Arrangements for:

HNC Marine Engineering

Group Award Code: G9W8 15

HND Marine Engineering

Group Award Code: GF08 16

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Acknowledgement

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

History of changes

It is anticipated that changes will take place during the life of the qualification and this section will record these changes. This document is the latest version and incorporates the changes summarised below. Centres are advised to check SQA's APS Navigator to confirm they are using the up to date qualification structure.

NOTE: Where a Unit is revised by another Unit:

- No new centres may be approved to offer the Unit which has been revised.
- Centres should only enter candidates for the Unit which has been revised where they are expected to complete the Unit before its finish date.

Version number	Description	Date
03	Addition of a Credit Transfer Table *see Page 14*	16/01/15
02	**Revision of Units**: DG4L 34 *Mathematics for Engineering 2* revised by H7K1 34 *Engineering Mathematics 2* on framework finishing 31/07/2016.	23/10/14

Contents

1 Introduction

This is the Arrangements Document for the new Group Awards HNC Marine Engineering and HND Marine Engineering validated in June 2011. This document includes: background information on the development of the Group Award, its aims, guidance on access, details of the Group Award structure, and guidance on delivery.

2 Rationale for the development of the Group Awards

For the safety of life at sea and the protection of the marine environment it is essential that seafarers have a level of competence that enables them to carry out their duties safely and effectively.

It is, therefore, a requirement of the International Maritime Organisation (IMO) that Merchant Navy vessels are operated by seafarers who hold 'Certificates of Competency (COC)' relevant to the level or rank to which they are employed. The current COC requirements are detailed in the IMO 'Standards of Training, Certification and Watchkeeping' convention as amended in 1995 (STCW95).

As a signatory to IMO the UK Government is responsible under EC directive 2008/106/EC for ensuring compliance with STCW95 for UK Certificates of Competency. This task is undertaken by the UK Maritime and Coastguard Agency.

The initial training programmes for Merchant Navy Training which lead to the award of initial and subsequent COC's have been under review for a number of years. The creation of a new cadetship route has resulted in a change in the training and qualification framework required within the shipping industry. These changes have meant that new initial qualifications are required for Engineering Officers. The first phase in this was the development of an NC in Shipping and Marine Operations which was introduced in August 2009. The second stage was the development of an HNC in Marine Engineering, validated in June 2010, and the third stage was the development of an HND Marine Engineering which was validated in June 2011.

2.1 Recent changes to Engineer Office Training Programmes

The majority of Engineer Officers who join the Merchant Navy in the United Kingdom enter the industry and carry out their initial training as Engineer Cadets. Most Engineer Cadets enter the industry directly from school having achieved Standard Grade or Higher Qualifications. Prior to 2006 all cadet entrants followed a three year training programme which consisted of alternating college and sea phases. This training programme was based on an HND in Mechanical Engineering. This was problematic for various reasons. The UK Shipping Industry has, in recent years sought to raise the standard of entrants into its initial training programmes. The available HND qualification was not achieving this and so the Merchant Navy Training Board (MNTB) in collaboration with the shipping industry and maritime colleges developed the Scottish Professional Diploma (SPD) training programmes for entrants with 120 UCAS points or above.

The SPD programmes were introduced in 2006. This addressed the needs of entrants with Higher level qualifications but did not meet the needs of those entering with Standard Grade qualifications.

Prior to academic year 2009–2010 engineer cadets with Standard Grade qualifications have enrolled directly on to an HND programme in Mechanical Engineering. To help candidates deal with the mathematical elements included in these higher education programmes the initial college phase of the cadetship contained an element known as an ‘academic ramp’. The academic ramp was an intense mathematics course designed to bring Standard Grade level entrants up to a level where they could commence HND study. It has been recognized within the industry for some time that this process was ineffective. A short intense course in mathematics is no substitute for a year or two years studying Highers. A high proportion of trainees enrolling on the HND academic ramp route were failing to gain their HND. The MNTB in consultation with shipping companies and the marine colleges have developed a new route for Standard Grade entrants which commenced in August 2009, the NC Maritime and Shipping Operations. The HNC/HND in Marine Engineering being is the final key component in this new training route.

2.2 New cadetship for Standard Grade entrants

The new route for Standard Grade entrants was introduced in August 2009. Colleges wishing to offer the new route had to gain approval from the MNTB prior to delivery.

The MNTB consultation process, which covered the needs of both the engineering and deck groups, decided on a programme which would allow the candidates to achieve an HNC in their subject area. There would also be the option for additional college time in order to gain a HND. The indicative model developed for engineer cadets is as shown:

	Duration	Content
First College Phase	28–32 weeks	STCW Basic Training Courses Industry, company and college induction Higher Education Access course MNTB workshop skills (relevant proportion)
First sea phase	20–28 weeks	Shipboard induction, familiarisation with marine engineering operations Undertake planned training documented in the Training Record Book
Second College Phase	36–40 weeks	Assess/consolidate learning from sea phase. HNC programme to cover relevant National Occupational Standard for Engineer Officer of the Watch and to give academic exemptions from STCW95 Reg III/2 2nd Engineer Unlimited Engineer Officer of the Watch. MNTB workshop skills (relevant proportion)
Second sea phase	26–35 weeks	Development of shipboard operations and skills — emphasis moves from basic skills to engineering operations duties and responsibilities, including understudying the role of the EOOW Complete programme of shipboard training documented in the Training Record Book
Third College Phase	9–18 weeks	Complete MNTB Workshop skills. STCW advanced courses. Preparation for IAMI EK and MCA oral examination for STCW95 Reg III/1 Engineer Officer of the Watch certificate of competency.
Optional additional phase	26 weeks	HND programme to give academic exemptions from STCW95 Reg III/2 Chief Engineer Unlimited Certificate of Competency.

The NC in Shipping and Marine Operations meets the requirements of the first college phase, HNC in Marine Engineering meets the requirements of the second college phase and HND in Marine Engineering meets the needs of additional optional phase.

2.3 MNTB Criteria for HNC/HND Marine Engineering

There are two major criteria specified by the MNTB route for the HNC/HND within the new route framework. Firstly the HNC/HND qualification should address the relevant marine National Occupational Standards (NOS) and secondly it should allow successful candidates to gain exemption from the academic subjects for a STCW95 Reg III/2 2nd Engineer Unlimited Engineering Officer Certificate of Competency.

There is a direct link between the practical and technical knowledge and skills required for MCA Certificates of Competency in accordance with STCW95 and the skills and knowledge identified in the marine NOS. Programme specifications for the HNC/HND programme must, therefore, take account of the relevant NOS in meeting knowledge and skill requirements.

There are three levels of Certification for marine engineering officers in the merchant navy. These are STCW95 Reg III/1 Engineer Officer of the Watch, STCW95 Reg III/2 2nd Engineer Unlimited Engineering Officer and STCW95 Reg III/2 Chief Engineer Unlimited Engineering Officer. Each of these certificates requires the candidate to prove that they have the relevant academic and practical knowledge relating to the required level. A specific aim of the HNC in Marine Engineering is to allow candidates to gain exemption from the academic subjects for their STCW95 Reg III/2 2nd Engineer Unlimited Certificate of Competency. At the end of their initial training scheme engineer cadets normally gain their STCW95 Reg III/1 Engineer Officer of the Watch COC. After an additional 18 months sea time Engineer Officers are then eligible to sit the exams for their STCW95 Reg III/2 2nd Engineer Unlimited COC. A candidate with no exemptions must sit examination papers in the academic subjects of mathematics, engineering drawing, applied mechanics, applied heat, naval architecture and electrics. All candidates must also sit written examinations in marine engineering knowledge and an oral examination. Successful completion of the HNC in Marine Engineering is intended to give exemption from the STCW95 Reg III/2 2nd Engineer Unlimited academic subjects. Candidates would then require a further 18 months sea time to be eligible to sit the exams for their STCW Reg III/2 Chief Engineer Unlimited Certificate of Competency.

A candidate with no exemptions must sit examination papers in the academic subjects of Applied Mechanics, Applied Heat, Electro-technology and Naval Architecture. Successful completion of the HND in Marine Engineering would give exemption from these academic examinations. All candidates must also sit further written examinations in marine engineering knowledge and an oral examination.

The proposed changes to the STCW code set out in the Manila amendment of July 2010 indicate that there will be a substantive change in the academic knowledge levels required for Marine Engineers. The academic knowledge for both Second Engineer and Chief Engineer will be changed to SCQF level 8 (QCF level 5 in England) meaning that to gain exemption from academic subjects for both Second Engineer and Chief Engineer candidates will require a HND.

Appendix 1 shows how the HNC/HND Marine Engineering programme elements map to the required MNTB NOS criteria.

It is envisaged that the MCA examination route to Second and Chief Engineer qualifications will be phased out with all candidates requiring a minimum of an HND as the academic qualification required for STCW certification.

2.4 Market research for HNC/HND Marine Engineering

The HNC/HND in Marine Engineering has been designed to meet the requirements set out by the MNTB 'Merchant Navy Deck and Engineering HNC and HND Programmes Framework Document'. The HNC award is aimed at providing full coverage EOOW/Second Engineer competencies. The HND award is aimed at providing full coverage Chief Engineer competencies.

To ensure the Qualification Design Team provided the requirements the following table summarises the consultation methods employed:

Stakeholder	***Method of consultation***
Employers Shipping Companies	♦ Questionnaires
Shipping Industry Bodies Key Bodies Representing the Shipping Industry and Shipping Training	♦ Questionnaires ♦ Interviews ♦ Face to Face Meetings
Marine Colleges Key Colleges providing Marine Engineering training in the UK	♦ Face to Face Meetings

2.5 Employment opportunities

The HNC/HND in Marine Engineering has been designed to be an integral part of a marine engineering cadetship. The retention rates on these cadetship schemes are excellent and the majority of cadets who complete their cadetship will gain employment at sea as a Watchkeeping Engineer. By successfully completing the HNC and gaining STCW95 Reg III/2 2nd Engineer Unlimited exemptions a greater proportion of cadets will be given the opportunity to complete an HND and gain their senior engineering Certificates of Competency leading to employment opportunities worldwide.

2.6 Articulation routes

Candidates who complete the award will have the opportunity to progress to higher level qualifications. As previously explained successful candidates will be eligible to sit their STCW95 Reg III/2 2nd Engineer Unlimited Certificate of Competency after 18 months sea time and will be exempt from the academic examinations at this level.

Candidates who successfully achieve the HNC in Marine Engineering can progress to the HND in Marine Engineering. On completion of the HND articulation to the third year of a degree programme is possible.

3 Aims of the Group Awards

3.1 General aims of the Group Awards

- Develop the ability to analyse and plan tasks commonly encountered in the workplace.
- Develop approaches to problem solving and critical thinking.
- Develop an evaluative and reflective approach to work and studies.
- Develop the ability to plan and organise studies.
- Develop skills for employability and progression to higher qualifications.
- To enable the candidate to consolidate knowledge and skills to enhance career progression.
- To develop Core Skills required by employers
- To develop skills which are capable of being transferred to any employment.
- Progression within the SCQF framework.

3.2 Specific aims of the HNC Group Award

- Prepare candidates for written and oral examinations for Engineer Officer of the Watch
- Provide academic exemptions for STCW95 Reg III/2 2nd Engineer Unlimited Engineering Certification.
- Contribute towards developing skills to enable candidates to operate a vessel in a safe and effective manner.
- Contribute towards developing skills to enable candidates to work with others in safe and effective manner.
- Contribute towards developing skills to deal with emergency situations.
- Develop awareness of current maritime legislation.

3.3 Specific aims of the HND Group Award

- Provide an award that on successful completion will allow candidates to progress to a degree in engineering or a related subject discipline area
- Provide an award that will give academic exemptions for STCW95 Reg III/2 Chief Engineer Unlimited Engineering Certification.
- Develop knowledge and understanding of the external and internal factors that influence the performance of modern marine plant and vessels.
- Develop a range of Communication knowledge and skills relevant to the needs of marine engineers
- Develop a range of project management skills
- Develop the analysis and synthesis skills necessary to ensure the efficient operation of marine plant.

3.4 Target groups

The course has been designed as part of the new MNTB cadetship scheme. The majority of entrants to the HNC will have completed the initial NC phase of the cadetship. Candidates who enter the HND will have completed the HNC Marine Engineering.

Delivering centres may also consider candidates with relevant work experience in either the engineering or shipping industries for the award.

4 Access to Group Awards

Access to the award is at the discretion of the centre. The following recommendations are for guidance only.

4.1 HNC Marine Engineering Recommended Access: Formal Qualifications

- National Certificate in Shipping and Marine Operations (with marine engineering options)
- At least two Higher level (SCQF level 6) passes at of which one should be Mathematics or a Physical Science. Candidates should also have Standard Grade English at SCQF level 4 or better.

4.2 HND Marine Engineering Recommended Access: Formal Qualifications

Most candidates for the HND Marine Engineering would be expected to firstly gain the HNC Marine Engineering Award which would allow automatic progression to the HND in Marine Engineering. Other candidates' suitability would be assessed on their present qualifications but would be expected to have the equivalent of HNC in a science based subject.

5 Group Awards structure

5.1 HNC Marine Engineering Framework

Unit title	Code	SCQF credit points	SCQF level	SQA credit value
Marine Engineering: Marine Heat Engine Principles	F90Y 34	8	7	1
Marine Engineering: Auxiliary Thermodynamic Principles	F90T 34	8	7	1
Marine Engineering: Dynamics and Machines	F90V 34	8	7	1
Marine Engineering: Statics and Strength of Materials	F90R 34	8	7	1
Marine Engineering: Propulsion	F912 34	8	7	1
Marine Engineering: Mathematics	F910 33	8	6	1
Marine Engineering: Naval Architecture	F911 34	8	7	1
Marine Engineering: Ship Construction	F913 34	8	7	1
Engineering Drawing	DR1W 34	8	7	1
Marine Engineering: Electrical and Electronic Devices	F90W 34	8	7	1
Marine Engineering: Electrical Motors and Generators	F90X 34	8	7	1
Marine Engineering: Graded Unit 1	F914 34	8	7	1

5.2 HND Marine Engineering Framework

Unit title	Code	SCQF credit points	SCQF level	SQA credit value
Marine Engineering: Marine Heat Engine Principles	F90Y 34	8	7	1
Marine Engineering: Auxiliary Thermodynamic Principles	F90T 34	8	7	1
Marine Engineering: Dynamics and Machines	F90V 34	8	7	1
Marine Engineering: Statics and Strength of Materials	F90R 34	8	7	1
Marine Engineering: Propulsion	F912 34	8	7	1
Marine Engineering: Mathematics	F910 33	8	6	1
Marine Engineering: Naval Architecture	F911 34	8	7	1
Marine Engineering: Ship Construction	F913 34	8	7	1
Engineering Drawing	DR1W 34	8	7	1
Marine Engineering: Electrical and Electronic Devices	F90W 34	8	7	1
Marine Engineering: Electrical Motors and Generators	F90X 34	8	7	1
Marine Engineering: Auxiliary Systems	FT29 34	8	7	1
Fundamentals of Control Systems	DN3Y 34	8	7	1
Safety Engineering and the Environment	DR2D 34	8	7	1
Engineering Mathematics 2	H7K1 34*	8	7	1
Marine Engineering: Marine Management	H0EJ 35	16	8	2
Marine Engineering: Advanced Strength of Materials	H0EG 35	8	8	1
Marine Engineering: Advanced Applied Mechanics	H0EA 35	8	8	1
Marine Engineering: Advanced Marine Thermodynamic Principles	H0EC 35	8	8	1
Marine Engineering: Advanced Marine Heat Engine Principles	H0EB 35	8	8	1
Marine Engineering: Advanced Naval Architecture	H0ED 35	8	8	1
Marine Engineering: Advanced Ship Construction and Survey	H0EF 35	8	8	1
Marine Engineering: Electrical Distribution Systems	H0EL 35	8	8	1
Marine Engineering: Electrical Power	H0EH 34	8	7	1
Process Control	DX4K 34	8	7	1
Marine Engineering: Pneumatics and Hydraulic Systems	H0EK 34	8	7	1
Marine Engineering: Graded Unit 1	F914 34	8	7	1
Marine Engineering: Graded Unit 2	FW56 35	16	8	2

*Refer to History of Changes for revision changes.

5.3 HN Marine Engineering Graded Unit 1

The HNC Marine Engineering is an integral component of a Merchant Navy engineer cadet training scheme. At the end of an engineering cadetship the candidate should have gained the theoretical and practical knowledge to gain their initial Maritime and Coastguard Agency (MCA) Certificate of Competency. In order to gain this certificate the candidates must sit a written and an oral MCA examination. These examinations, which take place at the end of the cadetship, are designed to cover the full range of knowledge the cadet has studied throughout his or her cadetship. Although many of the Units in the new HNC programme will be assessed on end of Unit examinations these exams will normally be based on relatively narrow subject area. Introducing a Graded Unit examination which tests a candidate's knowledge across the award subjects will help to prepare the candidate for their Engineer Officer of the Watch examinations.

In addition to preparing the candidates for their initial Certificate of Competency the HNC programme has also been designed to give the candidate exemptions from their MCA STCW95 Reg III/2 2nd Engineer Unlimited academic subjects. Candidates who wish to gain their STCW95 Reg III/2 2nd Engineer Unlimited certificates of competency who have not completed an HNC are required to sit separate three hour examinations in mathematics, applied mechanics, applied heat, engineering drawing, electrotechnology, and naval architecture. The Units for the HNC have been designed in line with the MCA Syllabi for the above subjects. The MCA examination subjects have, in some cases, split in to two separate Units where each Unit is assessed by a short end of Unit assessment. This process does not place the same demands on an HNC candidate as those placed on his or her counterpart who is sitting the MCA written examinations. A three hour Graded Unit examination which assesses a candidate's ability across the majority of the academic subjects will increase the validity of the exemption process for the MCA written papers. All candidates who wish to gain a STCW95 Reg III/2 2nd Engineer Unlimited Certificate of Competency must sit three hour written examinations in Motor/Steam and General Engineering knowledge. No one is exempt from these examinations. Completion of a formal 3 hour written examination within the HNC will provide valuable experience for these later examinations.

The HNC may be the highest academic qualification gained by some within their cadetship. Those who wish to gain their First Class Certificate of Competency will be required to undertake the MCA academic written examinations for STCW95 Reg III/2 Chief Engineer Unlimited. These, again, are number of separate three hour examinations in academic subjects. The Graded Unit examination within the HNC will again provide valuable examination experience for candidates who are moving up to STCW95 Reg III/2 Chief Engineer Unlimited level.

5.4 HN Marine Engineering Graded Unit 2

A project was preferred at HND level because an investigative project-based assignment provides candidates with opportunities to demonstrate not only their knowledge and skills in a technical area(s) relating to modern marine plant, but also in areas such as planning, scheduling, testing, evaluating and reporting which are important aims within the HND Marine Engineering award.

An investigative assignment will allow candidates to demonstrate research, analytical and evaluative skills acquired during the course. It allows them to use reporting skills by producing a logbook/diary of their activities as well as the final report including practical recommendations for improvement

An investigative project based assessment allows candidates to develop their research skills as well as require them to work with other candidates thus developing interpersonal skills.

5.5 MCA Exemptions

It has been highlighted on several occasions that a major aim of the HNC/HND is to enable candidates to gain exemption from the academic exemptions for their STCW95 Reg III/2 2nd Engineer Unlimited Certificate of Competency. The link between HNC/HND and MCA Second Engineer level subjects is shown below:

MCA Subject	SQA Unit
Mathematics	Marine Engineering: Mathematics Marine Engineering: Statics and Strength of Materials Marine Engineering: Naval Architecture Marine Engineering: Auxiliary Thermodynamic Principles
Engineering Drawing	Engineering Drawing DR1W 34
Applied Mechanics	Marine Engineering: Dynamics and Machines Marine Engineering: Statics and Strength of Materials
Applied Heat	Marine Engineering: Marine Heat Engine Principles Marine Engineering: Auxiliary Thermodynamic Principles
Electrotechnology	Marine Engineering: Electrical and Electronic Devices Marine Engineering: Electrical Motors and Generators
Naval Architecture	Marine Engineering: Naval Architecture Marine Engineering: Ship Construction

The link between HND and MCA Chief Engineer level subjects is shown below:

MCA Subject	SQA Unit
Applied Mechanics	Marine Engineering: Advanced Strength of Materials Marine Engineering: Advanced Applied Mechanics
Applied Heat	Marine Engineering: Advanced Marine Thermodynamic Principles Marine Engineering: Advanced Marine Heat Engine Principles
Electrotechnology	Marine Engineering: Electrical Power Marine Engineering: Electrical Distribution Systems
Naval Architecture	Marine Engineering: Advanced Naval Architecture Marine Engineering: Advanced Ship Construction and Survey

The Units have been designed to cover the relevant MCA syllabi. To meet MCA requirements candidates must achieve a pass mark of more than 50% in end of Unit assessments.

