Higher National Unit specification: general information

Unit title: Marine Engineering: Advanced Applied Mechanics

Unit code: H0EA 35

Superclass: XQ

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Version: 01

Unit purpose

This Unit is designed to enable candidates to further develop knowledge and understanding of applied mechanics 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.

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

1. Solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems.
2. Solve problems involving combinations of linear, angular and relative motion.
3. Solve problems involving simple harmonic motion.
4. Solve problems involving fluid mechanics.

Recommended prior knowledge and skills

It is recommended that candidates should have undertaken the following Units prior to this one — F5K8 12 *Engineering Statics*, F5K7 12 *Engineering Dynamics*, F90R 34 *Marine Engineering: Statics and Strength of Materials*, F90V 34 *Marine Engineering: Dynamics and Machines*.

Credit points and level

1 Higher National Unit 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 Access 1 to Doctorates.*

General information (cont)

Core Skills

There are opportunities to develop the Core Skills 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.

Higher National Unit specification: statement of standards

Unit title: Marine Engineering: Advanced Applied Mechanics

Unit code: H0EA 35

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 equilibrium problems related to bodies subjected to coplanar and non coplanar force systems.

Knowledge and/or Skills

(a) Cranks and connecting rods.
(b) Non coplanar force system.
(c) Rapson's slide.
(d) Bodies on an inclined plane.
(e) Bodies hauled or lowered on an inclined plane.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

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 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:

- solve a problem involving cranks and connecting rods
- explain the terms, co-planar and non co-planar force systems *and* solve a problem to determine the force required to bring a non coplanar force system containing up to four forces into equilibrium
- explain the term Rapson's slide *and* solve a problem relating to the force acting on a Rapson's slide
- solve a problem for a body on an inclined plane to determine the force required to hold, raise or lower the body taking account of friction where the force applied may not be parallel with the plane
- solve a problem where a body is hauled up or lowered down by a winch on an inclined plane

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

Outcome 2

Solve problems involving combinations of linear, angular and relative motion.

Knowledge and/or Skills

(a) Single and double projectiles.
(b) Velocity diagrams of simple mechanisms.
(c) Elastic and non elastic collisions
(d) Stepped rope and flywheel systems.
(e) Angular momentum and impulse.
(f) Clutches.
(g) Balancing of rotating masses.
(h) Governors.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

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 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 four out of eight 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:

- solve a problem on an individual or a double projectile
- solve a problem to determine the relative velocities of the connected bodies in simple mechanisms by drawing a velocity diagram
- solve a problem involving momentum, impulse, energy and work done on elastic and non elastic collisions
- solve a problem involving masses connected to separate ropes on stepped flywheels which include the effects of inertia and friction
- solve a problem involving angular momentum and impulse
- explain by means of simple sketches a flat plate clutch, a conical clutch and a centrifugal friction clutch *and* solve a problem to determine the power transmitted to either, a flat plate clutch, a conical clutch, or a centrifugal friction clutch
- solve a problem to determine the forces acting on bearings supporting out of balance shafts
- explain the function and operation of a governor *and* solve a problem relating to either, a Watt governor, a Porter governor, or a Hartnell governor

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

Outcome 3

Solve problems involving simple harmonic motion.

Knowledge and/or Skills

(a) Spring and mass systems.
(b) Pendulums.
(c) Simply supported mass-less beam with centrally positioned load.
(d) Crank and connecting rods.
(e) Cams and followers.

Evidence Requirements

Candidates will need to provide evidence to demonstrate their Knowledge and/or Skills by showing that they can:

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:

- Solve a simple harmonic problem involving a spring and mass system.
- Solve a simple harmonic problem involving a pendulum.
- Solve a simple harmonic problem involving a simply supported mass-less beam with a centrally positioned load.
- Explain the terms crank and connecting rod *and* solve a simple harmonic problem involving a crank and connecting rod.
- *Explain the terms cam and follower and* solve a simple harmonic problem involving a cam and follower.

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

Outcome 4

Solve problems involving fluid mechanics.

Knowledge and/or Skills

(a) Parallel and tapering pipe work systems.
(b) Venturi meters.
(c) Forces on pipe bends.
(d) Hydraulic jets.
(e) Centrifugal pumps.

Higher National Unit specification: statement of standards (cont)

Unit title: Marine Engineering: Advanced Applied Mechanics

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 the term venture meter *and* solve a problem for either a parallel or tapering pipe which includes a venturi meter. The pipe work can be either, horizontal, vertical or inclined. The effect of friction is to be included in the problem.
- Explain and solve a problem which calculates the resultant force on a pipe bend due to change of momentum.
- Explain and solve a problem that calculates the reaction force of a hydraulic jet.
- Explain and solve a problem related to the impact of a jet on a flat plate which is positioned either perpendicularly or at an incline to the jet.
- Explain the principles of operation of a centrifugal pump *and* solve a problem relating to a pump impeller for a single stage centrifugal pump which includes, speed, blade angles, capacity, efficiency and power.

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: support notes

Unit title: Marine Engineering: Advanced Applied 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 knowledge, understanding and skills in the following areas:

1 Solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems.
2 Solve problems involving combinations of linear, angular and relative motion.
3 Solve problems involving simple harmonic motion.
4 Solve problems involving fluid mechanics.

This Unit closely follows aspects of the Statics, Dynamics and Hydraulics sections of the MCA syllabus for the First Class Engineer Applied Mechanics 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 candidates in this Unit.

