module title: **ANALYTICAL MECHANICS**		
field of study: **Mechanical Engineering**	type of study: **full-time**	course code: **S6_2-5**
course: **Modelling & Simulation in Mechanics**	degree: **Master (MSc)**	year: **I** semester: **I**
type of classes: **lecture, classes, EXAM**	hours per week: **2L, 2C**	No of ECTS credits: **5**

MODULE DESCRIPTION

TARGETS

T1. Provide a mathematically sophisticated reformulation of Newtonian mechanics and build up a good foundation in analytical mechanics.
T2. Learn how to set up Lagrangian equations and obtain the equations of motion in generalized coordinates.
T3. Provide an introduction to the Hamiltonian formulation of dynamics.
T4. To acquire capabilities to perform analysis of the classic mechanical phenomena.
T5. Solve variety of problems analytically and systematically with confidence.

PREREQUISITES & ADDITIONAL REQUIREMENTS

R1. Fundamentals of Newtonian mechanics, basic knowledge of differential calculus,
R2. Fundamentals of vector algebra and dynamics.
R3. Capability of using source literature.
R4. Capability of individual work and collaboration in a group.
R5. Analysis and presentation of results.

LEARNING OUTCOMES

LO1. Knowledge on how to manipulate vectors fluently, including use of scalar and vector products and time-differentiation thereof.
LO2. Knowledge on constraints, generalized coordinates, velocities and accelerations.
LO3. Knowledge on calculus of variations and the concept of virtual displacement.
LO4. Knowledge on how to derive and apply Lagrange's equations.
LO5. Knowledge on the constrained Lagrangian dynamics and the concept of Lagrange multipliers.
LO6. Knowledge on dissipative systems and the idea of Rayleigh dissipation function.
LO7. Knowledge on how to derive and apply Hamilton's equations.

TEACHERS

Module coordinator: prof. Jacek Przybylski - j.przybylski@imipkm.pcz.pl
Academic teachers:
- prof. Jacek Przybylski - j.przybylski@imipkm.pcz.pl
- dr Tomasz Skrzypczak - t.skrzypczak@imipkm.pcz.pl

MODULE CONTENT

LECTURE	hours
L1-4 - Introduction to analytical mechanics. Vectors and their products (revision). Time-derivatives of vectors and their products. Work and kinetic energy.	**4**
L5-8 - Classification of constraints. Generalized coordinates, velocities and accelerations. Configuration space and its transformation. Virtual displacement.	**4**
L9-10 - Ideal constraints. Virtual work principle. A particle sliding without friction on a rotating ellipse.	**2**
L11-12 - D'Alembert's principle. Hamilton's principle.	**2**
L13-18 - Lagrange's equations. Equations of motion of holonomic systems with one and two degrees of freedom. Atwood machines. Sliding down a sliding plane.	**6**
L19-22 - Nonholonomic systems. Lagrange multipliers. Spherical pendulum.	**4**
L23-26 - A cylinder rolling down an inclined plane. Dissipative systems.	**4**
L27-28 - Hamilton's canonical equations.	**2**
L29-30 - Hamilton's equation of motion for a one-dimensional harmonic oscillator and for a particle in a central field.	**2**

TUTORIALS	hours
C 1-2 - Derivative of a composite function. Chain rule. (revision)	**2**
C 3-4 - Introduction to analytical mechanics. Classification of constraints.	**2**
C 5-8 - Generalized coordinates, velocities and accelerations.	**4**
C 9-10 - Generalized forces.	**2**
C 11-12 - Work and kinetic energy.	**2**
C 13-16 - Virtual displacement. Ideal constraints. Virtual work principle.	**4**
C 17-20 - D'Alembert's principle.	**4**
C 21-24 - Lagrange's equations. . Equations of motion of holonomic systems with one and two degrees of freedom.	**4**
C 25-26 - Hamilton's principle.	**2**
C 27-30 - Hamilton's canonical equations.	**4**

TEACHING TOOLS

1 - lecture with the use of multimedia presentations
2 - tutorials

SOURCE LITERATURE

1. Fasano A., Marmi S.: Notes on Analytical Mechanics. Oxford University Press, 2006
2. Chaichian M., Merches I., Tureanu A.: Mechanics: An Intensive Course. Springer-Verlag, Berlin Heidelberg, 2012
3. Fowles G. R., Cassiday G. L.: Analytical Mechanics. Cengage Learning, 7 edition, 2004
4. Meirovitch L.: Analytical Methods in Vibrations, Macmillan Company New York, 1967, reprinted by Pearson Education POD 1997
5. Tőrők J.: Analytical Mechanics. John Wiley & Sons Inc., New York, 2000