Previous qualifications allowed candidates to gain MCA exemptions for individual subjects when they had not completed the Group Award. This will not be the case with the new HNC/HND. In order to gain Second Engineer exemptions the candidate must complete and pass all of the HNC subjects, in order to gain Chief Engineer exemptions the candidate must complete and pass all of the HND subjects. The MCA STCW95 Reg III/2 Chief Engineer and 2nd Engineer Unlimited syllabi are included as Appendix 4. More detailed mappings showing the relationship between the HNC Units and the STCW95 Reg III/2 2nd Engineer Unlimited and HND Units with STCW95 Reg III/2 Chief Engineer syllabi are included as **Appendix 5**.

5.6 Core Skills Entry/Exit profile

The Group Award sign posts the five Core Skills of *Communication, Numeracy, Information and Communication Technology (ICT), Problem Solving* and working with others. A matrix mapping Core Skills to individual Units can be found in **Appendix 6**.

Core Skills	HNC/HND Recommended Entry profile	HNC/HND Recommended Exit profile
Communication	SCQF level 6	SCQF level 6
Information and Communication Technology (ICT)	SCQF level 6	SCQF level 6
Numeracy	SCQF level 6	SCQF level 6
Problem Solving	SCQF level 6	SCQF level 6
Working with Others	SCQF level 6	SCQF level 6

6 Approaches to delivery and assessment

In the design of the HNC and HND Marine Engineering a high level of priority has been placed on producing an award which will allow candidates to develop appropriate technical and practical skills which will meet the requirements of employers, prepare candidates for the level of responsibility aboard ship and allow future progression to higher rank within the industry or to progress to higher qualifications.

It is not possible to quantify such technical and practical skills in exact detail. The best way, however to prepare candidates to meet the changing requirements of the modern maritime industry is to have a solid foundation of theory and practice on which they can build new knowledge, understanding and skills.

Essential skills and Core Skills have been built into the HNC award to allow easy progression on to the HND award.

Centres should seek opportunities to integrate Core Skills within their teaching and learning programmes. Opportunities are identified in the support notes of the HNC/HND mandatory Units.

6.1 Open Learning

Units could be delivered by distance learning or other open learning methods which may incorporate some degree of on-line support and is included within the Unit specification. With regard to assessment, planning would be required of the Centre concerned to ensure the sufficiency and authenticity of candidate evidence. Arrangements would be required to be put in place to ensure that written assessment was conducted under controlled conditions.

When the Group Awards are to be used as a route to MCA certification assessment must be under the direct supervision of the approved centre.

6.2 Assessment

From the outset of this development it was recognized that there was a need to have an appropriate assessment strategy in place for the HNC/HND Marine Engineering. This strategy had to reflect the needs of the award with regard to MCA exemptions.

6.2.1 Aims

To ensure that:

- a consistent, rigorous and efficient approach to assessment is used.
- assessment instruments for Units and Graded Units satisfy national agreed standards.
- the assessment load on candidates and staff is sensible and does not unduly detract from teaching and learning.

6.2.2 Objectives

Adopt a holistic approach to assessment. The implications of this are.

1 Assessment instruments will be designed to sample knowledge and skills in each Unit.
2 A Unit assessment strategy will be adopted, where possible, to produce a single assessment instrument for the whole Unit. Where this is not possible the minimum number of assessment instruments required should be used.
3 While not seeking to be entirely prescriptive with regard to time spent on assessment in each HN Unit, over assessment should be avoided.

6.2.3 Graded Unit assessment

It is recommended that candidates study the key contributing HN Units prior to sitting the Graded Unit examination for the HNC. The HND Graded Unit is a project type during which candidates should be studying, and include, the contributing HN Units.

6.2.4 Credit Transfer

New Unit Title	New Unit Code	Old Unit Title	Old Unit Code	Credit Transfer Conditions
Engineering Mathematics 1	H7K0 33	Mathematics for Engineering 1:Electronics and Electrical	DG4H 33	To gain credit transfer to the new unit candidates will have to provide additional evidence relating to functions as specified in the Evidence requirements in respect of the first three knowledge/skills in Outcome 1 and relating to vectors as specified in the first three knowledge/skills in outcome 3.
Engineering Mathematics 1	H7K0 33	Mathematics for Engineering 1:Mechanical and Manufacturing	DT5X 33	To gain credit transfer to the new unit candidates will have to provide additional evidence relating to functions as specified in the Evidence requirements in respect of the first three knowledge/skills in Outcome 1 and relating to 3D vectors and complex numbers as specified in the knowledge/skills in outcome 3.

Engineering Mathematics 2	H7K1 34	Mathematics for Engineering 2	DG4L 34	To gain credit transfer to the new unit candidates will have to provide additional evidence relating to trigonometric and hyperbolic functions as specified in the Evidence requirements in respect of Outcome 1.

7 General information for centres

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**.

Internal and external verification

All instruments of assessment used within this/these Group Award(s) should be internally verified, using the appropriate policy within the centre and the guidelines set by SQA.

External verification will be carried out by SQA to ensure that internal assessment is within the national guidelines for these qualifications.

Further information on internal and external verification can be found in *SQA's Guide to Assessment* **(www.sqa.org.uk)**.

8 General information for candidates

8.1 HNC Marine Engineering

The HNC in Marine Engineering has been designed as a component of a Merchant Navy Engineer Officer Training Scheme. This five phase training scheme consist of alternating college and sea phases. The duration of the training scheme is approximately three years. Approximately nine months of the training will take place at sea.

Access to the HNC is at the discretion of the delivering centre however you would normally be expected to be have achieved either

The National Certificate in Shipping and Marine Operations (with Marine Engineering options)

Or

At least two Higher (SCQF level 6) level passes of which one should be mathematics or a physical science. You should also have Standard Grade English at Grade 3 (SCQF level 4) or better

Or

Delivering centres may also consider you if you have relevant work experience in either the engineering or shipping industries.

If you study the HNC you are likely to have completed the first college and sea phase of your Engineering Cadetship and will have gained an NC in Shipping and Marine Operations. On completion of the HNC you will complete further sea time before returning to college to complete your training and sit the examinations for your Maritime and Coastguard Agency (MCA) Engineering Officer of the Watch Certificate (EOOW).

(Please note if you study the NC you will have the Merchant Navy Training Board (MNTB) suggested qualifications of Standard Grades 1–3 in English, Maths, a science based subject and at least one other subject.)

If you wish to go to sea you should be aware that you must meet the medical standards laid down by the Maritime and Coastguard Agency.

The specific aims of the HNC are:

- Prepare you for written and oral examinations for Engineer Officer of the Watch.
- Provide academic exemptions for STCW95 Reg III/2 2nd Engineer Unlimited Engineering Certification.
- Contribute towards developing skills to enable you to operate a vessel in a safe and effective manner.
- Contribute towards developing skills to enable you to work with others in safe and effective manner.
- Contribute towards developing skills to deal with emergency situations.

- Develop awareness of current maritime legislation.

If you complete the full Merchant Navy training programme you can progress to become Engineer Officer of the Watch on a Merchant Navy vessel. On completion of 18 months sea time you can return to College to sit the examinations for your Second Engineers Certificate (STCW95 Reg III/2 2nd Engineer Unlimited Engineer Certificate of Competency). After completing this certificate and an additional 18 months sea time you can return to College to sit your Chief Engineers Certificate (STCW95 Reg III/2 Chief Engineer Unlimited Certificate of Competency). Those who have successfully completed the HNC in Marine Engineering will be exempt from the academic examinations for the Second Engineers Certificate which are Mathematics, Applied Mechanics, Applied Heat, Engineering Drawing, Electrotechnology and Naval Architecture. You would have to sit two MCA Engineering Knowledge examinations for your Second Engineers Certificate.

In addition to the career path shown above if you are successful in the HNC you will be able to progress on to an HND in Marine Engineering.

The majority of HNC Units are assessed by one or more closed-book assessments. In order to meet with MCA exemption requirements the pass marks for your assessments have been set at 50%.

In addition the HNC award also contains a Graded Unit examination. This is a three hour examination which will take place towards the end of your course. The exam is based on a selection of questions from key Units in the programme.

During the HNC you will develop five Core Skills — *Communication, Numeracy, Information and Communication Technology (ICT), Problem Solving* and *Working with Others*. You will develop these Core Skills to SCQF level 6.

8.2 HND Marine Engineering

Access to the HND is at the discretion of the delivering centre however you would normally be expected to have achieved:

The Higher National Certificate in Marine Engineering at SCQF level 7.

Delivering Centres may also consider you if you have relevant work experience in either the Engineering or Shipping Industries.

If you study the HND you are likely to have completed the first college and sea phase of your Engineering Cadetship and will have gained an NC in Shipping and Marine Operations. You will then have continued on the pathway by studying the HNC in Marine Engineering. On completion of the HNC you will complete further sea time before returning to college to complete the HND and sit the examinations for your Maritime and Coastguard Agency (MCA) Engineering Officer of the Watch Certificate (EOOW).

If you wish to go to sea you should be aware that you must meet the medical standards laid down by the Maritime and Coastguard Agency.

The specific aims of the HND are:

- Provide an award that on successful completion will allow you to progress to a degree in engineering or a related subject discipline area.
- Provide an award that will give academic exemptions for STCW95 Reg III/2 Chief Engineer Unlimited Engineering Certification.
- Develop knowledge and understanding of the external and internal factors that influence the performance of modern marine plant and vessels.
- Develop a range of project management skills.
- Develop the analysis and synthesis skills necessary to ensure the efficient operation of marine plant.

If you successfully complete the HND in Marine Engineering you will be exempt from the academic examinations for the Chief Engineers Certificate which are Applied Mechanics, Applied Heat, Electrotechnology and Naval Architecture. After a further 18 months sea time after gaining your Second Engineers Certificate you will have to sit two MCA Engineering Knowledge examinations for your Chief Engineers Certificate.

In order to gain an HND in Marine Engineering you must gain the 30 SQA credits from the Units and Graded Units you study.

As part of the 2nd year HND Marine Engineering programme of study you will have to complete a 2 credit Graded Unit Project.

The Marine Engineering: Graded Unit 2 has been designed to allow you to develop many of the skills you will require to see a project through from start to finish. Such skills will include technical ones, but you will also develop a very important range of non-technical skills which are required to successfully manage a project such as planning and organisation, oral and written communication, customer care, evaluation skills, time management and many more.

The project will be broken down into the following three stages: planning, development and evaluation. Your Lecturer will expect you to produce documentation for all three stages. Typical documentation will include a project brief, specification, objectives and schedule, a log book and a project report. You will also be required to do 10 minute presentation about your project followed by a 5 minute question and answer session.

Your project will be graded based on the following:

Grade	Marks achieved
A	70%–100%
B	60%–69%
C	50%–59%

Your Lecturer will mark your work using a 23 point checklist which will allow your mark to be identified for each of the three Graded Unit stages — planning, development and evaluation, each with its own Minimum Evidence Requirements. If you meet the Minimum Evidence Requirements and obtain the required minimum 50% mark overall, your achievement will be graded as C (competent), A (highly competent), or B (somewhere between A and C) as indicated above.

Your lecturer will provide you with a guide on how you should undertake project work and explain to you the Minimum Evidence Requirements and the criteria on which your project work will be assessed.

During this HND you will develop five Core Skills — *Communication, Numeracy, Information and Communication Technology (ICT), Problem Solving* and *Working with Others*. You will develop these Core Skills to SCQF level 6, and in addition you will be certificated for the Core Skill Numeracy at SCQF level 6 if you pass the *Marine Engineering: Mathematics* Unit.

As explained previously there are several entry possibilities to the HND Marine Engineering, however the progression through the qualifications to HND would mostly follow the route below:

Entrance
Standard Grade/GCSE passes in four subjects at grade 3/C or above, including Mathematics, a Physical Science, English.

→

NC
Shipping and Marine Operations (With marine engineering options)

→

HNC
Marine Engineering

→

HND
Marine Engineering

↓

Employment
Engineering Officer on worldwide trading vessels.
Maritime regulatory authorities
Ship repair and marine equipment production management
Marine insurance
System Engineer
Plant Engineer

9 Glossary of terms

SCQF: This stands for the Scottish Credit and Qualification Framework, which is a new way of speaking about qualifications and how they inter-relate. We use SCQF terminology throughout this guide to refer to credits and levels. For further information on the SCQF visit the SCQF website at **www.scqf.org.uk**

SCQF credit points: One HN credit is equivalent to 8 SCQF credit points. This applies to all HN Units, irrespective of their level.

SCQF levels: The SCQF covers 12 levels of learning. HN Units will normally be at levels 6–9. Graded Units will be at level 7 and 8.

Subject Unit: Subject Units contain vocational/subject content and are designed to test a specific set of knowledge and skills.

Graded Unit: Graded Units assess candidates' ability to integrate what they have learned while working towards the Units of the Group Award. Their purpose is to add value to the Group Award, making it more than the sum of its parts, and to encourage candidates to retain and adapt their skills and knowledge.

Dedicated Unit to cover Core Skills: This is a non-subject Unit that is written to cover one or more particular Core Skills.

Embedded Core Skills: This is where the development of a Core Skill is incorporated into the Unit and where the Unit assessment also covers the requirements of Core Skill assessment at a particular level.

Signposted Core Skills: This refers to the opportunities to develop a particular Core Skill at a specified level that lie outwith automatic certification.

Qualification Design Team: The QDT works in conjunction with a Qualification Manager/Development Manager to steer the development of the HNC/HND from its inception/revision through to validation. The group is made up of key stakeholders representing the interests of centres, employers, universities and other relevant organisations.

Consortium-devised HNCs and HNDs are those developments or revisions undertaken by a group of centres in partnership with SQA.

Specialist single centre and specialist collaborative devised HNCs and HNDs are those developments or revisions led by a single centre or small group of centres who provide knowledge and skills in a specialist area. Like consortium-devised HNCs and HNDs, these developments or revisions will also be supported by SQA.

Merchant Navy Training Board is the shipping industry's central body for promoting and developing seafarer education, training and skills.

Merchant and Coastguard Agency approves centres offering SQA qualifications that lead to Certificates of Competency.

Certificate of Competency is a legal requirement and proves that you have the relevant qualification, training and expertise to perform a job at sea.

International Convention on Standards of Training, Certification and Watchkeeping for Seafarers sets qualification standards for masters, officers and watch personnel on seagoing merchant ships.

10 Appendices

Appendix 1: MNTB Mapping
Appendix 2: MCA Syllabi
Appendix 3: MCA Unit mapping
Appendix 4: Core Skills
Appendix 5: Preferred order of Unit delivery

Appendix 1: MNTB Mapping

		Phase 3 — HNC Units												Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
UPK	Material selection and testing				x	x													
	General engineering						x							x					
	Maths for engineering												x						
	Single-phase ac circuits										x	x							
	Dynamics				x	x													
	Statics & strength of materials				x	x													
	Thermodynamics		x	x															
	Communications						x			x				x		x			
	IT						x			x				x					
	Quality management															x			
	Safety engineering & the environment													x		x			
	Fundamentals of control systems														x				

Phase 3 — HNC Units														Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
Core/Key Skills	Communication	x				x	x												
	Application of number	x	x	x	x	x		x			x	x	x						
	Working with Others																	x	
	Improving own learning and performance	x														x			
	Problem Solving	x	x	x	x	x		x			x	x	x		x				
	Information and Communication Technology (ICT)						x		x	x				x	x				
Competences	Use appropriate tools for fabrication and repair operations typically performed on ships																x		x
	Use hand tools and measuring equipment for dismantling, maintenance, repair and re-assembly of shipboard plant and equipment																x	x	

Phase 3 — HNC Units														Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
	Use hand tools, electrical and electronic measuring and test equipment for fault finding, maintenance and repair operations																	x	
NOS	A01 Contribute to the stability and watertight integrity of a vessel							x						x					
	A02 Ensure the stability and watertight integrity of a vessel							x						x					
	A12 Respond to emergencies on board a vessel																		
	A13 Control the response to emergencies on board a vessel																		

		Phase 3 — HNC Units												Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
NOS	A32 Maintain safe, legal and effective working practices on board a vessel															x			
	A33 Ensure safe, legal and effective working practices on board a vessel															x			
	A34 Create, maintain and enhance productive working relationships on board a vessel																		
	C03 Take charge of an engine room watch						x							x					
	C11 Prepare and operate vessel propulsion machinery and ancillary systems						x							x					
	C12 Operate vessel auxiliaries and service machinery													x					
	C13 Operate and adjust vessel electrical equipment										x	x							

Phase 3 — HNC Units														Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
	C21 Manage the operation of vessel propulsion machinery and ancillary systems						x							x					
	C22 Manage the operation of vessel auxiliaries, auxiliary boilers and service machinery													x					
NOS	C23 Manage the operation of vessel electrical, electronic and control systems											x			x				
	C24 Manage the Safety of Vessel High Voltage Electrical Systems																		
	C33 Carry out maintenance of vessel electrical machinery and systems																	x	
	C34 Carry out maintenance of vessel mechanical machinery and systems						x							x				x	
	C35 Carry Out Maintenance of Vessel Telecommunication and Navigation Systems																		

		Phase 3 — HNC Units												Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
	C36 Carry out maintenance of vessel instrumentation and control equipment														x				
	C37 Manage Maintenance of Vessel Instrumentation and Control Systems														x				
	C42 Diagnose the Causes of Variations in Vessel Mechanical Systems																	x	
	C43 Diagnose the causes of variations in vessel electrical and electronic systems										x	x							
NOS	C44 Diagnose the causes of variations in vessel instrumentation and control systems														x				
	C45 Diagnose the Causes of Variations in Vessel Telecommunications and Navigation Systems																		
	C51 Plan and schedule vessel engineering operations						x							x					

Phase 3 — HNC Units														Additional					
		Graded Unit 1	Marine Engineering: Marine Heat Engine Principles	Marine Engineering: Auxiliary Thermodynamic Principles	Marine Engineering: Dynamics and Machines	Marine Engineering: Statics and Strength of Materials	Marine Engineering: Propulsion	Marine Engineering: Naval Architecture	Marine Engineering: Ship Construction	Engineering Drawing	Marine Engineering: Electrical and Electronic Devices	Marine Engineering: Electrical Motors and Generators	Marine Engineering: Mathematics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment	Machine Workshop	Plant Workshop	Welding
	C52 Direct Vessel Engineering Operations						x							x					
	C53 Plan maintenance for vessel engineering systems						x							x					
	C54 Develop Maintenance Plans for Vessel Engineering Systems						x							x					
	C55 Prepare vessel response plans for engineering contingency situations						x							x					

HND Units																	
		Graded Unit 2 (Project)	Mathematics for Engineering 2	Marine Engineering: Marine Management	Marine Engineering: Advanced Statics and Dynamics	Marine Engineering: Advanced Marine Thermodynamic Principles	Marine Engineering: Advanced Marine Heat Engine Principles	Marine Engineering: Advanced Naval Architecture	Marine Engineering: Advanced Ship Construction and Survey	Marine Engineering: Electrical Distribution Systems	Marine Engineering: Electrical Power	Process Control	Marine Engineering: Pneumatics and Hydraulic Systems	Marine Engineering: Advanced Applied Mechanics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment
UPK	Engineering skills								x	x		x	x		x	x	x
	Strengths of materials – advanced	x															
	Further Maths for engineering		x														
	Heat transfer and fluid mechanics	x				x	x										
	Applied industrial plant maintenance			x					x	x							
	Three-phase systems	x									x				x	x	
	Business awareness and Continuing Professional Development	x		x													
	Electric motor drive systems	x															
	Plant systems	x			x		x								x		x
	Statutory and operational requirements	x		x											x		x
	Marine engineering			x	x	x	x		x					x	x	x	x
Core/Key Skills	Communication	x		x											x		
	Application of number	x	x		x	x	x	x		x	x			x			
	Working with Others	x		x													
	Improving own learning and performance	x															x
	Problem Solving		x		x	x	x	x		x	x	x	x	x		x	

	Information and Communication Technology (ICT)			x								x	x		x	x	

HND Units																	
		Graded Unit 2 (Project)	Mathematics for Engineering 2	Marine Engineering: Marine Management	Marine Engineering: Advanced Statics and Dynamics	Marine Engineering: Advanced Marine Thermodynamic Principles	Marine Engineering: Advanced Marine Heat Engine Principles	Marine Engineering: Advanced Naval Architecture	Marine Engineering: Advanced Ship Construction and Survey	Marine Engineering: Electrical Distribution Systems	Marine Engineering: Electrical Power	Process Control	Marine Engineering: Pneumatics and Hydraulic Systems	Marine Engineering: Advanced Applied Mechanics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment
NOS	A01 Contribute to the stability and watertight integrity of a vessel			x				x	x								
	A02 Ensure the stability and watertight integrity of a vessel			x				x	x								
	A12 Respond to emergencies on board a vessel			x													
	A13 Control the response to emergencies on board a vessel			x													
	A14 Direct the response to emergencies on board a vessel																x
	A32 Maintain safe, legal and effective working practices on board a vessel			x													x

