Higher National Unit specification

General information for centres

Unit title: Marine Engineering: Statics and Strength of Materials

Unit code: F90R 34

Unit purpose: This Unit is designed to enable candidates to develop knowledge and understanding of static mechanical systems and how these principles are relevant in a Marine Engineering Environment. This Unit is designed for use in the training of Merchant Navy Engineering Officers.

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

1 Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.
2 Explain and solve problems relating to compressive/tensile loading and bending of sections.
3 Explain and solve problems relating to sections under shear and shafts under torsion.
4 Derive and solve problems related to manometers and fluids at rest.

Credit points and level: 1 HN credit(s) at SCQF level 7: (8 SCQF credit points at SCQF level 7*)

*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 Access 1 to Doctorates.

Recommended prior knowledge and skills: Candidates should have knowledge of mathematics and/or physics at SCQF level 6 or a National Certificate in Engineering at SCQF level 6.

Core Skills: There are opportunities to develop the Core Skill(s) of *Numeracy*, *Communication* and *Problem Solving* at SCQF level 6 in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

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: The assessment for all four Outcomes of this Unit could be combined together into one assessment paper. This paper could be taken by candidates at one single assessment event that should last two hours. Assessment should be conducted under closed-book, controlled and supervised conditions. Candidates are permitted to use a scientific calculator but not a programmable calculator.

Higher National Unit specification: statement of standards

Unit title: Marine Engineering: Statics and Strength of Materials

Unit code: F90R 34

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

Explain and solve problems involving forces and moments concerned with static equilibrium and simple framed structures.

Knowledge and/or Skills

- Vector and scalar quantities.
- Equilibrium, resultant and equilibrant.
- Moment of a force.
- Principle of moments.
- Conditions of equilibrium for non-concurrent coplanar force systems.
- Concurrency of three non parallel coplanar forces for equilibrium.
- Resolution of forces.
- Stable, unstable and neutral equilibrium.
- Pin joints.
- Bows Notation.
- Reaction forces.
- Strut and tie.
- Magnitude and nature of a force.

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 he/she can answer questions correctly based on a sample of the items shown above. In any assessment of this Outcome eight from thirteen 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 eight out of thirteen knowledge and/or skills items is required each time the Outcome is assessed. Candidates must provide a satisfactory response to all eight 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:

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

Evidence Requirements

♦ Explain the terms vector and scalar quantities.
♦ Explain the terms equilibrium, resultant and equilibrant and solve a problem using at least onethe aforementioned terms.
♦ Explain what the moment of a force is.
♦ Using the principles of moments, solve a problem to determine unknown forces or distances.
♦ Solve a problem to determine unknown force or forces in a non coplanar force system.
♦ Solve a problem involving concurrency of three non parallel coplanar forces.
♦ Solve a problem to resolve a force system into horizontal and vertical forces.
♦ Explain the terms: stable, unstable and neutral equilibrium.
♦ Explain the term pin joint as used in frame structures.
♦ Use Bow's Notation to solve a framework problem involving internal and external forces.
♦ Solve a problem to determine the reaction force.
♦ Explain the terms strut and tie and in what context they are used.
♦ Explain the terms for a force: magnitude and nature.

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

Assessment Guidelines

Questions used to elicit candidate 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 Outcome 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 two and a half hours.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

Outcome 2

Explain and solve problems relating to compressive/tensile loading and bending of sections.

Knowledge and/or Skills

- Stress.
- Direct stress and shear stress.
- Strain.
- Elasticity and modulus of elasticity.
- Load / extension graphs.
- Ultimate tensile stress and breaking stress.
- Stress in thin cylinders and thin rotating rims
- Ductility, hardness, malleability and plasticity.
- Proof stress.
- Factor of safety.
- Cantilever and simply supported beams.
- Bending moment equation.

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 six from twelve 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 six out of twelve 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:

- Explain the term stress as related to force per Unit of cross sectional area and solve a problem which involves stress.
- Explain the terms direct stress and shear stress and solve a problem relating to direct stress and shear stress.
- Explain the term strain and solve a problem relating to strain.
- Explain the terms elasticity and modulus of elasticity 'E' and solve a problem involving elasticity and the modulus of elasticity.
- Solve a problem that incorporates a load extension graph for a particular material.
- On a load extension graph for a particular material identify ultimate tensile stress and breaking stress.
- Solve a problem that involves stress in thin cylinders or stress in rotating rims.
- Explain the terms ductility, hardness, malleability and plasticity.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

♦ Explain the term proof stress and state how it is obtained from a stress/strain graph.
♦ Solve a problem incorporating factor of safety.
♦ Solve a problem for either a cantilever or simply supported beam with point loading and/or uniformly distributed load.
♦ Solve a problem for a simply supported beam made from either a solid square, solid rectangular, solid round or an annular cross sectional area. The problem to include; (a) shear force and bending moment diagrams, (b) The determination of the maximum bending moment and the point of contraflexture, (c) solving an unknown value using the bending moment equation.

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

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

Assessment Guidelines

Questions used to elicit candidate 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 Outcome 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 two and a half hours.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

Outcome 3

Explain and solve problems relating to sections under shear and shafts under torsion.

Knowledge and/or Skills

♦ Torsion equation.
♦ Polar axis.
♦ Polar second moment of area.
♦ Maximum and mean torque.
♦ Shear force.

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 three from 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 three out of five 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:

♦ Explain each of the terms in the torsional equation: $\dfrac{T}{J} = \dfrac{\sigma}{y} = \dfrac{G\theta}{l}$ and solve a problem

   using the torsional equation.
♦ Explain the term polar axis.
♦ State the polar second moment of area values for solid and hollow circular sections.
♦ Explain the difference between maximum and mean torque.
♦ Solve a problem with regards to shear force in shaft coupling bolts given the transmitted torque.

