Higher National Unit specification

General information

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Unit code: H94R 35

Superclass: XP

Publication date: May 2015

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This Unit is designed to enable learners to build on the knowledge developed in the Unit *Aerodynamics and Flight Mechanics 1* at SCQF level 7. The Unit should provide the learner with a greater knowledge of the subject and develop their awareness of important facets of aircraft flight such as stability and performance. Learners will also be provided with an overview of how an aircraft is designed to improve aerodynamic efficiency and the impact flying at transonic and supersonic speeds has on aircraft aerodynamics.

The Unit is aimed at learners who wish to work in the aircraft engineering industry.

Outcomes

On successful completion of the Unit the learner will be able to:

1 Explain the stability of an aircraft in flight.
2 Explain the principles of high speed flight of an aircraft.
3 Explain the design of an aircraft from an aerodynamic perspective.
4 Analyse aircraft performance throughout the flight envelope.

Credit points and level

1 Higher National Unit credit at SCQF level 8: (8 SCQF credit points at SCQF level 8)

Recommended entry to the Unit

Entry is at the discretion of the centre. However, it is recommended learners have completed Unit H94G 34 *Aerodynamics and Flight Mechanics 1* before commencing this Unit.

Higher National Unit Specification: General information (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the Support Notes for this Unit specification.

There is no automatic certification of Core Skills or Core Skill components in this Unit.

Context for delivery

If this Unit is delivered as part of a Group Award, it is recommended that it should be taught and assessed in the subject area of the Group Award to which it contributes.

The Assessment Support Pack (ASP) for this Unit provides assessment and marking guidelines that exemplify the national standard for achievement. It is a valid, reliable and practicable assessment. Centres wishing to develop their own assessments should refer to the ASP to ensure a comparable standard. A list of existing ASPs is available to download from SQA's website **(http://www.sqa.org.uk/sqa/46233.2769.html)**.

Equality and inclusion

This Unit specification has been designed to ensure that there are no unnecessary barriers to learning or assessment. The individual needs of learners should be taken into account when planning learning experiences, selecting assessment methods or considering alternative evidence.

Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**.

Higher National Unit specification: Statement of standards

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

Outcome 1

Explain the stability of an aircraft in flight.

Knowledge and/or Skills

- Aircraft Degrees of Freedom
- Aircraft axes systems (principal, wind and body)
- Trimmed flight and static equilibrium
- Longitudinal, lateral and directional static stability
- Stabilising surfaces and design features introduced to improve aircraft stability
- Stability derivatives for longitudinal, lateral and directional stability
- Dynamic stability and stability modes

Outcome 2

Explain the principles of high speed flight of an aircraft.

Knowledge and/or Skills

- The different speed regimes (subsonic, transonic and supersonic)
- Mach number, critical Mach number and the speed of sound
- The generation of shock waves
- The impact of shock wave formation on lift and drag
- The development of supercritical aerofoils and the introduction of the transonic area rule
- The effect normal and oblique shock waves have on flow properties

Outcome 3

Explain the design of an aircraft from an aerodynamic perspective.

Knowledge and/or Skills

- The importance of the lift-to-drag ratio and aerodynamic efficiency
- The significance of the drag polar including optimum angle of attack and maximum lift-to-drag ratio
- The operating principles of design features introduced to improve aerodynamic efficiency

Higher National Unit specification: Statement of standards (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Outcome 4

Analyse aircraft performance throughout the flight envelope.

Knowledge and/or Skills

- Take-off performance
- Take-off flight path
- Climb performance
- Cruise performance
- Glide performance (unpowered descent)
- Landing performance

Evidence Requirements for this Unit

Outcome 1

Learners will need to provide written and/or oral recorded evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- define and explain an aircraft's Degrees of Freedom.
- define and explain aircraft axes systems — to include principal axes, wind axes and body axes.
- define trimmed flight and static equilibrium and explain how it is established.
- define and explain longitudinal, lateral and directional static stability.
- identify the stabilising surfaces and design features introduced to improve aircraft stability — to include horizontal stabiliser, vertical stabiliser, dihedral and wing sweep.
- explain how the stabilising surfaces and design features are used to improve aircraft stability.
- define the stability derivatives for longitudinal, lateral and directional stability.
- define and explain dynamic stability and the stability modes — to include Short Period Pitch Oscillation (SPPO), phugoid, spiral mode and Dutch Roll.

Evidence for the Knowledge and/or Skills in this Outcome will be generated by a closed-book assessment.

