Higher National Unit Specification

General information for centres

Unit title: Navigational Mathematics and Science

Unit code: F0M0 34

Unit purpose: This Unit introduces the mathematical theory required for candidates 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 candidate's ability to use a calculator for complex calculations. It is primarily aimed at candidates 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.

On completion of the Unit the candidate should 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 HN Credit 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: Access to this Unit is at the discretion of the centre. However, candidates would benefit most from this Unit if they have successfully completed the *Marine Induction Course* associated with the HNC/HND Nautical Science.

Core Skills: There are opportunities to develop the following Core Skills in this Unit, although there is no automatic certification of Core Skills or Core Skills components.

Communication: Reading at SCQF level 5
Numeracy: Graphical Information at SCQF level 5
Numeracy: Using Number and Problem Solving: Critical Thinking at SCQF level 6
Problem Solving: Critical Thinking at SCQF level 6

General information for centres (cont)

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: 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. The outstanding elements may be assessed by means of a closed-book assessment under supervised conditions.

Higher National Unit specification: statement of standards

Unit title: Navigational Mathematics and Science

Unit code: F0M0 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

Describe and apply navigational terms and calculate courses and distances

Knowledge and/or skills

- Navigational terms
- Plane trigonometry
- Spherical trigonometry
- Sailings on the earths surface: (Parallel, Plane, Mercator and Great Circle)
- Load lines and limiting latitudes
- Estimated Time of Arrival (ETA) calculations

Evidence Requirements

All knowledge and skills are assessed, however there is sampling **within** each of the knowledge and skills.

Candidates will need to demonstrate evidence of all 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

A different sample should be used on each occasion.

(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 candidates 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.

Candidates 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.

(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 candidate's understanding of the various load line limits should be utilised.

Distances should be calculated accurate 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

Assessment guidelines

Outcome 1 may be assessed by means of an unseen open-book assessment, under supervised conditions, consisting of structured questions involving the application of sailing formulae in the calculation of courses and distances between points on the earth's surface and definitions of commonly used navigational terms.

Candidates should have MCA approved formula sheets available for this assessment.

Higher National Unit specification: statement of standards (cont)

Unit title: Navigational Mathematics and Science

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

Evidence Requirements

All knowledge and skills are assessed, however there is sampling **within** each of the knowledge and skills.

Candidates will need to demonstrate evidence of all 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 candidates 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 candidates 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.

On each assessment occasion a different sample should be used for elements (a), (b) and (c) above. Elements (d) and (e) must be assessed on each assessment occasion.

Assessment guidelines

Outcome 2 may be assessed by means of closed-book assessment under supervised conditions.

It is recommended that items (a) and (b) and (c) be assessed using structured short answer questions. A closed-book assessment covering items (d) and (e), using a compass binnacle would be appropriate to allow candidates to demonstrate their knowledge.

Outcomes 1 and 2 may be combined in the case of closed-book assessment.

Outcome 3

Describe the operation of the marine gyrocompass and its associated errors

Knowledge and/or skills

- Free gyroscope
- Marine gyrocompass
- Gyrocompass errors

Evidence Requirements

All knowledge and skills are assessed, however there is sampling **within** each of the knowledge and skills.

Candidates will need to demonstrate evidence of all knowledge and/or skills by showing that they can:

(a) 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

(b) Describe the operation of a marine gyrocompass.

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

Where sampling is used a different sample should be used on each assessment occasion.

Assessment guidelines

Outcome 3 may be assessed by means of closed-book assessment under supervised conditions consisting of structured questions and one calculation on the course latitude and speed error. Outcomes 1, 2 and 3 may be combined for the purposes of assessment.

Administrative Information

Unit code: F0M0 34

Unit title: Navigational Mathematics and Science

Superclass category: ZF

Original date of publication: August 2006

Version: 01

History of Changes:

Version	Description of change	Date

Source: SQA

SQA acknowledges the valuable contribution that Scotland's colleges have made to the development of Higher National qualifications.

Additional copies of this Unit specification can be purchased from the Scottish Qualifications Authority. Please contact the Customer Contact Centre for further details, telephone 0845 279 1000.

Higher National Unit specification: support notes

Unit title: Navigational Mathematics and Science

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

The content of this Unit forms part of the underpinning knowledge for the level 3 SVQ *Marine Vessel Operations* and reflects the content of International Maritime Organisation's *Standards of Training Certification and Watchkeeping (STCW).*

Guidance on the delivery and assessment of this Unit

It is suggested that this Unit should be delivered concurrently with HN Units F0LS 35 *Celestial Navigation*, F0LR 34 *Bridge Watchkeeping* and F0LV 34 *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 F0LG 35 *Marine Passage Planning*, F0LW 35 *Management of Bridge Operations* and F0LC 35 *Ship Stability: Theory and Practical Application* which feature in the later stages of the HND Nautical Science.

The Unit is primarily intended for candidates 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 candidates 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 candidate 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.

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 candidates 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.

The means of correcting the deviation of the magnetic compass will be examined at a basic level and candidates 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 candidates 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 candidates 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 candidates 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 candidates will encounter during the normal day to day operations on board a ship

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

Higher National Unit specification: support notes (cont)

Unit title: Navigational Mathematics and Science

Opportunities for developing Core Skills

There are opportunities to develop the Core Skill of Numeracy: Using Number at SCQF level 6. This can be achieved by candidates demonstrating their ability to perform complex numerical calculations involving plane and spherical trigonometry. Candidates 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 candidates 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 candidate 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. Candidates will be required to appraise supplied extracts and pick out the relevant information and then apply this information to obtain the required solution.

Open learning

This Unit is not suited to delivery by distance learning because it requires candidates to be observed and questioned by a qualified practitioner to meet the requirements for the award of a Certificate of Competency.

Candidates with disabilities and/or additional support needs

The additional support needs of individual candidates should be taken into account when planning learning experiences, selecting assessment instruments or considering alternative Outcomes for Units. For information on these, please refer to the SQA document *Guidance on Alternative Assessment Arrangements for Candidates with Disabilities and/or Additional Support Needs,* which is available on SQA's website: **www.sqa.org.uk**.

General information for candidates

Unit title: Navigational Mathematics and Science

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 candidates to keep a bridge watch in an operational capacity as defined by STCW 95.

On completion of the Unit the candidate 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 may consist of a mixture of open and closed-book assessment. These assessments will allow the candidate to demonstrate that they have attained the required level of mathematical expertise to successfully achieve the Unit.

The assessments will allow candidates to demonstrate that they have attained the required knowledge and skills and wherever possible this should be done in an environment which is familiar to the candidates based on their own shipboard experience.