This course is an introduction to the fundamental concepts of turbulent flows and its importance in aerospace science and engineering. The course will focus on the physical processes involved in turbulence and turbulent mixing in general configurations such as jets, wakes, shear layers and boundary layers in engineering and in the atmosphere.

At the end of the course, the student will have the background necessary to understand and assess turbulence effects in aerodynamics, propulsion and air traffic management. Furthermore, the student will have the background for advanced courses and research in turbulence analysis and turbulence modeling.

Good knowledge of Fluid Mechanics is required, some knowledge of aerodynamics and propulsion is advantageous.

Prior skills

Good knowledge of Fluid Mechanics is required, some knowledge of aerodynamics and propulsion is advantageous.

Teaching methodology

Each session consists of a theoretical part and a practical part. In the practical part, a set of small exercises will be solved and discussed in class to fix the main ideas and concepts of the session. The take-home assignments will also be discussed during this practical part, when needed. The course material will be the course notes, slides, audiovisual material, and a small set of turbulence data to illustrate the analysis approaches described in the course.

Learning objectives of the subject

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Study load

<table>
<thead>
<tr>
<th>Total learning time: 75h</th>
<th>Hours large group: 30h</th>
<th>40.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group: 0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Guided activities: 0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Self study: 45h</td>
<td>60.00%</td>
</tr>
</tbody>
</table>

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# 205223 - Turbulence in Aerospace Science and Engineering

## Content

| Module 1: Introduction to turbulent flows | Learning time: 18h 45m  
Theory classes: 7h 30m  
Self study : 11h 15m |
|------------------------------------------|----------------------------------|
| **Description:**  
The need of studying turbulent flows in aerospace science and engineering. Defining properties of turbulent flows. Methods of Analysis. The Richardson energy cascade as an example of phenomenology and conceptual models.  
Short review of Navier Stokes equations, vorticity and dimensional analysis as needed for the remaining of the course. |

| Module 2: Statistical description of turbulent flows | Learning time: 18h 45m  
Theory classes: 7h 30m  
Self study : 11h 15m |
|------------------------------------------|----------------------------------|
| **Description:**  

| Module 3: The phenomenology of Richardson and Kolmogorov | Learning time: 12h 30m  
Theory classes: 5h  
Self study : 7h 30m |
|------------------------------------------|----------------------------------|
| **Description:**  

| Module 4: Reference configurations in aerospace science and engineering | Learning time: 25h  
Theory classes: 10h  
Self study : 15h |
|------------------------------------------|----------------------------------|
| **Description:**  
Major aspects of boundary-free shear turbulence (jet flows, shear layers and wakes). Major aspects of wall-bounded flows (channel flow, pipe flows and turbulent boundary layers). Major aspects of buoyancy effects (atmospheric turbulence and the atmospheric boundary layer). |
Qualification system

1 written in-class exam (50% of the final grade).
3 or 4 take-home assignments (50% of the final grade).

In case of failing, the grade will be based on one additional written in-class exam on the date fixed in the calendar of final exams. The grade obtained in the additional written in-class exam will range between 0 and 10 and will replace that of the previous written in-class exam only if it is higher.

Bibliography

Basic:


Complementary: