



Higher National Unit Specification

General information

Unit title: Navigational Mathematics and Science (SCQF level 7)

Unit code: HR02 34

Superclass: ZS

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Unit purpose

This unit introduces the mathematical theory required for learners to determine the course and distance between two points on the earth's surface. The unit will examine the concepts of plane and spherical trigonometry and their application in complex navigational calculations. The scientific theory of magnetism will be examined in the context of the earth's magnetic field and its interaction with the ship's magnetic compass and the theory of the marine gyro compass. It will develop knowledge of simple algebra and basic numeracy as well as develop the learner's ability to use a calculator for complex calculations. It is primarily aimed at learners who intend to seek sea-going employment as a Merchant Navy Deck Officer. However it could also be studied by someone with an interest in the subject area.

Outcomes

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

- 1 Describe and apply navigational terms and calculate courses and distances.
- 2 Describe the basic theory of the ship's magnetic compass and its associated errors and maintenance.
- 3 Describe the operation of the marine gyrocompass and its associated errors.

Credit points and level

1 Higher National Unit credit at SCQF level 7: (8 SCQF credit points at SCQF level 7)

Higher National Unit Specification: General information (cont)

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Recommended entry to the unit

Access to this unit is at the discretion of the centre. However, learners would benefit most from this unit if they have successfully completed the *Marine Induction Course* associated with the HNC/HND Nautical Science.

Core Skills

Opportunities to develop aspects of Core Skills are highlighted in the support notes for this unit specification.

There is no automatic certification of Core Skills or Core Skill components in this unit.

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.

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.

Higher National 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

Describe and apply navigational terms and calculate courses and distances.

Knowledge and/or skills

- ◆ Navigational terms
- ◆ Plane trigonometry
- ◆ Spherical trigonometry
- ◆ Sailings on the earth's surface: (parallel, plane, Mercator and great circle)
- ◆ Load lines and limiting latitudes
- ◆ Estimated Time of Arrival (ETA) calculations

Outcome 2

Describe the basic theory of the ship's magnetic compass and its associated errors and maintenance.

Knowledge and/or skills

- ◆ Earth's magnetic field
- ◆ Ship's magnetic field
- ◆ Compass errors and their causes
- ◆ Ship's magnetic compass and maintenance

Outcome 3

Describe the operation of the marine gyrocompass and its associated errors.

Knowledge and/or skills

- ◆ Free gyroscope
- ◆ Marine gyrocompass
- ◆ Gyrocompass errors

Higher National Unit Specification: Statement of standards (cont)

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Evidence requirements for this unit

Learners will need to provide written and/or recorded oral evidence in supervised open-book conditions. Outcomes 1, 2 and 3 should be assessed by means of a single unseen assessment using MCA approved data sheets, navigation tables and formulae sheet and not exceed two hours.

Outcome 1

For Outcome 1 a minimum of two out of four knowledge and skills should be sampled. A different sample should be used on each assessment occasion.

Learners are required to provide written and/or recorded oral evidence to demonstrate their knowledge and/or skills by showing that they can:

- (a) Describe the various navigational terms relating to surface navigation on the earth's surface.

On each assessment occasion four of the following should be sampled:

Earth's poles, earth's equator, meridians, parallels of latitude, small circles, great circles, vertex, difference of latitude, difference of longitude, rhumb line international nautical mile, meridional parts, estimated position, DR position

- (b) Apply the principles of plane trigonometry to calculate either:

- (i) the course and distance between two points on the earth's surface, or
(ii) calculate a final/initial position given a list of courses and distances steamed and a departure/arrival position

On each assessment occasion learners will be required to determine the appropriate method of solution dependent on the overall distance involved. For distances of less than 600nmls, a solution using plane sailing formulae will be acceptable. For distances in excess of 600nmls only Mercator sailing will be acceptable.

Learners must also produce evidence that they can carry out calculations using parallel sailing formulae.

- (c) Apply the principles of spherical trigonometry to great circle and composite great circle sailing problems.

On each assessment occasion one of the following must be sampled:

- (i) Calculation of the great circle distance and initial or final course between two points on the earth's surface. The position of the vertex should also be determined.

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- (ii) Calculation of the composite great circle distance between two points on the earth's surface given a boundary latitude. The position of both vertices should be determined. Where an assessment consists of a composite great circle, the opportunity to explore the learner's understanding of the various load line limits should be utilised.

