collisions theory, inelastic collision rate.	2
Lec14	Variational approach of Lagrangian mechanics.	2
Lec15	The central Lagrange's equation. Fundamental integral mechanical principle (Hamilton's principle)	2
		Total hours: 30
Form of classes – Classes		Number of hours
CI1	Introduction. Derivation of equations for possible velocities and virtual displacements.	2
CI2	Solving of static problems by using a principle of virtual work	2
CI3	Solving of dynamic problems by using a dynamic general equation (d'Alembert's principle).	2
CI4	Derivation of motion differential equations based on the energy conservation law and Lagrange's equations (comparison of methods and results) for systems with one and two degrees of freedom	2
CI5	Determination of the natural frequencies and modal parameters for conservative systems with two degrees of freedom	2
CI6	Solving some kinematic and dynamic problems in case of the spherical rotation about a fixed point of a rigid body.	2
CI7	Final test	2
CI8	Credits. Improvement of marks	1
		Total hours: 15

## TEACHING TOOLS USED

- N1. traditional lecture with the use of transparencies and slides
- N2. calculation exercises
- N3. tutorials
- N4. self study - self studies and preparation for examination

## EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT (Lecture)

Evaluation (F – forming (during semester), P – concluding (at semester end))	Educational effect number	Way of evaluating educational effect achievement
F1	PEK_W01- PEK_W03	written and oral exam
P = F1		

## EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT (Classes)

Evaluation (F – forming (during semester), P – concluding (at semester end))	Educational effect number	Way of evaluating educational effect achievement
F1	PEK_U01 - PEK_U03 PEK_K01 - PEK_K03	Final test
P = F1		

## PRIMARY AND SECONDARY LITERATURE

### PRIMARY LITERATURE

1. B. Gabryszewska, A. Pszonka, "Mechanics", part II, kinematics and dynamics, Wrocław University of Technology, 1988;
2. J. Zawadzki, W. Siuta, "General Mechanics", PWN, Warsaw, 1971;
3. B. Skalmierski, "Mechanics", PWN, Warsaw, 1982;
4. M. Lunn, A First Course in Mechanics, Oxford Science Publications, 1991

### SECONDARY LITERATURE

1. M. Kulisiewicz St. Piesiak, "Methodology of modeling and identification of mechanical dynamical systems", WUT. , 1994;
- 2 J. Leyko, "General Mechanics", WNT, Warsaw, 1980;
- 3 J. Giergiel, "General Mechanics", WNT, Warsaw, 1980

MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT  
**Analytical Mechanics**  
 AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY  
**Mechanical Engineering and Machine Building**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)	Subject objectives	Programme content	Teaching tool number
PEK_W01, PEK_W02, PEK_W03	K2MBM_W01, K2MBM_W02	C1, C2	Lec 1 to Lec 15	N1, N3, N4
PEK_U01, PEK_U02, PEK_U03	K2MBM_U02, K2MBM_U04	C3	CI 1 to CI 8	N2, N3, N4
PEK_K01, PEK_K02, PEK_K03	K2MBM_K01, K2MBM_K04, K2MBM_K05, K2MBM_K06	C4	CI 1 to CI 8	N2, N3, N4

SUBJECT SUPERVISOR

Prof. dr hab. inż. Maciej Kulisiewicz tel.: 320-27-60 email: [maciej.kulisiewicz@pwr.wroc.pl](mailto:maciej.kulisiewicz@pwr.wroc.pl)