SQA Advanced Unit Specification

General information

Unit title: Marine Engineering: Strength of Materials (SCQF level 8)

Unit code: HW5N 48

Superclass: XQ

Publication date: November 2017

Source: Scottish Qualifications Authority

Version: 01

Unit purpose

This unit is designed to enable learners to further develop knowledge and understanding of materials subjected to varying conditions and to appreciate how this knowledge and understanding is relevant in a mechanical and marine engineering environment. This unit is designed for use in the training of Merchant Navy Engineering Officers.

Outcomes

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

1 Explain terminology as used in strength of materials and solve related problems.
2 Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams.
3 Explain and solve problems on the theory of torsion involving circular sections and close coiled helical springs.
4 Explain and solve problems on elastic strain energy and stresses on oblique planes of stressed material.

Credit points and level

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

Recommended entry to the unit

Entry onto this module is at the discretion of the awarding centre but it is recommended that the learner has completed the SCQF level 7 (HW5J 47) *Marine Engineering: Mechanical Principles* unit.

Core Skills

Achievement of this unit gives automatic certification of the following Core Skills component:

Complete Core Skill	None
Core Skill component	Using Number at SCQF level 6

There are also opportunities to develop aspects of Core Skills which are highlighted in the support notes of this unit specification.

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.

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**.

SQA Advanced unit specification: Statement of standards

Unit title: Marine Engineering: Strength of Materials (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.

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. Learners 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

Explain terminology as used in strength of materials and solve related problems.

Knowledge and/or Skills

- Direct stress and strain, shear stress and strain, modulus of elasticity “E”, factor of safety and proof stress
- Stresses in simple and stepped bars subjected to linear thermal strain
- Temperature change on composite members
- Differential thermal expansion and contraction
- Compound bars subjected to both direct loading and temperature change

Outcome 2

Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams.

Knowledge and/or Skills

- Support reactions for beams subjected to point or uniformly distributed loads
- Shear force and bending moment diagrams for simply supported and cantilever beams
- Point of contraflexure
- Uniformly varying distributed loading
- Bending Equation

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

- Section modulus “Z”

Outcome 3

Explain and solve problems on the theory of torsion involving circular sections and close coiled helical springs.

Knowledge and/or Skills

- Assumptions for deriving the torsion theory
- Torsion equation

$$\frac{T}{J} = \frac{G\theta}{L} = \frac{\tau}{R}$$

- Power transmitted by a rotating shaft
- Torsional stiffness
- Relationship between torque transmitted by a shaft and shear force induced in the coupling bolts
- Formula for stress and deflection of a helical spring subjected to an axial load
- Design of helical springs

Outcome 4

Explain and solve problems on elastic strain energy and stresses on oblique planes of stressed material.

Knowledge and/or Skills

- Strain energy and resilience
- Expression for elastic strain energy

$$U = \frac{\sigma^2 AL}{2E}$$

- Impact Loading
- Conversion of PE and KE into strain energy to determine maximum instantaneous stress deformation
- Expression for strain energy of a helical spring

Evidence Requirements for this unit

Outcomes 1–4 should be combined using holistic assessment This combined assessment should last for 2.5 hours.

Assessment should be conducted under closed-book, controlled and supervised conditions. Learners are permitted to use a scientific calculator but not a programmable calculator.

Outcome 1

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **three from five** Knowledge and/or Skills items should be provided in any assessment of this Outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of three out of five Knowledge and/or Skills items is required each time the Outcome is assessed.

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

- Explain the following terms, with units as appropriate: shear stress and strain, modulus of elasticity "E", proof stress, factor of safety.
- Solve a problem involving compound members subjected to direct axial loading.
- Solve a problem to determine stresses set up in either a simple or stepped bar subjected to linear thermal strain.
- Solve a problem involving differential expansion or contraction.
- Solve a problem involving compound members subjected to both direct loading and temperature change.

Outcome 2

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **four from six** Knowledge and/or Skills items should be provided in any assessment of this Outcome.

In order to ensure that the learners 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. Learners must achieve a satisfactory pass mark via their responses to the sampled items.

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

- Solve a problem to determine the support reactions for beams subjected to point or uniformly distributed loads.
- Sketch shear force and bending moment diagrams for simply supported and cantilever beams.
- Solve a problem to determine the position of any point of contraflexure on a loaded beam.
- Solve a beam problem that involves resolving a uniformly varying distributed load.
- Explain the terms used in the bending equation.
- Explain the term section modulus 'Z'.

