COURSE DESCRIPTION CARD - SYLLABUS

Course name
Virtual design [N1MiBM2>PrW]

Course

Field of study
Mechanical Engineering

Year/Semester
3/6

Area of study (specialization)
–

Profile of study
general academic

Level of study
first-cycle

Course offered in
Polish

Form of study
part-time

Requirements
compulsory

Number of hours

Lecture
8

Laboratory classes
16

Other
0

Tutorials
0

Projects/seminars
0

Number of credit points

3,00

Coordinators

Lecturers

Prerequisites

KNOWLEDGE: Knowledge of geometry modeling methods in CAD systems. Basic knowledge of computer system design. Basic knowledge of structural analysis. SKILLS: Skill in operating computer systems. Ability to use CAD system to a basic extent. Ability to model geometry in a CAD system. Ability to use finite element method in practice.

Course objective

To introduce knowledge of the methods and processes involved in advanced virtual design using CAD design systems. To discuss graphical libraries of CAD systems and an overview of the engineering software market. To develop practical skills in creating a virtual design. To discuss and test practically the use of information exchange formats in CAD systems. To indicate the role of structural optimization in the design process. To indicate the factors stimulating the market need for the development of such design methods, which is the increasing manufacturing potential of additive methods. With the mastery of the possibility of additive manufacturing of products directly in metal, the demand for a design process that breaks with traditional technological limitations has increased by leaps and bounds. Introducing the virtual design process from concept development to product fabrication, taking into account spatial scanning methods and the development of subsequent virtual design stages up to the design for fabrication using CNC and Rapid Prototyping technologies. Discuss the role of "Generative Design" in the development of virtual design methods. To provide students with the competencies and skills needed to work in any company in a position requiring general engineering knowledge. To provide students with the opportunity to work in research centers and research and development departments of companies related to the manufacturing and service sectors.

Course-related learning outcomes

Knowledge:
1. The student has basic knowledge of engineering design and engineering graphics to design objects and processes, systems in terms of systems, machine components; formulate and analyze problems; seek solution concepts requiring complex engineering calculations, select and evaluate solution options; apply modeling for structural analysis and has knowledge of structural optimization methods.
2. The student has basic knowledge of graphical libraries of CAD systems, standards for information exchange, and the specifics of reconstructing geometry created in various CAD systems.
3. The student has basic knowledge of the development trends of computer-aided engineering design, is familiar with selected numerical optimization methods, and the development trends of Cax systems.
4. The student has basic knowledge covering "Generative Design" issues.

Skills:
1. The student is able to obtain information from literature, databases and other appropriately selected sources; he/she is able to integrate the obtained information, interpret it, and evaluate its usefulness for solving issues in the area of virtual design.
2. The student is able to use information and communication techniques appropriate to the performance of tasks typical of engineering activities.
3. The student is able to conduct computer simulations, interpret the obtained results and draw conclusions. He/she is able to use computer-aided engineering to solve technical tasks, especially in the area of virtual design.
4. He/she is able to solve technical problems based on the laws of mechanics; perform strength analyses of machine elements and mechanical systems, and use numerical tools for structural, flow and structural optimization analyses.

Social competences:
1 The student is able to interact and work in a group, taking different roles in it.
2. The student is able to set priorities for the realization of a task defined by him/herself or others, especially in the area of virtual design.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Oral and written tests. Individual evaluation of completed projects. The condition for receiving a passing grade is to obtain at least 50% of the possible points. This applies to any form of conducted classes, in particular, the degree of mastery of the material in the following is evaluated:
- knowledge of current trends in the application of modern engineering methods
- theoretical and practical knowledge of the basics of the operation of numerical algorithms used in virtual design
- practical use of virtual design procedures in the CAD environment.

