

SQA Advanced Unit specification

General information for centres

Unit title: Strength of Materials: Advanced

Unit code: HT81 48

Unit purpose: This Unit is designed to enable candidates to develop their knowledge, understanding and skills in solving problems involving complex beams, cantilevers, and thin, thick and combined cylinders. It should also provide candidates with an opportunity to develop their analytical and problem-solving skills.

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

- 1 solve complex beam and cantilever problems
- 2 solve problems relating to thin, thick and combined cylinder theory

Credit points and level: 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: Candidates should have a knowledge and understanding of static equilibrium, shear force and bending moment diagrams and integration. This may be evidenced by the possession of the following SQA Advanced Units: Engineering Principles and Statics and Strength of Materials.

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.

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|-------------------|--------------|
| Using Numbers | SCQF level 6 |
| Critical Thinking | 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.

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Assessment: The assessment for Outcome 1 in this Unit should consist of a written assessment paper. Candidates should undertake this paper at a single assessment event lasting no more than one hour conducted under controlled, supervised conditions. Outcome 2 should be assessed by an assignment in which candidates are asked to complete a series of tasks covering the assessment criteria. Candidates should complete the assignment in 8 hours and should have access to any relevant course notes, textbooks and reference material.

SQA Advanced Unit specification: statement of standards

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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, the whole of 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 and different items should be sampled on each assessment occasion.

Outcome 1

Solve complex beam and cantilever problems

Knowledge and/or skills

- ◆ reaction forces for complex loading
- ◆ deflection using standard formulae
- ◆ slope using standard formulae
- ◆ MacCaulay's method of determining deflection and slope for complex loading on simply supported beams
- ◆ MacCaulay's method of determining deflection and slope for complex loading on cantilevers

Evidence requirements

Evidence for the knowledge and/or skills items in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **four out of five** 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 five 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 satisfactory where evidence provided is sufficient to meet the requirements for each item by showing that the candidate is able to:

- ◆ calculate the reactions of a complexly loaded simply supported beam or cantilever
- ◆ select the correct standard formula relating to deflection
- ◆ calculate a deflection using a standard formula
- ◆ select the correct standard formula relating to slope
- ◆ calculate a slope using a standard formula
- ◆ calculate deflection using MacCaulay's theory for a beam
- ◆ calculate deflection using MacCaulay's theory for a cantilever

The assessment for this Outcome should consist of a written assessment paper undertaken by candidates at a single assessment event lasting one hour. The paper should be conducted under controlled, supervised conditions. Candidates should not be allowed to bring any textbooks, handouts

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or notes to the assessment. However, they are permitted to use a scientific calculator but not a programmable calculator during the assessment. Candidates should also be supplied with a list of standard formulae for the assessment.

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 problems relating to thin, thick and combined cylinder theory

Knowledge and/or skills

- ◆ thin cylinder conditions
- ◆ thick cylinder conditions
- ◆ hoop stress in a cylinder
- ◆ axial stress in a cylinder
- ◆ radial stress in a cylinder
- ◆ stress — strain relationship
- ◆ Mohr's circle of stress
- ◆ Mohr's circle of strain
- ◆ strain gauge configuration
- ◆ theories of failure relating to factors of safety (eg Tresca)

Evidence requirements

Evidence for the knowledge and/or skills in this Outcome will be provided on a sample basis. The evidence may be presented in response to specific questions. Each candidate will need to demonstrate that she/he can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome **seven out of ten** 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 seven out of ten knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all seven items.

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

- ◆ state whether a cylinder is a thin or thick cylinder
- ◆ calculate wall thickness, internal radius, and stresses in a thin cylinder
- ◆ calculate hoop, axial and radial stress in a thick cylinder
- ◆ calculate hoop, axial and radial stress in a combined cylinder situation
- ◆ determine hoop, axial and radial stress in a combined cylinder situation using a graphical solution
- ◆ draw Mohr's circle of stress
- ◆ determine hoop and axial stress values using Mohr's circle of stress either practically or from given stress conditions
- ◆ draw Mohr's circle of strain
- ◆ determine hoop and axial strain values using Mohr's circle of strain either practically or from given stress conditions
- ◆ apply a theory of failure to determine safety

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Assessment should be conducted as a series of assignments and as such candidates should be allowed to use textbooks, handouts, or notes during the assignments. The exact form each assignment takes is left to a centre to decide. The assignment series could be, for example, a series of laboratory exercises, or a series of computer simulations or a combination of the two. Likewise the exact number of assignments is left to the discretion of the centre albeit that seven out of the ten knowledge and/or skills items in the knowledge and skills list for Outcome 2 must be covered. Regardless of the number of assignments candidates undertake for each assignment they must provide a written report that includes the following:

- 1 purpose of assignment
- 2 description of how the assignment was undertaken
- 3 results
- 4 analysis of results (including sources of error)
- 5 conclusions

Candidates can complete assignment reports in their own time. Centres should make every reasonable effort to ensure the assignment solution is the candidate's own work. Where copying or plagiarism is suspected candidates may be interviewed to check their knowledge and understanding of the subject matter. A checklist should be used to record oral evidence of the candidate's knowledge and understanding.