		HND Units															
		Graded Unit 2 (Project)	Mathematics for Engineering 2	Marine Engineering: Marine Management	Marine Engineering: Advanced Statics and Dynamics	Marine Engineering: Advanced Marine Thermodynamic Principles	Marine Engineering: Advanced Marine Heat Engine Principles	Marine Engineering: Advanced Naval Architecture	Marine Engineering: Advanced Ship Construction and Survey	Marine Engineering: Electrical Distribution Systems	Marine Engineering: Electrical Power	Process Control	Marine Engineering: Pneumatics and Hydraulic Systems	Marine Engineering: Advanced Applied Mechanics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment
	A33 Ensure safe, legal and effective working practices on board a vessel			x													
	A34 Create, maintain and enhance productive working relationships on board a vessel	x		x											x		
	A35 Ensure compliance with the commercial obligations of a vessel			x													
	C03 Take charge of an engine room watch				x	x	x	x		x		x	x		x		
	C11 Prepare and operate vessel propulsion machinery and ancillary systems				x	x	x			x		x	x				
	C12 Operate vessel auxiliaries and service machinery				x	x	x			x		x	x				
	C13 Operate and adjust vessel electrical equipment									x	x				x		

		HND Units															
		Graded Unit 2 (Project)	Mathematics for Engineering 2	Marine Engineering: Marine Management	Marine Engineering: Advanced Statics and Dynamics	Marine Engineering: Advanced Marine Thermodynamic Principles	Marine Engineering: Advanced Marine Heat Engine Principles	Marine Engineering: Advanced Naval Architecture	Marine Engineering: Advanced Ship Construction and Survey	Marine Engineering: Electrical Distribution Systems	Marine Engineering: Electrical Power	Process Control	Marine Engineering: Pneumatics and Hydraulic Systems	Marine Engineering: Advanced Applied Mechanics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment
	C21 Manage the operation of vessel propulsion machinery and ancillary systems			x	x	x	x			x		x	x	x			
	C22 Manage the operation of vessel auxiliaries, auxiliary boilers and service machinery			x	x	x	x					x	x	x		x	
	C23 Manage the operation of vessel electrical, electronic and control systems			x						x	x						
	C24 Manage the Safety of Vessel High Voltage Electrical Systems																
	C33 Carry out maintenance of vessel electrical machinery and systems									x	x				x		

HND Units

		Graded Unit 2 (Project)	Mathematics for Engineering 2	Marine Engineering: Marine Management	Marine Engineering: Advanced Statics and Dynamics	Marine Engineering: Advanced Marine Thermodynamic Principles	Marine Engineering: Advanced Marine Heat Engine Principles	Marine Engineering: Advanced Naval Architecture	Marine Engineering: Advanced Ship Construction and Survey	Marine Engineering: Electrical Distribution Systems	Marine Engineering: Electrical Power	Process Control	Marine Engineering: Pneumatics and Hydraulic Systems	Marine Engineering: Advanced Applied Mechanics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment
NOS	C34 Carry out maintenance of vessel mechanical machinery and systems			x	x	x	x							x			
	C35 Carry Out Maintenance of Vessel Telecommunication and Navigation Systems															x	
	C36 Carry out maintenance of vessel instrumentation and control equipment			x	x	x	x					x	x	x		x	
	C37 Manage Maintenance of Vessel Instrumentation and Control Systems											x					
	C42 Diagnose the Causes of Variations in Vessel Mechanical Systems									x							
	C43 Diagnose the causes of variations in vessel electrical and electronic systems			x						x	x					x	

HND Units

		Graded Unit 2 (Project)	Mathematics for Engineering 2	Marine Engineering: Marine Management	Marine Engineering: Advanced Statics and Dynamics	Marine Engineering: Advanced Marine Thermodynamic Principles	Marine Engineering: Advanced Marine Heat Engine Principles	Marine Engineering: Advanced Naval Architecture	Marine Engineering: Advanced Ship Construction and Survey	Marine Engineering: Electrical Distribution Systems	Marine Engineering: Electrical Power	Process Control	Marine Engineering: Pneumatics and Hydraulic Systems	Marine Engineering: Advanced Applied Mechanics	Marine Engineering: Auxiliary Systems	Fundamentals of Control Systems	Safety Engineering and the Environment
	C44 Diagnose the causes of variations in vessel instrumentation and control systems			x						x		x	x				
	C45 Diagnose the Causes of Variations in Vessel Telecommunications and Navigation Systems														x		
	C51 Plan and schedule vessel engineering operations			x	x	x	x					x	x	x	x		
	C52 Direct Vessel Engineering Operations			x											x		
	C53 Plan maintenance for vessel engineering systems			x	x	x	x		x	x		x	x	x	x		
	C54 Develop Maintenance Plans for Vessel Engineering Systems			x											x		
	C55 Prepare vessel response plans for engineering contingency situations			x	x	x	x		x	x		x	x	x	x		

Appendix 2: MCA Syllabi

Second Engineer Reg III/2 — Applied Mechanics

LIST OF TOPICS

A Statics
B Friction
C Kinematics
D Dynamics
E Machines
F Strength of Materials
G Hydrostatics
H Hydrodynamics

A STATICS

1 Solves problems involving forces in static equilibrium.

1.1 Defines vector and scalar quantities.

1.2 States examples of vector and scalar quantities.

1.3 Represents graphically the vector quantity force.

1.4 Determines the addition and difference of forces — graphically and analytically.

1.5 Explains the terms: Equilibrium; Resultant and Equilibrant.

1.6 Solves graphically problems involving Equilibrium Resultant and Equilibrant in concurrent coplanar force systems.

1.7 Defines the moment of a force.

1.8 Explains the principle of moments.

1.9 States the conditions of equilibrium for non-current coplanar force systems.

1.10 Solves problems graphically involving 1. 9 for a maximum of four forces.

1.11 Explains that three non parallel coplanar forces must be — concurrent for equilibrium.

1.12 Resolves forces into components at right angles, and in one or two planes.

1.13 Repeats 1.6 and 1.10 by analytical methods.

1.14 Describes stable, unstable and neutral equilibrium.

2 Discusses pin jointed frameworks and their solution.

2.1 Explains what is meant by a pin joint.

2.2 Explains Bows notations with reference to simple frameworks.

2.3 Determines the support reactions for simple frameworks subjected to a maximum of three vertically applied forces, by graphical and/or analytical methods.

2.4 Explains the terms Strut and Tie.

2.5 Determines the magnitude and nature of the force in the members of simple frameworks by graphical methods.

3 Solves problems involving centres of gravity and centroids.

3.1 Explains how a centre of gravity can be determined by taking moments of mass.

3.2 Explains how a centroid can be determined by taking moments of area.

3.3 Solves problems involving centres of gravity for bodies made up of combinations of: Cubes, rectangles, cylinders, square pyramids, cones and hemispheres. (NB, C of G positions for pyramids, cones and hemispheres to be given).

3.4 Solves problems involving centroids for laminas made up of combinations of: Rectangles, Circles, Triangles, Semi circles. (NB, Centroid position for semicircle — to be given).

3.5 Repeats 3.3 and 3.4 when negative quantities are involved.

B FRICTION

4 **Discusses the effects of friction when one rigid body slides or tends to slide over another rigid body**.

4.1 States the laws of dry friction.

4.2 Defines friction angle.

4.3 Distinguishes between static and dynamic friction.

4.4 Describes in simple terms the effects of lubrication.

4.5 States examples of both useful and detrimental effects of friction in engineering.

4.6 Solves simple problems involving: frictional force, normal reaction and coefficient of friction, for bodies on horizontal planes subjected to normal and inclined forces.

4.7 Describes the resolution into normal and parallel components of the gravitational forces of a body on an inclined plane.

4.8 Defines angle of repose.

4.9 Solves problems involving: frictional force, normal reaction and coefficient of friction for bodies both at rest and moving up or down an inclined place with uniform velocity.

C KINEMATICS

5 Solves problems involving linear, angular and relative motion.

5.1 Explains the terms displacement, velocity, speed and acceleration for linear motion.

5.2 Sketches distance/time graphs for constant velocity and identifies the slope as velocity.

5.3 Solves problems related to 5.2.

5.4 Sketches velocity/time graphs for uniform acceleration and identifies the slope as acceleration and the area as displacement.

5.5 Solves problems related to 5.4.

5.6 Derives the equations:

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

$$s = \frac{(u+v)}{2}t$$

5.7 Solves the problems involved in 5.6.

5.8 Repeats 5.1 to 5.7 for angular motion.

6 Describes the motion of projectiles and solves associated problems involving moving objects.

6.1 Resolves the velocity of an inclined projectile into horizontal and vertical components.

6.2 States that the acceleration of the vertical motion is 'g' and the acceleration of the horizontal motion is zero.

6.3 Solves problems involving vertical and inclined projectiles (assuming no air resistance).

7 Understands and uses the concept of relative velocity.

7.1 Defines relative and absolute velocity.

7.2 Determines the relative velocity between two coplanar linear velocities.

7.3 Solves problems relating to 7.2 and to include elapsed time and closest approach.

D DYNAMICS

8 Discusses the concepts of force and energy and solves associated problems.

8.1 States Newtons 1st law of motion and explains the effect of force.

8.2 Defines linear momentum.

8.3 States Newtons 2nd law of motion.

8.4 Derives the expression: force = mass x acceleration.

8.5 Defines the newton.

8.6 States Newtons 3rd law of motion.

8.7 Explains the terms tractive effort and tractive resistance.

8.8 Solves problems involving force, mass and acceleration on vertical horizontal and inclined planes, and to include friction.

8.9 States the Law of conservation of linear momentum.

8.10 Solves problems relating to 8.9.

8.11 Defines work done and energy.

8.12 Derives the expressions for Potential Energy and Kinetic Energy of translation.

8.13 States the law of conservation of energy.

8.14 Defines power.

8.15 Derives the expression: Power = Force x Velocity.

8.16 Solves problems involving energy, work and power.

8.17 Sketches work diagrams for both constant forces and uniformly varying forces.

8.18 States that the areas under the diagrams at 8.17 above represents work done.

8.19 Determines the mean height of work diagrams from:

$$\frac{TotalArea}{BaseLength}$$

8.20 Discusses 8.17 with reference to springs and relates the slope of the diagram to spring rate (stiffness).

8.21 Solves problems relating to 8.17 to 8.20.

8.22 Defines torque.

8.23 Derives the expressions:

$$WorkDone = T \times \Theta \quad Power = T \times \omega = 2\pi NT$$

8.24 Solves problems relating to 8.23 and to include power lost due to bearing friction.

9 Discusses centripetal and centrifugal effects and solves associated problems.

9.1 Derives the expression for centripetal acceleration.

9.2 Relates centripetal acceleration and centripetal force.

9.3 Explains the concept of centrifugal force.

9.4 Determines graphically whether a coplanar rotating mass system is in equilibrium.

9.5 Determines the unbalanced force and balancing mass required for coplanar rotating mass systems not in equilibrium.

9.6 Describes a conical pendulum.

9.7 Solves problems involving simple conical pendulum.

E MACHINES

10 Discusses the principles of simple machines and solves associated problems.

10.1 Describes the concepts of a simple lifting machine.

10.2 Defines the terms: *Effort, Load, Mechanical advantage (MA), Velocity or Movement ratio (VR) and Efficiency.*

10.3 Derives the expression: $Efficiency = \frac{MA}{VR}$

10.4 Derives the expressions for the Velocity Ratios of the following lifting machines: wheel and axle, differential wheel and axle, rope pulley blocks, differential rope pulley blocks, chain blocks, screw jack, Warwick screw, worm and wheel mechanisms, hydraulic jack.

10.5 Solves problems relating to 10.2, 10.3 and 10.4.

10.6 Describes the transmission of power and torque through simple and compound gear systems.

10.7 Explain briefly the term: Involute, Addendum Dedendum, Pitch circle and Pressure angle.

10.8 Discusses the characteristic of straight cut and helical gears.

10.9 Solves problems involving speed ratio, power and torque transmitted for geared system.

10.10 Derives expressions for the velocity ratios of single and double purchase winches.

10.11 Solves problems relating to 10.2, 10.3 and 10.10.

10.12 Sketches graphs of: Effort/Load, MA/Load, Efficiency/Load, for lifting machines.

10.13 Explains the law of a machine.

10.14 Determines the law of a machine by both graphical and analytical methods.

10.15 Explains power transmission via flat belt drives.

10.16 Determines the torque transmitted in terms of belt tensions.

10.17 Solves problems involving: speed ratios, power and torque transmitted for belt drive system.

F STRENGTH OF MATERIALS

11 Discusses the effects on a material caused by the application ofexternal forces and solves associated problems.

11.1 Defines stress as force per unit cross sectional area.

11.2 Defines direct stress and shear stress.

11.3 Defines direct strain.

11.4 Explains the term Elasticity and defines Modulus of Elasticity ‘E’.

11.5 Solves simple problems relating to 11.1 to 11.4.

11.6 Sketches the load/extension graph for mild steel loaded in tension to destruction and indicates: limit of proportionality, elastic limit, yield point, ultimate load and breaking load.

11.7 Sketches a typical specimen for the test at 11.6 and to indicate a cup and cone fracture.

11.8 Defines UTS and breaking stress.

11.9 Draws a load/extension graph from experimental data and from it obtain: E, UTS yield stress, limit of proportionality, % area reduction, % elongation.

11.10 Defines ductility and states how it is indicated by a tensile test.

11.11 Explains the terms: Hardness, Malleability and Plasticity.

11.12 Explains the term proof stress and states how it is obtained from a stress/strain graph.

11.13 Defines 'Factor of Safety' and states features to be considered when deciding upon its value.

11.14 Solves problems related to 11.1 to 11.13.

12 Discusses the effect of temperature change on materials.

12.1 Defines the term ‘Coefficient of Linear expansion’.

12.2 Determines the linear expansion (or contraction) of members subjected to a temperature change.

12.3 Determines the linear strain in single members when expansion (or contraction) is restricted.

12.4 Determines the thermal stresses associated with 12.3.

13 Solves problems involving stresses in thin cylinders subjected to an internal pressure.

13.1 Explains the term 'thin cylinder'.

13.2 Derives the expression for Hoop Stress and Longitudinal stress in thin cylinders.

13.3 States the assumptions made when developing the expression in 13.2.

13.4 Solves problems related to 13.2.

14 Solves problems involving stress in thin rotating rims.

14.1 Derives the expression for the Hoop Stress in a thin — rotating rim.

14.2 Solves problems related to 14.1.

15 Solves problems involving cantilever and simply supported beams.

15.1 Explains the terms 'cantilever1 and simply supported' with reference to beams.

15.2 Describes point loading and uniformly distributed loading.

15.3 Determines support reactions for beams subjected to combinations of the loading at 15.2.

15.4 Defines the terms Shear Force and Bending Moment.

15.5 Explains the need for sign convention when dealing with SF_s and BM_s

15.6 Determines the SF and BM at any section along a beam.

15.7 Sketches and draws to scale SF and BM diagram from results of 15.6.

15.8 Defines point of contraflexure.

15.9 Determines maximum bending moment and point(s) of contraflexure from BM diagram.

15.10 States the expression-. $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$ and defines each term.

15.11 Explains the term Neutral Axis.

15.12 States the I_{NA} values for the following sections: square, rectangle, circle, annulus.

15.13 Solves problems relating to 15.6, 15.10 and 15.12.

16 Solves problems involving torsion on circular shafts.

16.1 States the expression: $\frac{T}{J} = \frac{\sigma}{y} = \frac{G\Theta}{l}$ and defines each.

16.2 Explains the Polar Axis.

16.3 States the J values for solid and hollow circular sections.

16.4 Differentiates between maximum torque and mean torque.

16.5 Determines the shear force in shaft coupling bolts given the transmitted torque.

16.6 Solves problems relating to 16.1 to 16.5.

G HYDROSTATICS

17 Discusses the principle of Archimedes and solves associated problems.

17.1 States Archimedes principle.

17.2 Solves problems involving bodies totally and partially immersed in liquids.

18 Solves problems involving hydrostatic forces on immersed areas.

18.1 Derives the expression: Pressure pgh.

18.2 Describes the principle of: U-Tube manometers; inclined manometer; and mercury barometer.

18.3 Solves problems related to 18.1 and 18.2.

18.4 Sketches the pressure distribution diagram for an immersed vertical surface with one edge in the free surface.

18.5 Derives the expression for the resultant force on a vertical immersed surface.

18.6 Sketches the force diagram for a rectangular surface vertically immersed with one edge in the free surface.

18.7 Defines 'centre of pressure and identifies its position in 18.6 above.

18.8 Solves problems on rectangular and triangular surfaces vertically immersed in single liquids with one edge in the free surface and to include centre of pressure and wetted on each side.

H HYDRODYNAMICS

19 Solves problems related to liquids in motion.

19.1 Derives the continuity equation in terms of both volume and mass.

19.2 Applies 19.1 above to the flow of liquid through parallel pipes.

19.3 Explains the concepts of: C_v, C_c and C_d for a sharp edge orifice.

19.4 Discusses the motion of the jet in relation to the projectile theory.

19.5 Solves problems involving the flow of liquids through a sharp edged orifice under a constant liquid head.

Second Engineer Reg III/2 — Engineering Drawing

LIST OF TOPICS

The expected learning Outcome is that the candidate:

General Note:

It is expected that candidates will be aware of, and work in accordance with, the British Standard BS 308.

A ENGINEERING COMMUNICATION

1 Discusses the need for Engineering Drawing as a means of communication.

1.1 States the need for:

(a) single component detail drawings;
(b) sub-assembly and assembly drawings.

B DRAWING EQUIPMENT

2 Discusses the use and care of drawing instruments.

2.1 Demonstrates the use of the following:

(a) Drawing Board;
(b) Tee Square;
(c) Set Squares (45° and 30°);
(d) Compasses;
(e) Spring Bows;
(f) Metric Scale Rule;
(g) Pencils;
(h) Eraser;
(i) Protractor;
(j) Dividers.

2.1 States how the above instruments should be cared, for.

C PROJECTION

3 Discusses the use of orthographic projection in Engineering Drawing.

3.1 States the need for orthographic projection.

3.2 Explains the terms by reference to simple examples:

(a) 1st angle projection;
(b) 3rd angle projection.

3.3 Prepares drawings of simple components in both 1st and 3rd angle projections.

3.4 Repeats 3.3 above to include sectional views.

D ASSEMBLY DRAWINGS

4 Produces general assembly drawings from dimensioned isometric views of components comprising a common piece of marine engineering machinery.

4.1 Prepares general assembly drawings as identified at 4 above; scales, lines, dimensions, abbreviations, conventions and standard parts to be in accordance with BS 8888:2004 Technical Product Documentation and PD 7308

Second Engineer Reg III/2 — Marine Electrotechnology

LIST OF TOPICS

A Electric and Electronic Components
B Electric Circuit Principles
C Electromagnetism
D Electrical Machines

The expected learning Outcome is that the candidate:

A ELECTRIC AND ELECTRONIC COMPONENTS

1 Understands the physical construction and characteristics of basic components.

1.1 Compares the characteristics of conductors, semi-conductors and insulators in terms of the Electron Theory.
1.2 Defines the basic quantities of electricity, eg charge, current, emf, potential difference, energy and power.
1.3 Describes resistance, inductance and capacitance in terms of physical dimensions and materials.
1.4 Solves numerical problems relating R, L and C to their physical parameters.
1.5 Appreciates how temperature affects conductors, semi- conductors and insulators.
1.6 Defines temperature coefficient of resistance at O˚C (α_0) and also at a stated temperature (α_t).
1.7 Calculates change in conductor resistance using the temperature coefficients in 1.6.
1.8 Draws and labels the principal parts of a lead acid cell.
1.9 Describes (without using chemical formulae) the action of charge and discharge on the components of the cell.
1.10 Explains how the state of charge of a lead acid cell may be measured using a hydrometer.
1.11 Draws and labels the principal parts of an alkaline cell, Nickel iron or nickel cadmium.
1.12 Explains how the state of charge may be assessed for alkaline cells.
1.13 Compares lead acid and alkaline cells on the basis of:
(a) voltage per cell;
(b) performance under poor conditions of charge/discharge;
(c) retention of charge;
(d) effect of temperature;
(e) mechanical strength;
(f) weight;
(g) cost.
1.14 States that the capacity of a battery is measured in ampere hours at a given rate.

1.15 Solves problems on efficiency of batteries in terms of ampere-hours and watt-hours.

1.16 Solves problems involving batteries in series and in parallel combinations including internal resistance and current in a connected load.

1.17 Draws a simple charging circuit from a dc supply.

1.18 Measures the state of charge of a battery before and after carrying out the charging procedure.

1.19 States the two common types of semi conductor material as germanium and silicon.

1.20 Explains the formation of 'p' type and 'n' type semi conductor materials referring to the doping process.

1.21 Draws a p-n junction in forward and reverse bias modes and indicates electron flow and conventional current flow in the junction and in the external circuit.

1.22 Obtains the static characteristic curves for forward and reverse biasing of the pn junction from test results.

1.23 States the need for rectification of alternating voltages.

1.24 Explains and draws circuit diagrams to show how rectification of an ac single phase supply is obtained using:

one diode; two diodes and centre tapped transformer; and bridge connected diodes.

