AE317 AUG/JAN 3:0

Aeroacoustics

Instructor

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Teaching Assistant

None
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Department: Aerospace Engineering

Course Time: Tue, Thu, 10 - 11:30 AM

Lecture venue: AE 106

Detailed Course Page: https://samanta.coursesites.com/

Announcements

Brief description of the course

This course is designed for advanced graduate students and practising engineers with an interest in aeroacoustics. Significant background in acoustics is required to grasp the subject matter, although this course assumes little and instead develops most of those concepts during the first half of the lectures. However, strong background in a graduate-level fluid dynamics course is essential as is a good exposure to applied mathematics concepts to credit this course. After introducing the required basics in acoustics, this course teaches the fundamentals of aeroacoustics theory with an emphasis at each step in how to extend this theory to practical problems. A necessary background in developing numerical codes in aeroacoustics, along with its unique challenges, is given.

Prerequisites

1. A graduate level course in fluid dynamics or equivalent.

2. A graduate level course in engineering mathematics or equivalent.

3. A course in acoustics, although not essential, is desirable.

Syllabus

I. Introduction: historical perspectives; challenges in CAA; basics on sound waves.

II. Classical Acoustics: linearized equations of motion; Kovasznay's decomposition; classical wave equation, plane wave solution of wave equation; examples of plane wave propagation, spherical wave solution; causality; compactness; acoustics in Fourier space, propagation in inhomogeneous media: discontinuity in impedances and velocities. Acoustic sources: pulsating sphere; point sources, free-space Green's functions; monopoles, dipoles and quadrupoles; Green's function solutions for 1-D, 2-D and 3-D wave equations. General solutions for medium at rest: distributed source, point force, point stress; moving point sources, Kirchhoff--Helmholtz theorem for rigid boundaries; radiation from baffled pistons, near-wall sources; extensions for moving boundaries.

III. Sound Sources: Lighthill's analogy; interpretation; analysis of Lighthill source; moving source version, integral solution of Lighthill's equation; far-field approximation; acoustically compact and non-compact sources; Lilley/Lilley--Goldstein equations; Goldstein's generalized analogy; effect of solid surfaces: Curle's equation; sound produced by turbulence near rigid boundary; Powell's image theorem; generalized function theory; Ffowcs Williams--Hawkings equation; comparison with Kirchhoff method.

IV. CAA: challenges and simplifications; spatial and temporal discretizations; boundary conditions, hybrid methods: numerical evaluation of Lighthill's integral; direct methods: direct simulations; methods based on coherent structures; applications of RANS and LES.

Course outcomes

Students would learn the fundamentals of acoustics and aeroacoustics theory during this course. A serious student should be able to extend such concepts to practical applications. Further, students are given significant exposure to computational aeroacoustics with an emphasis to the unique challenges that this particular application of CFD entails which should prepare them well for developing advanced codes in this area.

Grading policy

Homework: 20%

Quiz: 30%

Final project: 25%

Final exam: 25%

Assignments

Approximately three homework sets (roughly one per month) are expected to be assigned during the term.

Most of the problems will require theoretical deductions and/or computer programming. A knowledge of any computer programming language or software is essential.

Resources