



COURSE DESCRIPTION CARD - SYLLABUS

Course name

Biomechanical modelling of human movement [S2IBio1E>BMRC]

Course

Field of study

Biomedical Engineering

Year/Semester

1/1

Area of study (specialization)

–

Profile of study

general academic

Level of study

second-cycle

Course offered in

English

Form of study

full-time

Requirements

compulsory

Number of hours

Lecture

15

Laboratory classes

30

Other

0

Tutorials

0

Projects/seminars

0

Number of credit points

4,00

Coordinators

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Lecturers

Prerequisites

Engineering knowledge of first cycle of study comprising mathematics, biomechanics and mechanics.

Course objective

Widening of knowledge of: dynamic modelling of biomechanical systems and devices for supporting human's organism. constructing of empirical models and performing numerical simulations in selected software aiding engineering calculations.

Course-related learning outcomes

Knowledge:

1. The student has knowledge of load models and structure of human's bone-muscle system.
2. Has knowledge of differential equations and numerical integration.
3. Knowledge of fundamental methods and computer techniques applied for solving complex biodynamical problems.
4. Knowledge of various mathematical models in various human activities.

Skills:

2. To work out a mathematical model for biodynamical system, formulate simplifications, perform numerical simulation and discuss model limitations.
3. To carry out numerical simulations to assess the strength of structures applied in rehabilitation and healing motion systems.

Social competences:

1. The student understands the need of life-long learning, of inspiring and organising other person's teaching process.
2. Is aware of importance of engineering knowledge and its importance for society and environment.
3. Understands the need for popularisation of knowledge of biomedical engineering.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Learning outcomes presented above are verified as follows:

Laboratory: Assessment of the skill to solve the assigned project: 2 tasks on numerical implementation of the problem (2,5 points for a task).

Lecture: Theoretical questions (plus presence on the lectures): criteria of assessment: >50% – ndst., 50%÷59% – dst, 60%÷69%– dst+, 70%÷79%. – db, 80%÷89% – db+, 90%÷100% – bdb).

Programme content

Lecture

1. Analytical statics.
2. Analytical Dynamics.
3. Mathematical modelling, biomechanical models.
4. Dynamical models for analysis of selected human activities. Determination of muscle and joint forces.
5. Modeling of muscle forces. Problems of redundant control.
6. Modeling aimed at assessing the effect of vibrations on humans body.

Laboratory

1. Introduction to software Mathematica for symbolic and numerical calculations in engineering. Exemplary applications (matrices, systems of linear equations, minima of multivariable functions, linear interpolation).
2. Determination of muscle forces in statically determinate and statically indeterminate systems.
3. Determination of muscle forces in the upper limb in isometric contraction.
4. Determination of muscle forces in the upper limb during exercises with expander.
5. Two-mass dynamic model for jump analysis without friction.
6. Two-mass dynamic model for jump analysis with friction.
7. Integrating of differential motion equation and numerical solutions of selected problems of sport biomechanics.

Course topics

Lecture

1. Analytical statics.
2. Analytical dynamics.
3. Mathematical modelling, biomechanical models for analysis of selected human activities. Determination of muscle and joint forces.
4. Modeling of muscle forces. Problems of redundant control.
5. ISB recommendation on definition of joint coordinate systems for the reporting of human joint motion. Transformation matrices.

Laboratory

Working in a software designed to model the kinematics and dynamics of the human movement system - OpenSim. Topics covered during the laboratory will include: the use of motion analysis techniques in biomechanical modeling, the influence of the length of muscles and tendons on the muscle torque generated in the joint, predicting the effectiveness of surgical procedures performed by changing the length or transplanting a tendon, using methods of inverse kinematics and inverse dynamics in observing various movement patterns, estimating muscle forces using redundant control methods and analysis of the effectiveness of orthopedic equipment in injury prevention.

Teaching methods

1. Lecture: the presentation illustrated with examples and problems solutions written down on the blackboard.
2. Laboratory: numerical modelling, implementation and simulations of the problems related with the human motion system.

Bibliography

Basic

1. Technical mechanics V. XII Biomechanics. Part 5 Problems of dynamics in biomechanics and modeling of human body (Mechanika Techniczna, t. XII Biomechanika, pod red. R. Będzińskiego, Część 5. Problemy dynamiki w biomechanice, Modelowanie ciała człowieka, Wojciech Błajer). IPPT PAN, Warszawa, 2011.
2. R. Będziński, Engineering biomechanics - selected problems (Biomechanika inżynierska - zagadnienia wybrane) Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław, 1997.
3. A. Morecki, J. Knapczyk, K. Kędzior, Teoria mechanizmów i manipulatorów, Dział 8 – wybrane zagadnienia biomechaniki ruchu człowieka, (Theory of mechanisms and manipulators. Section 8 – selected problems of human biomechanics) WNT, Warszawa, 2002.

Additional

1. J. Józwiak, J. Podgórski, Basics of statistics (Statystyka od podstaw), PWE Warszawa, 1994
2. R.S. Guter, A.R. Janpolski, Differential equations (Równania różniczkowe), PWN, Warszawa, 1989.
3. Praca zbiorowa pod redakcją D. Tejszerskiej, E. Świtońskiego, M. Gzika, Biomechanics of motion system (Biomechanika narządów ruchu), Wydawnictwo Naukowe Instytut Technologii Eksploatacji – PIB, Radom, 2011.

Breakdown of average student's workload

	Hours	ECTS
Total workload	100	4,00
Classes requiring direct contact with the teacher	45	2,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	55	2,00