Turbulence

Academic Year: (2023 / 2024) **Review date: 29-05-2023**

Department assigned to the subject: Aerospace Engineering Department, Thermal and Fluids Engineering Department

Coordinating teacher: FLORES ARIAS, OSCAR

Type: Electives ECTS Credits : 6.0

Year : 1 Semester : 2

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Ordinary Differential Equations / Dynamical Systems
Partial Differential Equations

DESCRIPTION OF CONTENTS: PROGRAMME

1. Introduction
1.1 Laminar flow, turbulence and transition
1.2 Bifurcations
2 Stability of confined flows
2.1 Rayleigh¿Benard
2.2 Taylor¿Couette
3 Stability of parallel and quasi-parallel flows
3.1 Spatial, temporal, and spatiotemporal instability
3.2 Viscous and non-viscous instabilities
3.4 Stability of quasi-parallel flows
4 Global and non-modal stability (transient growth)
5 Transition
5.1 Pipes, boundary layers, jets, and mixing layers
5.2 Secondary instabilities, by-pass transition
6 Turbulence
6.1 Statistical description: Reynolds-averaged Navier Stokes and the closure problem.
6.2 Free shear flows: mixing layers, jets, wakes.
6.3 The scales of turbulent flows: the energy cascade
6.4 Wall-bounded flows: channels, pipes and boundary layers.
7 Introduction to turbulence modeling
7.1 DNS
7.2 LES
7.3 RANS

LEARNING ACTIVITIES AND METHODOLOGY

There will be theory lectures to introduce the theory of stability and the physics of transition and turbulence. The students will need to solve simple problems with analytical solution. In addition they will need to solve numerical problems using Matlab or any other programming environment of their choice.

% end-of-term-examination:	60
% of continuous assessment (assigments, laboratory, practicals…):	40

BASIC BIBLIOGRAPHY

- C. Godreche, P. Manneville Hydrodynamics and nonlinear instabilities, Cambridge University Press, 2005

- P.J. Schmid, D.S. Henningson Stability and transition in shear flows, Springer, 2001

- S.B. Pope Turbulent Flows, Cambridge Univ. Press, 2000

ADDITIONAL BIBLIOGRAPHY

- H. Tennekes, J.L. Lumley A first course in turbulence, MIT Press, 1972

- P. A. Davidson Turbulence: An Introduction for Scientists and Engineers: An Introduction for Scientists and Engineers. , Oxford Univ. Press, 2004

- P. A. Durbin, B.P. Reif Statistical theory and modeling for turbulent flows., John Wiley & Sons., 2011

- Wilcox, D. C. Turbulence modeling for CFD , DCW industries, 1998