SQA Advanced Unit specification

General information for centres

Unit title: Heat Transfer and Fluid Mechanics

Unit code: HT7R 48

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding of heat transfer and fluid mechanics.

On completion of the Unit the candidate should be able to:

1 Analyse fluid flow patterns.
2 Solve flow measurement problems.
3 Solve problems involving incompressible flow in pipe systems.
4 Analyse heat transfer rates through typical industrial plant.

Credit value: 1 SQA Credit at SCQF level 8: (8 SCQF credit points at SCQF level 8*)

**SCQF credit points are used to allocate credit to qualifications in the Scottish Credit and Qualifications Framework (SCQF). Each qualification in the Framework is allocated a number of SCQF credit points at an SCQF level. There are 12 SCQF levels, ranging from National 1 to Doctorates.*

Recommended prior knowledge and skills: It would be beneficial for candidates to have prior knowledge and understanding of basic thermodynamics and fluid mechanics.
This may be evidenced by possession of the following SQA Advanced Units: Engineering Principles and Thermofluids.

Core Skills: There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Written Communication	SCQF level 6
Use of Numbers	SCQF level 6
Use of Graphical Information	SCQF level 6
Critical Thinking	SCQF level 6
Reviewing and Evaluating	SCQF level 6

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

Assessment: This Unit lends itself to holistic assessment. The assessment for Outcomes 1, 2, 3 and 4 should be combined together into one written assessment paper. This paper should be taken by candidates at a single assessment event that should last no more than 2 hours 30 minutes. Assessment should be conducted under closed-booked, controlled, supervised conditions. A formula sheet should be provided to candidates.

SQA Advanced Unit specification: statement of standards

Unit title: Heat Transfer and Fluid Mechanics

The sections of the Unit stating the Outcomes, knowledge and/or skills, and evidence requirements are mandatory.

Where evidence for Outcomes is assessed on a sample basis, all the content listed in the knowledge and/or skills section must be taught and available for assessment. Candidates should not know in advance the items on which they will be assessed. Different items should be sampled on each assessment occasion.

Outcome 1

Analyse fluid flow patterns.

Knowledge and/or skills

- viscosity; dynamic viscosity and kinematic viscosity
- flow types (laminar, transitional and dynamic)
- Reynolds Number
- relationship between Reynolds Number with dynamic and kinematic viscosity
- drag
- component drag forces
- flow separation
- patterns around bodies on which flow separation occurs (bluff body shape; streamlined shape; cube or rectangle)

Evidence Requirements

Evidence for the knowledge and/or skills items in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome, **five out of eight** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of five out of eight knowledge and/or skills items is required each time the Outcome is assessed Candidates must provide a satisfactory response to all five items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing the candidate is able to:

- define the terms viscosity; dynamic viscosity and kinematic viscosity
- classify flow types (laminar; transitional and turbulent)
- classify flow types in terms of Reynolds Number
- define the term drag
- state the component drag forces
- define the term flow separation
- explain why flow separation occurs
- sketch patterns around bodies on which flow separation occurs (bluff body shape; streamlined shape; cube or rectangle)

The assessment of this Outcome must be combined with that for Outcome 2, 3 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements in Outcome 4.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 2

Solve flow measurement problems.

Knowledge and/or skills

- dynamic, static and hydrostatic pressure
- principle of operation of flow measurement systems (venturi meter, orifice plate, rotameter)
- principle of operation of velocity measuring devices (pitot tube, anemometer, pitot static tube, turbine meter)
- appropriate measurement system for defined applications
- determination of flow velocity and volumetric flow rate by the application of Bernoulli equation to flow and velocity measurement devices (venturi meter, orifice plate, pitot tube and pitot static tube)
- determination of coefficient of discharge for venturi meters and orifice plates by the application of Bernoulli equation

Evidence Requirements

Evidence for the knowledge and/or skills items in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome, **four out of six** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of four out of six knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all four items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- define total and static pressure
- describe the principle of operation of one of the flow measurement systems (venturi meter, orifice plate, rotameter)
- describe the principle of operation of one velocity measuring device (pitot tube, anemometer, pitot static tube, turbine meter)
- identify an appropriate measurement system for a defined application
- determine flow velocity and volumetric flow rate by the application of Bernoulli equation to one flow measurement device (venturi meter, orifice plate, pitot tube and pitot static tube)
- determine from given data the coefficient of discharge for either a venturi meter or orifice plate by the application of Bernoulli equation

The assessment of this Outcome must be combined with that for Outcome 1, 3 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements in Outcome 4.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 3

Solve problems involving incompressible flow in pipe systems.

Knowledge and/or skills

- define Reynolds Number
- velocity profiles in laminar and turbulent flow
- friction factor in laminar flow
- energy losses in pipe lengths for laminar flow
- pipe friction (or Moody) chart
- energy losses in pipe lengths for turbulent flow
- pressure drop in horizontal and non-horizontal pipe lengths
- energy losses in pipe fittings, sudden enlargements and contractions
- equivalent lengths in pipe diameters (L/D)

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **six out of nine** knowledge and/or skills items should be sampled.