1.25 Draws the input and output waveforms for the rectifier circuits in 1.24.

1.26 Explains the formation of a pnp and npn alloy junction transistor.

1.27 Draws a circuit diagram showing pnp and npn transistors connected in the common emitter mode.

1.28 Draws and explains a circuit diagram illustrating the use of a transistor as a switch.

1.29 Draws and explains a circuit diagram illustrating the use of a transistor as an alternating small signal amplifier.

1.30 Describes the photo-electric effect and its application to photo-diodes.

1.31 State some marine applications of 1.28 and 1.30.

B ELECTRIC CIRCUIT PRINCIPLES

2 Understands the operation of simple linear dc and ac electrical circuits and solves related problems.

2.1 States Ohms Law.

2.2 Solves problems on 2.1.

2.3 States Kirchhoffs Current Law.

2.4 States Kirchhoffs Voltage Law.

2.5 Describes a series circuit configuration using a variety of components and finds the equivalent resistance.

2.6 Describes a parallel circuit configuration using a variety of components and finds the equivalent resistance.

2.7 Solves problems on series/parallel circuits.

2.8 Solves problems on power and energy in dc resistive circuits.

2.9 Solves problems using Kirchhoffs laws by application of simultaneous equations (two unknowns only).

2.10 Explains the principle of the Wheatstone bridge and derives the balance equation.

2.11 Solves problems related to 2.10.

2.12 Defines an alternating emf in terms of its maximum value, rms level, periodic time, frequency and its time equation.

2.13 States that e = E MAX sin 2reft volts.

2.14 Explains that the resultant current will also be sinusoidal and represented by i = I MAX sin 21-rft amperes.

2.15 Solves problems related to 2.13 and 2.14.

2.16 Draws the wave forms for above and indicates peak value; peak to peak value; periodic time; frequency.

2.17 Explains terms, mean value, rms value and form factor with reference to a sine wave.

2.18 Calculates the rms value, mean value and form factor of sinusoidal and non-sinusoidal wave forms.

2.19 Explains the term phasor quantity.

2.20 Explains how phasors 535353àbe used to represent sinusoidal quantities.

2.21 Solves graphical problems involving addition and subtraction of ac voltages and currents using phasor method.

2.22 Sketches the current, voltage and power waveform patterns of a pure:

(a) resistor;
(b) inductor;
(c capacitor;

when connected to a sinusoidal supply.

2.23 Draws phasor diagrams for pure resistive, inductive and capacitive circuits and distinguishes between in phase, lagging and leading currents.

2.24 Defines and calculates inductive reactance and capacitive reactance.

2.25 Constructs and uses phasor diagrams for R-L, R-C and R-L-C series circuits.

2.26 Sketches and uses impedance triangles for the series circuits in 2.25.

2.27 Defines phase angle and active and reactive components.

2.28 Resolves phasor quantities into active, and reactive components, eg I cos 0 and I sin 0.

2.29 Solves circuit problems using circuit elements connected as in 2.28.

2.30 Constructs a diagram in terms of active power, apparent power and reactive power.

2.31 Defines power factor as the ratio of active power to apparent power.

2.32 Solves problems related to 2.30 and 2.31.

2.33 Measures and notes value of V, I and P in an R-C and R-L series ac circuit.

2.34 Draws a phascr diagram from the results in 2.33 and calculates the power factor and capacitance/inductance of the circuit.

C ELECTROMAGNETISM

3 Understands the principles of magnetism and electromagnetic induction.

3.1 Explains the terms magnetic polarity, magnetic field, magnetic flux, magnetic flux density.

3.2 States that a current carrying conductor produces a magnetic field.

3.3 Draws the magnetic field pattern for a straight conductor, loop and a solenoid carrying current.

3.4 Determines the polarity of fields in 3.3 using corkscrew rule, right-hand gripping rule, end rule as appropriate.

3.5 Explains the terms magnetomotive force and magnetic field strength.

3.6 Explains the effect of introducing a magnetic material into a magnetic field.

3.7 States the Units of flux and flux density.

3.8 Explains the use of magnetic screening.

3.9 Explains the term reluctance and states the advantages and disadvantages of leaving air gaps in magnetic circuits.

3.10 States that $S = \frac{F}{\Phi}$

3.11 Explains the terms

(a) absolute permeability;
(b) permeability of free space;
(c) relative permeability.

3.12 States that $B = \mu_0 \mu_r H$ and explains that μ_r is not a constant.

3.13 Draws the B-H curve for a non magnetic material.

3.14 Draws the B-H curve for a typical ferromagnetic material.

3.15 States that different ferromagnetic materials will give different B-H curves.

3.16 Solves problems on simple non composite magnetic circuits to include the use of graphs.

3.17 Solves problems on composite magnetic circuits (to include air gap) and the effect of fringing and leakage.

3.18 States that a current carrying conductor in a magnetic field has a force exerted on it.

3.19 Determines the direction of the force in 3.18.

3.20 States that the magnitude of the force is given by $F = BIl$

3.21 Solves problems related to 3.20.

3.22 States that the ampere is defined on the basis of the force between two current carrying conductors.

3.23 States Faraday's law of electromagnetic induction.

3.24 States Lenz's Law.

3.25 States that the magnitude of the emf induced in a coil is determined by:

(a) the number of turns;

(b) the rate of change of flux cutting the coil and $e = \frac{N\Delta\Phi}{\Delta t}$ volts.

3.26 Explains that other factors, principally the material of the coil core, also determine the value of induced emf.

3.27 Solves problems related to 3.25.

3.28 States that an emf can be self induced in a coil.

3.29 States that $e = \frac{L\Delta_i}{\Delta t}$ volts.

3.30 Defines the unit of self inductance.

3.31 States that $L = N\frac{\Delta\Phi}{\Delta I}$ and $L = \frac{N^2}{S}$

3.32 Solves problems related to 3.29, 3.31.

3.33 Shows that the energy stored in the magnetic field of a current carrying coil is given by $\frac{1}{2}L^2$ joules.

3.34 States that changing magnetic flux emanating from one circuit can induce an emf in another.

3.35 States that the effect in 3.34 is called mutual inductance.

3.36 Defines the unit of mutual inductance.

3.37 States that the emf of mutual inductance is given by:

$e = M\frac{\Delta_i}{\Delta_t}$ and $M = k\sqrt{L_1}L_2$

3.38 States examples of mutual inductance effect, eg transformer, engine ignition coil.

3.39 Solves problems related to 3.37.

3.40 States that a conductor moved in and at right angles to a magnetic field will have an emf induced between its ends and determines its direction.

3.41 States that the magnitude of the emf will be determined by $E = Blv$ volts.

3.42 Solves problems related to 3.41.

D ELECTRICAL MACHINES

4 Understands the principles and applications of dc and ac motors and generators.

4.1 States that:

(a) motors convert electrical energy into mechanical energy;
(b) generators convert mechanical energy into electrical energy.

4.2 Explains using simple sketches the action of a single loop dc generator and motor.

4.3 Describes the function of a commutator.

4.4 Labels on a given diagram the essential parts of a dc machine.

4.5 Sketch circuits for shunt, series and compound wound dc machines.

4.6 Relates the emf induced in the armature of a dc generator to the expression $E = 2Z\Phi n\frac{p}{A}$ volts

4.7 Solves problems related to 4.6.

4.8 Solves dc generator circuit problems using $V = E - I_A R_A$

4.9 Obtains the load characteristics of shunt and compound dc generators.

4.10 Relates the 'back emf' (E_b) induced in the armature of a dc motor to the expression $E_b = 2Z\Phi n\frac{p}{A}$ volts.

4.11 Solves dc motor circuit problems using $V = E_b + I_a R_a$.

4.12 Explains the need for starting resistance for a dc motor.

4.13 Explains the method of speed control for a dc motor using variation of armature voltage and field methods.

4.14 Explains that for a dc machine $E \alpha \Phi n$ and $E \alpha Ia \Phi$

4.15 Solves problems using

$\frac{E_1}{E_2} = \frac{\Phi_1}{\Phi_2} \times \frac{n_1}{n_2}$ and $\frac{T_1}{T_2} = \frac{Ia_1}{Ia_2} \times \frac{\Phi_1}{\Phi_2}$

4.16 Recognises the power losses which occur in dc machines.

4.17 Obtains the load characteristics (T/Ia) of shunt, series and compound dc motors.

4.18 Explains the basic operation of an ac generator.

4.19 Labels on a given diagram the essential parts of a 3-phase, ac generator of both salient and cylindrical rotor construction.

4.20 Explains how to safely synchronise an incoming 3-phase ac generator to live busbars using lamps and/or synchroscope and voltmeters.

4.21 Obtains the load characteristics of a 3-phase ac generator under various power factor conditions.

4.22 Explains the basic principle of operation of the 3-phase single cage ac induction motor.

4.23 Describes with sketches the construction of the 3-phase single cage ac induction motor.

4.24 Obtains the load characteristic (T/n) of a 3-phase ac single cage induction motor.

4.25 States typical marine applications for the motors in 4.17 and 4.23 and generators.

Second Engineer Reg III/2 — Mathematics

LIST OF TOPICS

A Arithmetic
B Algebra
C Logarithms
D Graphs
E Trigonometry
F Mensuration
G Calculus: Differentiation
H Calculus: Integration

A ARITHMETIC

1 Expresses quantities in the form of a ratio, proportion or percentage.

1.1 Compares two quantities of the same kind by expressing one as a Ratio of the other.

1.2 States that proportion is an equation of ratios.

1.3 States that percentage is a ratio multiplied by 100.

1.4 Expresses fractional and decimal quantities in the form of a percentage.

1.5 Expresses an increase or gain as a percentage.

1.6 Expresses a decrease or contraction as a percentage.

1.7 Expresses an error as a percentage.

1.8 Solves problems related to 1.1 to 1.7.

1.9 Understands similarity and proportion; simple objects to scale (length, area, volume and mass).

1.10 Understands rates, averages, proportional rates of doing work and cost.

1.11 Understands concepts such as ‘man hours’, ‘kWh’, etc.

1.12 Solves problems related to 1.9 to 1.11.

B ALGEBRA

2 Uses the rules of Algebra and solves associated problems.

2.1 Represents quantities by numbers, letters and symbols.

2.2 Adds algebraic quantities, both positive and negative.

2.3 Subtracts algebraic quantities, both positive and negative.

2.4 States the effect of plus or minus signs in front of a bracketed quantity or quantities.

2.5 States the effect of the plus or minus signs in the multiplication and division of quantities.

2.6 Defines the term index (power).

2.7 States what is meant by fractional, negative and zero indices.

2.8 States the rules for addition, subtraction and product of indices.

2.9 Solves problems related to 2.6, 2.7 and 2.8.

2.10 States the 'Law of Distribution'.

2.11 States the product of two binomial expressions.

2.12 States the square of a binomial expression (a ± b)2.

2.13 States the product of the sum and difference of two algebraic quantities (a + b) (a - b).

2.14 Expands (a ± b)3 and factors of a3 $\underline{+}$ b3.

2.15 Solves problems involving the multiplication and division of polynomial expressions by binomial expressions.

2.16 Factorises expressions which have one factor consisting of one term only.

2.17 Factorises expressions of four terms which can be expressed as the product of two binomials.

2.18 Factorises expressions of the type ax2 + bx + c, where a, b and c have numerical values, including both

- (a) cases when a is equal to 1;
- (b) cases when a is not equal to 1.

2.19 Factorises trinomials which form a perfect square.

2.20 Factorises the difference of two squares.

2.21 Solves problems involving the addition and subtraction of algebraic fractions.

2.22 Solves problems involving the multiplication and division of algebraic fractions (both 2.21 and 2.22 to be limited to polynomials no greater than binomial expressions).

2.23 Defines an equation as a statement of equality.

2.24 Simplifies and solves linear equations.

2.25 Understands the axioms

- (a) if equal quantities be added to two quantities that are already equal, the results will be equal;
- (b) if equal quantities be subtracted from two quantities that are already equal, the remainders will be equal;
- (c) equal quantities when multiplied or divided by the same quantity will give results that are equal.

2.26 Solves problems on the transposition of algebraic expressions.

2.27 Develops linear equations consistent with data provided in a question, and finds the solution to these equations.

2.28 Solves linear simultaneous equations of two unknowns

- (a) by the method of substitution;
- (b) by the method of elimination.

2.29 Solves linear simultaneous equations of three unknowns.

2.30 Develops linear simultaneous equations of two unknowns consistent with data provided in a question, and finds the solution to those equations.

2.31 States what is meant by the roots of a quadratic equation.

2.32 Solves quadratic equations that factorise.

2.33 States the general formula for solution of a quadratic $ax^2+bx+c=0$.

2.34 Solves quadratic equations using the general formula.

2.35 Solves simultaneous equations of two unknowns consisting of linear and quadratic equations.

2.36 Describes direct and inverse variation.

2.37 Describes the use of the constant of variation.

2.38 Solves problems involving 2.35 and 2.36.

C LOGARITHMS

3 Uses logarithms to undertake simple calculations (not directly examinable but such knowledge will be assumed).

3.1 Define's logarithms.

3.2 States laws of logarithms.

3.3 Uses laws of logarithms to evaluate powers etc.

3.4 States base of natural logarithms.

3.5 Evaluates expressions involving natural logarithms.

D GRAPHS

4 Discusses the graphic representations of numerical quantities.

4.1 States that graph axis are abscissa and ordinate, and indicates their positions.

4.2 Defines the dependent and independent variables.

4.3 Identifies the axis on which the dependent and independent variables are plotted.

4.4 Determines plotting points, having been given or having calculated x and y values.

4.5 Determines suitable scales for plotting values calculated at 4.4.

4.6 Plots linear and non-linear graphs (scales to be given in examination).

4.7 States that for a linear graph, only two plotting points are required.

4.8 States that plotting points may be given in the form: $x = 1$, $y = 2$, or (1,2).

4.9 States that the law of a straight line graph is of the form: $y = ax + b$, and defines a and b.

4.10 Writes the equation $y = aX^2 + b$ in the form of a straight line.

4.11 Solves graphically problems of the form $pV^n = C$, where n is unknown.

4.12 States that two simultaneous equations plotted as graphs on the same axis have solutions where the graphs intersect.

4.13 States that the solution to a quadratic equation is given by the points where the graph of the quadratic equation crosses the x-axis, ie where $y = 0$.

4.14 States that the solution to simultaneous quadratic equations is given by the points where the graphs of the equations intersect.

4.15 Solves equations by graphical addition.

4.16 Solves graphic problems of trigometric form no more complex than $y = a \sin mx + b \cos nx$, and finds the solution of simultaneous equations involving such graphs.

4.17 Solves graphical problems of the form $y = a \tan mx$.

E TRIGONOMETRY

5 Discusses and uses the basic laws of trigonometry.

5.1 States that angles are measured in degrees or radians and relates the two.

5.2 Defines acute, right, obtuse and reflex angles.

5.3 Defines complementary angles and supplementary angles.

5.4 Defines Sine, Cosine, Tangent, Secant, Cosecant, Cotangent and the relationships between them.

5.5 Determines Sin, Cos and Tan from given right angled triangle.

5.6 Reads values of Sin, Cos, Tan, Sec, Cosec and Cot for any angle between 0’ and 90’.

5.7 Determines an angle from tables knowing its sin, cos, tan, sec, cosec or cot.

5.8 Determines values of sin, etc for angles 90’–360’ and also is able to obtain an angle (00–360’) knowing its sin, etc.

5.9 States the theorem of Pythagoras.

5.10 Solves right angled triangles for any side or angle.

5.11 States the Sine Rule.

5.12 States the Cosine Rule.

5.13 Solves any triangle for any side or angle using the above rules.

F MENSURATION

6 Solves problems related to plane figures and solids.

6.1 States the formulae for the determination of the areas of a rectangle, parallelogram, triangle, polygon, trapezium, circle, annulus, ellipse, segment and sector.

6.2 Determines the area of a triangle, given

(a) all three sides;
(b) two sides and an included angle;
(c) the base and vertical height.

6.3 Solves problems involving 6.1 and 6.2 to include the application of trigonometry and geometry as specified in previous objectives.

6.4 Determines the mean height of a figure from area and length.

6.5 States the formulae for determining the volume of a cube, oblong, cylinder, cone, square, pyramid and sphere.

6.6 Determines masses of solids at 6.5.

6.7 Determines the surface area of solids given at 6.5 (formulae for sphere to be given).

G CALCULUS — DIFFERENTIATION

7 Discusses differential calculus and solves associated problems.

7.1 Determines the gradient of a chord.

7.2 Discusses the concept of elemental lengths x and y.

7.3 Discusses the meaning of the limiting value of δy/δx as X - 0, defining it as dy/dx

7.4 Derives the derivative of ax^n where n is +ve or -ve.

7.5 Determines the derivatives of multinomial algebraic expressions.

7.6 States the derivative of a constant.

7.7 Discusses the concept of 2nd derivatives.

7.8 Repeats 7.5 for 2nd derivatives.

7.9 States the derivatives for sinx, cosx and lnx.

7.10 Determines the 1st derivatives of functions involving

7.11 Discusses the concept of rate of change.

7.12 Determines velocity from displacement-time functions and acceleration from velocity-time functions.

7.13 States that at the turning point of a curve, the differential coefficient is zero.

7.14 Discusses the concept of maximum and minimum.

7.15 Identifies max/min values for examination of 2nd derivative.

7.16 Determines the max and/or min volumes for given functions.

7.17 Writes derivatives in terms of functional notation.

H CALCULUS — INTEGRATION

8 Discusses integral calculus and solves associated problems.

8.1 States that integration is the reverse of differentiation.

8.2 Discusses the concept of the indefinite integral and the need for a constant.

8.3 States the integral of ax^{n} where n 3≠ -1.

8.4 Determines the integrals of multinomial algebraic expressions by applying 8.3.

8.5 Determines the constant of integration from given conditions.

8.6 Discusses the concept of limits.

8.7 Repeats 8.4 and includes limits.

8.8 States the integrals of sinx and cosx.

8.9 Determines the integrals of functions involving 8.8.

8.10 Discusses the concept of elemental summation to determine areas and volumes and relates this to integration.

8.11 Determines areas and volumes by integration given the law of the boundary curve and limits.

8.12 Derives expressions for the area under the curve, given by $pV^{n} = C$.

8.13 Solves problems relating to 8.12.

Second Engineer Reg III/2 — Naval Architecture

LIST OF TOPICS

A Hydrostatics
B Simpson's Rule
C Ship Stability
D Ship Resistance
E Admiralty Coefficients
F Fuel Consumption
G Ship Terminology
H Ship Construction
I Ship Stresses
J Ventilation and Drainage of Compartments

The expected learning Outcome is that the candidate:

A HYDROSTATICS

Calculations — Displacement and Buoyancy

1 Understands the principles of flotation.

1.1 Applies the principle of floating bodies to ships.

1.2 Explains that the displacement of a ship is equal to the mass of the volume of water which the ship displaces.

1.3 Demonstrates that the volume of displacement is represented by the area of the curve of immersed cross-sectional areas.

1.4 Demonstrates that the volume of displacement at any given draught is represented by the area of the waterplane area curve to that draught.

1.5 Calculates values of displacement for a range of draughts and plots the displacement curve.

1.6 Shows that the displacement curve is one of the hydrostatic curves.

1.7 Defines buoyancy and centre of buoyancy.

1.8 Explains the relation between buoyancy and displacement.

1.9 Explains that if a ship is upright the transverse centre of buoyancy lies on the centreline.

1.10 Explains that the longitudinal centre of buoyancy is represented by the longitudinal centroid of the curve of immersed cross-sectional areas.

1.11 Shows that the curve of longitudinal centre of buoyancy against draught is one of the hydrostatic curves.

1.12 Explains that the vertical centre of buoyancy at any given draught is represented by the vertical centroid of the curve of waterplane areas to that draught.

1.13 Determines the position of the vertical centre of buoyancy from a displacement draught curve.

1.14 Shows that the curve of vertical centre of buoyancy against draught is one of the hydrostatic curves.

Tonne Per Centimetre Immersion TPC

2 Describes the use of TPC in calculating displacement and effect of addition of masses on draught.

2.1 Defines TPC.

2.2 Derives a formula for TPC in terms of waterplane area and water density.

2.3 Sketches the curve of TPC against draught.

2.4 Shows that the TPC curve is one of hydrostatic curves.

2.5 Demonstrates that the displacement at any given draught is represented by the area of the TPC curve to that draught.

2.6 Explains why TPC can only be considered constant over small changes of mean draught.

2.7 Explains that the vertical centre of buoyancy is represented by the vertical centroid of the TPC curve.

2.8 Uses TPC to determine the change in mean draught due to the addition or removal of small masses.

Change in Draught due to Density

3 Calculates change in mean draught due to change in density.

3.1 Shows that for a given displacement the draught of a ship varies with density of the water.

3.2 Derives a formula for the change in mean draught due to change in density.

3.3 Applies the formula to derive the fresh water allowance.

3.4 Calculates the changes in mean draught due to changes in density and loading.

Coefficients of Form

4 Describes coefficients of form and their uses.

4.1 Defines waterplane area coefficient, midship section area coefficient, block coefficient, prismatic coefficient.

4.2 Solves problems, involving coefficients of form.

Wetted Surface Area

5 Describes the wetted surface area and calculates its value.

5.1 Defines wetted surface area.

5.2 Calculates wetted surface area using transverse girths and makes allowance for longitudinal curvature.

5.3 Calculates wetted surface area using Taylor's approximate formula.

5.4 Explains the rules for area, volume and displacement of similar bodies.

5.5 Applies the rules for similar bodies to wetted surface area and displacement.

5.6 Derives the relation between wetted surface area and displacement of similar ships.

5.7 Solves problems involving rules in 5.4, 5.5 and 5.6.

B SIMPSON'S RULE

6 Applies Simpson's Rule to the determination of Areas, Volumes and Masses and first moments of Area, Volume and Mass.

6.1 Applies Simpson's Rule to the determination of a ship's:

- (a) waterplane area at a particular draught using half ordinates at equally spaced stations along the vessel.
- (b) volume of Displacement at a particular draught using:
  - (i) Immersed cross-sectional areas at equally spaced stations along the vessel.
  - (ii) Waterplane areas at equally spaced stations above the keel.
- (c) displacement at a particular draught using the TPC values at equally spaced stations above the keel.