Distances should be calculated accurately to the nearest nautical mile and courses should be accurate to one tenth of a degree.

- (d) Calculate and determine the ETA at an arrival position given the departure position, route to be followed and the vessel's speed and departure time. Arrival times should be accurate to within 10 minutes.

In the case of (a), (b), (c) above a different sample should be used on each assessment occasion. (d) must be assessed on every assessment occasion

Outcome 2

For Outcome 2 a minimum of two out of five knowledge and skills should be sampled. A different sample should be used on each assessment occasion.

Learners are required to provide written and/or recorded oral evidence to demonstrate their knowledge and/or skills by showing that they can:

- (a) Describe the three components of the earth's magnetic field and how these vary with position on the earth's surface, causing variation of the compass.

On each assessment occasion the horizontal and vertical components of the earth's field should be included and learners should explain how these change with magnetic latitude.

- (b) Explain how the ship's permanent and induced magnetic fields are formed and how they interact with the earth's field causing deviation of the compass.

On each assessment occasion learners must describe how the ship's permanent and induced magnetic fields affect the compass deviation from a sample of one of the following; P, Q or R force (in the case of the permanent field) and fore and aft, thwartships or vertical magnetism (in the case of induced fields).

- (c) Describe how the deviations caused by the fields produced in (b) above are corrected.
- (d) Identify the components of a compass binnacle.
- (e) Describe the maintenance requirements of a magnetic compass.

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Outcome 3

For Outcome 3 a minimum of one out of three knowledge and skills should be sampled. A different sample should be used on each assessment occasion.

Learners are required to provide written and/or recorded oral evidence to demonstrate their knowledge and/or skills by showing that they can:

1 Describe the properties of a free gyroscope.

On each assessment occasion one of the following should be sampled:

- ◆ The degrees of freedom of a free gyroscope
- ◆ Gyroscopic inertia
- ◆ Gyroscopic precession

2 Describe the operation of a marine gyrocompass.

3 Calculate the effect of course, latitude and speed on the error associated with a gyrocompass.



Higher National 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

The content of this unit reflects the content of International Maritime Organisation's Standards of Training Certification and Watchkeeping (STCW) Table A-II/1 Plan and conduct a passage and determine position.

The following notes give additional information on the knowledge and skills for each of the three outcomes.

Outcome 1

The basic navigational terms relating to navigation on the earth's surface will be explored and defined in the context of normal navigational operations on board a ship on an ocean passage.

The theory of plane and spherical trigonometry will be explored in terms of mathematical principles and then applied to the problem of determining course and distance between two points on the earth's surface.

This will involve the consideration of the earth's surface as being flat over small areas and how the curvature of the earth is dealt with over larger areas. In particular the concepts of parallel, plane and Mercator sailing will be developed and learners will be expected to use the appropriate method to determine courses and distances between points on the earth's surface.

The concept of great circle and composite great circle sailing will be examined and the advantages and disadvantages of this type of sailing and rhumbline sailing compared. The limitations of rhumbline and great circle sailing should be considered and the use of Mercator and gnomonic charts in determining the suitability of the two types of sailing explained. The methods of solution for the various types of sailing calculations will be demonstrated and the use of calculators in solving trigonometrical equations mastered.

Outcome 2

This outcome considers the properties and characteristics of the earth's magnetic field and the basic concept and construction of the ship's magnetic compass. The causes and nature of the ship's own magnetic field will be discussed and the concept of permanent and temporary magnetic field within the ship developed. The concept of variation and deviation will be examined and the causes of each explained. The effect of the earth's field and the ship's position on the variation and deviation will be investigated.

Higher National Unit support notes (cont)

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The means of correcting the deviation of the magnetic compass will be examined at a basic level and learners will be expected to explain the purpose of each of the correctors and its effect on the compass needle.

Outcome 3

The basic concept of the free gyroscope will be explained and the principles of gyroscopic inertia and precession will be developed at a basic level. These principles will then be used to enable learners to give a simple explanation of the operation of the marine gyrocompass and its use as a means of determining the direction of true north at any point on the earth's surface. The factors affecting the accuracy of the marine gyrocompass will be discussed and learners will be shown how to make the necessary corrections for the latitude, speed and course the vessel is following.

