COURSE DESCRIPTION CARD - SYLLABUS

Course name
APPLICATION OF VARIATIONAL METHODS IN ENGINEERING

Course

Proposed by Discipline
Civil engineering and transport

Year/Semester
II/3

Type of studies
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
4

Tutorials

Projects/seminars

Number of credit points

1

Lecturers

Responsible for the course/lecturer:
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Responsible for the course/lecturer:

Prerequisites

Knowledge: knowledge of mathematics covered within engineering courses of studies at the level of the Master of Science degree. Knowledge of physics or mechanics will be an additional asset.

Skills: ability to apply the acquired knowledge and to obtain further information from the literature or other sources.

Social competencies: awareness of the necessity to expand the theoretical knowledge in order to justify its application in professional career. Taking responsibility for one's own work.

Course objective

The first objective is to present and discuss the basic concepts of variational methods and their applications in engineering. The second objective is to introduce the necessary mathematical background of modern variational methods in order to familiarize the PhD student with the latest ideas and computational methods within this short course.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:
1) modern achievements, encompassing both a theoretical foundation as well as practical implementation of general and selected aspects that are specific to engineering problems, especially in the fields of mechanics of materials and structures, [P8S_WG/SzD_W01]
2) effectivel description of a physical phenomenon or process and knows how to formulate its corresponding boundary value problem in a variational form so that they will be compatible with each other, [P8S_WG/SzD_W02]
3) the scientific research methodology and principles of presenting and promoting results of scientific activity. [P8S_WG/SzD_W03]

Skills

A PhD student who graduated from doctoral school can:
1) able to use the acquired knowledge to formulate a given boundary value problem as a variational problem and to determine its solution, [P8S_UW/SzD_U01]
2) able to critically analyze the determined solution and to draw conclusions. [P8S_UW/SzD_U02]

Social competences

A PhD student who graduated from doctoral school is ready to:
1) critically assess the achievements within their own field of research and understands the need to deepen and popularize knowledge about the achievements of science and technology, [P8S_KK/SzD_K01]
2) work in a team and is open to cooperation with other people and institutions, [P8S_KK/SzD_K02]
3) acknowledge the importance of knowledge in solving cognitive and practical problems. [P8S_KK/SzD_K03]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

PQF code	Methods for verification of learning outcomes	Assessment criteria
W01, W02, W03	Assessment of the PhD student's knowledge acquisition in terms of his or her active involvement in lectures. Adequate presentation and defence of their individual project	Level of detail and correctness of acquired knowledge, positive attitude to scientific research
U01, U02	Assessment of the PhD student's ability to solve an assigned problem in written form (project) and their ability to substantiate the applied solution method and obtained results	Corectness of the determined solution, diligence and quality of performance

K01, K02, K03	Assessment of the PhD student's ability to effectively present the results of his or her research in front of others, and their ability to critically reflect on the role of individual and team work in science and technology	Quality of critical reasoning, use of referencing and supporting evidence in drawing conclusions

Programme content

1. Mathematical concepts of variational analysis defined, explained and illustrated by means of examples from mechanics, physics, engineering (Set, convex sets, functions, functionals, convex functionals, linear vector spaces, duality pairing, differential equations, continuity, semicontinuity, weak and strong solutions to a differential equation, energy of a system, potential, minimization problem, differential and derivative of a functional, variational equation – Euler-Lagrange equation, constraints, variational inequalities, subdifferential, subderivative, discretization of functions and boundary value problems by finite dimensional approximation, solution algorithms for a system of linear and nonlinear algebraic equations).
2. Analytical and numerical examples of application.

Teaching methods

Lecture: multimedia presentation including illustrations and examples.

Bibliography

Basic

1. D. Cassel: Variational Methods with Applications in Science and Engineering. Cambridge University Press, 2013.

2. P. Blanchard, E. Brüning: Variational Methods in Mathematical Physics. A Unified Approach. Springer-Verlag, 1992.

3. I.M. Gelfand, S.W. Fomin: Calculus of Variations. Prentice-Hall, Inc. 1963.

Additional

1. I.M. Gelfand, S.W. Fomin: Rachunek wariacyjny. PWN, 1979.

2. T. Tatarkiewicz: Rachunek wariacyjny. WNT, cz. I (1969), cz. II (1970).

3. E. Zeidler: Nonlinear Functional Analysis and its Applications. III: Variational Methods and Optimization. Springer Science+Business Media, 1985.

4. M. Struwe: Variational Methods Applications to Nonlinear Partial Differential Equations and Hamiltonian Systems. Springer, 2008.

5. J. T. Oden, L. Demkowicz: Applied Functional Analysis. 3rd Ed., CRC Press, 2018.

6. M. Kuczma: Podstawy mechaniki konstrukcji z pamięcią kształtu. Modelowanie i numeryka (rozdz. 3: Nierówności wariacyjne i zadania komplementarności, str. 35-107). Wyd. UZ, 2010.

7. M. Kuczma, J. Mikołajski: Zastosowania rachunku wariacyjnego w inżynierii (w przygotowaniu).

Breakdown of average student's workload

	Hours	ECTS
Total workload	20	1.0
Classes requiring direct contact with the teacher	8	0.5
Student's own work (literature studies, project preparation) [1]	12	0.5

[1] delete or add other activities as appropriate