6.2 Derives the method of calculating the first moment of area of a plane about an end ordinate using Simpson's Rule.

6.3 Derives the method of calculating the first moment cf area of a plane about its base using Simpson's Rule.

6.4 Calculates the position of the centroid of a plane using 6.2 and 6.3.

6.5 Calculates the position of a vessel's vertical centre of buoyancy given:

- (a) Waterplane areas at equally spaced stations above the keel.
- (b) TPC values at equally spaced stations above the keel.

6.6 Calculates the position of the Longitudinal Centre of Buoyancy given 'Immersed Cross Sectional Areas' at equally spaced stations along the vessel.

C SHIP STABILITY

Centres of Gravity

7 Calculates the position of the centre of gravity of a ship under any condition of loading.

7.1 Explains that a ship is a system of masses.

7.2 Expresses the position of the centre of gravity of a ship without heel as a distance above the keel and as a distance forward or aft of midships.

7.3 Explains the importance of the position of the centre of gravity in stability and trim calculations.

7.4 Calculates the position of the vertical centre of gravity of a ship.

7.5 Calculates the position of the longitudinal centre of gravity of a ship.

7.6 Explains that the centre of gravity of a ship moves towards the centre of gravity of an added mass or away from the original centre of gravity on a removed mass.

7.7. Calculates the change in centre of gravity due to the addition or removal of a mass.

7.8 Explains that the shift in centre of gravity due to movement of a mass already on board a ship is the change in moment divided by the displacement.

7.9 Calculates the shift in centre of gravity of a ship to a movement of mass.

7.10 Explains that the centre of gravity of a suspended mass on a ship may be taken as the point of suspension.

7.11 Solves problems involving suspended masses.

Stability at Small Angles

8 Understands the term stability and the importance of the centre of buoyancy, centre of gravity and transverse metacentre with regard to stability.

8.1 Explains the meaning of the term stability.

8.2 Demonstrates that if a vessel is in equilibrium the centre of buoyancy and the centre of gravity are in the same vertical line.

8.3 Explains that the centre of buoyancy will move when the ship is heeled.

8.4 Shows that if the heel is due to an external force, the movement of the centre of buoyancy will produce a couple.

8.5 Explains that this couple is the righting moment which is the product of the displacement and the righting lever.

8.6 Explains that if the couple tends to cause the ship to heel to a greater angle the righting lever is regarded as negative.

8.7 Defines transverse metacentre.

8.8 Defines transverse metacentric height.

8.9 Explains that the initial stability of a ship may be represented by the transverse metacentric height.

8.10 Discusses stable, unstable and neutral equilibrium.

8.11 Explains that if a ship is initially unstable the metacentric height is regarded as negative.

8.12 Discusses the effects of small and large positive metacentric heights and defines tender and stiff ships.

8.13 States an expression for the distance of the transverse metacentre above the centre of buoyancy.

8.14 Calculates heights of centre of buoyancy and metacentre above the keel at regular intervals of draught and plots same to form the metacentric diagram.

8.15 Explains that the metacentric diagram is part of the hydrostatic curves.

8.16 Calculates height of metacentre above keel for vessels of ship form and of simple geometric form.

8.17 Calculates values of metacentric height for given positions of the centre of gravity.

8.18 Solves problems relatinq to stability at small angle of heel.

8.19 States the object of the inclining experiment.

8.20 Derives an expression for transverse metacentric height from the angles of heel due to moving a small mass across the ship.

8.21 Solves problems relating to the inclining experiment

8.22 Calculates vertical centre of gravity of ship using the metacentric diagram and result of 8.20.

8.23 Explains that displacement and longitudinal centre of gravity are also obtained from the inclining experiment.

8.24 Discusses precautions to be carried out when perform the experiment.

8.25 Discusses the procedure of the experiment.

8.26 Discusses the amendments necessary to obtain the lightship displacement and KG.

8.27 Calculates the final lightship displacement and KG inclining experiment.

8.28 Uses 8.20 to calculate the angle of heel due to a transverse shift of mass.

Change in Draughts due to Bilging

9 Solves problems on the change in mean draught due to bilging including the effect of permeability and the effect on transverse stability.

9.1 Explains that buoyancy may be represented by the intact, watertight volume which lies below the waterline.

9.2 Explains the term permeability.

9.3 Defines bilging.

9.4 Explains that bilging may be regarded as a loss in buoyancy which must be compensated by increasing the draught.

9.5 Defines volume of lost buoyancy, and area of intact waterplane.

9.6 Derives expression for the increase in mean draught due to bilging.

9.7 Discusses the conditions under which 9.6 may be applied.

9.8 Calculates the change in mean draught due to bilging.

9.9 Explains that a change in mean draught due to bilging will cause a change in the position of the centre of buoyancy and in the position of the transverse metacentre.

9.10 Calculates the change in metacentric height due to bilging.

D SHIP RESISTANCE

10 Understand the basic factors involved in the resistance to motion exerted by water on a ship moving through it.

10.1 Explains that total resistance to motion of a ship through water consists of two major components, frictional and residuary resistance.

10.2 States that total resistance to motion is given by the sum of the frictional and residuary resistances.

10.3 Discusses the components of frictional resistance.

10.4 Discusses the components of residuary resistance.

10.5 Explain that with modern vessels the resistance due to wavemaking is often by far the largest part of the residuary resistance.

10.6 Explains that in slow to medium speed vessels the residuary resistance is small in comparison to the frictional resistance, but is more significant in higher speed vessels.

10.7 Discusses the work carried out by Froude on frictional resistance to motion and states the results of that work in the form Rf = fSV.

10.8 Explains that residuary resistance is estimated from tests on models during the design stages of a vessel.

Propellers

11 Understands basic propeller terminology.

11.1 Defines propeller terms: pitch, diameter, pitch ratio pitch angle, projected area, developed area, blade area ratio.

11.2 Defines theoretical speed (pitch x revs) and apparent slip.

11.3 Discusses the causes of wake and expresses wake in the form of a wake fraction (Taylor).

11.4 Defines speed of advance and real slip.

11.5 Solves problems involving apparent and real slip.

11.6 Explains that the action of a propeller is to produce thrust.

11.7 Defines thrust power and expresses it in terms of thrust and speed of advance.

11.8 Defines delivered power and expresses it in terms of torque and speed of shaft rotation.

11.9 Expresses propeller efficiency in terms of thrust power and delivered power.

11.10 Solves simple problems involving thrust, effective delivered power and propeller slip.

E ADMIRALTY COEFFICIENTS

12 Uses Admiralty Coefficient as an approximate method of estimating power.

12.1 Derives the Admiralty Coefficient formula.

12.2 Explains the assumptions and limitations of the Admiralty Coefficient.

12.3 Sketches the form of the Admiralty Coefficient curve.

12.4 Describes the conditions under which the Admiralty Coefficient method may be used.

12.5 Derives a relationship between power and displacement for similar ships at their corresponding speeds.

12.6 Solves problems related to Admiralty Coefficient.

F FUEL CONSUMPTION

13 Calculates the variation in fuel consumption with speed and the fuel required to be loaded for a given voyage.

13.1 Defines specific fuel consumption.

13.2 Sketches a typical curve of specific fuel consumption

13.3 Explains that over a reasonable range of speeds, specific fuel consumption may be regarded as constant.

13.4 Derives an expression for fuel coefficient.

13.5 Derives an expression for variation in fuel consumption per day with speed.

13.6 Derives an expression for variation in fuel consumption for a voyage with speed.

13.7 Shows modifications necessary to 14.5 and 14.6 for variations in specific fuel consumption.

13.8 Solves problems related to fuel consumption.

G SHIP TERMINOLOGY

14 Knows ship terminology.

14.1 Defines the following terms:

(a) forward perpendicular;
(b) after perpendicular;
(c) length between perpendiculars;
(d) length overall;
(e) amidships;
(f) station or section;
(g) moulded and extreme breadth;
(h) moulded and extreme depth;
(i) moulded and extreme draught;
(j) sheer;

(k) freeboard;
(l) camber;
(m) rise of floor;
(n) bilge radius;
(o) tumble home;
(p) flare;
(q) parallel middle body;
(r) lightweight;
(s) deadweight.

H SHIP CONSTRUCTION

Framing Systems

15 Distinguishes between different framing systems used in the construction of ships.

15.1 Illustrates the following framing systems:

(a) transverse;
(b) longitudinal;
(c) combined.

15.2 Describes the systems illustrated in 15.1

15.3 Discusses the relative merits of the systems illustrated and described in 3.1 and 3.2.

Ship Types

16 Recognises the design features of various types of ships.

16.1 Illustrates the profiles of the following ship types:

(a) general cargo ship;
(b) bulk dry cargo carrier;
(c) petroleum, gas and chemical tankers;
(d) OBO carrier;
(e) container ship;
(f) Ro-Ro ship.

16.2 Sketches transverse cross sections through the vessels illustrated in 14.1.

16.3 Discusses the design features of the vessels illustrated in 14.1 and 14.2.

Construction of Structural Components

17 Understands the functions and constructional details of components of the ships structure:

17.1 Explains with the aid of sketches the function and structural details of the following components:

(a) double bottom;
(b) side shell;
(c) decks;
(d) watertight bulkheads;
(e) hatches;
(f) watertight doors;
(g) fore end structure;
(h) bulbous bow;
(i) stern structure.

Rudders and Sternframes

18 Distinguishes between different types of rudders, their construction, and their integration into the ship structure.

18.1 Distinguishes between unbalanced, balanced and semi-balanced rudders.

18.2 Sketches the outlines of the rudders in 6.1 indicating their attachment to the ship.

18.3 Describes with the aid of a sketch the structure of a double plate rudder including its attachment to the ship.

18.4 Sketches in detail the bearings associated with the rudder in 16.3.

18.5 Describes with the aid of a sketch a rudder carrier.

18.6 Describes with the aid of a sketch a sternframe suitable for the rudder in 16.3

Anchor and Cable Arrangement

19 Understands the arrangement and method of operation of anchor equipment.

19.1 Describes with the aid of sketches a typical anchor and cable arrangement.

19.2 Explains with the aid of sketches how the following are carried out:

(a) securing of cable;
(b) securing of anchor;
(c) connection of anchor to cable;
(d) connection of cable lengths.

I SHIP STRESSES

20 Recognises the causes and effects of stresses acting on ships.

20.1 Explains the meaning of the following terms:

(a) hogging;
(b) sagging;
(c) racking;
(d) panting;
(e) pounding.

20.2 Explains how the conditions in 18.1 stress the ships structure.

20.3 Identifies the structural items resisting the stress in 18.2.

20.4 Explains the stresses created on a ship during the process of dry-docking and methods of resisting same.

J VENTILATION

21 Recognises the need for shipboard ventilation and how this is carried out.

21.1 Explains why spaces must be ventilated.

21.2 Explains with the aid of sketches how the following ventilated:

(a) hold and tween deck spaces (mechanical and natural);
(b) double bottom tanks;
(c) cargo tanks of oil tankers;
(d) pump rooms of oil tankers;
(e) engine room;
(f) accommodation spaces.

Drainage of Compartments

22 Understands the need for the safe drainage and/or filling of compartments and how this is carried out.

22.1 Explains the dangers of accumulation of water on boa, ships.

22.2 Describes with the aid of sketches how the following are drained and where relevant, filled;

(a) weather decks;
(b) enclosed superstructures on, and spaces below the freeboard deck;
(c) holds;
(d) chain locker;
(e) fore peak;
(f) double bottom tanks;
(g) deep tank.

22.3 Discusses with the aid of sketches the functions, position and construction of air and sounding pipes.

Second Engineer Reg III/2 — Applied Heat

LIST OF TOPICS

The expected learning Outcome is that the candidate:

A PRESSURE, TEMPERATURE, ENERGY

1 Recognises and measures the effect of pressure in fluid.

1.1 Defines pressure as force per unit area.

1.2 Recognises the effect of atmospheric pressure.

1.3 States that standard atmospheric pressure is 1.01325 bar = 1.01325 x $10^5 N/m^2$.

1.4 Measures atmospheric pressure using a mercury barometer.

1.5 Converts pressure Units using water lead, mercury lead with bar Units.

1.6 Defines:

(a). vacuum;
(b). partial vacuum;
(c). gauge pressure;
(d). absolute pressure.

1.7 Solves simple problems relating to 1.1 to 1.6.

2 Defines and measures temperature.

2.1 Defines temperature.

2.2 Defines the absolute scale of temperature.

2.3 Differentiates between Celsius and Kelvin Scales.

2.4 Defines Standard Temperature and Pressure (STP) and Normal Temperature and Pressure (NPT).

3 **Discusses heat as a form of energy, specific heat capacity, sensible heat, latent heat and solves associated problems.**

3.1 Defines heat energy.
3.2 Defines specific heat capacity of a solid and of a liquid.
3.3 Defines sensible heat.
3.4 Explains phase change and defines the latent heat of fusion.
3.5 Sketches the change of phase (solid/liquid) diagram for water.
3.6 Determines the resultant temperature when a solid is placed in a liquid at a different temperature.
3.7 Determines the resultant temperature when up to three liquids at different temperatures are mixed.
3.8 Defines water equivalent.
3.9 Solves simple problems relating to 3.1 to 3.8.

4 **Discusses the physical changes of solids and liquids associated with changes in temperature.**

4.1 Defines the coefficient of linear expansion.
4.2 States the equation of linear expansion/contraction.
4.3 States the equation of superficial expansion.
4.4 States that the coefficient of volumetric expansion is three times the coefficient of linear expansion.
4.5 States the equation of volumetric expansion.
4.6 Defines differential expansion with reference to solids and liquids.
4.7 Solves simple problems relating to 4.1 to 4.6.

B HEAT TRANSFER

5 **Describes the way in which heat may be transferred and the factors which may influence heat transfer. Solves simple problems involving conduction, convection and radiation.**

5.1 Describes heat transfer by conduction.
5.2 Gives practical examples of heat transfer by conduction.
5.3 Defines the term coefficient of thermal conductivity.
5.4 States an expression for the rate of heat transfer through a single plane wall.
5.5 States that for a composite wall the rate of heat transfer is constant.
5.6 States an expression for the transfer of heat through a composite wall made up of not more than three flat layers in contact.
5.7 Solves simple problems relating to 5.1 to 5.6.
5.8 Describes heat transfer by convection.
5.9 Lists practical examples of forced and natural convection.
5.10 Defines the term 'coefficient of conductance'.

5.11 States an expression for the rate of heat transfer from a flat surface to its surroundings.

5.12 Solves simple problems relating to 5.8 to 5.11.

5.13 Describes heat transfer by radiation.

5.14 Gives practical examples of heat transfer by radiation.

C INTERNAL ENERGY, THERMO-DYNAMIC SYSTEMS, FIRST LAW

6 Defines and describes Thermo-dynamic Systems and solves problems involving the First Law of Thermodynamics.

6.1 Defines Internal Energy.

6.2 States Joules Law for the internal energy of a gas.

6.3 Defines a Thermodynamic system.

6.4 Differentiates between an open and a closed system.

6.5 Give examples of:

a) closed system with fixed boundary (constant volume);
b) closed system with elastic boundary (constant pressure);
c) open system with fixed boundary.

6.6 Defines work with reference to a thermodynamic system.

6.7 States the First Law of Thermodynamics in terms of heat energy, work energy and internal energy.

6.8 States that Q = W + U and that this is the non-flow energy equation.

6.9 States that power is the rate of transfer of energy.

6.10 States that H + Q = H + W and that this is the flow energy equation.

6.11 Solves simple problems relating to 6.1 to 6.10.

D GAS LAWS, DISPLACEMENT WORK

7 Solves simple problems involving the basic gas laws.

7.1 Defines a perfect gas.

7.2 States Boyles Law.

7.3 States Charles Law.

7.4 Shows Boyles Law and Charles Law on a pV diagram.

7.5 Combines Boyles Law and Charles Law and states that for a perfect gas pV/T = a constant.

7.6 Derives the Characteristic Gas Equation pV = mRT.

7.7 Derives the Units of the Characteristic Gas Constant R from the Units of pressure, volume, temperature and mass.

7.8 Solves simple problems relating to 7.1 to 7.7.

8 **Describes processes which will produce a change of state in a non-flow system and solves problems concerned with non-flow processes.**

8.1 Differentiates between constant pressure and constant volume operations.

8.2 Defines specific heat capacities of a gas at constant pressure and at constant volume.

8.3 States that the ratio of the specific heat capacities of a gas Cp/Cv = γ (gamma) the adiabatic index.

8.4 Defines:

a) an Isothermal operation;
b) an Adiabatic operation;
c) a Polytropic operation.

8.5 Shows the Isothermal, Adiabatic and Polytropic Operations on a pV diagram

8.6 Shows that the area of the pV diagram represents W.D. during the operation.

8.7 States expressions for the work done during isothermal, adiabatic and polytropic non-flow processes.

$$\frac{T_2}{T_1} = \frac{P_2}{P_1} = \frac{V_1}{V_2}$$

8.8 States the temperature - pressure and temperature -volume relations for an operation to the law pV = a constant.

8.9 States that change in internal energy is given by $mC_v (T_2 – T_l)$.

8.10 States that the relationship between the Characteristic Gas Constant and the specific heat capacities of a gas is $R = (C_p - C_v)$.

8.11 Solves simple problems relating to 8.1 to 8.10.

E IDEAL CYCLES AND I.C. ENGINES

9 **Sketches p - V diagram and describes the operation for the ideal constant volume (Otto) cycle, the Diesel cycle and the Dual Combustion cycle.**

9.1 Sketches the pV diagram for the ideal Otto, Diesel and Dual Combustion cycles and names the processes making up these cycles.

9.2 Names the practical engines that operate on these cycles.

9.3 Compares the ideal cycle with the practical four stroke cycle.

9.4 Gives reasons for the differences between the ideal and the practical cycle.

9.5 Answers simple descriptive questions only on the Otto, Diesel and Dual Combustion cycles.

9.6 Defines air standard efficiency and solves problems involving engine cycles.

10 Determines indicated power, brake power and mechanical efficiency of an Ie engine and solves problems involving power, efficiency, fuel consumption and heat balance.

10.1 Defines mean effective pressure (mep).

10.2 Determines the area of an indicator card using the mid-ordinate rule.

10.3 States the terms, spring rate, spring stiffness and spring constant when referred to indicators.

10.4 Determines the indicated mep from an actual indicator diagram.

10.5 Defines indicated power.

10.6 Derives an expression for calculating indicated power.

10.7 Defines brake power.

10.8 Defines brake mean effective pressure (bmep) and uses this term in the determination of brake power.

10.9 Derives an expression for brake power in terms of torque and angular velocity.

10.10 Determines mechanical efficiency.

10.11 Calculates indicated power, brake power and mechanical efficiency from engine test data.

10.12 Defines thermal efficiency for an actual engine.

10.13 Differentiates between brake and indicated thermal efficiencies.

10.14 Calculates thermal efficiency from engine data.

10.15 Defines specific fuel consumption based on indicated power and brake power.

10.16 Relates specific fuel consumption to thermal efficiency.

10.17 Calculates specific fuel consumption from engine data.

10.18 Draws up a heat energy balance for an Ie engine.

10.19 Solves simple problems relating to 10.1 to 10.18.

10.20 Solves problems involving thermal, mechanical and overall efficiency.

F AIR COMPRESSORS

11 Describes the factors which influence the performance of a reciprocating air compressor and solves simple problems involving single stage single acting compressors.

11.1 Sketches the ideal p - V diagram for a compressor without clearance volume.

11.2 Sketches the ideal p - V diagram for a compressor with clearance volume.

11.3 Defines clearance volume.

11.4 Defines induced volume.

11.5 Defines 'free air' delivery for an air compressor.

11.6 Defines volumetric efficiency based on 'free air1 and actual air conditions.

$$V = \frac{ActualVolumeInduced}{SweptVolume}$$

11.7 Solves simple problems relating to 11.1 to 11.6.

11.8 Solves problems involving work input and mechanic efficiency.

G WORKING FLUIDS

12 Recognises the differences in the properties of vapours, gases and the perfect gas and uses the steam tables to solve simple problems related to water and steam in the wet, saturated and superheated states.