In order to ensure that candidates will not be able to foresee what items they will be questioned on, a different sample of six out of nine knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all six items.

Where sampling takes place, a candidate’s response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- define and calculate Reynolds Number
- sketch velocity for profiles for laminar and turbulent flow in pipes
- calculate friction factor in laminar flow
- calculate energy losses in pipe lengths for laminar flow
- use pipe friction (or Moody) chart
- calculate energy losses in pipe lengths for turbulent flow
- calculate pressure drop in horizontal and non-horizontal pipe lengths
- calculate energy losses in pipe fittings, sudden enlargements and contractions
- determine equivalent lengths in pipe diameters (L/D)

The assessment of this Outcome must be combined with that for Outcome 1, 2 and 4 to form a single assessment paper, details of which are given under the Evidence Requirements in Outcome 4.

Assessment guidelines

Questions used to elicit candidate evidence should take the form of an appropriate balance of short answer, restricted response and structured questions.

Outcome 4

Analyse heat transfer rates through typical industrial plant.

Knowledge and/or skills

- ♦ Modes of heat transfer:
  - — conduction
  - — convection
  - — radiation
- ♦ Heat loss through composite plane walls
- ♦ Heat loss through insulated pipe walls
- ♦ Operation of heat exchangers (parallel flow; contra flow):
  - — overall heat transfer coefficient
  - — surface area
  - — length and number of tubes in each pass

Evidence Requirements

Evidence for the knowledge and/or skills in this Outcome should be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that they can answer questions correctly based on a sample of the items shown above.

In any assessment of this Outcome **three out of four** knowledge and/or skills items should be sampled.

In order to ensure that the candidates will not be able to foresee what items they will be questioned on, a different sample of three out of four knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all three items.

Where sampling takes place, a candidate's response can be judged to be satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ♦ provide a clear and concise explanation of conduction, convection and radiation
- ♦ calculate heat loss through composite plane walls
- ♦ calculate heat loss through an insulated pipe wall
- ♦ calculate and compare parameters (overall heat transfer coefficient; surface area; length and number of tubes in each pass) for parallel and contra flow exchanger

The assessment of this Outcome must be combined with that of Outcomes 1, 2 and 3 to form one assessment paper for the Unit. This single assessment paper should be taken at a single assessment event lasting no more than 2 hour 30 minutes and carried out under closed-book, controlled, supervised conditions. A formula sheet should be provided to the candidates.

Assessment guidelines

The assessment paper should be composed of an appropriate balance of short answer, restricted response and structured questions.

Administrative information

Unit code: HT7R 48

Unit title: Heat Transfer and Fluid Mechanics

Superclass category: XH

Original date of publication: August 2017

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of SQA Advanced qualifications.

FURTHER INFORMATION: Call SQA's Customer Contact Centre on 44 (0) 141 500 5030 or 0345 279 1000. Alternatively, complete our Centre Feedback Form.

SQA Advanced Unit specification: support notes

Unit title: Heat Transfer and Fluid Mechanics

This part of the Unit specification is offered as guidance. The support notes 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 Unit has been written in order to allow candidates to develop further their knowledge and understanding of thermofluids principles as well as develop their abilities to assess and analyse flow measurement systems, fluid flow systems and heat transfer systems.

In designing this Unit, the writers have identified the range of topics expected to be covered by lecturers. Recommendations are also given as to how much time should be spent on each Outcome. This has been done to help lecturers to decide what depth of treatment should be given to the topics attached to each of the Outcomes. Whilst it is not mandatory for centres to use this list of topics, it is strongly recommended that they do so to ensure continuity of teaching and learning. The list of topics is as follows. Lecturers are advised to study this list in conjunction with the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

1 Analyse fluid flow patterns (2.5 hours)

- define the terms viscosity; dynamic viscosity and kinematic viscosity
- describe, with the aid of a sketch, laminar and turbulent flows in pipes
- classify laminar, transitional and turbulent flow in terms of Reynolds Number
- define the term drag
- state the component drag forces
- define the term flow separation
- explain why flow separation occurs
- sketch patterns around bodies on which flow separation occurs (bluff body shape; streamlined shape; cube or rectangle)

2 Solve flow measurement problems (5.5 hours)

- define total and static pressure
- describe the principle of operation of flow measurement systems (venturi meter, orifice plate, rotameter)
- describe the principle of operation of velocity measuring devices (pitot tube, anemometer, pitot static tube, turbine meter)
- identify the appropriate measurement system for defined applications
- determination of flow velocity and volumetric flow rate by the application of Bernoulli equation to flow measurement devices (venturi meter, orifice plate, pitot tube and pitot static tube)
- determination of coefficient of discharge for venturi meters and orifice plates by the application of Bernoulli equation