Higher National Unit specification: Statement of standards (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Outcome 2

Learners will need to provide written and/or oral recorded evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- define the different speed regimes (subsonic, transonic and supersonic).
- define and explain Mach number, critical Mach number and speed of sound.
- explain how shock waves are generated.
- define and explain the impact of shock wave formation on lift and drag.
- define and explain the development of supercritical aerofoils and the introduction of the transonic area rule.
- define normal and oblique shock waves and analyse the effect their presence has on flow properties — to include pressure, density, temperature, velocity and Mach number.

Evidence for the Knowledge and/or Skills in this Outcome will be generated by a closed-book assessment.

Outcome 3

Learners will need to provide written and/or oral recorded evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- identify the importance of the lift-to-drag ratio and aerodynamic efficiency.
- define and explain the significance of the drag polar.
- make use of experimental data to establish the optimum angle of attack and maximum lift-to-drag ratio for an aerofoil section.
- define and explain the operating principles of design features introduced to improve aerodynamic efficiency — to include winglets, taper and aspect ratio.

Evidence for the Knowledge and/or Skills in this Outcome will be generated by an open-book assessment.

Higher National Unit specification: Statement of standards (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Outcome 4

Learners will need to provide written and/or oral recorded evidence to demonstrate their Knowledge and/or Skills by showing that they can:

- analyse take-off performance — to include a typical take-off profile with reference to V-speeds and distances covered.
- analyse the take-off flight path — to include reference to changes in configuration, speed and engine setting and the minimum climb gradients that must be achieved.
- analyse climb performance — to include climb angle, rate of climb and excess thrust.
- analyse cruise performance — to include reference to the Breguet range equation and the range parameter.
- analyse glide performance (unpowered descent) — to include minimum equilibrium glide angle, maximum range and sink rate.
- analyse landing performance — to include a typical landing profile with reference to approach angle (normal and steep approach), V-speeds and distances covered.

Evidence for the Knowledge and/or Skills in this Outcome will be generated by a closed-book assessment.

Higher National Unit Support Notes

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Unit Support Notes are offered as guidance and are not mandatory.

While the exact time allocated to this Unit is at the discretion of the centre, the notional design length is 40 hours.

Guidance on the content and context for this Unit

This is a mandatory Unit within the HND Aircraft Engineering Group Award. The Unit is primarily intended to allow the learner to enhance and build upon the knowledge developed in the Unit H94G 34 *Aerodynamics and Flight Mechanics 1* Unit at SCQF level 7 and to prepare them for a career in the aircraft engineering industry or for progression on to a degree programme (SCQF level 9 and 10). The Unit should emphasise what influence the degree of stability an aircraft has on how it performs and highlight the significance of the drag polar when carrying out performance calculations. How the aircraft operates at the different stages of the Flight Envelope and flying at transonic and supersonic speeds should also be analysed.

The list of topics presented below for each Outcome offers lecturers guidance on the level of coverage for each Outcome.

Outcome 1

Explain the stability of an aircraft in flight.

- Aircraft Degrees of Freedom:
  - define and explain translational and rotational degrees of freedom
  - define and explain longitudinal and lateral degrees of freedom

- Aircraft axes systems:
  - define and explain principal axes, wind axes and body axes

- Trimmed flight and static equilibrium:
  - define trim
  - explain how trim is established

- Longitudinal, lateral and directional static stability:
  - define longitudinal stability and identify the axis of rotation
  - define lateral stability and identify the axis of rotation
  - define directional stability and identify the axis of rotation

- Stabilising surfaces and design features introduced to improve aircraft stability:
  - horizontal stabiliser
  - vertical stabiliser
  - lateral dihedral
  - wing sweep

- Stability derivatives for longitudinal, lateral and directional stability:
  - introduce the stability derivative for longitudinal stability
  - introduce the stability derivative for lateral stability
  - introduce the stability derivative for directional stability

- Dynamic stability and stability modes:
  - Damping
  - Short Period Pitch Oscillation
  - Phugoid
  - Spiral Mode
  - Dutch Roll

It is intended that Outcome 1 could provide an introduction to the subject of aircraft stability, focusing on an aircraft's Degrees of Freedom, aircraft axes systems (principal, wind and body) and trimmed flight and static equilibrium. This may provide the foundation for a discussion on longitudinal, lateral and directional static stability. Stabilising surfaces and design features introduced to improve aircraft stability should also be discussed and the stability derivatives introduced. The Outcome should be completed with a look at dynamic stability and stability modes (SPPO, phugoid, spiral mode and Dutch Roll).

Outcome 2

Explain the principles of high speed flight of an aircraft.