12.1 Differentiate between a gas and a perfect gas.

12.2 Differentiate between a gas and a vapour.

12.3 Defines the term ENTHALPY (h).

12.4 States that h = u + pV.

12.5 Defines the term pV as flow energy.

12.6 Shows that pV is the work transfer in pumping a fluid under constant pressure conditions.

12.7 Defines the term 'saturated' when applied to a vapour.

12.8 Defines saturation temperature.

12.9 Differentiates between wet, dry-saturated and superheated vapours.

12.10 Defines the term dryness fraction.

12.11 Defines the terms 'quality' and 'degree of superheat' as applied to a vapour.

12.12 Demonstrates how to obtain values of specific enthalpy, specific volume and internal energy for water and for wet dry saturated and superheated vapours from the Thermodynamic Properties tables by direct reading or interpolation.

12.13 Sketches a pressure-enthalpy diagram.

12.14 States that the specific enthalpy of a wet vapour is given by hf + x hfg.

12.15 States that the specific internal energy of a wet vapour is given by uf + x ufg.

12.16 States that the specific volume of wet vapour is given by x Vg + (1 - x) Vf.

12.17 Determines from information given in the tables the pressure-temperature relationship for a saturated vapour.

12.18 Determines the mass of a given volume of wet, dry or superheated vapour.

12.19 Calculates changes in the enthalpy and internal energy of a vapour during constant pressure and constant volume operation.

12.20 States that an operation following the law pV^n = a constant is a hyperbolic operation when the working fluid is a vapour.

12.21 Calculates the final condition of the vapour after an operation to the law pV^n = a constant.

12.22 States that for a throttling operation on a vapour enthalpy before throttling = enthalpy after throttling.

12.23 Solves problem relating to 12.1 to 12.22.

12.24 Sketches the arrangement of a combined separator and throttling calorimeter.

12.25 Determines the quality of steam in a main line from data obtained using the combined separator and throttling calorimeter.

12.26 States the limitations of pressure and dryness fraction which apply to the throttling calorimeter.

12.27 Determines Boiler Efficiency and Equivalent Evaporation rates from given plant data.

12.28 Solves simple problems relating to 12.1 to 12.27.

H NOZZLES AND STEAM TURBINES

13 Solves simple problems involving the flow of steam through a nozzle.

13.1 Defines a nozzle and gives practical applications of where nozzles are used in a steam turbine.

13.2 Recognises that increase in K.E. at nozzle exit is proportional to the enthalpy drop.

13.3 Solves simple problems relating to 13.1 to 13.2.

13.4 Sketches the combined velocity diagrams and determines the power developed in a single stage impulse turbine and a single stage reaction turbine.

13.5 Draws the vector diagrams for inlet and outlet steam velocities over a turbine blade for shockless flow.

13.6 Combines the inlet and outlet diagrams to form a single diagram.

13.7 Shows velocity of whirl on a combined diagram.

13.8 Shows the effect of blade friction (blade velocity coefficient).

13.9 States an expression for the power developed in a single stage of an impulse turbine.

13.10 Solves problems relating to 13.1 to 13.5.

13.11 Draws the combined velocity diagram for a single stage reaction turbine.

13.12 Discusses degree of reaction and states that 50% reaction is usual and refers to a Parsons turbine.

13.13 States an expression for the power developed in a reaction turbine pair.

13.14 Solves simple problems relating to 13.12 to 13.13.

13.15 Solves problems involving axial force on blades.

I REFRIGERATION

14 Understands the concepts of the reversed heat engine cycle and its applications to vapour compression refrigeration plant and solves simple problems.

14.1 Sketches the circuit diagram for the basic vapour compression refrigeration cycle.

14.2 Identifies the principal components of a vapour compression refrigerator and describes its operation.

14.3 Sketches a vapour compression cycle on a p - h diagram showing:

a) wetness before entering compressor;
b) dryness before entering compressor;
c) superheat before entering compressor;
d) superheat after entering compressor;
e) undercooling after condenser.

14.4 Defines 'refrigerating effect' in kJ/kg, mass flow rate in kg/s and 'cooling load' in kW.

14.5 Shows that work transfer from the compressor during an adiabatic operation is equal to the enthalpy change of the vapour.

14.6 Defines 'coefficient of performance' of a refrigeration plant.

14.7 Defines 'capacity' of a refrigeration plant.

14.8 Uses property tables to determine the specific enthalpy and specific volume of wet, dry and superheated refrigerants.

14.9 Solves simple problems relating to 14.1 to 14.8.

J COMBUSTION

15 Discusses the combustion of solid and liquid fuels by mass in terms of theoretical air and excess air required and the products of combustion. Solves problems involving the combustion of a fuel.

15.1 Defines the chemical definitions of atom, molecule, atomic mass, molecular mass, element, compound and a mixture.

15.2 States the combustion equations for the complete combustion of Carbon to Carbon Dioxide, Hydrogen to Water, and Sulphur to Sulphur Dioxide.

15.3 States the equation for the partial combustion of Carbon to Carbon Monoxide.

15.4 Derives the equations for the combustion of simple hydro-carbon fuels.

15.5 States that air contains approximately 23% oxygen and 77% nitrogen by mass.

15.6 Determines the stoichimetric mass of air required for the complete combustion of a hydro-carbon fuel.

15.7 Determines the percentage excess air required for complete combustion of a hydro-carbon fuel.

15.8 Defines the Higher Calorific Value and the Lower Calorific Value of a fuel.

15.9 Determines the Higher and Lower Calorific Values of a fuel given the calorific value of its constituents.

15.10 Lists on a percentage basis the products of combustion of a fuel, burned in excess air, by mass.

15.11 Solves problems relating to 15.1 to 15.10.

K BOILER FEED DENSITIES

16 Discusses the effects of using feed water containing dissolved solids on boiler and evaporator plant. Solves simple problems on the change in density of boiler and evaporator plant due to build up of dissolved solids during intermittent and continuous blowdown.

16.1 Defines parts per million (ppm).

16.2 Discusses the meaning of density when referring to dissolved solids in boiler or evaporator feed water.

16.3 Determines the change in density of the boiler or evaporator water content when operating with:

a) no blowdown;
b) intermittent blowdown
c) continuous blowdown.

16.4 Determines the heat lost to blowdown.

16.5 Defines boiler efficiency.

16.6 Solves simple problems relating to 16.1 to 16.5.

Chief Engineer Reg III/2 — Marine Electrotechnology

LIST OF TOPICS

A Electric Circuit Principles
B Electronic Circuit Principles
C Generation
D Distribution
E Utilisation

The expected learning Outcome is that the candidate:

A ELECTRIC CIRCUIT PRINCIPLES

1 Solves dc linear circuit problems under steady and transient conditions.

1.1 States Kirchhoff's current and voltage laws.

1.2 Solves steady-state dc circuit problems involving not more than three unknowns using Kirchhoff's laws.

1.3 Predicts graphically transient voltage and current relationships in simple resistance-inductance (R-L) and resistance-capacitance (R-C) circuits when switched on and off a steady dc supply.

1.4 States the time constants of simple R-L and R-C circuits as

$\tau = \frac{L}{R}$ and $\tau = CR$ respectively

1.5 States the form of exponential growth and decay formulae applied to R-L and R-C circuits.

1.6 Uses exponential growth and decay formulae to obtain particular values of current or voltage at a given time or vice-versa in simple R-L and R-C circuits.

2 Solves dc non-linear circuit problems under steady-state conditions.

2.1 States that a non-linear device is one that does not obey ohm's law.

2.2 Shows that a non-linear element may be described by its V/1 characteristic in a graphical or mathematical form.

2.3 Lists typical examples of non-linear devices, eg generators, rectifier elements, transistors, thermistors, etc.

2.4 Estimates dc and ac resistances of a non-linear element under given operating conditions.

2.5 Derives graphically an overall (dynamic) V/1 characteristic for a simple dc series or parallel circuit including a non-linear element and a linear resistor.

2.6 Solves simple dc non-linear circuits mathematically given the V/1 law of the non-linear element.

2.7 Solves simple dc non~linear circuits graphically using load-line technique or dynamic characteristics.

3 Understands operation of single-phase and three-phase ac circuits.

3.1 Describes using phasor diagrams, voltage and current relationships obtained in pure resistance, pure inductance and pure capacitance circuits when energised from a single phase sinusoidal ac supply.

3.2 Calculates impedance M of simple R-L-C circuit combinations in series and in parallel.

3.3 Defines circuit power factor as ratio of active power to apparent power and as cos φ = R/Z.

3.4 Solves simple series and parallel ac circuit problems including pf correction.

3.5 Sketches voltage and current phasor diagrams representing simple R-L-C series and parallel circuits.

3.6 Recognises that voltage and current resonance occurs when series and parallel R-L-C circuits respectively operate at unity power factor.

3.7 Derives $f = \frac{1}{2\pi\sqrt{LC}}$ as the resonant frequency of a series R-L-C circuit.

3.8 Defines active power (P), apparent power (S) and reactive power (Q).

3.9 Sketches a power triangle (P Q and S) to represent operating conditions in a single-phase circuit.

3.10 Solves single-phase circuit problems using P Q and S quantities.

3.11 Sketches the interconnection of three separate single phases to form 3-phase star and delta connections.

3.12 Sketches 3-phase voltage and current phasor diagrams to represent balanced star or delta connection.

3.13 Derives relationships $V_L = \sqrt{3}$ Vph for star and $I_L = \sqrt{3}$ Iph for delta balanced connections using phasor diagrams.

3.14 Shows mathematically that total 3-phase power is given as $P = \sqrt{3} V_L I_L Cos\theta$ for both star and delta connections.

3.15 Solves 3-phase balanced circuit problems using voltage, current and power relationships.

B ELECTRONIC CIRCUIT PRINCIPLES

4 Understands the operation of junction diodes in rectification circuits.

4.1 Recognises typical forward and reverse V/I characteristics for Si and Ge diodes.

4.2 Compares half-wave, bi-phase and bridge rectification circuits supplied from single and three phase power supplies.

4.3 Sketches typical dc output waveforms from rectifier circuits in 4.2.

4.4 Calculates mean dc voltage at output of half and full-wave single-phase circuits given the ac input supply and vice-versa.

4.5 Describes the action of a simple C-only smoothing circuit in conjunction with a rectifier.

4.6 Tests complete dc power supply circuits.

5 Understands the operation of the Thyristor as a controlled rectifier.

5.1 Describes the construction of a thyristor as a 4-layer p-n device with anode, cathode and gate terminals.

5.2 States bias voltage polarities necessary for 'turn-on' of a thyristor.

5.3 States conditions necessary for thyristor turn-off.

5.4 Sketches simple circuit diagram of series connected thyristor controlling a dc load from an ac supply (no gate circuitry required).

5.5 Describes circuit action of 5.4 under variable phase shift gate pulse control and block firing control.

5.6 Sketches typical load current and voltage in a simple ac driven thyristor controller with variable phase shift gate control.

5.7 Tests a complete single-phase thyristor power controller.

6 Understands the function of a Zener Diode as a dc voltage stabilizer.

6.1 Defines voltage stabilisation as the ability of a power supply to maintain its output voltage against changes in loading and input voltage.

6.2 Describes the action of a p-n junction Zener diode with forward and reverse bias voltages applied.

6.3 Recognises that a Zener diode must be worked with reverse voltage bias to become a stabilising element.

6.4 States that a Zener diode is rated in terms of its Zener voltage (V Z) and its power handling ability.

6.5 Describes the action of a simple voltage stabilising circuit of a Zener diode and current limiting resistor in series across an unregulated dc supply.

6.6 Calculates values of voltages, currents and powers in a given simple dc stabiliser circuit under changes in supply voltage and loading conditions.

6.7 Tests a complete dc voltage stabiliser circuit.

7 Understands the action of a transistor and its function as a switch and signal amplifier device.

7.1 Describes the basic construction of p n p and n p n bi-polar transistors.

7.2 Describes the current distribution in p n p and n p n transistors when the emitter-base junction is forward biased and the collector-base junction is reverse biased.

7.3 Defines dc current relationships as $h_{FB} = \frac{I_c}{I_e}$ and $h_{FE} = \frac{I_c}{I_b}$

7.4 Sketches the basic common-base, common-emitter and common-collector connections of a transistor.

7.5 Recognises static transistor characteristics in common-emitter and common-base mode.

7.6 Describes the ‘cut-off’ condition of a transistor when the base-emitter junction is zero or reverse biased.

7.7 Describes the ‘fully-on’ (saturated) condition of a transistor when the base-emitter junction is heavily forward biased.

7.8 Compares cut-off and saturation of a transistor with an ideal electric switch.

7.9 Describes the action of a simple transistor switching circuit used for alarm and/or control purposes.

7.10 Sketches a practical common-emitter circuit arrangement showing dc bias arrangements, temperature stabilisation resistor and input and output signal connections.

7.11 Describes the action of a common-emitter circuit as a small-signal amplifier.

7.12 Draws a load-line onto the static output characteristics of a transistor to predict current gain.

C GENERATION

8 Understands the principles of operation of a dc generator.

8.1 Reviews basic operation of a dc generator.

8.2 Derive the emf equation $E = 2p\Phi \frac{Z}{A} \quad n = k\Phi n$.

8.3 Evaluates generated emf.

8.4 Describes self excitation and states factors which may prevent it.

8.5 Estimates generated emf from magnetisation curve and given shunt field resistance.

8.6 Estimates critical shunt field resistance from a given magnetisation curve.

8.7 Sketches field and armature circuits for shunt and compound wound machines (long shunt and short shunt).

8.8 Explain voltage control using shunt field regulator.

8.9 Describes armature reaction and its effects.

8.10 Describes commutation, its effect and method of improving commutation, eg brush shifting and interpoles.

8.11 Solves problems involving E, V, Ia, Rf and Ra.

8.12 Sketches V/I load characteristics of shunt and compound generators (cumulative and differential connections).

8.13 Estimates voltage regulation from $\frac{E-V}{V}$

8.14 Lists typical marine applications of generators in 8.7.

8.15 Calculates series turns required to produce given terminal voltage on load.

8.16 Describes the connection of a dc compound generator to live busbars and effects of varying excitation.

8.17 Explains the use of the equalising connection.

8.18 Describes method of disconnecting a generator from the busbars.

8.19 Solves load sharing problems graphically and mathematically for shunt and compound generators.

8.20 States the reasons for a dc generator failing to excite.

8.21 Describes the methods of exciting dc generators that have lost their residual magnetism.

8.22 Explains the need for preference trips.

8.23 Describes, with the aid of a schematic diagram, the operation of a preference trip.

8.24 Explains the need for a reverse current relay.

8.25 Describes the operation of a reverse current relay.

9 Understands the principles of operation of ac generators.

9.1 Describes the arrangement of an armature *winding to* produce a three phase emf.

9.2 Sketches wave form diagram of three phase voltages.

9.3 Derives relationship between frequency, poles *and* speed.

9.4 Derives emf equation $E = 2 \cdot 22.\Phi.z.f$

9.5 Sketches equivalent circuit per phase including Eph, Xs assuming resistance to be negligible.

9.6 Explains the effect of load and power factor on terminal voltage.

9.7 Calculates emf given terminal voltage inductive load conditions and winding reactance.

9.8 Estimates voltage regulation from $\frac{E-V}{V}$

9.9 Describes connection of a three phase generator to live busbars, disconnection and shut-down.

9.10 Explains the effects of operating:

(a) governor;
(b) field regulator.

9.11 Solves load sharing problems where information is limited to kW, kVA, kVAr.

9.12 Describes the construction of salient and cylindrical pole ac generators.

9.13 Appreciate the reason for the two types of rotor.

9.14 Explains why an AVR is required for ac generators.

9.15 Describes the methods of exciting ac generators.

9.16 Describes, with the aid of diagrams, how brushless ac generators are excited using:

(a) rectifiers;
(b) silicon controlled rectifiers (thyristors).

9.17 Describes, with the aid of a schematic diagram, the operation of a compounded ac generator.

9.18 States the advantages and disadvantages of:

(a) the insulated neutral system;
(b) the earthed neutral system

for marine ac generators.

9.19 Explains the need for a reverse power relay.

9.20 Describes the operation of a reverse power relay.

9.21 Explains the need for preference trips.

D DISTRIBUTION

10 Understands typical arrangements of marine ac and dc distribution systems.

10.1 Calculates current distribution and load potentials in dc:

(a) radial feeders;
(b) ring mains;
(c) double fed systems using dissimilar voltages.

10.2 Describes three phase, three wire and four wire systems.

10.3 Calculates value of the neutral current in a three phase, four wire unbalanced system.

10.4 Describes the function of the transformer in an ac distribution system.

11 Understands the principles of operation of a transformer.

11.1 Relates induced emf. to rate of change of flux linkages.

11.2 Derives voltages and currents from turns ratios of single phase transformer.

11.3 Derives emf equation $E = 4 \cdot 44.f\Phi z$.

11.4 Sketches phasor diagrams on and off load lag pf only and solves related problems.

11.5 Sketches three phase connections, eg star/delta, star/star, etc. using correct terminal markings.

11.6 Solves problems involving three phase transformers using turns and voltage ratios.

11.7 Sketches circuit diagram of auto-transformer.

11.8 Explains principles of operation of auto-transformer.

11.9 Solves problems on auto-transformers involving voltages, turns and tapping point.

11.10 Lists losses which occur in transformers.

11.11 Calculates efficiency of a transformer given load conditions and losses.

11.12 Explains the need for instrument transformers.

11.13 Explains the reasons for earthing the secondary winding of instrument transformers.

E UTILISATION

12 Understands the principles of operation of a dc motor. Reviews the basic operation of shunt, series and compound dc motors.

12.1 Derives speed equation $n = \frac{V - I_a R_a}{k\Phi}$.

12.2 Explains speed control using shunt field regulator, diverter resistance, tapped field or armature voltage control methods.

12.3 Derives torque equation $T = p\Phi \frac{Z}{a} \quad \frac{I_a}{2\pi} = k\Phi I_a$

12.4 Sketches torque/armature current, speed/armature current characteristics and derives from these torque/speed curves for shunt, series and compound motors (cumulative only).

12.5 Solves problems involving changing load, field and/or circuit conditions.

12.6 Lists the losses which occur in dc motors and generators.

12.7 Calculates constant losses from no-load input as a motor and hence estimates efficiency of motor or generator under load conditions.

12.8 Tests a dc motor using Swinburne test and assesses efficiency under stated load conditions.

13 Understands the principles and operation of the three-phase induction motor.

13.1 Explains the production of a magnetic field rotating at synchronous speed by a three phase stator winding.

13.2 Calculates slip given number of poles, frequency and motor speed.

13.3 Evaluates rotor frequency.

13.4 Shows that input to rotor equals motor input minus stator losses and that this input equals $2\pi T n_S$ watts.

13.5 Calculates rotor output = $2\pi T n_r$ watts.

13.6 Evaluates rotor resistive power loss from difference between 13.4 and 13.5.

13.7 Calculates motor output = $2\pi T_L n$.

13.8 Calculates efficiency from 13.4 to 13.7.

13.9 Describes the construction of single, double-cage and slip ring motors.

13.10 Sketches typical torque/slip curves for single, double-cage and slip-ring motors.

13.11 Describes with the aid of sketches the following starters:
DOL: Star/Delta: slip-ring.

13.12 Explains the reasons why a motor may ‘single-phase’.

13.13 Describes the effect of a motor ‘single-phasing’.

13.14 Describes the motor enclosures used in the marine environment.

13.15 Describes the methods of varying the speed of ac induction motors.

14 Understands principles of operation of 3-phase synchronous motor.

14.1 Relates synchronous motor to ac generator.

14.2 Describes pony motor and induction motor starting methods.

14.3 Describes effects of changing load and excitation.

14.4 Solves problems of pf improvement type.

14.5 States marine applications of the synchronous motor.

15

15.1 Describes with the aid of a sketch, the operation of a fluorescent lighting circuit.

15.2 Sketches a navigation lighting circuit.

15.3 Describes, with the aid of sketches, how earth faults are detected for (i) 1-phase and (ii) 3-phase supplies.

Chief Engineer Reg III/2 — Applied Mechanics

LIST OF TOPICS

A Vector Representation
B Statics
C Friction
D Kinematics
E Dynamics
F Machines
G Strength of Materials
H Hydrostatics
I Hydrodynamics
J Control System Mathematics

The expected learning Outcome is that the candidate:

A VECTOR REPRESENTATION

1 Understands the use of vectors for graphical solutions.

1.1 Recalls the procedures for the addition and subtraction of parallel and non-parallel vectors by both graphical and analytical methods.

1.2 Recalls the terms: Resultant and Equilibrant.

1.3 Explains that three non-parallel vectors must be concurrent for equilibrium.

1.4 Resolves vectors into mutually perpendicular components.

1.5 Solves problems involving coplanar-concurrent and coplanar non-concurrent vector quantities.

1.6 Solves problems involving non-coplanar concurrent vector quantities.

B STATICS

2 Understands the conditions of equilibrium of a body subject to a system of coplanar and non-coplanar forces and/or moments, and applies the conditions of equilibrium to solve relevant practical problems.

2.1 Recalls a moment of force.

2.2 Resolves forces applied obliquely into perpendicular components.

2.3 States the Principle of Moments.

2.4 States the conditions for equilibrium of a rigid body subject to a number of non-concurrent coplanar forces.

2.5 Describes the classification of the lever:
- (a) as one of three orders;
- (b) straight or cranked;
- (c) simple or compound.

