Tárgytematika / Course Description
CAE methods

GKNM_AMTA011

Tárgyfelelős neve / Teacher's name: dr. Pere Balázs

Félév / Semester: 2024/25/2

Beszámolási forma / Assesment: Vizsga

Tárgy heti óraszáma / Teaching hours(week): 2/1/0

Tárgy féléves óraszáma / Teaching hours(sem.): 0/0/0

OKTATÁS CÉLJA / AIM OF THE COURSE

Computer simulations play an important role in the early phases of engineering design nowadays. These can be applied in a wide range of
problems (structural analysis, dynamics, thermodynamics, fluid dynamics, electrodynamics, etc.) and their common element is, that they solve
mathematical equations - which describing a certain physical phenomenon - via approximation. The most widespread methods of
approximations are the Finite Volume (fluid- and thermo-dynamics) and the Finite Element (structural end electrodynamics analyses)
methods. In order to be able to use these methods, and to generate reliable data with them, an engineer in training must become familiar with
the underlying mathematical equations solved, the modelling approaches, as well as the limitations of the methods. The goal of the course is
to provide a generic introduction into the basics of these methods, especially the ones used most commonly in the design of vehicles
nowadays, i.e. fluid dynamics, structural analysis and electrodynamic analysis methods.

TANTÁRGY TARTALMA / DESCRIPTION

1. week Boundary value problem in linear elasticity. Weak formulation
of the boundary value problem. Introduction to commercial finite element softwares: Solving a simple 2D problem with ANSYS.
2. week Finite element discretization of the 2D plane strain problem. Constructing the element level stiffness matrix and load vector.
Introduction to commercial finite element softwares: Solving a simple 2D problem with ABAQUS.
3. week Assembling the global stiffness matrix and load vector. Applyingthe displacement and force boundary conditions. Solving a simple 2D problem with self developed finite element code in MATLAB - 1.
4. week Solving the discretized equations, evaluating the results. Solving a simple 2D problem with self developed finite element code in MATLAB - 2. Comparing the results
5. week Overview of the basics of electromagnetics, Maxwell’s equations and constitutive relations. Electrostatic, static magnetic field formulation. Basics of finite element method in computational electromagnetics.

Demonstration of the main steps of the finite element method through a static magnetic example (fuel injection solenoid).
6. week national holiday national holiday
7. week The basic equation of time-harmonic magnetic field formulation. The phenomena of induced current (eddy current) as one of the heat source of electric machines.
Demonstration of eddy current through a threedimensional eddy current brake problem.
8. week Equations of low-frequency transient electromagnetic problems. Initial and boundary conditions. Coupled finite element formulation with rigid body motion and circuit equations.
Deadline for the homework A solution of a permanent magnet synchronous motor, examination of results (torque, losses, etc.).
9. week Electromagnetic field calculation in the radio frequency range. Automotive cable harness analysis.
10. week Basics of Vehicle Fluid- and Thermodynamics (drag, thermal phenomenon, etc.). The 3 branches of Fluid Mechanics, importance of numerical simulations within the development
process. Examples of applications.
11. week Fundamentals of Fluid Mechanics: Properties of fluids, fluid as a continuum, boundary conditions, Lagrangian and Eulerian
viewpoints, Control Volume principle and applications, conservation of mass, momentum and energy, Bernoulli equations and its limitations 2D CFD simulation of a flat plate boundary layer flow:
overview of the task.
12. week Navier-Stokes equations and their mathematical properties. Role of initial and boundary conditions. 2D CFD simulation of a flat plate boundary layer flow:
overview of simulation steps.
13. week Discretisation of the governing equations: Finite Difference, Finite Volume, Finite Element and Spectral Mehods. Elements of running simulations, i.e. mesh generation, verification,
validation, convergence. 2D CFD simulation of a flat plate boundary layer flow:consultation about the individual solutions.
14. week Homework consultation Homework consultation

SZÁMONKÉRÉSI ÉS ÉRTÉKELÉSI RENDSZERE / ASSESMENT'S METHOD

Conditions for signature (to be fulfilled during the class-period and necessary to be allowed to write an exam):
- At least one **homework must be written and submitted until the deadline**. The homework will be marked on a scale of 0-30
points. Minimum 15 points shall be achieved on a homework.
- Additional homework(s) from the other topics are worth 30-30 more points.
- Any homework written in LaTeX based text editors are worth additional max. 10 points.
- A homework that was not submitted by the deadline can be submitted **within one week** after the deadline. The final deadline
for the late submission of the homework is Sunday 23:59 of the last week of the class-period. These late submissions are subject
to **extra process fee**. **If the homework was not submitted within one week after the deadline, then the semester cannot be
validated and a signature will be refused.**
- A homework that is not accepted shall be resubmitted again within one week of receipt.
- A homework, which **does not fulfill the minimum requirements for the layout and content, will not be accepted**.
(Requirements for the layout and content can be downloaded from the homepage of the subject.)
- Those students, whose homework verifiably proves to be the work of a third party and referred to as their own work, will be
disqualified. In this case, the semester cannot be validated and signature will be refused as a consequence of their action.
Midterm tests:
- In every lesson (except for the first lesson of the three main topics) a short (cca. 5 minutes long) test will be performed from the
topic of the previous lecture, which is worth 2 or 3 points.
- The sum of the points of short tests gives 20% of the total amount of points.
Exam:
- In the exam period a **written exam** is taken from the three main topics. The maximum point in the exam is 50 points.
- The exam is **compulsory** and **valid only if at least 50% of the 50 points** is reached.
- The sum of the points of the homework(s), short tests and the exam determines the exam mark. The grading is as follows
0-49 points fail (1)

50-59 points pass (2)
60-69 points satisfactory (3)
70-79 points good (4)
80-100 (or more) points excellent (5)
- Students must provide proof of their identity with an official card (eg. ID card, passport, driving license, etc.) at the exam.
- Those students, who apply unauthorized means (book, lecture notes, infocommunication means, tools for storing and forwarding electronic information, etc.) different from those listed in the course requirement or adopted by the lecturer in charge of the course assessment will be disqualified from the exam as a consequence of their action, and the exam mark will
automatically become “Fail (1)”.
Consultation:
- Each lecturer will have one hour per week for consultation. Time and place will be determined according to the needs of students.

KÖTELEZŐ IRODALOM / OBLIGATORY MATERIAL

Anderson, J.D. “Computational Fluid Dynamics: the basics with applications”, McGraw-Hill, 1995.

B. Pere: CAE Methods (lecture notes), 2019
Kuczmann M.: Potential Formulations in Magnetics Applying the Finite Element Method, 2009. (maxwell.sze.hu/docs/C4.pdf)

AJÁNLOTT IRODALOM / RECOMMENDED MATERIAL