- The different speed regimes:
  - define and explain subsonic, transonic and supersonic speeds

- The generation of shock waves:
  - define and explain Mach number, speed of sound and the critical Mach number
  - explain how shock waves are generated on the upper and lower surfaces of a wing
  - explain the formation of the bow shock wave

- The impact of shock wave formation on lift and drag:
  - define and explain the effect shock waves have on lift
  - define and explain the effect shock waves have on drag

- The development of supercritical aerofoils and the introduction of the transonic area rule:
  - explain how supercritical aerofoils and the transonic area rule help to reduce the drag penalty associated with high speed flight

- The effect normal and oblique shock waves have on flow properties:
  - define and explain how normal shock waves affect pressure, density, temperature, velocity and Mach number
  - define and explain how oblique shock waves affect pressure, density, temperature, velocity and Mach number

Outcome 2 should provide an introduction to the subject of high speed flight, focussing on flight at transonic and supersonic speeds. Fundamental parameters such as Mach number, critical Mach number and the speed of sound should be introduced and the generation of shock waves discussed, with the impact of shock wave formation on lift and drag analysed. The philosophy behind the development of supercritical aerofoils and the transonic area rule should be studied.

Normal shock waves and oblique shock waves should be introduced, concentrating on the impact that the formation of these shock waves has on flow properties downstream of the shock wave.

Outcome 3

Explain the design of an aircraft from an aerodynamic perspective.

- The importance of the lift-to-drag ratio and aerodynamic efficiency:
  - define and explain how the lift-to-drag ratio gives a measure of an aircraft's aerodynamic efficiency

- The significance of the drag polar:
  - define and explain the constituent parts of the drag polar
  - define and explain how the drag polar is used to determine the maximum aerodynamic efficiency

- The operating principles of design features introduced to improve aerodynamic efficiency:
  - define and explain how winglets may improve aerodynamic efficiency
  - define and explain how changing aspect ratio affects aerodynamic efficiency

It is proposed that Outcome 3 introduces the importance of the lift-to-drag ratio and how it provides a measure of an aircraft's aerodynamic efficiency. The drag polar, introduced in the Unit *Aerodynamics and Flight Mechanics 1* at SCQF level 7, could be revisited and broken down into its constituent parts. Relationships between zero-lift drag and drag due to lift should be analysed and how the aerodynamic information contained in the drag polar equation and the drag polar graph is used to determine the maximum aerodynamic efficiency. Design features such as winglets, introduced to improve the aerodynamic efficiency of an aircraft, should also be discussed.

Higher National Unit Support Notes (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Outcome 4

Analyse aircraft performance throughout the flight envelope.

- Take-off performance:
  - define and explain a typical take-off profile including V-speeds and distances covered

- Take-off flight path:
  - define and explain the different segments of the take-off flight path
  - explain changes in configuration and speed and the minimum climb gradients that must be achieved in the second and final segments

- Climb performance:
  - define and explain how to determine climb angle, rate of climb and excess thrust

- Cruise performance:
  - define the Breguet range equation and explain the significance of the range parameter

- Glide performance (unpowered descent):
  - define and explain how to determine minimum equilibrium glide angle, maximum range and sink rate

- Landing performance:
  - define and explain a typical landing profile including V-speeds and distances covered

It is expected that Outcome 4 will analyse how an aircraft performs from brakes release prior to take-off to brakes on following touchdown. Take-off performance should be introduced, looking at a typical take-off profile, V-speeds such as V_s, V_{mcg}, V_1, V_R, V_{MU}, V_{LO} and V_2 and the distances covered from brakes release to the 35 ft (11 m) 'screen' height. This should be followed by an overview of an aircraft's take-off flight path, focusing on changes in aircraft configuration, engine setting and speed during the different segments. Reference could also be made to the minimum climb gradient requirements in the second and fourth segments. Climb performance and gliding performance should be analysed followed by a discussion on how to maximise cruise performance (reference could be made to how the aerodynamics of the aircraft in the drag polar impact cruise performance) and Outcome 4 may be concluded with a summary of a typical landing profile including reference to the landing speeds V_{REF}, V_{MCL} and V_{TD} and the fundamental distances covered during landing. Reference could also be made to typical approach angles for a normal and steep approach.

Higher National Unit Support Notes (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Guidance on approaches to delivery of this Unit

This Unit forms part of a Group Award designed to provide learners with technical and professional knowledge and skills for the specific occupational area of aircraft engineering. Those who successfully complete the award are likely to progress on to an apprenticeship programme or on to further and/or higher education.

It is logical to deliver this Unit at the beginning of the Group Award. It should be delivered sequentially by Outcome, and may include a mixture of direct teaching lectures, interactive discussion, tutorial exercises and case studies. Having access to relevant publications is recommended and course work and laboratory reports must be the work of individuals.