2.6 Solves problems related to 2.1 to 2.5.

2.7 Describes concurrent coplanar force systems.

2.8 Solves problems on 2.7 involving up to four forces in equilibrium to include the static condition of crank and overhung connecting rod.

2.9 Describes concurrent non-coplanar force systems.

2.10 Solves problems on 2.9 involving up to four forces in equilibrium.

2.11 Resolves forces acting on a body resting on a frictionless plane inclined to the horizontal.

2.12 Defines moments of mass, volume and area.

2.13 Understands the principle of Rapson's slide.

2.14 Solves problems related to 2.11 to 2.13.

C FRICTION

3 Discusses the effect of friction when one rigid body slides or tends to slide over another rigid body, and applies the principles established to the solution of practical problems.

3.1 Sates the 'laws of dry friction'.

3.2 Defines the terms for a body sliding or tending to slide over a horizontal plane.

(a) static friction;
(b) sliding friction;
(c) normal reaction;
(d) plane reaction;
(e) friction angle;
(f) limiting friction force.

3.3 Discusses the forces involved when a body is stationary or sliding at uniform speed on a plane inclined to the horizontal.

3.4 Solves problems involved in holding or causing the body to ascend and descend the plane at uniform speed by means of:

(a) a force acting parallel with the plane;
(b) a force acting horizontally;
(c) the least force;
(d) forces acting at any angle.

3.5 Solves problems involving wedges and cotters.

3.6 Solves problems involving static equilibrium when friction forces are involved.

3.7 Solves problems involving work lost due to friction.

D KINEMATICS

4 Solves problems involving linear, angular and relative motion.

4.1 Recalls the terms: displacement, speed, velocity and acceleration and states the Units for both linear and angular cases.

4.2 Sketches distance/time graphs for both constant speed and uniform acceleration and defines the slope.

4.3 Sketches velocity/time graphs for both constant speed and uniform acceleration and relates the slope and area to the motion.

4.4 States the equations of motion for constant acceleration in both linear and angular terms.

4.5 Derives the relationship between linear and angular motion.

4.6 Solves problems related to 4.1 to 4.5.

4.7 Derives the equations for the horizontal and vertical components of the motion of a projectile.

4.8 Solves problems on individual and double projectiles.

4.9 Defines relative and absolute velocity.

4.10 Determines the relative velocity of unconnected bodies.

4.11 Solves problems involving closest approach and elapsed time related to 4.10 above.

4.12 Determines the relative velocity of connected bodies in simple mechanisms.

NB, (Objectives 4.7 to 4.12 to be solved by analytical and/or graphical methods).

E DYNAMICS

5 Applies the laws of motion to translational dynamics.

5.1 Recalls Newton's laws of motion and discusses the concept of inertia.

5.2 Defines power.

5.3 Defines linear momentum and impulse.

5.4 Discusses the Conservation of Momentum.

5.5 Defines kinetic energy, potential energy and work done.

5.6 Discusses the Conservation of Energy.

5.7 Solves problems involving momentum, impulse, energy, work done and power, to include impact of non-elastic bodies.

5.8 Explains the traction of vehicles on horizontal and inclined planes.

5.9 Considers tractive effort as the algebraic sum of the forces arising from:

- (a) force to overcome the component of weight of the vehicle on the inclined plane
- (b) acceleration forces;
- (c) friction forces.

5.10 Expresses the friction forces as tractive resistance in terms of force per tonne of vehicle.

5.11 Solves problems involving motion on an inclined plane.

5.12 Solves problems in which bodies are hauled by a connected body or winch in ascent and/or descent of an inclined plane.

5.13 Solves problems in which bodies are hauled up inclined planes and the hauling force is limited by conditions of overturning of the body.

6 Applies the laws of motion to rotational dynamics.

6.1 Derives the relationship between torque, angular acceleration and moment of inertia.

6.2 States the expression for the moment of inertia of an annular disc.

6.3 Determines the moment of inertia for composite flywheels comprising of plain and annular discs.

6.4 Explains the concept of radius of gyration.

6.5 Discusses the concept of a thin rim type flywheel.

6.6 States the expression for the work done by a torque.

6.7 Represents graphically angular work done.

6.8 States the expression for the power developed by a torque.

6.9 Derives the expression for the kinetic energy of rotation.

6.10 Shows that the vertical force acting on a freely suspended mass is given by the expression: mg± ma.

6.11 Solves problems involving connected masses passing over frictionless light pulleys, including inclined planes.

6.12 Solves problems involving masses connected to separate ropes on stepped flywheels and to include inertia and friction.

6.13 Discusses the concept of fluctuation of speed and energy.

6.14 Solves problems involving 6.13 above.

6.15 Solves problems involving combinations of translational and rotational motion.

6.16 Defines angular momentum (moment of momentum).

6.17 States the conservation of angular momentum.

6.18 Derives the expression for the rate of change of angular momentum and hence angular impulse.

6.19 Solves problems involving angular momentum and impulse.

6.20 Derives the simple expression for the torque to overcome friction on a thrust collar bearing.

6.21 Solves problems on 6.20 above.

6.22 Solves problems involving torque and power transmitted by single flat plate friction clutches; relevant formulae to be given.

6.23 Repeats 6.22 for cone friction clutches.

7 Describes centripetal and centrifugal effects and solves associated problems.

7.1 Derives the expression for the centripetal acceleration of a body moving in a circular path with uniform angular velocity.

7.2 Relates centripetal acceleration and centripetal force.

7.3 Recognises that centrifugal force is an inertial reaction to centripetal force.

7.4 Determines by graphical or analytical means whether a rotating coplanar force system is in equilibrium.

7.5 Determines the out-of-balance force and the balancing mass required for systems not in equilibrium.

7.6 Calculates the forces on bearings supporting out-of-balance shafts.

7.7 Discusses the conical pendulum.

7.8 Solves problems involving conical pendulums.

7.9 Discusses centrifugal governors.

7.10 Sketches and describes the Watt governor, Porter governor and the Hartnell governor.

7.11 Solves problems related to 7.10 by analytical and graphical methods.

7.12 Describes the effects of vehicles negotiating curved paths.

7.13 Solves problems due to the overturning effect on a vehicle negotiating a curved track in the horizontal plane.

7.14 Solves problems due to the centrifugal force on a vehicle negotiating a banked or superelevated track, neglecting overturning.

7.15 Solves problems when frames are subjected to a dynamic force, such as the centrifugal force, arising when the mass on the end of a crane cable swings in the plane of the frame.

7.16 Solves problems involving torque and power transmitted by centrifugal clutches.

8 Describes and solves problems involving simple harmonic motion SHM.

8.1 Defines SHM.

8.2 Derives expressions for displacement, velocity and acceleration of the projection, on a diameter, of a point moving in a circular path at constant angular velocity and hence concludes the motion is SHM.

8.3 Defines amplitude, frequency and periodic time.

8.4 Derives the general expression: frequency =

$$\frac{1}{2\pi}\sqrt{\frac{Acceleration}{Displacement}}$$

8.5 Derives the expression for the acceleration of a mass vibrating on a helical spring and concludes the motion is SHM.

8.6 Derives the expression for the frequency of a mass vibrating on a helical spring.

8.7 States the assumptions made for the spring mass effect.

8.8 Repeats 8.5 and 8.6 above for a simple pendulum.

8.9 Repeats 8.5 and 8.6 above for a liquid in a U-Tube.

8.10 Repeats 8.5 and 8.6 above for a simply supported massless beam with a central paint load (expression for deflection to be given).

8.11 Solves problems on 8.2 to 8.10 above.

8.12 Discusses Scotch Yoke mechanism as pure SHM.

8.13 Discusses the reciprocating crank/connecting rod mechanism with reference to SHM and modified SHM.

8.14 Describes the component forces of the piston effort.

8.15 Explains the effect of friction at the crosshead.

8.16 Discusses crankshaft torque with reference to piston effort.

8.17 Solves problems involving 8.13 to 8.16 above (expressions for instantaneous displacement, velocity and acceleration of piston to be given as required).

8.18 Determines crankshaft speed from piston speed.

8.19 Discusses cam operation.

8.20 Describes the following cam profiles:

(a) giving SHM motion to the follower;
(b) a motion resulting from a cam which has an elliptical silhouette;
(c) a motion resulting from a cam which is cylindrical but eccentrically mounted;
(d) a motion in which the cam provides a Period of dwell of the follower.

8.21 Solves problems involving spring force, friction, gravitational force, accelerating force and reaction force for on centre line followers for the cams at 8.22.

F MACHINES

9 Understands the principles involved in the determination of movement ratio for geared mechanisms.

9.1 Recalls the term movement ratio (velocity ratio).

9.2 Determines the movement ratio for simple and compound gear trains.

9.3 Solves problems related to 9.2 above.

G STRENGTH OF MATERIALS

10 Revises the terminology and solves simple problems in strength of materials.

10.1 Recalls the terms, with Units as appropriate: direct stress and strain; shear stress and strain; Modulus of Elasticity E; Modulus of Rigidity G; proof stress; and factor of safety.

10.2 Solves problems involving simple and stepped bars subjected to axial loading.

10.3 Solves problems involving the shear stress in simple components, eg jointed stays.

10.4 Discusses the effect of axial loading on compound members.

10.5 Solves problems involving compound members subjected to direct axial loads.

11 Discusses the effect of temperature change on the physical dimensions of components.

11.1 Determines the stresses set up in simple and stepped bars subjected to linear thermal strain.

11.2 Discusses the effects of temperature change on composite members.

11.3 Solves problems involving differential thermal expansion (and contraction).

11.4 Solves problems involving compound members subjected to both direct loading and temperature change, eg nut, bolt and tube assembly.

12 Solves problems involving shear forces and bending moments on simply supported and cantilever beams.

12.1 Determines the support reactions for beams subjected to point and/or uniformly distributed loads.

12.2 Recalls the terms Shear Force, SF, and Bending Moments, BM.

12.3 Calculates the SF and BM at any point along a beam.

12.4 Explains the need for a sign convention when dealing with SFs and BMs.

12.5 Sketches the SF and BM diagrams for the four standard cases:

(a) simply supported beam with point load at mid span;
(b) cantilever with point load at free end;
(c) simply supported beam with UDL along total length;
(d) cantilever with UDL along total length.

12.6 Draws to scale SF and BM diagrams for beams subjected to combinations of point loads and uniformly distributed loading.

12.7 Repeats 12.6 above when beam is subjected to an offset bracketed load.

12.8 Explains the relationship between SF and BM.

12.9 Calculates the position and magnitude of maximum bending moment.

12.10 Defines 'point of contraflexure'.

12.11 Calculates the position of any point of contraflexure on a loaded beam.

12.12 Discusses the concept of uniformly varying distributed loading, eg hydrostatic loading.

12.13 Sketches SF and BM diagrams for the loading case given at 12.12 above.

12.14 Discusses slope and deflection of loaded beams.

12.15 States the expression for the maximum deflection for the four standard cases listed at 12.5 above.

13 Solves problems related to the Theory of Simple Bending.

13.1 Lists the assumptions necessary in deriving the bending theory.

13.2 Derives the expression: $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$

13.3 Shows that the NA of the section passes through the centroid.

13.4 Defines Section Modulus 'Z'.

13.5 Sketches simple diagrams showing the bending stress distribution across the beam section.

13.6 Solves problems using the bending theory, together with the concepts of 12.6 and 12.15.

13.7 Discusses the concept of combined bending and direct stress.

13.8 Describes how eccentric and inclined loading can induce both bending and direct stresses.

13.9 Solves problems referring to the loading cases identified above involving sections symmetrical and non-symmetrical above their NA.

13.10 Sketches the stress distribution diagrams for the above, inserting principal values and postion of zero stress.

14 Solves problems relating to the stability of axially loaded columns.

14.1 Discusses the concept of buckling and defines the term ‘slenderness ratio'.

14.2 Discusses the four basic end conditions for struts.

14.3 Discusses the use of the Euler formulae for struts.

14.4 Solves problems using given Euler formulae, for any of the four basic conditions.

15 Derives and uses the simple theory of torsion for members of circular sections.

15.1 Lists the assumptions necessary in deriving the torsion theory.

15.2 Derives the expression: $\frac{T}{J} = \frac{G\theta}{L} = \frac{\tau}{R}$

15.3 Recalls the expression for the power transmitted by a rotating shaft.

15.4 Defines torsional stiffness.

15.5 solves problems applying the expressions above to uniform and stepped shafts of solid and/or hollow section and to shaft and pulley arrangements.

15.6 States the relationship between the torque transmitted by a shaft and the shear force induced in the coupling bolts.

15.7 Solves problems involving shaft coupling bolts associated with 15.5 above.

15.8 Compares the masses of solid and hollow shafts.

15.9 Determines the stresses set up in the materials of compound shafts.

16 Applies the theory of torsion to close coiled helical springs.

16.1 Develops the formula for stress and deflection of a helical spring subjected to an axial load.

16.2 Solves problems on the design of such springs.

17 Solves problems relating to the concept of elastic strain energy.

17.1 Defines strain energy and resilience.

17.2 Derives the expression: $U = \frac{\sigma^2 AL}{2E}$

17.3 Solves problems by applying 17.2 above for members subjected to gradually applied loading.

17.4 Discusses the concept of impact loading.

17.5 Solves problems involving conversion of PE and/or KE into strain energy to determine the maximum instantaneous stress and deformation.

17.6 Derives expressions for the strain energy of a helical spring in terms of both linear deflection and torque.

17.7 Solves problems involving strain energy of springs.

18 Solves problems involving the concept of stresses on oblique planes of stressed material.

18.1 Shows that a material subjected to a direct force experiences both direct and shear stresses on an oblique plane.

18.2 Determines the direct and shear stresses on an oblique plane of a material subjected to axial force and mutually perpendicular forces (or stresses).

18.3 Shows that the maximum shear stress occurs on a 45’ plane.

18.4 Discusses the concept of complementary shear stress.

18.5 Repeats 18.2 above, including applied shear stress.

18.6 Recalls the, expressions for hoop and longitudinal stress in a thin cylinder subjected to internal pressure.

18.7 Solves problems involving direct and shear stresses on oblique seams of thin cylinders.

H HYDROSTATICS

19 Solves problems involving hydrostatic forces on immersed areas.

19.1 Recalls the terms: mass, density, relative density, pressure, gauge pressure and absolute pressure.

19.2 Derives the expression for the pressure at any depth in a liquid.

19.3 Determines pressures from given piezometer, manometer and barometer readings.

19.4 Derives the general expression for the resultant hydrostatic force on an area immersed at any depth in a liquid.

19.5 Defines the term 'centre of pressure'.

19.6 Derives the general expression for the position of the centre of Pressure of an area immersed at any depth in a liquid.

19.7 Solves problems relating to the resultant thrust and centre of pressure for: bulkheads, tanks, door and lock gates, positioned vertically and inclined.(Immersed areas limited to rectangular, circular, triangular and trapezoidal).

19.8 Determines the resultant thrust and centre of pressure for a vertical rectangular area wetted by two immiscible liquids.

19.9 Repeats 19.7 and 19.8 above when the free surface is subjected to a gas pressure.

20 Applies Archimedes Principle to solve problems.

20.1 States Archimedes Principle with reference to floating and submerged bodies.

20.2 Solves problems applying 20.1 above and to include bodies floating in two immiscible liquids.

20.3 Solves problems applying 20.1 above for bodies descending vertically through liquids, the motion being frictionless.

I HYDRODYNAMICS

21 Discusses the concepts of energy related to the steady flow motion of liquids and solves associated problems.'

21.1 Discusses the volumetric and mass flow rates of liquidsand states the continuity equation.

21.2 Explains the concept of coefficient of velocity $C_{V,}$ coefficient of contraction C_C, and coefficient of discharge C_d for a sharp edged orifice.

21.3 Applies 21.2 above to solve problems involving flow of liquids through sharp edged orifices.

21.4 Identifies the various forms of energy possessed by a liquid in motion and states the expression for these in terms of energy and equivalent head.

21.5 Applies the principle of the conservation of energy and hence derives the Bernoulli expression.

21.6 Discusses the effect of friction related to flow problems and explains how this is included with the Bernoulli statement.

21.7 Applies the above to a venturi meter.

21.8 Explains the concept of the coefficient of discharge, c_d, with reference to a venturi meter.

21.9 Solves problems applying 21.5 above to:

parallel and tapering pipes and venturi meters positioned horizontally, vertically and inclined; both frictionless and systems with friction to be included.

21.10 States D'Arcy's formula for friction losses in pipelines.

21.11 Discusses 'equivalent length' of pipes to allow for energy losses at bends and valves.

21.12 Solves problems related to 21.9 and 21.10 above.

22 Solves problems related to changes in momentum of liquids in motion.

22.1 Recalls that force is equal to the rate of change of momentum.

22.2 Derives an expression for the instantaneous pressure rise due to rapid valve closure and solves associated problems.

22.3 Determines the resultant force on pipe bends due to change of momentum.

22.4 Determines the reaction force at hydraulic nozzles.

22.5 Determines the power of a hydraulic jet.

22.6 Solves problems related to the impact of jets on stationary flat plates positioned perpendicular and inclined to jet.

22.7 Repeats 22.6 above for moving plates.

22.8 Draws the velocity diagram for the impact of a jet on a curved vane.

22.9 Discusses the principles of a centrifugal pump.

22.10 Determines impeller width for constant and variable radial flow velocity through impeller.

22.11 Determines volumetric flow rate through impeller.

22.12 Determines the work done on the fluid passing through a centrifugal pump.

22.13 Derives the expression for manometric head and determines manometric efficiency.

22.14 Solves problems involving: impeller speed, blade angles for shockless flow, fluid velocity, pump efficiency, capacity and power.

J MATHEMATICAL SOLUTIONS OF CONTROL SYSTEM PROBLEMS

23 Derives equations and in certain cases solves mathematical problems related to control.

23.1 Solves mathematical problems related to pneumatic and hydraulic systems given, where necessary, the relevant formulae.

23.2 Be able to analyse a simple pneumatic or hydraulic control system and derive the equation of motion.

Chief Engineer Reg III/2 — Applied Heat

LIST OF TOPICS

A Thermodynamics Systems
B Thermodynamic Processes
C Heat Engine Cycles
D IC Engine Performance
E Reciprocating Air Compressors
F Combustion
G Heat Transfer
H Properties of Steam and Steam Cycles
I Nozzles and Steam Turbines
J Refrigeration

The expected learning Outcome is that the candidate:

A THERMODYNAMIC SYSTEMS

1. **Defines and applies the fundamental concepts of thermodynamic properties to a system.**

   1.1. Defines a thermodynamic system.
   1.2. Distinguishes between open and closed thermodynamic systems giving examples.
   1.3. Defines Heat and Work with reference to a thermodynamic system.
   1.4. States the conservation of energy in thermodynamic terms and identifies it as the First Law of Thermodynamics.
   1.5. Defines enthalpy in terms of internal energy and flow work.
   1.6. Defines a non-flow system and derives the non-flow energy equation $Q - W = \Delta U$
   1.7. Defines a steady flow system and derives the steady flow energy equation $Q - W = \Delta H + \Delta KE$
   1.8. Solves problems involving closed and open systems 1.1 to 1.7.

B THERMODYNAMIC PROCESSES

2. Defines and applies the fundamental properties of thermodynamics to a process.

2.1. Recalls Boyle's and Charles' Law and the combination law.

2.2. Recalls the Equation of State.

2.3. Derives the relationship between p, V and T for polytropic and adiabatic processes.

$\frac{T_2}{T_1} = \frac{P_2}{P_1}^{\frac{n-1}{n}} = \frac{V_1}{V_2}^{n-1}$ and

$\frac{T_2}{T_1} = \frac{P_2}{P_1}^{\frac{\delta-1}{\delta}} = \frac{V_1}{V_2}^{\delta-1}$

2.4. Derives graphically and analytically the polytropic index -n'.

2.5. Defines a reversible process.

2.6. States the conditions to be satisfied for a process to be reversible.

2.7. Defines a reversible process carried out with an ideal gas as follows:

(a) Constant volume process;
(b) Constant pressure process;
(c) Isothermal process;
(d) Isentropic or Adiabatic or constant heat process;
(e) Polytropic process;
(f) Defines Isentropic as Reversible Adiabatic and identifies the difference between — Isentropic and non-reversible adiabatic.

