THE DOCTORAL SCHOOL OF IPPT PAN

COURSE OFFERED IN THE DOCTORAL SCHOOL OF IPPT PAN

Name of the course	Polish	**Wprowadzenie do obliczeń przy wykorzystaniu komputerów dużej mocy poprzez aplikacje**
	English	**Introduction to High-Performance Computing Through Applications**

Type of the course	**Specialized course**		
Course coordinator	**Eligiusz Postek, Ph.D., D.Sc., Eng.**	Course teacher	**Eligiusz Postek, Ph.D., D.Sc., Eng.**
Implementing unit	**ZINO**	Scientific discipline / disciplines	**Mechanical Engineering/ Technical Informatics and Telecommunication**

Level of education	**Doctoral studies**	Semester	**Summer or Fall**		
Language of the course	**English or Polish**				
Type of assessment	**Pass**	Number of hours in a semester	**36**	ECTS credits	**4**

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week	**2**			**2**	
	in a semester	**16**			**20**	

1. Prerequisites

Knowledge of mathematics within the scope of higher technical studies. Basics of mechanics. Basics of programming. Knowledge of the basics of one of the programming languages (Fortran 90, C, python). Basics of the Linux operating system.

2. Course objectives

The main objective of the course is to familiarize students with the basics of working on high-performance multiprocessor computers. Students will implement a computer version of a selected finite element in an open, simplified finite element method program with a parallel solver. This will allow them to work with more complex programs that have source code available, as well as those whose solver operates on the "black box" principle.

3. Course content (separate for each type of classes)

Lecture

1. Review of applications available on HPC computers.
2. Derivation of a nonlinear system of equilibrium equations of the finite element method.
3. Presentation of the basic types of isoparametric finite elements (four- and ten-node tetrahedron, eight- and twenty-node cube).
4. General algorithm of the finite element method.
5. Solving a linear system of equilibrium equations.
6. Solving a nonlinear system of equilibrium equations.

Laboratory

1. Opening accounts on the HPC computer.
2. Implementing the selected finite element procedure in a serial program.
3. Implementing the MUMPS parallel solver in a serial program (extension of the program).

4. Comparing the results for a single element with those obtained by another program (Abaqus). 5. Calculation of a bigger example. 6. Visualization of results (GiD program). Students should have laptops with access to the network. In addition to the Windows system (10 or 11), they should have Linux (one of the partitions) or Cygwin-X installed on them. The program constituting the model will be written in Fortran 90, as well as its further modifications, and students will create their own application in this programming language. Classes will be held in an auditorium with access to the Internet and a monitor allowing the instructor to demonstrate the program "live".

4. Learning outcomes			
Number of the learning outcome	Learning outcomes description	Reference to the learning outcomes according to the 8th level of PRK	Learning outcomes verification methods*
	Knowledge		
1	The graduate knows the derivation of the nonlinear system of equations of the finite element method.	P8S_WG	
2	The graduate knows the iterative procedures used when solving a nonlinear system of equations using the finite element method.	P8S_WG	
3	The graduate knows the basic types of finite elements.	P8S_WG	
	Skills		
1	The graduate is able to implement a finite element in a computer program having its source code in Fortran 90.	P8S_WG	
2	The graduate knows how to work on remotely accessible high-performance computers (queue system, serial program compilation and using MPI libraries)	P8S_WG	
3	The graduate is able to build libraries used when solving a system of equations (MPI).	P8S_WG	
4			
	Communication		
1	The graduate is able to communicate on specialist topics appropriate to the scientific discipline represented.	P8S_UK	
2	A graduate may disseminate the results of scientific activity.	P8S_UK	
3			

Social competences			
1	The graduate is prepared to work in a creative way.	P8S_KO	
2	A graduate can critically analyze the achievements of a scientific discipline. A graduate is also able to critically evaluate his or her own contribution to the development of the discipline.	P8S_KK	

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria

6. Literature

Primary references:

[1] **R.D. Cook.** Concepts & Applications of Finite Element Analysis (4e). John Wiley & Sons, 2001.

[2] **O.C. Zienkiewicz, R.L. Taylor, J.Z. Zhu**, The Finite Element Method: Its Basis and Fundamentals, (6e). Butterworth Heinemann, 2000

Secondary references:

[1] Theoretical Manual, program Abaqus.

[2] **W. Gropp,** Using MPI: Portable Parallel Programming with the Message-passing Interface (Scientific and Engineering Computation), MIT Press, 2000.

7. PhD student's workload necessary to achieve the learning outcomes**

No.	Description	Number of hours
1	Hours of scheduled instruction given by the lecturer in the classroom	**36**
2	Hours of consultations with the lecturer, exams, tests, etc.	**12**
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	**25**
4	Amount of time devoted to the preparation for exams, test, assessments	**36**
	Total number of hours	**109**
	ECTS credits	**4**

** 1 ECTS = 25–30 hours of the PhD students work (2 ECTS ≈ 60 hours; 4 ECTS ≈ 110 hours, etc.)