Course Code/Title: AEM-ADV14 Separated Flows and Fluid-Structure Interaction

Course Aims
To develop an understanding of the concepts of flow separation. This knowledge should help in determining, in each particular situation, what measures should be taken in order to avoid separation. To develop an understanding of the concepts of fluid-structure interaction, in particular as applied to interaction of structures with separated flows. This knowledge should help in determining, in each particular situation, what measures should be taken in order to eliminate or reduce the loads on the structure.

Syllabus

Separation
Introduction: phenomenon of separation, main features of separated flows, influence of separation on lift and drag.
Inviscid separation: Kirchhoff flow, Batchelor model.
Boundary layer separation: mechanism, influence of pressure, dual role of viscosity, laminar vs turbulent separation.
High-Reynolds-number asymptotics, at descriptive level: viscous-inviscid interaction, global steady separation.
Discrete vortex method - numerical methods suitable for calculating separated flows: the idea, simplest case of point vortices applied to the flow past a circular cylinder

Fluid-structure interaction
Galloping: general idea; quasi-steady theory of galloping; Glauert - Den Hartog criterion; prevention of galloping; galloping of general sections and other forms of galloping; wake galloping; single degree of freedom stall flutter of an aerofoil; amplitude of galloping (expansion in small damping/energy approach).

Added mass
Vortex-induced vibrations: linear oscillator under the action of a sinusoidal force; lock-in phenomenon; non-dimensional parameters controlling vortex-induced vibrations; Griffin plot; regimes of vortex shedding; response branches; prevention of vortex-induced vibrations.
Buffeting: Froude-Krylov force and Morison’s equation; forced in-line oscillations of a body in a steady flow; power spectral density; linear damped oscillator under the action of random force; quasi-steady buffeting and aerodynamic admittance.

Pre-Requisites
As this is an MSc course taken by students of various backgrounds, no other course is a formal pre-requisite. However, the students are expected to be familiar with ordinary differential equations and with the basics of fluid dynamics and elasticity. The necessary knowledge of separated flows is given in the first part of the same module.

Learning Outcomes
Knowledge and understanding:
On successfully completing this course unit, students will understand the main concepts of flow separation and fluid-structure interaction, know the main facts about these phenomena and know the main methods used in this area of fluid dynamics

Skills and other attributes:
On successfully completing this course unit, students will be able to:

Intellectual skills:
• Perform research on separated flows.
• Perform research on fluid-structure interaction

Practical skills
• Ability to estimate the likelihood of separation in a given situation, both intuitively and using numerical calculations.
Ability to estimate the likelihood of galloping or vortex-induced vibrations, both intuitively and using numerical calculations.

**Teaching Methods**
Lectures and tutorials

**Assessment**
Examined Assessment
2 hour written examination (70%) in Summer term, 1 coursework assignment (30%).

**Reading List**
Category as defined by Central Library:
Core – Multiple copies available; Supplementary – 1 or 2 copies available

Title: The theory of jets in an ideal fluid
Author: M.I.Gurevich
Publisher: Pergamon Press 1966
Grade: Supplementary

Title: Boundary layer theory. (A very famous book, any edition will do)
Author: H. Schlichting
Publisher: Springer, 2000 (Older 6th edition, 1968, might be better)
Grade: Supplementary

Title: Asymptotic theory of separated flows
Author: V.V.Sychev, A.I.Ruban, Vik.V.Sychev, G.L.Korolev
Publisher: Cambridge University Press, 1998
Grade: Supplementary

Title: Asymptotic theory of global separation
Author: Chernyshenko S.I
Grade: Supplementary

Title: Vortex methods: theory and practice
Author: G.-H. Cottet, P. D. Koumoutsakos
Publisher: Cambridge University Press, 2000
Grade: Supplementary

Title: Vortex shedding from oscillating bluff bodies
Author: P.W. Bearman
Grade: Supplementary

Title: Vortex-induced vibrations
Author: C.H.K.Williamson and R. Govardhan
Grade: Supplementary

Title: Defining the ‘modified Griffin plot’ in vortex-induced vibration: revealing the effect of Reynolds number using controlled damping
Grade: Supplementary