**Title of the Unit:** Vortex Dynamics

**Unit code:** MU5MEF06

**Total time per student:** 15h lecture 11h tutorial 4h lab

**Credit number: 3** ECTS

**Master’s degree:**  Mecanics  Robotics & Auto. Cont.  Electrical Eng.

**Master program:** E3A : CIMES  Syscom  IPS

AR :  SAR  ISI

MECA :  MS2  MF2A  EE  CompMech  ACOU  EE APP

**Semester:**  S1  S2  S3  S4

**Teaching language:**  French  English

**Involved students:**  Sorbonne Université  Other (to be specified): MF2A students of ENSAM and EP

**Localization:**  PMC campus  Other (to be specified):

**Objectives of the unit:**

The aim of the course is to get students familiar with one of the central concepts of fluid mechanics: vorticity and vortices. The presence of coherent vortex-like structures in a wide variety of flows of fundamental (turbulence), geophysical and environmental, or applied (aeronautics in particular) nature will be demonstrated through numerous examples. This course provides the students with physical and analytical tools necessary to understand the notion of vortices, their dynamics and their characterisation. This course is also intended for PhD students.

**Knowledge and skills mastered at the end of the unit :**

At the end of the course, the student will be able to characterise, analyse or predict the dynamics of vortex systems, from the point of view of their trajectory and interactions, but also of their internal structure and deformation.

**Detailed content of the unit :**

Vorticity: definitions, examples, vortex models, Biot-Savart law, Kelvin's theorem, Helmholtz conservation laws.

Two-dimensional approach: circulation, centroid, dispersion radius, point vortices, extended vortices, vortex/vortex interaction, merging, near-wall dynamics, dipoles.

Three-dimensional vortices: Burgers vortex, vortex rings, vorticity filaments, instabilities, reconnection. Applications to aerodynamics.

Vortex characterisation.

**Prerequisites of the unit :**

Basics of incompressible fluid mechanics (Navier-Stokes equations).

**Evaluation of the unit (informative) :**

Written exam on the course (50%), study of a scientific publication (50%).

**Bibliography :**

Hydrodynamique Physique, Guyon, Hulin et Petit, Editions du CNRS (2012).  
Elementary fluid dynamics, Acheson, Clarendon Press, Oxford (1990).

Saffman : vortex dynamics, Cambridge (1995).

**Teaching sequence (informative) :**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| week | lecture | tutorial | lab | project | test |
| W1 | C1 (2h) | TD1 (2h) |  |  |  |
| W2 | C2 (2h) | TD2 (2h) |  |  |  |
| W3 | C3 (2h) | TD3 (2h) |  |  |  |
| W4 | C4 (2h) | TD4 (2h) |  |  |  |
| W5 | C5 (2h) |  | TD5 (2h) |  |  |
| W6 | C6 (2h) |  | TD6 (2h) |  |  |
| W7 | C7 (2h) | TD7 (2h) |  |  |  |
| W8 | C8 (2h) | TD8 (2h) |  |  |  |
| W9 |  |  |  |  |  |
| W10 |  |  |  |  | Written (3h) |
| W11 |  |  |  |  |  |
| W12 |  |  |  |  |  |
| W13 |  |  |  |  |  |
| W14 |  |  |  |  |  |

**Date**: 9th May 2022

**Author**: I. Delbende