

Course code

Course item

## 1. INFORMATION ABOUT THE COURSE

### a. Basic information

Course title	<b><i>Machine Design and Optimization</i></b>
Field of study	<i>Mechanical Engineering</i>
Cycle	<i>first / second degree</i>
Study profile	<i>general academic</i>
Study mode	<i>full-time</i>
Specialisation	
Unit responsible for the field of study	<i>Faculty of Mechanical Engineering, Department of Design</i>
Lecturer	<i>Michał Piotrowski, PhD</i>
Introductory courses	<i>Mathematics, Mechanics, Physics, Information Technology, Organization and Management, Fundamentals of Machine Design (FMD - lectures and practical classes) Engineering Graphics (EG with CAD)</i>
Prerequisites	<i>Basic knowledge of mathematics, mechanics, physics, information technology and management is required. CAD, machine design etc..</i>

### b. Semester/ weekly timetable

Semester	Lectures (W)	Classes (C)	Laboratories (L)	Project classes (P)	Seminars (S)	Fieldwork (T)	ECTS credits ECTS*
winter /summer	30	15	15	30			6

**C. Assumed outcomes and aims** - aims bind the course programme with the study programme and are referred to in learning outcomes point 2

## 2. LEARNING OUTCOMES (acc. to National Qualifications Framework)

No.	Description of learning outcomes	Reference to learning outcomes for the field of study	Reference to learning outcomes for the area of study
<b>KNOWLEDGE</b>			
K1	<i>Has basic knowledge of general engineering construction principles of fields of studies associated with field of stud</i>	K1_W10	P6S_WG
K2	<i>Knows basic models and numerical methods used to machine design process</i>	K1_W19	P6S_WG
K3	<i>Knows principles of safety rules related to that work and the reliability of machine</i>	K1_W09	P6S_WG
K4	<i>Has basic knowledge of machine engineering</i>	K1_W18	P6S_WG

	<i>construction to the extent enabling the preparation of engineering documentation</i>		
K5	<i>Has knowledge of basic optimization methods and criteria used in machine design, including multi-criteria decision making.</i>	K1_W16	P6S_WK
K6	<i>Has knowledge of measurement and data analysis methods supporting evaluation and optimization of machine design solutions.</i>	K1_W12	P6S_WG
<b>Skills</b>			
S1	<i>is able to plan and carry out measurements of geometric features of machine elements</i>	K1_U04	P6S_UW
S2	<i>is able to design simple machines and devices, taking into account the given technical, operational and economic criteria</i>	K1_U05	P6S_UW
S3	<i>is able to plan the production process of simple machines and devices and to estimate its costs initially</i>	K1_U06	P6S_UW
S4	<i>is able to design simple operating systems for machines and devices</i>	K1_U07	P6S_UW
S5	<i>is able to plan and carry out measurements of basic properties of engineering materials</i>	K1_U13	P6S_UO
S6	<i>Is able to analyse and optimize selected design parameters of machine elements with respect to given criteria (e.g. strength, mass, cost)</i>	K1_U08	P6S_UW
S7	<i>Is able to present and justify design and optimization results, including comparison of alternative solutions based on selected criteria</i>	K1_U11	P6S_UK
S8	<i>Is able to formulate engineering problems, develop simplified calculation models and evaluate design solutions under given loading and operating conditions</i>	K1_U08	P6S_UW
<b>SOCIAL COMPETENCES</b>			
SC1	<i>understands the need and knows the possibilities of continuous training (second and third degree studies, postgraduate studies, courses) - improving professional, personal and social competences</i>	K1_K01	P6S_KK
SC2	<i>Is aware of the impact of engineering design and optimization decisions on safety, economy and environment, and takes responsibility for these decisions.</i>	K1_K04	P6S_KO

### 3. TEACHING METHODS

*Multimedia lecture, laboratory lessons, project, design classes, presentation, discussion, case study*