Assessment of this unit should be designed such that learners are able to produce sufficient evidence that they have a thorough grasp of the various concepts involved and are able to calculate to the nearest nautical mile the distance involved in parallel, plane, Mercator or great circle sailing. Every opportunity should be utilised to design assessments so that the evidence produced is in a form that learners will encounter during the normal day to day operations on board a ship

Oral assessment of certain elements may be appropriate for learners as again this can be used to allow the learner to demonstrate their understanding in a context that is familiar to them from being on board a working vessel.

Guidance on approaches to delivery of this unit

It is suggested that this unit should be delivered concurrently with HN Units *Celestial Navigation, Bridge Watchkeeping and Chartwork and Tides*. The knowledge and skills acquired in this unit will be practised extensively at sea so that the experience gained can be utilised in the HN Units *Marine Passage Planning, Management of Bridge Operations and Ship Stability: Theory and Practical Application* which feature in the later stages of the HND Nautical Science.

The unit is primarily intended for learners who are new entrants to the Merchant Navy via one of the Merchant Navy Training Board (MNTB) approved deck cadet training schemes or for seafarers who are enrolled on a rating to Officer conversion course. Ideally learners would have already accrued some shipboard experience prior to attempting this unit, although this is not a prerequisite.

The knowledge and skills contained within the unit cover all the requirements as laid down by Standards for Training and Certification of Watchkeepers (STCW) 95 at the Operational level aboard ship.

Completion of the unit will also ensure that the learner complies with all the requirements laid down by the UK Maritime and Coastguard Agency (MCA) for the issue of an Officer of the Watch Unlimited Certificate of Competency as a Deck Officer. The required knowledge and skills for MCA certification can be found in a document detailing the requirements for the issue of an Education and Training Certificate (A&B), which is available from the MNTB.

Higher National Unit support notes (cont)

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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.

Elements of Outcomes 1, 2 and 3 may be assessed by means of a single unseen assessment under open-book supervised conditions consisting of a mixture of short answer questions on navigational terms and the ship's compasses and structured questions on sailings.

Wherever possible this should be done in an environment which is familiar to the learners based on their own shipboard experience.

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

There are opportunities to develop the Core Skill of *Numeracy*: Using Number at SCQF level 6. This can be achieved by learners demonstrating their ability to perform complex numerical calculations involving plane and spherical trigonometry. Learners will require a good knowledge of simple trigonometrical identities and trigonometrical formula and will be able to manipulate complex formulae using algebra. The use of calculators will be required and a knowledge of coordinate transformation will be developed.

Numeracy: Using Graphical Information at SCQF level 5 will be developed by the use of Mercator and gnomonic charts to determine appropriate types of sailings for ocean passages.

Problem Solving: Critical Thinking at SCQF level 6 can be developed by learners successfully solving composite great circle problems where consideration of limiting latitudes, loadline zones and or fuel considerations are involved. This type of problem will involve the learner determining which consideration is the most important and then determining if the proposed solution actually complies with the initial restriction imposed.

Communication: Reading at SCQF level 5 will be developed by including extracts from nautical publications in the solution of great circle and composite great circle problems. Learners will be required to appraise supplied extracts and pick out the relevant information and then apply this information to obtain the required solution.

History of changes to unit

Version	Description of change	Date

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General information for learners

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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 is about applying the mathematical principles to common navigational problems that are encountered in the day to day working of the vessel. Mastering the use of these mathematical principles will be of great assistance when studying higher level units later in the course.

The theory of magnetism will be examined in the context of the ship's magnetic compass and you will gain a basic knowledge of how the magnetic fields of the earth and the ship combine to produce the directional properties of the ship's magnetic compass and how this property varies with heading of the ship and the ship's position

The basic theory of gyroscopes will be considered and the directional properties of a marine gyrocompass will be investigated.

The use of magnetic and gyrocompasses in the ship's steering systems will be explained at a basic level which will be sufficient for learners to keep a bridge watch in an operational capacity as defined by STCW '78 as amended.

On completion of the unit you should be able to:

- ◆ describe and apply navigational terms and calculate courses and distances
- ◆ describe the basic theory of the ship's magnetic compass and its associated errors and maintenance
- ◆ describe the operation of the marine gyrocompass and its associated errors

Assessment of this unit will be open-book and under supervised conditions. Assessment will allow you to demonstrate that you have attained the required level of mathematical expertise to successfully achieve the unit.

Wherever possible this should be done in an environment which is familiar to the learners based on their own shipboard experience.