3 Solve problems involving incompressible flow in pipe systems (15.5 hours)

- define and perform calculations of Reynolds Number
- velocity profiles in laminar and turbulent flow
- calculation of friction factor in laminar flow
- calculation of energy losses in pipe lengths for laminar flow
- use of the pipe friction (or Moody) chart
- calculation of energy losses in pipe lengths for turbulent flow
- calculation of pressure drop in horizontal and non-horizontal pipe lengths
- calculation of energy losses in pipe fittings, sudden enlargements and contractions
- equivalent lengths in pipe diameters (L/D)

4 Analyse heat transfer rates through typical industrial plant (15 hours)

- description of the modes of heat transfer (conduction; convection; radiation)
- statement of Fourier's Law of heat conduction
- statement of Newton's Law of cooling
- definition of thermal resistance and values for different materials
- definition of surface and overall heat transfer coefficients
- calculation of heat loss through composite plane walls and insulated pipe walls
- description of heat transfer coefficients and means whereby they may be calculated
- description of the operation of heat exchangers (parallel flow; contra flow)
- calculation and comparison of parameters (overall heat transfer coefficient; surface area; length and number of tubes in each pass) for parallel and contra flow exchangers

Assessment = 2.5 hours

Guidance on the delivery and assessment of this Unit

This Unit should be delivered by a combination of lecturing and whole class and group discussion. The Unit has also been written such that there is sufficient time built in for candidates to practise what they have learnt through appropriate formative assessment. Additionally, the Unit has been designed to incorporate time for some experimental work (and computer simulations where possible) which should not be assessed formally in the Unit. This laboratory work should provide candidates with the opportunity to confirm mechanical theory and assess engineering systems in practice.

It is recommended that this Unit is delivered after the SQA Advanced Unit Thermofluids.

Where this Unit is incorporated into other Group Awards it is recommended that it be delivered in the context of the specific occupational area(s) that the award is designed to cover.

Areas for practical work to reinforce learning may include, but not be limited to, the following:

- use of a friction rig to determine losses through valves and fittings
- the use of a fluid flow test rig to demonstrate the flow patterns around bluff bodies, streamlined shape as well as a cube or rectangle
- the use of a concentric tube heat exchanger rig to determine the heat flow rate and other parameters for parallel and contra flow exchangers
- the use of a flow measurement test rig to determine the flow velocity, volumetric flow rate as well as the coefficient of discharge for a venturi meter or an orifice plate

Details on the approaches to assessment are given under the Evidence Requirements in Outcome 4 of the statement of standards section.

Opportunities for developing Core Skills

There may be opportunities to gather evidence towards the following listed Core Skill components in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Written Communication	SCQF level 6
Use of Numbers	SCQF level 6
Use of Graphical Information	SCQF level 6
Critical Thinking	SCQF level 6
Reviewing and Evaluating	SCQF level 6

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of online support. However, with regard to assessment, planning would be required by the centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that the assessment, which is required to be at a single event, was conducted under controlled, supervised conditions.

For information on normal open learning arrangements, please refer to the SQA guide *Assessment and Quality Assurance of Open and Distance Learning (SQA 2000).*

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.

General information for candidates

Unit title: Heat Transfer and Fluid Mechanics

This Unit has been designed to allow you to develop knowledge, understanding and skills in fluid mechanics and heat transfer principles that underpin so much of Mechanical Engineering.

This Unit will provide you with an opportunity to study fluid flow patterns and give you an understanding of the terms used in fluid mechanics, namely: viscosity, dynamic viscosity, kinematic viscosity, Reynold's Number, drag and drag forces and also flow separation. In addition you will learn about the principle of operation of flow measuring systems — venturi meter, orifice plate, rotameter, anemometer, pitot static tube as well as the turbine meter. You will also find out how to identify appropriate flow measurement systems for defined applications.

You will be provided with the opportunity to develop the necessary knowledge and skills to solve problems involving incompressible flow in pipe systems. From this you will learn how to classify flow types by correct calculation and application of Reynold's Number; correctly use the Pipe Friction Chart to relate Reynold's Number, relative roughness and friction factor as well as correctly determine energy losses for given situations and correctly determine flow rates in pipe systems.

You will also be provided with the opportunity to give a clear and concise explanation of conduction, convection and radiation; correctly evaluate heat transfer rates through composite plane walls and insulated pipe walls using Fourier's Law of Heat Conduction; correctly evaluate heat exchange rates between fluids and other parameters for parallel and contra-flow exchangers.

It is good to gain sound theoretical knowledge and understanding but it is also important that you are able to set your theoretical knowledge within a practical Mechanical context. Thus, it is likely during the Unit that you will be provided with opportunities to relate theory to practice by doing practical experiments eg using a fluid flow test rig to determine the coefficient of discharge for a venturi meter and/or an orifice plate as well as using a concentric tube heat exchanger rig to determine the heat flow rate and other parameters for parallel and contra-flow exchangers.

The formal assessment for this Unit will consist of a written test lasting no more than 2 hours and 30 minutes conducted under controlled, supervised conditions. The assessments will be conducted under closed-book conditions in which you will not be allowed to take notes, textbooks etc into the assessment. However, you will be allowed to use a scientific calculator. You will also be supplied with a formula sheet.