Guidance on approaches to assessment of this Unit

Evidence can be generated using different types of assessment. The following are suggestions only. There may be other methods that would be more suitable to learners.

Centres are reminded that prior verification of centre-devised assessments would help to ensure that the national standard is being met. Where learners experience a range of assessment methods, this helps them to develop different skills that should be transferable to work or further and higher education.

Evidence for this Unit could be generated through two assessment events.

The assessment of Outcomes 1, 2, and 4 can be combined as a single, holistic closed-book assessment consisting of a number of multiple-choice and extended response questions enabling Unit Evidence Requirements to be met and breadth and depth of learner knowledge to be demonstrated. It should last no longer than two hours. Learners should not know in advance the items on which they will be assessed.

The second assessment, covering Outcome 3, could be a laboratory exercise. Learners might conduct a series of wind tunnel tests to plot lift and drag curves and a drag polar for an aerofoil section and use the graphical data to determine the optimum angle of attack for the aerofoil and the maximum lift-to-drag ratio. In generating the Evidence Requirements for this assessment, learners will need to show that they can evaluate and interpret information from a variety of sources such as wind tunnel experiments and textbooks, in order to produce a balanced report that is referenced as per the Harvard Referencing format. This assessment should be carried out under open-book conditions and all submissions should be the learner's own work.

Accurate records should be made of the assessment instruments used showing how evidence is generated for each assessment/examination, giving marking schemes and/or checklists, etc. Records of learners' achievements should be kept. These records will be available for external verification.

Higher National Unit Support Notes (cont)

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

Opportunities for e-assessment

E-assessment may be appropriate for some assessments in this Unit. By e-assessment we mean assessment which is supported by Information and Communication Technology (ICT), such as e-testing or the use of e-portfolios or social software. Centres which wish to use e-assessment must ensure that the national standard is applied to all learner evidence and that conditions of assessment as specified in the Evidence Requirements are met, regardless of the mode of gathering evidence. The most up-to-date guidance on the use of e-assessment to support SQA's qualifications is available at **www.sqa.org.uk/e-assessment**.

Opportunities for developing Core and other essential skills

There are opportunities in this Unit to develop the Core Skill *Numeracy* at SCQF level 6. Learners can achieve this by demonstrating that they can evaluate wind tunnel test data. There are also opportunities in the Unit to develop the Core Skills component *Communication* (Written) at SCQF level 6. This could be achieved through a written laboratory report for the wind tunnel exercise. However, there is no automatic certification of Core Skills or Core Skills components.

History of changes to Unit

Version	Description of change	Date

General information for learners

Unit title: Aerodynamics and Flight Mechanics 2 (SCQF level 8)

This section will help you decide whether this is the Unit for you by explaining what the Unit is about, what you should know or be able to do before you start, what you will need to do during the Unit and opportunities for further learning and employment.

This Unit is designed to enable learners to build on the knowledge developed in the Unit H94G 34 *Aerodynamics and Flight Mechanics 1* at SCQF level 7. The Unit should provide the learner with a greater knowledge of the subject and develop their awareness of important facets of aircraft flight such as stability and performance. Learners will also be provided with an overview of how an aircraft is designed to improve aerodynamic efficiency and the impact flying at transonic and supersonic speeds has on aircraft aerodynamics.

The Unit is primarily intended for learners who are interested in aircraft engineering and is a mandatory Unit in the HND Aircraft Engineering Group Award, although it may be of interest to learners of other disciplines.

The Unit has four main areas, each area covered by a separate Outcome. The four main areas the Unit covers are:

1 Explain the stability of an aircraft in flight.
2 Explain the principles of high speed flight of an aircraft.
3 Explain the design of an aircraft from an aerodynamic perspective.
4 Analyse aircraft performance throughout the flight envelope.

The Knowledge and/or Skills contained in Outcomes 1, 2 and 4 will be assessed under closed-book conditions while those under Outcome 3 will be assessed under open-book conditions. To complete the Unit successfully you will have to achieve a satisfactory level of performance in the assessment events.

The Unit may be of particular interest if you are interested in pursuing a career in aircraft engineering as an aerodynamicist or design engineer or if you intend to look to undertake an aircraft engineering degree course.

There are opportunities in this Unit to develop the Core Skill *Numeracy* at SCQF level 6. Learners can achieve this by demonstrating that they can evaluate wind tunnel test data. There are also opportunities in the Unit to develop the Core Skills component *Communication* (Written) at SCQF level 6. This could be achieved through a written laboratory report for the wind tunnel exercise. However, there is no automatic certification of Core Skills or Core Skills components.