Unit 84: Aerodynamic Principles and Aircraft Stability and Performance

Unit code: Y/601/7190
QCF level: 5
Credit value: 15

- **Aim**

This unit will give learners an understanding of experimental aerodynamics, the analysis of aircraft manoeuvres and aircraft performance.

- **Unit abstract**

This unit will enable learners to carry out practical wind tunnel investigations and will develop their understanding of the use and limitations of experimental aerodynamics. Learners will also examine aircraft instability and the methods used to control it. The forces acting on an aircraft during manoeuvres are explored along with the related potential hazards. Finally, learners will investigate the effects that aerodynamics can have on aircraft performance.

- **Learning outcomes**

On successful completion of this unit a learner will:

1. Be able to carry out experimental wind tunnel investigations
2. Understand aircraft stability and control methods
3. Understand the forces acting on aircraft during manoeuvres
Unit content

1  **Be able to carry out experimental wind tunnel investigations**

   *Model and tunnel parameters*: scale effect; dynamic similarity; Reynolds number; Mach number; wind tunnel types eg sizes, pressures, temperatures
   
   *Wind tunnel investigation*: flow visualisation; lift, drag and pitching moment measurement
   
   *Contribution of wind tunnel tests*: limitations eg size, inability to produce extremes of weather; aerodynamic development eg Concorde wing, variable geometry wings, large aircraft configurations; aircraft performance eg wing profiles, external equipment such as aerials and external loads

2  **Understand aircraft stability and control methods**

   *Instability modes*: long- and short-period oscillations; spiral dive; Dutch roll
   
   *Common control systems*: forces; hinge moments; stick forces; stick gearing; trim; trim curves; non-conventional controls; canard; elevons; taileron; flaperons; active control; artificial stability; control response speed; control power; manoeuvrability; flight envelope protection; weight and drag savings
   
   *Less common control configurations*: Vertical Take-Off and Landing (VTOL); Very Short Take-Off and Landing (VSTOL); helicopters; variable geometry winged aircraft

3  **Understand the forces acting on aircraft during manoeuvres**

   *Forces on aircraft*: gravitational forces due to aircraft manoeuvres; weight, thrust, drag and atmospheric conditions
   
   *Manoeuvres*: instantaneous level co-ordinated turn and symmetrical pull-up/push-over; load factors; power/thrust for sustained turn and pull-up; spin; incipient; developed; recovery
   
   *Manoeuvre envelope*: buffet limits; lg-stall; cruise; manoeuvre speeds; limit load factors; gust load lines
   
   *Aeroelastic effects*: aeroelasticity; wing torsional divergence; control reversal; flutter of fixed surfaces and control surfaces; methods of alleviation

4  **Understand how aerodynamics affects aircraft performance**

   *Aircraft performance*: aircraft drag and power required versus airspeed curves; minimum drag and power speeds; unpowered flight; glide angle; rate of descent; speed; range; endurance; stalling speed; powered flight; piston propeller and jet power/thrust available versus airspeed; minimum and maximum level flight speeds; rate of climb; airspeed for maximum rate of climb; absolute and service ceilings; take-off; ground roll; air distance; climb-out; \( V_1 \); \( V_{TD} \); factors affecting take-off and landing; temperature; pressure altitude; ground effect; wind; runway surface; brakes; airworthiness performance regulations
## Learning outcomes and assessment criteria

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<thead>
<tr>
<th>Learning outcomes</th>
<th>Assessment criteria for pass</th>
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<td><strong>On successful completion of this unit a learner will:</strong></td>
<td><strong>The learner can:</strong></td>
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| LO1 Be able to carry out experimental wind tunnel investigations | 1.1 specify appropriate model and tunnel parameters for a proposed wind tunnel test  
1.2 conduct an experimental investigation in a wind tunnel, record and comment on the validity of the results  
1.3 give examples of the contribution of wind tunnel tests in the development of aerodynamics and in individual aircraft performance |
| LO2 Understand aircraft stability and control methods | 2.1 describe common instability modes and explain their effects and means of avoidance or mitigation  
2.2 analyse the size and balance of forces within a control system  
2.3 assess the merits and disadvantages of less common control configurations  
2.4 review current application of automatic/active control and discuss the implications of future developments |
| LO3 Understand the forces acting on aircraft during manoeuvres | 3.1 calculate the forces acting on an aircraft during manoeuvres  
3.2 identify and describe the potential hazards arising from manoeuvres  
3.3 explain and interpret manoeuvre envelopes  
3.4 analyse aeroelastic effects and explain methods of alleviation |
| LO4 Understand how aerodynamics affects aircraft performance | 4.1 evaluate aircraft performance in relation to airworthiness regulations and operators’ requirements  
4.2 use and explain the terminology required to describe aircraft performance  
4.3 draw conclusions from equations, graphs and tables of aircraft performance. |
Guidance

Links
This unit links with Unit 83: Aerodynamic Principles and Aircraft Design, Unit 85: Automatic Flight Control Systems and Unit 89: Aircraft Structural Integrity.

Essential requirements
Learners will need access to a subsonic wind tunnel with facilities for flow visualisation, lift, drag and pitching moment measurement and pressure distribution measurement.

Employer engagement and vocational contexts
Centres should try to develop links with aerospace companies so that learners can gain access to full-size aircraft.