Assessment guidelines

None.

Administrative information

| | |
|--------------------------------------|---------------------------------|
| Unit code: | HT81 48 |
| Unit title: | Strength of Materials: Advanced |
| Superclass category: | XH |
| Original date of publication: | August 2017 |
| Version: | 01 |

History of changes

| Version | Description of change | Date |
|---------|-----------------------|------|
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SQA Advanced Unit specification: support notes

Unit title: Strength of Materials: Advanced

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 knowledge, understanding and skills in the following areas:

- 1 the solution of both deflection and slope using standard equations and MacCaulay's theorem
- 2 the use of basic material strength concepts in analysing complex stress and strain on a variety of cylinder types

In designing the Unit, the writers have identified the range of topics they would expect to be covered by lecturers. The writers have also given recommendations 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 a centre to use this list of topics it is strongly recommended that it does so to ensure continuity of teaching and learning across the Strength of Materials: Advanced Unit.

The list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the knowledge/skills section of this document and the assessment exemplar pack so that they can get a clear indication of the standard of achievement expected of candidates in this Unit.

1 Solve complex beam and cantilever problems (15 hours)

- ◆ effects of changing the shape of a beam cross-section and/or the material from which the beam has been manufactured
- ◆ standard formulae are acceptable and useful when used in isolation but may cause confusion when used in combination

2 Solve problems relating to thin, thick and combined cylinder theory (25 hours)

- ◆ hoop and axial stresses occurring in thin cylinders under pressure
- ◆ hoop, radial and axial stresses in both thick and compound cylinders
- ◆ stress — strain relationship by calculation and/or graphical means

Areas of practical work for both Outcomes may include, but are not limited to, those covered with thin cylinder laboratory experiments, strain gauge analysis of combined thick cylinders, Mohr's circle construction, CAD.

Guidance on the delivery and assessment of this Unit

Practical demonstration and realistic problem solving should support the application of Mohr's circle theory and thin, thick and combined cylinder principles and concepts. Computer software should be made available where appropriate and candidates should be encouraged to take a logical problem solving approach throughout.

It should be noted that this Unit could be delivered on a free-standing basis.

The Unit has been written such that there is sufficient time built in for candidates to practise what they have learnt through appropriate formative assessment exercises. Additionally, the Unit has been designed to incorporate time for experimental work and computer simulations so that candidates have an opportunity to confirm theories in practice. Whilst, it is recognised that computer simulation can be a valuable tool in confirming mechanical theories, it is nevertheless felt important that candidates do practical laboratory work so that they can gain experience in using test equipment and analysing the results of experiments.

As this Unit provides advanced strength of materials concepts it is recommended that the Unit is delivered towards the end of the SQA Advanced Diploma in Mechanical Engineering.

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.

Details on approaches to assessment are given under Evidence Requirements and Assessment guidelines under each Outcome in the SQA Advanced Unit specification: statement of standards section. It is recommended that these sections are read carefully before proceeding with the assessment of candidates.

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.

| | |
|-------------------|--------------|
| Using Numbers | SCQF level 6 |
| Critical Thinking | SCQF level 6 |

Open learning

This Unit could be delivered by distance learning, which may incorporate some degree of on-line 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 paper, which is required to be sat 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: Strength of Materials: Advanced

This Unit has been designed to allow you to develop knowledge, understanding and skills in advanced strength of materials concepts and theorems that underpin so much of advanced studies in Mechanical Engineering.

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 the opportunity to relate theory to practice by doing practical experiments and computer simulations on mechanical problems.

By the end of the Unit you will be expected to solve strength of material problems using the concepts and theorems you have learned. You will also be expected to relate calculated values to engineering design problems.

The formal assessment for this Unit will consist of a single assessment paper lasting no more than one hour and a series of assignment exercises.

The assessment paper will be conducted under supervised, closed book conditions and 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 sit this assessment paper at the end of the first Outcome

You should ask your lecturer how many and exactly what form each of the assignment exercises take. For each assignment you will be expected to submit a written report.