Aerodynamics and Fluid Mechanics 3: Quick introduction

There are two laboratory exercises for the course Aerodynamics and Fluid Mechanics 3. These are run at the Acre Road facility. You need to make your own way out to the laboratory, post-code is G20 0TL. Take care in the laboratory environment. The wind tunnels are high value, precision pieces of equipment, and while you are allowed inside the wind tunnels, they must be treated with the greatest care. Listen to the demonstrators, do not go where you are not allowed to, and when inside a wind tunnel look around you before you move anywhere. Do not tread on any pipes or cables.

WARNING: TRIPPING HAZARD
WARNING: SLIPPING HAZARD
WARNING: WEAR WARM CLOTHING

1 Semester 1: Flow over a circular cylinder

The flow around a circular cylinder is one of the canonical problems in fluid mechanics. A cylindrical body is one of infinite span and uniform cross-section, and the circular cylinder has circular cross-section. It is the simplest geometric shape for this class of body. The solution for the potential flow over a circular cylinder is relatively straightforward to arrive at, but the actual flow is completely different due to flow separation. The fluid dynamics are rich with phenomena, but the circular cylinder is an important structural shape also, so the flow is important from a fundamental and applied perspective. In the experiment you will record surface pressure over the circular cylinder, and the pressure in the wake.

The experiment is run in the Handley-Page wind tunnel at Acre Road. This is a closed-return wind tunnel, with a 7 feet wide $\times$ 5 feet high working section and is capable of a maximum speed of some 50ms^{-1}. A circular cylinder model is placed in the wind tunnel with its axis vertical spanning the ceiling and floor. A series of 48 equally spaced pressure tappings are located on the surface of the model at the mid-span. These are numbered, with 1 and 48 straddling the centre-line on the windward surface. The pressure tappings are connected to a pressure scanning unit. When the experiment is run, a computer controls the pressure scanner and samples the pressure. The wind tunnel is also instrumented with a traverse system to measure the wake pressure and velocity profiles. The traverse is computer controlled, and the Pitot-static probe attached to the traverse in the wake is connected to two manometers, one for the dynamic pressure, the other for the local static pressure, and these pressures are recorded at each traverse position. Analysis of the surface pressure will indicate where surface separation points are, and the body forces drag and lift due to pressure can be evaluated. Measurements of the wake flow will indicate the physical extent of the wake, and will allow the drag coefficient to be evaluated. You will take data at three Reynolds numbers to help understand how the flow regime changes according to where separation occurs.

2 Semester 2: Finite wing aerodynamics and vortex flow

The laboratory is run in the deHavilland wind tunnel at Acre Road. This is a closed-return wind tunnel, with a 9 feet wide $\times$ 7 feet high working section and is capable of a maximum speed of some 70ms^{-1}.

For session 2020-2021 you will look at data from a Delta wing mounted on the sting balance in the wind tunnel. The Delta wing is so-called because its planform is that of a triangle, Δ. The wing has a 0.8m root chord and leading edge angle 60^o (so it is an equilateral triangle). The wing leading edges are sharp, so the flow separates at low angle of attack and the flow is dominated by vortices that spring from the Δ wing apex. We do not study Delta wings in the course, and any flows we study are attached. However, the Delta wing produces an interesting flow field that is a useful topic of study in itself. The Delta wing model has been built to support undergraduate final year projects, and it was in the tunnel in Autumn 2020, so it was useful to do the laboratory walk through. In normal circumstances a half aircraft body would be tested, but the Delta wing test takes the same measurements, data processing methodologies are similar, all that changes are the conclusions reached.

The test model is mounted on a six component balance mounted on a sting in the wind tunnel. The turntable system allows the model yaw, pitch and roll angles to be set. The balance measures all three orthogonal forces and moments; the model is fixed to the balance, so resolving the balance normal and axial forces (F_z and F_x) using the angle of attack will give the body lift L and drag D. The wake flow field on the starboard side of the wing is to be investigated using a 7-hole pressure probe. This can be used to get the flow field local pressure p. stagnation pressure p_o, and the three velocity components (u, v, w). The probe is mounted on a computer controlled traverse, so the probe can be moved around in the wake flow. You will take force measurements at a range of angles of attack. You will then use flow visualisation to locate the trailing vortex at a candidate angle of attack, and then use the probe to investigate the structure of the trailing vortex, the data will allow you to calculate the circulation Γ, vortex core diameter, pressure field in the vortex.