Tárgytematika / Course Description
CAE methods

GKNM_AMTA011

Tárgyfelelős neve / Teacher's name: dr. Pere Balázs
Félév / Semester: 2025/26/2
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

Témakör név: CFD 1

Témakör leírása: Basics of Vehicle Fluid- and Thermodynamics (drag,thermal phenomenon, etc.). The 3 branches of Fluid Mechanics,importance of numerical simulations within the developmentprocess. Examples of applications.
Témakör kulcsszavai:

Témakör név: CFD 2
Témakör leírása: Fundamentals of Fluid Mechanics: Properties of fluids,fluid as a continuum, boundary conditions, Lagrangian andEulerian viewpoints, Control Volume principle and applications,conservation of mass, momentum and energy, Bernoulli equations and its limitations
Témakör kulcsszavai:

Témakör név: CFD 3
Témakör leírása: Navier-Stokes equations and their mathematical properties. Role of initial and boundary conditions.
Témakör kulcsszavai:

Témakör név: CFD 4
Témakör leírása: Discretisation of the governing equations: Finite Difference, Finite Volume, Finite Element

and Spectral Methods. Elements of running simulations, i.e. mesh generation, verification, validation, convergence.
Témakör kulcsszavai:

Témakör név: FEM 1
Témakör leírása: Boundary value problem in linear elasticity. Weak formulation of the boundary value problem.
Témakör kulcsszavai:

Témakör név: FEM 2
Témakör leírása: Finite element discretization of the 2D plane strain problem. Constructing the element level stiffness matrix and load vector.
Témakör kulcsszavai:

Témakör név: FEM 3
Témakör leírása: Assembling the global stiffness matrix and load vector.Applying the displacement and force boundary conditions.
Témakör kulcsszavai:

Témakör név: FEM 4
Témakör leírása: Solving the discretized equations, evaluating the results.
Témakör kulcsszavai:

Témakör név: MBS 1
Témakör leírása: Introduction and application examples for multibody simulations. Structural components, difference between open and closed kinematic chains, calculation of degrees of freedom.
Témakör kulcsszavai:

Témakör név: MBS 2
Témakör leírása: Kinematics of single rigid bodies, open and closed kinematic chains. Geometric constraints. Dynamics of point mass and single rigid bodies. Dynamics of open chains: Newton-Euler equations, Lagrange equation of the second kind.
Témakör kulcsszavai:

Témakör név: MBS 3
Témakör leírása: Dynamics of closed kinematic chains, Lagrange equations of the first kind. Concept of constraint forces and constraint Jacobian.
Témakör kulcsszavai:

Témakör név: MBS 4
Témakör leírása: Differential-algebraic equations and a simple solution technique.
Témakör kulcsszavai:

Tevékenység típusok

Kontakt előadás
Mérték: 28 tanóra (hour)
Leírás: Előadás
Kötelező: Nem
Becsült Idő: 28 óra

Kontakt gyakorlat

Mérték: 14 tanóra (hour)
Leírás: Gyakorlat
Kötelező: Nem
Becsült Idő: 14 óra

Otthon elolvasandó szöveg (új anyag)
Mérték: 1 db (PCS)
Leírás: Tananyag olvasása, tanulása
Kötelező: Nem
Becsült Idő: 46 óra

Otthoni gyakorlás
Mérték: 1 db (PCS)
Leírás: Számítógépes feladatok gyakorlása
Kötelező: Nem
Becsült Idő: 30 óra

SZÁMONKÉRÉSI ÉS ÉRTÉKELÉSI RENDSZERE / ASSESMENT'S METHOD

Számonkérési forma:
Vizsga (Exam)

Kötelező írásbeli beszámolók, jegyzőkönyvek
Mérték: 1 db (PCS)
Leírás: Házi feladat
Kötelező: Igen
Becsült Idő: 30 óra

Vizsga számítógép által kiértékelt része
Mérték: 1 db (PCS)
Leírás: Számítógépes vizsga
Kötelező: Nem
Becsült Idő: 1 óra

Kötelező félévközi zárthelyik (számítógép által kiértékelt)
Mérték: 9 db (PCS)
Leírás: Rövid teszt kérdések
Kötelező: Nem
Becsült Idő: 1 óra

Aláírás kialakításának módja:

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 of0-30 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 finaldeadline for the late submission of the homework is Sunday 23:59 of the last week of the class-period. These latesubmissions 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 fulfil 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.

Érdemjegy kialakításának módja:

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 0-59 points fail (1) 60-69 points pass (2) 70-79 points satisfactory (3) 80-89 points good (4) 90-100 (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 andforwarding electronic information, etc.) different from those listed in the course requirement or adopted by the lecturer incharge 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)”.

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

Anderson, J.D.: Computational Fluid Dynamics: the basics with applications (1995), McGraw-Hill, ISBN: ISBN 0-07-001685-2 https://www.amazon.com/Computational-Fluid-Dynamics-Anderson/dp/0071132104