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

Assessment Guidelines

Questions used to elicit candidate 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 Outcome 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 two and a half hours.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

Outcome 4

Derive and solve problems related to manometers and fluids at rest.

Knowledge and/or Skills

- Pressure.
- Manometers.
- Pressure diagram.
- Resultant force on a vertical immersed surface.
- Force diagram.
- Centre of Pressure.

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 four from 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:

- Derive the expression for pressure pgh and solve a problem that includes the terms pgh
- Describe the principle of operation of either a U tube manometer, inclined manometer or a mercury barometer. Solve a problem for one of the aforementioned measuring devices.
- Sketch the pressure distribution diagram for an immersed vertical surface with one edge in the free surface.
- Derive the expression for the resultant force on a vertical immersed surface.
- Sketch the force diagram for a rectangular surface vertically immersed with one edge in the free surface.
- Also explain the term centre of pressure and how to identify its position
- Solve a problem on rectangular and triangular surfaces vertically immersed in single liquids with one edge in the free surface to include centre of pressure and wetted on each side.

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

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

Assessment Guidelines

Questions used to elicit candidate 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 Outcome 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 two and a half hours.

Administrative Information

Unit code: F90R 34

Unit title: Marine Engineering: Statics and Strength of Materials

Superclass category: XQ

Original date of publication: August 2010

Version: 01

History of changes:

Version	Description of change	Date

Source: SQA

Higher National Unit specification: support notes

Unit title: Marine Engineering: Statics and Strength of Materials

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   Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.
2   Explain and solve problems relating to compressive/tensile loading and bending of sections.
3   Explain and solve problems relating to sections under shear and shafts under torsion.
4   Derive and solve problems related to manometers and fluids at rest.

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 candidates in this Unit.

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

1   Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures (15 hours)

For example, forces in slings when lifting named engine room machinery, forces imposed on ships derricks and cranes when lifting loads, forces generated in a two stroke engine mechanism consisting of piston, piston rod, crosshead /guide, connecting rod and crank. Problems in relation to crane frameworks.

2   Explain and solve problems relating to compressive/tensile loading and bending of sections (12.5 hours)

For example, stress and strain imposed on cylinder head studs, rivets and couplings, the selection of materials with regards to marine applications, the introduction of Factor of Safety with regards to machinery component materials. Shear forces, bending moments, maximum bending moment and points of contraflexure of different types of cross sections of beams and frames as used in ship construction.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Statics and Strength of Materials

3 Explain and solve problems relating to sections under shear and shafts under torsion (5.5 hours)

For example torque and shear force applicable to electric motor/pump drives, crankshafts and propeller shafts.

4 Derive and solve problems related to manometers and fluids at rest (7 hours)

For example engine room pressure gauges and manometers. Centres of pressure and pressure heads exerted on ballast, fresh water, and fuel oil and lubricating oil tanks

Guidance on the delivery and assessment of this Unit

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

It should be noted that this Unit can be delivered on a free standing basis or combined with the Engineering Principles Unit for teaching and learning. Such flexibility may be important to a centre where, for example, both Units are included in a number of HN Engineering courses.

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 some experimental work and computer simulations (these will not be formally assessed in the Unit) 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 some practical laboratory work so that they can gain experience in using test equipment and analysing the results of experiments.

As this Unit provides core static and strength of materials principles which underpin much of the studies done in other areas of the HNC and HND Marine Engineering awards it is recommended that the Unit be delivered towards the start of these awards.

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 Higher National Unit specification: statement of standards section. It is recommended that these sections can be read carefully before proceeding with the assessment of candidates.

Unit title: Marine Engineering: Statics and Strength of Materials

Opportunities for developing Core Skills

In all Outcomes each of the assessments requires the candidate to be able to solve problems involving statics. This will give the candidate the opportunity to develop the component 'Using Number' of the Core Skill *Numeracy* at SCQF level 6. The specific Core Skill elements that the candidate will have to complete are 'Work confidently to solve a numerical problem' and 'Carry out a number of sustained, complex calculations'.

The assessment of this Unit may also contribute towards the component 'Written Communication (writing)' of the Core Skill *Communication* at SCQF level 6. Candidates 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 candidates 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 candidate 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 candidate will be required to develop and justify their approach to a problem and draw conclusions with clear recommendations. The specific Core Skill elements that the candidate may have to complete are 'Develop and justify an approach to deal with the situation or issue', 'Draw conclusions and make recommendations'.

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, 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).

Disabled candidates and/or those with additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments, or considering whether any reasonable adjustments may be required. Further advice can be found on our website **www.sqa.org.uk/assessmentarrangements**

General information for candidates

Unit title: Marine Engineering: Statics and Strength of Materials

This Unit has been designed to allow you to develop knowledge, understanding and skills in static and strength of materials concepts and theorems that underpin so much of more advanced studies in Mechanical / Marine Engineering. If you have studied these subjects before the early parts of this Unit it will provide you with an opportunity to revise the concepts and theorems you have learnt in previous courses.

The Unit will also provide you with an opportunity to study the ways in which a variety of methods such as nodal analysis, vector analysis and method of section can lead to the same results and that material properties are extremely important within design.

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/Marine 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.

You will study 4 Outcomes within this Unit and by the end of the Unit you will be expected to solve static and strength of material problems using the concepts and theorems you have learned. You will also be expected to sketch vector, shear force and bending moment diagrams.

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.

Candidates studying towards an HNC or HND in Marine Engineering will also have to answer questions on this subject as part of the Graded Unit.