Outcome 3

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **four from seven** Knowledge and/or Skills items should be provided in any assessment of this Outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of four out of seven Knowledge and/or Skills items is required each time the Outcome is assessed.

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

- Explain the assumptions made for deriving the torsion theory.
- Explain the terms used in the torsion equation.
- Solve a problem involving power transmitted by a rotating shaft.
- Explain the term torsional stiffness.
- Solve a problem involving torque transmitted by a shaft and shear force induced in the coupling bolts.
- Explain the formula for stress and deflection of a helical spring subjected to an axial load.
- Solve a problem on the design of coiled helical springs.

Outcome 4

Evidence for the knowledge and or skills in this Outcome will be provided on a sample basis. Written and/or oral evidence based on a sample of **three from five** Knowledge and/or Skills items should be provided in any assessment of this Outcome.

In order to ensure that the learners will not be able to foresee what items they will be questioned on, a different sample of three out of five Knowledge and/or Skills items is required each time the Outcome is assessed.

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

- Explain strain energy and resilience.
- Solve a problem using the elastic strain energy expression for members subjected to gradually applied loading.
- Explain impact loading.
- Solve a problem that involves conversion of PE and/or KE into strain energy to determine the maximum instantaneous stress and deformation.
- Solve a problem involving strain energy of springs.

SQA Advanced unit Support Notes

Unit title: Marine Engineering: Strength of Materials (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 unit allows the learner to revise and build on knowledge and understanding gained from the *Marine Engineering: Mechanical Principles SQCF level 7 unit.*

This unit has been written in order to allow learners to develop knowledge, understanding and skills in the following areas:

1 Explain terminology as used in strength of materials and solve related problems.
2 Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams.
3 Explain and solve problems on the theory of torsion involving circular sections and close coiled helical springs.
4 Explain and solve problems on elastic strain energy and stresses on oblique planes of stressed material.

This unit closely follows the Strength of Materials section of the revised MCA Chief Engineer Reg III/2 Mechanics syllabus and as such should be used in conjunction with these guidance notes to bench mark the required standards.

In designing this unit the unit writers have identified the range of topics they would anticipate that lecturers might cover. There are recommendations as to how much time should be spent on each Outcome.

The list of topics is given below. Lecturers are advised to study this list of topics in conjunction with the Statement of Standards section of this specification so that they can get a clear indication of the standard of achievement expected of learners in this unit.

In each section where possible, it is advisable that the questions set should relate to terminology on board ship.

1 Explain terminology as used in strength of materials and solve related problems. **(10 hours)**

Topics covered but not limited to will include: stress, strain, ultimate tensile strength, shear strength, working stress and factor of safety, elasticity, modulus of elasticity ‘E’, load extension graphs, tensile testing to destruction, stress /strain graphs, stresses in compound bars, equivalent modulus of elasticity of compound bars, stress due to restricted expansion, stress due to thermal expansion of compound bars.

2 Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. **(10 hours)**

Topics covered but not limited to will include: simply supported beams, cantilever beams, concentrated loads, uniformly distributed loads, reaction forces, conditions of equilibrium, shear force and bending moment diagrams, determining point of contraflexture on a loaded beam, slope and deflection of loaded beams, bending moment, 2nd moment of area about the neutral axis, distance from neutral axis to outer fibres, modulus of elasticity of the material, radius of curvature, combined bending and direct stress, eccentric and inclined loading.

3 Explain and solve problems on the theory of torsion involving circular sections and close coiled helical springs. **(10 hours)**

Topics covered but not limited to twisting moment, polar 2nd moment of area, polar 2nd moment of area, shear stress at outer fibres, radius to outer fibres, modulus of rigidity, angle of twist, length of shaft under twist, relationship between torque and stress, experiment to determine the modulus of rigidity, torsional resilience, relationship between torque and power, maximum and mean torque, transmission of power through coupling bolts, deflection of close coil helical springs, spring stiffness.

4 Explain and solve problems on elastic strain energy and stresses on oblique planes of stressed material. **(10 hours)**

Topics covered but not limited to will include, deflection of close coil helical springs, spring stiffness, elastic strain energy or resilience, strain energy graph, impact or shock loading, PE and/or KE into strain energy, instantaneous stress and deformation, stresses on oblique planes, complimentary shear stress, hoop and longitudinal stress in a thin cylinder subjected to internal pressure.