In many instances the Unit allows the candidate to revise and build on knowledge and understanding gained from the previous Units, F5K8 12 *Engineering Statics*, F5K7 12 *Engineering Dynamics*, F90R 34 *Marine Engineering: Statics and Strength of Materials*, F90V 34 *Marine Engineering: Dynamics and Machines*.

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

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Advanced Applied Mechanics

Guidance on the delivery of this Unit

1 Solve equilibrium problems related to bodies subjected to coplanar and non-coplanar force systems. (10 hours). Topics covered will include:

- Forces within a reciprocating engine mechanism, ie connecting rod force, guide force, piston effort, all relative to the crank angle.
- Problems involving a system of forces which are not all in the same plane that can be reduced to a coplanar force system by substituting an imaginary member for each pair of straddled members of the structure. Problems could involve shear legs or ships derricks.
- Forces within a ships hydraulic steering gear, ie the principle of Rapson's slide.
- Friction problems to include, forces not parallel to the inclined plane, least force to pull body up or down the inclined plane, force at any angle to pull body up or down the inclined plane, angle of repose, cotters, wedges, square screw threads.
- Tractive effort, tractive resistance, frictional resistance, power, force, velocity.

2 Solve problems involving combinations of linear, angular and relative motion. (10 hours). Topics covered will include:

- Linear velocity equations, angular velocity equations, relationship between linera and angular velocity equations, range, vertical displacement, horizontal displacement, path of flight, maximum height.
- Absolute velocity, relative velocity, velocity diagrams.
- Momentum, mass, velocity, change of momentum, rate of change of momentum, inertia force, acceleration, conservation of momentum, impulse, work done, potential energy, kinetic energy, change in velocity due to change in momentum.
- Connected systems, inertia force, mass, acceleration, rope tension.
- Mass moment of inertia, radius of gyration, inertia torque, driving torque, friction torque, angular momentum, angular kinetic energy, angular impulse, Angular power equation, angular work done equation.
- Flat clutches: normal reaction, contact pressure, contact area, friction torque. power. Cone clutches: normal reaction, contact pressure, contact area, relationship between thrust and normal reaction, friction torque power. Centrifugal friction clutches: centrifugal force, spring force, extension of spring, spring stiffness, friction at clutch rim, torque, power.
- Forces acting on bearings: friction torque, energy absorbed by friction, work done, power, energy, power absorbed by friction.
- Governors: sketch diagrams for Watt, Porter & Hartnell governors, spindle, light arm, sleeve, flyweights. Throttle control, instantaneous centre, moments about instantaneous centre, centrifugal force, central mass, spindle friction, spring, spring force.

3 Solve problems involving simple harmonic motion. (10 hours). Topics covered will include:

- Spring and mass systems, pendulums, simply supported massless beam with centrally positioned load beams, crank/connecting rods, cams and followers: amplitude, periodic time, frequency, displacement from mid-point position.

4 Solve problems involving fluid mechanics. (10 hours). Topics covered include:

- For parallel/tapering pipes and venturi meters: Bernoulli's equation, continuity equation, pipe friction losses.
- For reaction force of a hydraulic jet: same as jet force plus reaction force and resultant force.
- For resultant force on a pipe bend: Bernoulli's equation, continuity equation, total thrust, pressure thrust, momentum thrust, resolution of horizontal and vertical forces, resultant force.
- For impact of a jet: force, area, density, volume, velocity, change in velocity, change of momentum, energy, resolution of horizontal and vertical forces.
- For single stage centrifugal pumps: blade tip speed at inlet, blade speed at outlet, absolute velocity at inlet, relative velocity inlet, absolute velocity at outlet, velocity of whirl, flow component at inlet, flow component at outlet, blade or vane inlet angle, impeller width at inlet, impeller width at outlet, impeller inlet diameter, impeller outlet diameter, quantity flowing through impeller, pump efficiency, pump power.

Practical demonstration and realistic problem solving should support the application of advanced mechanics principles and concepts. Computer software could be made available where appropriate and candidates 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 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.

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 the assessment of this Unit

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 2½ 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. Where sampling is used an alternative sample should be used when reassessing candidates.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Advanced Applied Mechanics

Assessment Guidelines

Outcome 1

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 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 2½ hours.

Outcome 2

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 & 4 to form a single assessment paper, details of which are given under Outcomes 1, 3 & 4. This combined assessment could last for 2 ½ hours.

Outcome 3

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 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 2½ hours.

Outcome 4

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 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 2½ hours.

Higher National Unit specification: support notes (cont)

Unit title: Marine Engineering: Advanced Applied Mechanics

Online and Distance 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.

Opportunities for developing Core Skills

In all Outcomes each of the assessments requires the candidate to be able to solve problems involving advanced applied mechanics. 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 require 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.

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**

History of changes to Unit

Version	Description of change	Date

General information for candidates

This Unit has been designed to allow you to further develop your knowledge and understanding in the concepts and theorems of applied mechanics at an advanced level in mechanical and marine engineering. If you have studied these subjects before the early parts of this Unit will provide you with an opportunity to revise the concepts and theorems you have learnt in previous courses.

This Unit closely follows aspects of the Statics, Dynamics and Hydraulics sections 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 advanced applied mechanics 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 advanced applied mechanics problems using the concepts and theorems you have learned. The four Outcomes of study are:

1 Solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems.
2 Solve problems involving combinations of linear, angular and relative motion.
3 Solve problems involving simple harmonic motion.
4 Solve problems involving fluid mechanics.

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 Core Skills of *Numeracy, Communication* and *Problem Solving* at SCQF level 6 within the teaching and assessment approaches in this Unit.