Programme content

Lecture:
1 The history of CAD systems.
2. Virtual design - environment and its elements.
3. Overview of contemporary CAD/CAE systems, software market.
4. Graphical libraries of CAD systems and basic geometry modeling algorithms.
5. Information exchange formats in CAD systems.
6. Reconstruction of imported geometry in CAD systems.
7. The role of optimization procedures, directions of development, the essence of the "Generative Design" approach
Laboratory classes:
1. Parametric modeling of geometry, ways for building solid models.
2. Information exchange formats in CAD systems - practical exercises of writing and reading information.
3. Eeconstruction of imported geometry in CAD systems - practical exercises of geometry reconstruction in various CAD systems.
4. Task construction for structural analysis based on parametric shape description.
5. Design variants - cooperation of a CAD system with a spreadsheet.
6. Summary of the conducted laboratory classes and colloquium No. 1
7. Specification of preparing geometric models for topological optimization and shape optimization.
8. Conducting optimization for a selected technical problem.
9. Interpretation of optimization results and transition to a parametric model.
10. Modeling of geometry of solid objects for CFD calculations.
11. Performance of flow calculations for a selected technical problem.
12. "Generative Design" - familiarization with the software.
13. "Generative Design" - conducting a design study for a selected technical problem.
14. Summary of the conducted laboratory classes and colloquium No. 2
15. Discussion of the course results and determination of the final grades.

Course topics

none

Teaching methods

Interactive lecture with multimedia presentations.
Laboratory - computer exercises using specialized software.

Bibliography

Basic:
[1] Agston M.K., Computer Grapchics and Gemetric Modeling Mathematics, Springer, London 2005.
[2] Allen T.J., Managing the Flow of Technology, MIT Press, Boston 1977.
[3] Armstrong C.G., Modelling Requirements for Finite-Element Analysis, “CAD” 1994, 26(7), pp. 573-578.
[4] Arora R.K., Optimization - algorithms and applications, CRC Press, United States 2015.
[5] Baumgart B.G., Geometric modeling for computer vision, AD/A-002261, Stanford University, Stanford 1974.
[6] Bendsoe M.P., Sigmund O., Topology optimization. Theory, Methods and Applications, Springer-Verlag, Berlin-Heidelberg 2003.
[7] Bezier P., Numerical Control: Mathematics and Applications, John Wiley & Sons, London 1972.
[8] Braid I.C., Hillyard R.C., Stroud I.A., Stepwise construction of polyhedra in geometric modeling, in: Mathematical Methods in Computer Graphics and Design, ed. K.W. Brodlie, Academic Press, Leicester 1980.
[9] Díaz G., Herrera R.F., Muñoz-La Rivera F.C., Atencio E., Applications of generative design in structural engineering, “Revista Ingeniería de Construcción” 2021, 36(1), pp. 29-47
[10] Nowak M., Ziętak W., Projektowanie wirtualne z wykorzystaniem systemów CAD, Wydawnictwo Politechniki Poznańskiej, ISBN 978-83-7775-685-0, Poznań, 2023. [in Polish]

Additional:
[1] Dryja M., Jankowska J., Jankowski M., Przegląd metod i algorytmów numerycznych, cz. 1-2, WNT, Warszawa 1982. [in Polish]

[2] Rusiński E., Metoda elementów skończonych: system COSMOS/M, Wydawnictwa Komunikacji i Łączności, Warszawa 1994. [in Polish]
[3] Sigmund O., A 99-line topology optimization code written in Matlab, “Structural Multidisciplinary Optimization” 2001, 21, pp. 120-127.
[4] Zienkiewicz O.C., Taylor R.L., The finite element method, vol. 1-2, McGraw-Hill, London 1991.
[5] Zoutendijk G., Methods of Feasible Directions, Elsevier Publishing Company, Amsterdam, Netherlands, 1960.

Breakdown of average student's workload

	Hours	ECTS
Total workload	75	3,00
Classes requiring direct contact with the teacher	24	1,00
Student's own work (literature studies, preparation for laboratory classes/ tutorials, preparation for tests/exam, project preparation)	51	2,00