UCL SUMMER SCHOOL

Industrial Applications: Modelling Aircraft Icing

Key Information

Module code: ISSU0082
Taught during: Session Two: Monday 22 July - Friday 9 August 2019
Module workload: 45 teaching hours plus approximately 100 study hours
Module leader: Dr Ryan Palmer
Department: Department of Mathematics
Credit: 15 UCL credits, 7.5 ECTS, 4 US
Level: Level 2, second year undergraduate
Pre-requisites: Standard entry requirements
Assessment: Presentation (30%), Report (70%)

Module Overview

This module is in the interdisciplinary field of icing in relation to aircraft. Ultimately, this course will draw from mathematics, physics, chemistry and engineering to provide students with a broad overview of the field of aircraft icing, and how the problem may be approached mathematically. This will involve understanding the problem, discussing the current state of engineering solutions, and study of how mathematics can help to improve, enhance and further this field.

Modelling of this phenomenon is a threefold approach. Firstly, the trajectory of particles within the fluid flow concerning an oncoming aircraft is calculated. Secondly, the behaviour and mechanics of impinging particles (particles that make contact with the aircraft) needs to be understood. Thirdly, how ice builds up on a surface alongside the possibility of it shedding are important.

This course will serve as an introduction to understanding this field and the analytical modelling of this problem.

Week One

- Introduction and overview of aircraft icing
- Engineering approaches to prevent icing
- The science of icing events
- Introduction to the threefold modelling approach
- Introduction to fluid dynamic modelling

Week Two

- Analytical modelling
- Numerical modelling

Please note that this module description is indicative and may be subject to change.
- Impingement modelling
- Secondary trajectories, rotation and non-spherical particles
- Accretion modelling

**Week Three**
- Mock workshop on modelling industrial problems

**Module Aims**
The overarching aim is to generate interest in industrial modelling and make a connection between what students study in their degrees and how this can help industry. A strong theme throughout the course will be the importance of industrial research and the demonstrable value and need for cross-disciplinary research. This importance will be emphasised in general for industry related modelling and not just icing.

The course will highlight an application of fluid dynamic theory to a real world problem and introduce students to advance analytical techniques that may be used to understand deep real world problems. Throughout the course students will be introduced to a range of models that would not appear on an undergraduate mathematics/engineering course, showing them that the world of industrial problems, natural phenomena and mathematical solutions stretches far beyond the bounds of an undergraduate degree.

**Teaching Methods**
The primary form of delivery will be lecture based. Furthermore there will be a literature review/study element of the course, where students may work in groups to study, summarise and present important papers as part of the examination. The third week will be more student led as they participate in a working group, drawing on all they have learned in the first two weeks. This will involve reviewing literature, developing a solution (or a planned methodology) to solving problems presented by industry. I am in discussion with industrial collaborators about them joining to help run and examine the mock working group. Students will be directed towards class materials, further support and discussion forums on UCL’s virtual learning environment Moodle.

**Learning Outcomes**
Upon successful completion of this module, students will:
- Possess a broad understanding of the field of aircraft icing
- Have a foundational knowledge of the problems that exist within this field ranging from the physical to the theoretical
- Have gained insight into the engineering and modelling solutions to solve/inform these problems
- Be able to use a range of methods, of varying depth, difficulty and insight, to model problems in this field
- Have gained skills important for working with industrial partners on research projects

**Assessment Methods**
- 20 minute group presentation (30%)
- 2,500-word report (70%)

**Key Texts**
2. Mason, Strapp, and Chow, 2006 *The ice particle threat to engines in flight*. In 44th AIAA Aerospace Sciences Meeting and Exhibit
5. Potential flow lecture notes.

Module Leader
Ryan Palmer (Research Associate, UCL) has a background in applied mathematics with industrial applications. Holding a PhD in Mathematics he has worked on several projects using fluid dynamics/modelling.

Ryan’s current work and interests lie in continuum mechanics, in particular particle trajectories near walls and within channels. He is presently collaborating with industry specialists (AeroTex) building expertise and working relationships in the area of aircraft icing — a field that combines modelling techniques in particle trajectories, particle collisions and ice growth, and unites several complex modelling processes and scientific fields — ranging from mathematics to physics and engineering.