Subject Guide – Computer-Aided Engineering Tools 1

Shortened Name	CAET1	**Semester**	1-2024
Class Time (weekly)	Fri, 13-16	**Lecture hours**	3h x 15w
Subject Code	090435102	**Assignment and self-study**	5h x 15w
ECTS credits	6	**Preparation for exam**	30
KMUTNB Credits	3(3-0-6)	**Total working hours/semester**	150

1 Revision date of this document, reasons for revision

- 12.07.2024

2 Course description

A series of self-contained modules to give students the necessary knowledge and practical skills needed for the application of computers and engineering software on engineering problems, specifically in the fields of

- Parametric 3D Computer-Aided Design (CAD),
- Structural Analysis by FEM,
- programming of C/C++ code for specific simulation purposes,
- programming of Python code for specific simulation purposes, and
- Machine Learning.

The class enables the students to apply the covered tools in other courses as well as research and thesis work and prepares industrial application. At least an introductory standard is established that enables the students to continue to develop their skills by further self-study or self-guided tutorials. The covered software includes commercial and non-commercial products and is constantly revised to keep up with current developments and to balance the requirements of industrial application and academic research.

3 Lecturers

- Coordinator (responsible for class) — Dr. Alex Brezing
- 3D-CAD (PTC Creo Parametric) — Dr. Alex Brezing
- FEM Fundamentals (ABAQUS) — Mr. Nattawood Prasartthong
- C/C++ programming & numerical methods: — Dr. Ekkapot Charoenwanit
- Python programming and Machine Learning: — Dr. Chinnawut Nantabut

4 Expected learning outcomes (in accordance with the MAE program ELOs)

Primary LOs (primary content of class, knowledge is explicitly evaluated (for example, by exams), larger share of overall grade):

- Knowledge and understanding of principles, techniques and the methodology of:
    - designing mechanical systems and components and producing drawings of these on commercial parametric 3D CAD software,
    - C/C++ and python programming for simulation,
    - fundamentals of Machine Learning,
    - structural mechanics simulations with structural elements.
- Ability to transform an actual technical scenario into a valid model that can be used for a simulation or design (SELO 4)
- Ability to use commercial software to simulate the bahavior of solid bodies and fluids relevant for engineering applications (SELO 5)
- Ability to apply methodology and commercial CAD software to design complex geometries (free-form surfaces) and structural components (SELO 6)

Secondary LOs (not primary content of class, but implictly taught by application, for example by project work or assignments. Is evaluated, lower share of overall grade)

- Ability to enhance and deepen one's knowledge and skills in the above-mentioned computer-aided applications without specific instructions or pre-selected materials. (GELO 8)
- Knowledge of engineering materials and modes of failure (SELO 7)
- Knowledge and understanding of scientific fundamentals relevant for the understanding of the behavior of solid bodies, structural components and fluids in engineering applications (SELO 2)

Notes on ELOs:

- These ELOs correspond to the Program ELOs (referenced in parentheses) but are specifically worded for this course by omissions and additions.

5 Assessment

Each student will be individually assessed based on the performance on assignments and a written exam, with the overall grade resulting from the shares as below:

	Assignments	Exam
3D-CAD - PTC Creo Parametric	(2 * 5%=) 10%	36/180 points
FEM - ABAQUS	(2 * 5%=) 10%	24/180 points
C/C++ Programming	(4 * 5%=) 20%	60/180 points
Python Programming and Machine Learning	(4 * 5%=) 20%	60/180 points
Total share	**60%**	**40%**

- Assignments will be given as homework during most classes (see below). All assignments are due at the beginning of the next class, submitted by email to the lecturer who held the class. Late submission results in 20% deduction per week.

- Comprehensive exam, closed book, mostly written/per-based; CAD-part possibly partly done on students' own laptop. 180 minutes.

6 Teaching materials

- Lecture slides and assignments are shared as electronic files.

7 Books and references

- Starting out with C++ Early Objects, 8th Ed., by Tony Gaddis, Judy Walters, and Godfrey Muganda. Pearson Education & Addison-Wesley
- Numerical Methods for Engineers, 6th Ed., by Steven C. Chapra and Raymond P. Candle. McGraw-Hill.
- Parallel Programming in C with MPI and OpenMP, by Michael J. Quinn. McGraw Hill International Edition