### 4. METHODS OF EXAMINATION

*class attendance, final project presentation, reports from the exercises*

### 5. COURSE CONTENT

Specify the content separately for each type of classes in accordance with point I.B.  Lecture	<i>The course may be delivered in two configurations, referred to as Part 1 and Part 2, depending on the semester and students' background. Each part includes both fundamental and advanced topics in machine design and optimization, allowing flexibility in content depth and complexity. The level of the course is adjusted to the students' academic background and the profile of their home universities. Particular emphasis is placed on practical applications of engineering knowledge and on demonstrating modern technologies used in machine design and testing. The course emphasizes practical understanding through real engineering examples, experimental work</i>
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	<p><i>and project-based learning. Students are introduced to industrial approaches, measurement techniques and contemporary tools used in engineering practice. The course is designed to be accessible and manageable for students with different academic backgrounds. Topics are introduced progressively, and their level of complexity is adapted to the group.</i></p> <p><i>The course is based on the following thematic blocks:</i></p> <p><i>Part 1 – Fundamental Design and Experimental Methods</i></p> <ul style="list-style-type: none"> <li>• <i>Investigation of the influence of cross-section shape of aluminium profiles on deflection and stiffness</i></li> <li>• <i>Determination of characteristics and stress distribution of helical springs</i></li> <li>• <i>Investigation of friction torque in bolted joints</i></li> <li>• <i>Determination of friction losses in sliding bearings</i></li> <li>• <i>Analysis of irregular operation of angular couplings</i></li> <li>• <i>Analysis of efficiency of brakes</i></li> <li>• <i>Analysis of efficiency and slip in belt transmissions</i></li> <li>• <i>Analysis of gear meshing and methods of involute tooth profile modification</i></li> <li>• <i>Introduction to strain gauge measurements and basic measurement systems</i></li> <li>• <i>Experimental verification of strength and stiffness of structural elements</i></li> <li>• <i>Analysis of the significance and sources of measurement errors in laboratory tests and their influence on result interpretation in machine design</i></li> </ul> <p><i>Part 2 – Advanced Analysis, Measurement and Optimization</i></p> <ul style="list-style-type: none"> <li>• <i>Advanced analysis of beam structures under complex loading conditions</i></li> <li>• <i>Extended analysis of deflection and stiffness with consideration of real geometry and material behaviour</i></li> <li>• <i>Advanced modelling and analysis of spring systems under variable loading</i></li> <li>• <i>Analysis of bearing applications, functions and technological differences with respect to operating conditions and industrial use</i></li> <li>• <i>Advanced analysis of couplings and dynamic behaviour of drive systems</i></li> <li>• <i>Advanced analysis of stress distribution in welded joints (fillet welds)</i></li> <li>• <i>Experimental stress analysis using strain gauge techniques - Design, building and calibration of a strain gauge Load Cell</i></li> <li>• <i>Analysis of measurement uncertainty and its influence on engineering decisions</i></li> <li>• <i>Parametric analysis and comparison of alternative design solutions</i></li> <li>• <i>Introduction to optimization of machine elements with respect to strength, mass and efficiency</i></li> <li>• <i>Data interpretation and decision-making in engineering design</i></li> <li>• <i>Elements of design automation and data-supported optimization</i></li> </ul>
Laboratory	<p><i>Students are divided into small groups in order to verify and deepen theoretical knowledge presented during lectures. Laboratory classes are closely related to the thematic blocks of the course and are conducted on real engineering objects and test stands available in the Laboratory of Materials and Structural Testing. The laboratory is accredited by the Polish Centre for Accreditation (PCA), which ensures high standards of measurement quality and testing procedures. Due to the scientific and industrial activities carried out in the laboratory, particular attention is paid to safety requirements. Students are required to exercise special caution and maintain a high level of responsibility for safety during all laboratory activities.</i></p>

Projects	<p><i>Project work is based on individual design tasks corresponding to the thematic blocks of the course and is carried out progressively during the semester. Students develop engineering solutions involving both classical machine design and elements of design optimization. The project includes the design and analysis of selected machine elements such as couplings, bolted joints, welded connections, helical springs and mechanical transmissions (belt or gear drives). Emphasis is placed on proper selection of design parameters, strength verification and evaluation of operational performance. Depending on the level of the group, the project may also include optimization aspects, such as comparison of alternative design solutions, selection of optimal parameters with respect to criteria (e.g. strength, mass, efficiency, cost) and basic parametric studies. Elements of numerical analysis are introduced within the project work, including the use of the Finite Element Method (FEM) for verification of stresses, deformations and structural behaviour. FEM is used as a supporting tool for analysis and improvement of the designed components. The project may integrate analytical calculations, experimental data and numerical simulations, reflecting modern engineering design practice and iterative development of machine components.</i></p>
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## 6. VALIDATION OF LEARNING OUTCOMES

(Each learning outcome from the list requires validation methods to ensure that it was achieved by a student.)

Learning outcome	Form of assessment (for example:)					
	Oral examination	Written examination	Test	Project	Report	Class attendance
W1 – W2				x	x	x
U1 – U2				x	x	x
K1				x	x	x

## 7. LITERATURE

Basic literature	<p><i>Golenko, Andrzej. "Fundamentals of machine design." A Coursebook for Polish and Foreign Students. Dolnośląska Biblioteka Cyfrowa, Wrocław (2010).</i></p> <p><i>Collins J.A., Staab G.H., Busby H.R., 2002. Mechanical Design of Machine Elements and Machines. Wiley.</i></p> <p><i>Oberg E., Jones F.D., McCauley J., Heald R.M., 2004. Machinery's Handbook (27th ed.). Industrial Press.</i></p> <p><i>Mroziński S., 2001. Podstawy konstrukcji maszyn: laboratorium. Wydaw. Uczelniane ATR Bydgoszcz.</i></p> <p><i>Bhandari V.B., 2010, Design of Machine Elements (3rd ed.). Tata McGraw-Hill Education.</i></p> <p><i>Shigley J.E., Mischke C.R., Budynas R.G., Mechanical Engineering Design, McGraw-Hill, latest edition</i></p>
Supplementary literature	<p><i>Norton R.L., Machine Design: An Integrated Approach, Prentice Hall</i></p> <p><i>Harris T.A., Rolling Bearing Analysis, Wiley</i></p> <p><i>Spotts M.F., Shoup T.E., Design of Machine Elements, Prentice Hall</i></p> <p><i>Budynas R.G., Nisbett J.K., Shigley's Mechanical Engineering Design, McGraw-Hill</i></p> <p><i>Rao S.S., Engineering Optimization: Theory and Practice, Wiley</i></p>

## 8. TOTAL STUDENT WORKLOAD REQUIRED TO ACHIEVE EXPECTED LEARNING OUTCOMES EXPRESSED IN TIME AND ECTS CREDITS

Student's activity	Student workload– number of hours (for example:)
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Classes conducted under a direct supervision of an academic teacher or other persons responsible for classes	Participation in classes indicated in point 2.2	75
	Supervision hours	90
	Supervision hours	5
Student's own work	Preparation for classes	45
	Reading assignments	15
	Other (preparation for exams, tests, carrying out a project etc)	15
Total student workload		170
Final number of ECTS credits		6