MJ2485 Introduction to Unsteady Aerodynamics 7.5 credits

Introduktionskurs instationär aerodynamik

This is a translation of the Swedish, legally binding, course syllabus.

Establishment

On 22/04/2022, the Dean of the ITM School has decided to establish this official course syllabus to apply from autumn term 2021 (registration number M-2022-0627).

Grading scale

A, B, C, D, E, FX, F

Education cycle

Second cycle

Main field of study

Mechanical Engineering

Specific prerequisites

SF1633 "Differential Equations I" or the equivalent
SG2214 Fluid Mechanics or the equivalent
SE1055 Strength of Materials and Solid Mechanics, Basic Course with Energy Methods or the equivalent

Only for TAETM

Language of instruction

The language of instruction is specified in the course offering information in the course catalogue.

Intended learning outcomes

After completing the course with a passing grade the student should be able to:

1. Apply aerodynamic design parameters and link aerodynamics and design

2. Use different methods to solve the two-dimensional Laplace equation and three-dimensional Prandtl theory in the scope of inviscid external aerodynamics

3. Explain the consequences of viscous effects and the influence of the boundary layer in inviscid flow including separation and transition to turbulence, and determine boundary layer parameters and aerodynamic loads

4. Explain the effects of compressibility on the flow field and their impact on the design, and calculate aerodynamic loads in subsonic, transonic and supersonic flow regimes

5. Apply analytical, numerical and experimental aerodynamic methods in a realistic case study

6. Develop aeroelastic equations of motion and analyse dynamic response of linear systems

7. Explain and discuss aeroelastic phenomena such as divergence, aileron reversal, flutter and imposed aerodynamic vibrations

8. Explain and apply classical potential flow theory to analyse unsteady aerodynamics in supersonic flow

Course contents

The course covers steady aerodynamics in detail and intends to introduce students to unsteady aerodynamics and aeroelasticity. The course consists of two parts: aerodynamics and aeroelasticity. In the first part of the course, focus is placed on fundamental aspects of stationary aerodynamics. The following subjects are included:

- Aerodynamic forces and moments: lift and drag, pitching moment, airfoil polar, aerodynamic center, center of pressure
- Incompressible potential flows, singularities (vortex, source, doublet), d'Alembert principle, circulation
- Superposition of fundamental solutions, lifting cylinder, Kutta-Joukowski theorem, conformal mapping, Joukowsky airfoil
- Thin airfoil theory: line distribution of singularities, effect of thickness and camber, Kutta condition

- Panel methods: potential-based, vortex-based, source-based, equivalence between source, doublet and vortex-based methods
- 3D wings: vortex sheet, Prandtl lifting line theory for large aspect ratio wings, distribution of circulation, induced drag, downwash velocity, elliptic lift distribution, optimal wing, general lift distribution
- Boundary layers: concepts and definitions, boundary conditions, thickness, von Karman integral equation, flow separation and airfoil stall, transition to turbulence
- Laminar boundary layer: self-similar solution (Blasius, Falkner-Skan), Pohlhaussen method, Thwaites method
- Turbulent boundary layer: transition, characteristics, Reynolds-averaging, Head method, log law
- Compressible aerodynamics: compressible potential flow, Prandtl-Glauert equation, flow past a thin airfoil (subsonic, transonic, supersonic)

The other part of the course focuses on the bases of aeroelasticity and interaction between the flow and the structure. The following is treated:

- Aeroelastic (coupled fluid-structural) equation of motion
- Solution to the aeroelastic equation of motion for linear dynamic systems
- Steady aeroelasticity (divergence, control surface reversal)
- Unsteady aeroelasticity (flutter, gust, aerodynamically imposed reactions)
- Classical potential flow theory of unsteady aerodynamics

Examination

- TEND - Written exam, 4.5 credits, grading scale: A, B, C, D, E, FX, F
- INL1 - Hand in exercise, 3.0 credits, grading scale: A, B, C, D, E, FX, F

Based on recommendation from KTH's coordinator for disabilities, the examiner will decide how to adapt an examination for students with documented disability.

The examiner may apply another examination format when re-examining individual students.

If the course is discontinued, students may request to be examined during the following two academic years.

Ethical approach

- All members of a group are responsible for the group's work.
- In any assessment, every student shall honestly disclose any help received and sources used.
- In an oral assessment, every student shall be able to present and answer questions about the entire assignment and solution.