

SQA Advanced unit specification

General information

Unit title: Marine Engineering: Applied Mechanics (SCQF level 8)

Unit code: HW5R 48

Superclass: XQ

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Unit purpose

This unit is designed to enable learners 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.

Outcomes

On successful completion of the unit the learner will 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 the dynamics of motion.

Credit points and level

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

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Recommended entry to the unit

Entry is at the discretion of the centre.

It is recommended that learners should have undertaken the following units prior to this one — F5K8 12 *Engineering Statics*, F5K7 12 *Engineering Dynamics*, *Marine Engineering: Strength of Materials*, *Marine Engineering: Electrical Machines*.

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

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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

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

Knowledge and/or Skills

- ◆ Cranks and connecting rods
- ◆ Non coplanar force system
- ◆ Bodies on an inclined plane
- ◆ Rapsos slide

Outcome 2

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

Knowledge and/or Skills

- ◆ Single and double projectiles
- ◆ Velocity vector diagrams of simple mechanisms
- ◆ Stepped rope and flywheel systems
- ◆ Angular momentum and impulse
- ◆ Moment of Inertia and Radius of Gyration

Outcome 3

Solve problems involving simple harmonic motion.

Knowledge and/or Skills

- ◆ Spring and mass systems
- ◆ Pendulums
- ◆ Crank and connecting rods
- ◆ Cams and followers

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Outcome 4

Solve problems involving the dynamics of motion

Knowledge and/or Skills

- ◆ Newton's 3 laws of motion
- ◆ Tractive effort and tractive resistance
- ◆ Bodies hauled or lowered on an inclined plane
- ◆ Power, force and velocity
- ◆ Potential and kinetic energy

Evidence Requirements for this unit

Outcomes 1–4 should be combined using holistic assessment. This combined assessment could 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.

Learners will need to provide evidence to demonstrate their Knowledge and/or skills across all Outcomes by showing that they can:

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 four** 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 four 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:

- ◆ Solve a problem involving cranks and connecting rods.
- ◆ Explain the terms, co-planar and non-coplanar 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.
- ◆ 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.

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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 **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:

- ◆ solve a problem on an individual or double projectile
- ◆ solve a problem to determine the relative velocities of the connected bodies in simple mechanisms by drawing a velocity vector diagram
- ◆ 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
- ◆ solve a problem involving moment of inertia and radius of gyration

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 **three from four** 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 four 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 characteristics of a body oscillating with simple harmonic motion and solve a problem involving spring and mass systems.
- ◆ Solve a simple harmonic problem involving pendulums.
- ◆ Solve a simple harmonic problem involving crank and connecting rods.
- ◆ Explain the terms cam and follower and solve a simple harmonic problem associated with them.

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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 by showing that the learner is able to:

- ◆ Explain each of newton's laws of motion and apply it to a given problem.
- ◆ Solve a problem involving tractive effort and resistance, including mass, acceleration and friction on an inclined plane.
- ◆ Solve a problem where a body is hauled up or lowered down by a winch on an inclined plane.
- ◆ Derive $\text{power} = \text{force} \times \text{velocity}$ and solve a problem using the equation.
- ◆ Explain the types of energy and solve a problem involving one or more types of energy.

SQA Advanced unit Support Notes

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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 has been written in order to allow learners 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 the dynamics of motion.

This unit closely follows aspects of the Statics, Dynamics and Kinematics sections of the revised MCA Chief Engineer Reg III/2 Applied 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 suggested topics can be found under the 'Guidance on approaches to delivery of this unit' section. 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 many instances the unit allows the learner to revise and build on knowledge and understanding gained from the previous units, F5K8 12 *Engineering Statics*, F5K7 12 *Engineering Dynamics*, *Marine Engineering: Strength of Materials*, *Marine Engineering: Electrical Machines*.

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

Guidance on approaches to 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.

- 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 linear and angular velocity equations, range, vertical displacement, horizontal displacement, path of flight, maximum height.
 - ◆ Absolute velocity, relative velocity, velocity diagrams.
 - ◆ 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.

- 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 dynamics of motion. (10 hours). Topics covered include:
 - ◆ Bodies being hauled at constant velocity or accelerating up an inclined plane.
 - ◆ Tractive effort, tractive resistance, frictional resistance, power, force, velocity.
 - ◆ Potential and kinetic energy problems involving the conversion between the two types.

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 learners may be encouraged to take a logical problem solving approach throughout.

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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 sampling is used an alternative sample should be used when reassessing learners. 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

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.

In all Outcomes each of the assessments requires the learner to be able to solve problems involving advanced applied mechanics. This will give the learner the opportunity to develop the component Using Number of the Core Skill Numeracy at SCQF level 6. The specific Core Skill elements that the learner 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. 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.

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History of changes to unit

Version	Description of change	Date

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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: Applied Mechanics (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 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 learned 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 the dynamics of motion.

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 components of the Core Skills of Numeracy, Communication and Problem Solving at SCQF level 6 within the teaching and assessment approaches 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.