8 Course schedule

Week	Date (2024)	Activity, Class Title (unit number)	Evaluation %	Class Hours
1	09/08	CAD/CREO: Part Modelling and Drafting Strategies; Standard geometries (1)		3
2	16/08	CAD/CREO: Assembly Modelling Strategies (2)	5%	3
3	23/08	NO CLASS KMUTNB International Culture Days August 22-24		
4	30/08	CAD/CREO: Part Modelling Strategy: Advanced Geometries (3)	5%	3
5	06/09	FEM/ABAQUS: 2- and 3-dimensional elements (4)	5%	3
6	13/09	FEM/ABAQUS: FEM with imported geometry (5)	5%	3
7	20/09	C/C++: Basic C/C++ (6)		3
8	27/09	C/C++: Advanced Data Types (7)	5%	3
9	14/10	C/C++: Functions (8) (no Midterm Exam but class)	5%	3
10	11/10	C/C++: Dynamic Memory Allocation , Basic I/O (9)	5%	3
11	18/10	C/C++: Introduction to Numerical Methods (10)	5%	3
12	25/10	Python/ML: Introduction to Python and Packages (11)		3
13	01/11	Python/ML: Introduction to Machine Learning and Scikit-learn (I) (12)	5%	3
14	08/11	Python/ML: Introduction to Machine Learning and Scikit-learn (II) (13)	5%	3
15	15/11	Python/ML: Introduction to Deep Learning (14)	5%	3
16	22/11	Python/ML: Introduction to PyTorch (15)	5%	3
17	29/11	**FINAL EXAM**	40%	
18	06/12	**FINAL EXAM (optional)**		
		(Sums)	100%	45

9 Content details

Unit #	Title	Lesson (L) Contents
1	CAD/CREO: Part Modelling and Drafting Strategies; Standard geometries	• Methodology of sketching and dimensioning • Modelling strategy for machined parts and lathed parts • Drafting strategy and features
2	CAD/CREO: Assembly Modelling Strategies	• Overview of Industrial Engineering Design Process • CAD-modelling strategy: Top-Down/Bottom-Up • Assembly modelling with skeleton models
3	CAD/CREO: Part Modelling Strategy: Advanced Geometries	• Fully parametric geometry vs. freeform geometry • Modelling strategies for cast parts • Features for modelling cast geometry
4	FEM/ABAQUS: 2- and 3-dimensional elements	• Modelling and Manual meshing of simple geometries • Definition of 2-D and 3-D elements • Linear-elastic static loadcase with sandwich material
5	FEM/ABAQUS: FEM with imported geometry	• Importing complex geometry • Automatic, semi-automatic and manual meshing • Linear-elastic static loadcase with heat transfer
6	C/C++: Basic C/C++	• Basic C/C++ • Data Types and Variables • Control Flow
7	C/C++: Advanced Data Types	• Arrays & Multidimensional Arrays • Pointers and Pointer Arithmetic • References; Structures
8	C/C++: Functions	• Functions and Return Values • Passing by Value • Passing by References
9	C/C++: Dynamic Memory Allocation , Basic I/O	• Heap Memory vs Stack Memory • Memory Allocation/Deallocation • Basic I/O Operations in C/C++
10	C/C++: Introduction to Numerical Methods	• Finite Differences • Gradient Descent
11	Introduction to Python and Packages	• Variables, control flow and data structures • Modules and classes • NumPy, pandas and Matplotlib
12	Introduction to Machine Learning and Scikit-learn (I)	• Types and end-to-end machine learning projects • Dimensionality reduction and clustering • Regression
13	Introduction to Machine Learning and Scikit-learn (II)	• Regression with regularization • Classification • Support vector machines (SVM)
14	Python/ML: Introduction to Deep Learning	• (Deep) neural networks • Convolutional neural networks • Optimization algorithms, computation graph and backpropagation
15	Introduction to PyTorch	• Introduction to tensors • Defining (convolutional) neural networks • Training and testing (convolutional) neural networks

10 Details on the evaluation of Expected Learning Outcomes

		Assignments	MT-Exam	#
		70%	30%	
SELO1	Knowledge and understanding of principles, techniques and the methodology of • the design and reverse-engineering of complex geometries, • the simulation of a wide range of phenomena in the field of fluid dynamics, • the design of structural components by topology optimization approaches as well as structural simulations which are integrated into virtual product development (3D-CAD and modelling)	7.0%	3.0%	**10%**
SELO4	Ability to transform an actual technical scenario into a valid model that can be used for a simulation or design	7.0%	3.0%	**10%**
SELO5	Ability to use commercial software to simulate the bahavior of solid bodies and fluids relevant for engineering applications	25.0%	10.0%	**35%**
SELO6	Ability to apply methodology and commercial CAD software to design complex geometries (free-form surfaces) and structural components	8.0%	7.0%	**15%**
GELO8	Ability to enhance and deepen one's knowledge and skills in the above-mentioned computer-aided applications without specific instructions or pre-selected materials	14.0%		**14%**
SELO7	Knowledge of engineering materials and modes of failure	4.0%	2.0%	**6%**
SELO2	Knowledge and understanding of scientific fundamentals relevant for the understanding of the behavior of solid bodies, structural components and fluids in engineering applications	5.0%	5.0%	**10%**