Guidance on approaches to delivery of this unit

Practical demonstration and realistic problem solving should support the application of advanced strength of material principles and concepts. Computer software could be made available where appropriate and learners may be encouraged to take a logical problem solving approach throughout.

The unit has been written such that there is sufficient time built in for learners to practise what they have learnt through appropriate formative assessment exercises. Additionally, the unit has been designed to incorporate time for some experimental work and computer simulations (these will not be formally assessed in the unit) so that learners 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 learners do some practical laboratory work so that they can gain experience in using test equipment and analysing the results of experiments.

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.

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.

The assessment for all four Outcomes of this unit could be combined together into one assessment paper. This paper could be taken by learners at one single assessment event that should last 2.5 hours. Assessment should be conducted under closed-book, controlled and supervised conditions. Learners are permitted to use a scientific calculator but not a programmable calculator. Where learners are reassessed an alternative sample should be chosen.

Outcome 1

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

The assessment of this Outcome could be combined with that for Outcomes 2, 3 and 4 to form a single assessment paper, details of which are given under Outcomes 2, 3 and 4. This combined assessment could last for 2.5 hours.

Outcome 2

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

The assessment of this Outcome could be combined with that for Outcomes 1, 3 and 4 to form a single assessment paper, details of which are given under Outcomes 1, 3 and 4. This combined assessment could last for 2.5 hours.

Outcome 3

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

The assessment of this Outcome could be combined with that for Outcomes 1, 2 and 4 to form a single assessment paper, details of which are given under Outcomes 1, 2 and 4. This combined assessment could last for 2.5 hours.

Outcome 4

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

The assessment of this Outcome could be combined with that for Outcomes 1, 2 and 3 to form a single assessment paper, details of which are given under Outcomes 1, 2 and 3. This combined assessment could last for 2.5 hours. Assessment should take place under invigilated conditions and follow the assessment centres examination policy.

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

The assessment of this unit may also contribute towards the component Written Communication (writing) of the Core Skill Communication at SCQF level 6. Learners may have to structure their responses, which could include varying structure and presenting essential information in a logical manner. The specific Core Skill elements that learners may have to complete are 'Present all essential ideas/information and supporting detail in a logical and effective order' and 'Vary sentence structure, paragraphing, and vocabulary to suit the purpose and target audience'.

There is also the opportunity for the learner to develop the components Critical Thinking and Reviewing and Evaluating of the Core Skill Problem Solving at SCQF level 6 while completing their assessment. The learner will require to develop and justify their approach to a problem and draw conclusions with clear recommendations. The specific Core Skill elements that the learner may have to complete are 'Develop and justify an approach to deal with the situation or issue', 'Draw conclusions and make recommendations'.

This unit has the Using Number component of Numeracy embedded in it. This means that when learners achieve the unit, their Core Skills profile will also be updated to show they have achieved Using Number at SCQF level 6.

History of changes to unit

Version	Description of change	Date

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.

General information for learners

Unit title: Marine Engineering: Strength of Materials (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 has been designed to allow you to further develop your knowledge and understanding in the concepts and theorems of strength of materials at an advanced level in mechanical and marine engineering.

This unit closely follows the Strength of Materials section of the MCA syllabus for the First Class Engineer Applied Mechanics examination.

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 and marine engineering context. Thus, it could be possible during the unit that you may be provided with the opportunity to relate theory to practice by doing practical experiments and computer simulations on strength of materials related problems.

You will study four Outcomes within this unit and by the end of the unit you will be expected to explain related terminology and solve strength of material problems using the concepts and theorems you have learned. The four Outcomes you will study are:

1 Explain terminology as used in strength of materials and solve related problems; solve problems on the effect of temperature change on the physical dimensions of components.
2 Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams; explain and solve problems relating to the theory of bending.
3 Explain and solve problems relating to the stability of axially loaded columns; explain and solve problems on the theory of torsion for members of circular sections.
4 Explain and solve problems on torsion with regards to close coiled helical springs; explain and solve problems on elastic strain energy; explain and solve problems on stresses on oblique planes of stressed material.

The formal assessment for this unit could consist of a single assessment paper lasting two and half-hours. The assessment 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 may sit this assessment paper at the end of the unit.

There are opportunities for you to develop the component Core Skills of Numeracy, Communication and Problem Solving at SCQF level 6 in the assessment approaches used in this unit.

This unit has the Using Number component of Numeracy embedded in it. This means that when you achieve the unit, your Core Skills profile will also be updated to show you have achieved Using Number at SCQF level 6.