2.8. Derives the expression for the work transfer and heat transfer for each of, or combination of processes in 2.7.

2.9. Defines the specific head of a gas and shows the difference between specific heat at constant pressure and constant volume

2.10. Shows the relationships

$\Delta U = C_v$

$\Delta h = C_p$

$\delta = \frac{C_p}{C_v}$

$R = C_p - C_v$

and is able to combine these relationships by substitution

2.11. Solves problems relating to 2.1 to 2.10

2.12. Discusses the concept of entropy as a thermodynamic property of a perfect gas.

2.13. Applies change of entropy.

$$m\,C_p\,ln\,\frac{T_2}{T_1}$$

$$m\,C_v\,ln\,\frac{T_2}{T_1}$$

2.14. Defines heat transfer and work transfer and represents on p - v and T - S diagrams.

2.15. Shows the processes in 2.7 on T - S diagram.

2.16. Solves problems 2.12 to 2.15.

2.17. States Avogadro's Law.

2.18. Defines kg — mol and uses it in the Equation of State.

2.19. Defines 'Molar Volume' and gives its value at S.T.P.

2.20. Derives the Universal Gas Constant R and its relation to with M and R

2.21. Solves problems relating to 2.17 to 2.20.

C HEAT ENGINE CYCLES

3. Discusses the concept of heat engine cycles.

3.1. States the 2nd law of thermodynamics and relates this to the heat engine.

3.2. Describes the Carnot Cycle with reference to a heat engine.

3.3. Derives the thermal efficiency of a Carnot Cycle.

3.4. Application of Carnot's principle to show that no cycle can be more efficient without contravening the 2nd law.

3.5. Describe the ideal, ie engine cycles, Otto, Diesel, Dual Combustion and Joule and relates to p - v and T -S diagrams

3.6. Derives expressions for thermal efficiency, imep and net-work done, for the cycles in 3.5.

3.7. Derives Air Standard Efficiency.

3.8. Solves problems relating to 3.2 to 3.7.

3.9. Describes the practical counterparts of the cycles identified at 3.5.

3.10. Discusses simple ideal and actual open and closed cycle gas turbines, with two stage compressors and turbines, including reheat and optional heat exchanger.

3.11. Discusses heat exchanger 'Effectiveness' and hence derives 'Thermal Ratio'.

3.12. Expresses 3.10 with respect to T - S diagrams.

3.13. Derives cycles thermal efficiencies, work and heat transfer with respect to 3.10.

3.14. Solves problems relating to 3.10 to 3.13.

D IC ENGINE PERFORMANCE

4. Discusses internal combustion engines and engine performance.

4.1. Recalls the following engine powers and formulae:
- (a) Indicated power;
- (b) Brake power;
- (c) Friction power.

4.2. Recalls indicated and brake mean effective pressure and how to derive them.

4.3. Shows that brake mean effective pressure is directly-proportional to engine torque and independent of the engine speed.

4.4. Determines the distribution of energy in an engine and produces a heat balance account.

4.5. Describes the Morse Test and calculates power from given data.

4.6. Recalls mechanical efficiency, indicated thermal efficiency, brake thermal efficiency.

4.7. Defines specific fuel consumption.

4.8. Sketches typical performance curves for IC engines.

4.9. Solves problems relating to 4.1 to 4.8.

E RECIPROCATING AIR COMPRESSORS

5. Discusses and describes the use of reciprocating air compressors.

5.1. Sketches and describes the basic cycle for a single stage compressor running without clearance.

5.2. Derives the expression for indicated work transfer.

5.3. Sketches and describes the basic cycle for a single stage compressor running with clearance.

5.4. Derives the expression for net indicated work transfer given the area under the curve.

5.5. Derives expressions for volumetric efficiency.

5.6. States the effect of compressive index on net indicated work transfer.

5.7. Relates ideal (isothermal) and actual (polytropic) compression cycles and derives isothermal efficiency.

5.8. Discusses multi-stage compression and understands the advantages of same.

5.9. Defines conditions of minimum work with multi-stage compression.

5.10. Recognises multi-stage compression when 5.9 does not apply.

5.11. Distinguishes between indicated and input power requirements.

5.12. Discusses heat transfer during compression and interstage cooling.

5.13. States the significance of Clearance Ratio.

5.14. Solves problems relating to 5.1 to 5.13.

F COMBUSTION

6. Discusses combustion of solid, liquid and gaseous fuels by mass and by volume in terms of air requirements, excess air and products of combustion.

6.1. Recalls the chemistry definitions: Atom, Molecule, Compound, Atomic Mass, Molecular Mass.

6.2. Derives the equations of combustion by mass.

6.3. Derives the equations of combustion by volume for gaseous fuels.

6.4. Recalls stoichiometric and actual air requirements.

6.5. Understands and applies Avogadro's Hypothesis to exhaust and flue gas analysis.

6.6. Determines total flue gas and dry flue gas analysis by mass and by volume.

6.7. Determines air supply from flue gas analysis.

6.8. Derives the proportional gravimetric constituents of a fuel from flue gas analysis.

6.9. Determines the exhaust products resulting from insufficient air supply and determines C burned to CO and C burned to CO.

6.10. Determines the approximate HCV and LCV of a fuel from the heat energy released by the various constituents.

6.11. Applies Dalton's laws to stoichiometric and other mixtures of gaseous fuels and air.

6.12. Determines the mean molecular mass of a mixture of gases and the specific gas constant for the mixture.

6.13. Determines the ‘dew point’ of water vapour from flue gas analysis.

6.14. Determines heat carried away in flue gases and determines heat transfer to gas to air and gas to water heat exchanges.

6.15. Solves problems relating to 6.1 to 6.14.

G HEAT TRANSFER

7. Discusses modes of heat transfer by conduction, radiation convection.

7.1. States Fourier's Law for conductive heat transfer.

7.2. Applies 7.1 to single flat plate and composite flat plate and derives an expression for conductive heat transfer through composite flat plates.

7.3. Applies given formulae for heat transfer through thick cylinders.

7.4. Relates 7.3 to single and double lagged pipes, spheres and hemispherical ends of cylinders.

7.5. Discusses heat transfer through boundary layers and applies thermal conductance coefficients.

7.6. Determines the overall heat transfer coefficient ‘U’ for composite flat plates and composite lagged pipes, etc using thermal conductivity and surface heat transfer coeff.

7.7. States the Stefan Boltzmann constant for heat transfer by radiation. Defines ‘black body’ radiation and ‘emissivity factor’ and applies this to a simple system.

7.8. Solves problems relating to 7.1 to 7.7.

7.9. Solves problems involving heat exchangers using ‘log mean temp difference’.

H PROPERTIES OF STEAM AND STEAM CYCLES

8. Understands constant pressure steam formation, and the use of thermodynamic property tables and charts.

8.1. Understands steam formation, steam terms and demonstrates the use of thermodynamic property tables including interpolation of tables.

8.2. Recalls the formulae for boiler efficiencies.

8.3. Recalls formulae for ‘equivalent evaporation’ and explains its use.

8.4. Determines the heat energy distribution in a boiler plant and compiles a heat balance account.

8.5. Applies thermodynamic properties of water and steam to solve problems on mixtures, evaporators and steam generators.

8.6. Discusses the concepts of throttling.

8.7. Discusses the concepts of entropy of liquid, vapour and super heated steam and their evaluation from steam tables and from given formulae.

8.8. Understand the construction and demonstrates the use of H-S and T-S charts.

8.9. Discusses the isentropic expansion of steam and demonstrates this process on H-S and T-S diagrams.

8.10. Discusses the Carnot Vapour Cycles and modifications resulting in the basic Rankine Cycle.

8.11. Discusses the improvements to the basic cycle from super-heating, reheating and feed heating.

8.12. Relates these cycles to PV and TS diagrams.

8.13. Derives an expression for thermal efficiency when operating on the above cycles.

8.14. Determines feed pump work and relates this to thermal efficiency of the plant.

8.15. Describes bled steam feed heating and determines heat transfer by steam and feed water through multi-stage contact and surface feed heating.

8.16. States Dalton's Law of partial pressures, its application to partial volumes and its application to steam/air mixtures in condensers and associated plant.

8.17. Solves problems relating to 8.1 to 8.16 by calculation, thermodynamic tables and H-S charts.

I NOZZLES AND STEAM TURBINES

9. Understand the use of steam as a working fluid and discusses its behaviour during flow through nozzles under equilibrium conditions.

9.1. Applies steady flow energy equation to flow through steam nozzles and derives throat and exit velocities.

9.2. Distinguishes between isentropic and actual enthalpy drop in nozzles and defines nozzle efficiency.

9.3. States reasons for change of nozzle form and use of convergent and convergent/divergent sections.

9.4. Recognises critical pressure ratios for nozzle flow and applies the same, from given formulae.

9.5. Solves problems on 9.1 to 9.4 with equal regard to mass flow rates and flow areas.

9.6. Discusses compounding arrangements for simple turbines.

9.7. Recalls blade velocity diagrams for simple impulse turbine.

9.8. Defines kinetic or friction losses, leaving losses and derives expressions for same.

9.9. Constructs blade velocity diagrams for a Curtis stage.

9.10. Derives expressions for stage power, stage/diagram efficiency and stage axial thrust for a velocity overall and pressure compounded turbines.

9.11. Derives an expression for degree of reaction.

9.12. Constructs blade velocity diagram for a reaction turbine pair.

9.13. Defines mean blade height and calculates blade height.

9.14. Calculates number of stages from given steam conditions for reaction blading only

9.15. Shows the effect of blade friction, (blade velocity coefficient) and blade speed ratio.

9.16. Solves problem relating to 9.7 to 9.15.

J REFRIGERATION

10. Understands the concept of a reversed heat engine cycle and its application to refrigerating plant and heat pump, and recognises the properties of common refrigerants.

10.1. Recalls the basic vapour compression refrigeration cycle.
10.2. Recalls the use of thermodynamic tables including the interpolation of values.
10.3. Applies the concepts of entropy and its evaluation from tables and from given formulae.
10.4. Relates vapour compression cycles of p-H and T-S axes.
10.5. Relates reversed Carnot cycle on p-H and T-S axes.
10.6. Shows effects of superheating at evaporator outlet and undercooling at condensor outlet and relates to p-H and T-S.
10.7. States relationship between mass flow rate of refrigerant, refrigerating effect, cooling load.
10.8. Defines COP for heat pump and refrigerator.
10.9. Derives expressions for COP of actual plant and compares to COP of plant working on reversed Carnot cycle.
10.10. Defines volumetric efficiency of compressor and its effect on cylinder dimensions.
10.11. Solves problems relating to 10.1 to 10.9.
10.12. Understands the application of intermediate liquid cooling and solves simple problems involving flash chambers.

Chief Engineer Reg III/2 -—Naval Architecture

LIST OF TOPICS

The expected learning Outcome is that the candidate:

A SIMPSON'S RULE

1. Applies Simpson's first rule (including subdivided intervals) to the determination of second moments of area.

- 1.1. Derives the method of calculating the second moment of area of a plane about an end ordinate using Simpson's Rule.
- 1.2. Derives the method of calculating the second moment of area of a plane about its base using Simpson's Rule.
- 1.3. Calculates the second moment of area of a plane using 1.1 and 1.2.
- 1.4. Uses the Theorem of parallel Axen in conjunction with 1.3 to determine the second moment of area of a plane about its neutral axis.
- 1.5. Calculates the second moment of area of a waterplane about the centreline.
- 1.6. Calculates the second moment of area of a waterplane about a transverse axis passing through its centroid.
- 1.7. Calculates the second moment of area of an unsymmetrical tank top about a longitudinal axis passing through its centroid.

B FREE SURFACE EFFECT

2. Understands the effect of free surface liquids on transverse stability and solves problems involving free surface effect.

- 2.1. Explains that the effect of a free surface is to causea transverse shift of a ship’s centre of gravity when vessel heels.
- 2.2. Explains that this transverse shift of centre of gravity has the same effect on the stability as a reduction in the transverse metacentric height.
- 2.3. States an expression for the loss in metacentric height due to the free surface.

2.4. Explains the meaning of ‘effective metacentric height’.
2.5. Discusses the effect of tank divisions on free surface effect.
2.6. Solves problems involving free surface effect.
2.7. Discusses practical considerations of free surface of liquids, eg, the importance of restricting same and the methods of which it may be reduced.

C STABILITY

Stability at Large Angle of Heel

3. Uses cross-curves of stability to produce curves of statical stability.

3.1. Discusses the limitation of metacentric stability at large angles of heel.
3.2. Explains how the cross-curves of stability can be obtained from ship sections for an assumed position of a ship's centre of gravity.
3.3. Uses the cross-curves of stability to predict the righting lever for any given displacement and for an assumed position of the centre of gravity.
3.4. Calculates the necessary corrections to righting levers for the actual position of the ship's centre of gravity.
3.5. Sketches the final righting levers in the form of a statical stability curve.
3.6. Shows that the initial slope of the stability curve may be obtained from the metacentric height.
3.7. Defines range of stability.
3.8. Solves problems on stability at large angles of heel.
3.9. Defines dynamical stability.
3.10. Calculates dynamical stability from statical stability curve or curve of righting moments.

Stability of Wall-Sided Vessels

4. Makes use of particular features of wall-sided vessels to obtain an approximation to the stability of a ship.

4.1. States wall-sided formula for GZ values.
4.2. Discusses the limitations of the wall-sided formula.
4.3. Solves simple problems using the wall-sided formula.
4.4. Applies the wall-sided formula to vessel with negative metacentric height to derive an expression for ‘Angle of Loll’.
4.5. Solves problems using the Angle of Loll expression.
4.6. Discusses procedures used to improve stability when at Angle of Loll.

Effect of Form on Stability

5. Understands the effects of form on stability.

5.1. Discusses the effect of change of beam on the statical stability curve.
5.2. Discusses the effect of freeboard on the statical stability curve.
5.3. Discusses the effect of metacentric height on the statical stability curve.
5.4. Sketches typical stability curves for different types of ship.

6. Stability information supplied to ships.

6.1. Discusses the statutory requirements for the carriage of stability data on ships.
6.2. Discusses the relevance of the area under the stability curve.

D TRIM

Small Masses

7. Understands how to calculate the effects on the end draughts of addition, removal, or longitudinal movement of small masses.

7.1. Defines Trim.
7.2. Explains importance of the longitudinal centre of flotation (LCF) in relation to trim problems.
7.3. Explains that the mean draught of a ship is the draught at the LCF.
7.4. Defines longitudinal metacentre.
7.5. Defines longitudinal metacentric height.
7.6. States an expression for the distance of the longitudinal metacentre above the centre of buoyancy.
7.7. Derives an expression for the moment to change trim 1 cm.
7.8. Determines change of trim due to longitudinal movement of small masses already on board.
7.9. Determines the effect of small additions or removals mass on end draughts of a ship.
7.10. Solves problems involving the end draughts after masses have been added, removed or moved longitudinally.

Large Masses

8. Understands how to use hydrostatic data to determine end draught of a ship.

8.1. Demonstrates how geometrical properties are presented in the form of hydrostatic curves enumerating the curves concerned.

8.2. Sketches a set of hydrostatic curves.

8.3. Determines end draughts for loading conditions using hydrostatic curves or hydrostatic data.

8.4. Determines the displacement of a ship, lying at a trimmed waterline.

Bilging

9. Solves problems on the change in end draughts of a box-shaped vessel due to bilging a compartment which is not at midships.

9.1. Shows that when a compartment is bilged there can be changes in heel and or. in trim in addition to the change in mean draught.

9.2. Calculates the displacement of B and G due to bilging

9.3. Calculates the second moment of area of the intact waterplane about its neutral axis.

9.4. Calculates the effects of bilging on a non-midship compartment of a box-shaped vessel.

10. Understands the elements in ship design which are included in order to reduce the effects of bilging.

10.1. Discusses the effects of bilging.

10.2. Discusses subdivision of vessels with transverse and longitudinal watertight bulkheads in cargo and passenger ships.

10.3. Discusses the requirements indicated in 10.2.

E RUDDERS

11. Understands the principal forces acting on a ship and rudder, when helm is applied to a vessel.

11.1. Explains that when the rudder is moved to an angle, from a moving ship's centreline, a pressure build up on the forward side and a suction on the aft side of the rudder gives rise to a force (F) acting parallel to the ship's centreline.

11.2. States that the force acting on a rudder parallel to the ship's centreline is given by $F = kAV^2$

11.3. Expresses the force normal to the rudder as a component of the rudder force acting parallel to the ship's centreline.

11.4. Explains that the normal force acts at the centre of effort.

11.5. Calculates the torque applied by the rudder to the rudder stock.

11.6. Applies the torsion equation in order to determine the minimum diameter of rudder stock given the maximum allowable shear stress in the stock material.

11.7. Determines the work done in turning the rudder to a given angle from a graph of Torque against Rudder Angle.

11.8. Derives an expression for the angle of heel produced due to the force on the rudder.

11.9. Derives an expression for the angle of heel produced by a ship moving in a circular path.

11.10. Solves problems involving heeling of a ship due to rudder being applied to the vessel.

11.11. Describes types of rudder in use on merchant ships.

11.12. Discusses the reasons for using balanced rudders.

F SHIP RESISTANCE

12. Calculates the power required to drive a ship from the resistance to motion exerted by the water on a ship at any given speed.

12.1. Applies the expression $R_f = fsv^n$ to determine frictional resistance to motion of a vessel given the empirical formulae for frictional coefficient 'f' of the form: : $F = A + \frac{B}{L+C}$

12.2. States Froudes Laws of Comparison.

12.3. Explains the meaning of the term ‘corresponding speed’.

12.4. Applies the law of comparison to determine the residuary resistance of a ship if the residuary resistance of a scale model of the vessel is known or can be determined.

12.5. Explains the meaning of the terms:

(a) Effective Power (naked);
(b) Effective Power;
(c) Ship Correlation factor.

12.6. Calculates the effective power requirements of a full sized ship given the total resistance to motion measured on a scale model of the vessel towed at the corresponding speed.

Propellers

13. Understands the relationships between powers measured at points between the ship's engines and the propeller.

13.1. Explains the meaning and use of:

- (a) thrust deduction factor;
- (b) hull efficiency;
- (c) propeller efficiency;
- (d) transmission efficiency;
- (e) mechanical efficiency;
- (f) propulsive coefficient;
- (g) quasi propulsive coefficient

13.2. Develops the relationships between indicated power, shaft power, delivered power, thrust power and effective power.

13.3. Solves numerical problems using the relation between powers.

14. Understands the phenomenon of propeller cavitation, its causes and its effects.

14.1. Explains what is meant by cavitation.

14.2. Explains that cavitation may cause erosion of the blade surface, vibration and reduction in efficiency.

14.3. Explains that cavitation depends upon the net pressure of the blade surface and the vapour pressure of the water.

14.4. Discusses the factors in propeller design which reduce cavitation.

14.5. Discusses the practical reduction of cavitation by a ship's staff.

Ships' Trials

15. Understands the reasons for carrying out ships' trials, and the value of the data obtained from them.

15.1. Explains that ship trials are carried out primarily to measure power and its related speed

15.2. Explains that there are progressive speed trials and full speed trials.

15.3. Explains the value to ship staff and designers of the data measured during progressive trials.

15.4. Explains that the opportunity is taken on ship trails to test all systems under working conditions.

Shear Force and Bending Moments in Still Water

16. Evaluates shear forces and bending moments on ships of simple geometric form.

16.1. Identifies the purpose of a loading manual for a ship.

16.2. Outlines the use of a stress indicator for a ship.

16.3. Explains:

(a) weight curve of a ship;
(b) buoyancy curve of a ship

16.4. Shows that the load curve is the difference between the weight curve and the buoyancy curve.

16.5. Illustrates that the shear force at any point in the length of a ship is represented by the area of the load curve on one side of the point.

16.6. Uses 16.5 to produce a shear force diagram.

16.7. Illustrates that the bending moment at any point in the length of a ship is represented by the area of the shear force on one side of the point.

16.8. Uses 16.7 to produce a bending moment diagram.

16.9. Solves problems on box shaped vessels floating in still water on level keel.

H SHIP STRESSES

17. Recognises the causes and effects of stresses acting on ships.

17.1. Explains the circumstances under which the following stresses may occur in a ships structure:

(a) torsional stresses;
(b) whipping stresses.

17.2. Explains the steps taken to avoid or resist the stresses in 17.1.

17.3. Explains the circumstances which may result in the following occurring in ships structures:

(a) brittle fracture;
(b) fatigue.

17.4. Explains the steps taken to prevent the occurrence of brittle fracture and fatigue.

17.5. Identifies the points of discontinuity in a ships structure and explains measures adopted to minimise their effects.

I SHIP CONSTRUCTION

Ship types

18. Recognises the problems associated with and the structural arrangements for the carriage of liquefied gases.

18.1. Explains the difference between LNG and LPG by describing their origins and quoting the following physical properties:

a) boiling point;
b) critical temperature

18.2. Describes the following cargo systems and identifies the gases for which they are suitable:

a) fully pressurised;
b) semi pressurised/semi refrigerated;
c) semi pressurised/fully refrigerated;
d) fully refrigerated at atmospheric pressure.

18.3. Explains 'secondary barrier' and why it is required.

18.4. Describes with the aid of sketches the following containment systems and how they are insulated:

a) free standing-prismatic;
b) free standing-spherical;
c) membrane.

18.5. Describes in broad outline how cargo boil-off is dealt with.

18.6. Lists the safety devices fitted on board to ensure safe loading and unloading explaining their function.

19. Recognises the problems associated with and the structural arrangements for the carriage of chemical cargoes.

19.1. Explains what is meant by compatibility and how it is catered for in chemical carriers with respect to:

a) different cargoes;
b) air;
c) water;
d) tank coatings;
e) temperature;
f) self reaction.

19.2. Explains that chemical cargoes may be designated A, B or C according to the degree and nature of the hazard involved in their carriage.

19.3. Explains that the cargo tank arrangements are governed by the cargo designation.

19.4. Explains with the aid of sketches the tank arrangements for the cargoes designated in 19.2.

19.5. Explains that protection of the structure in 19.4 can be achieved by suitable materials or coatings.

19.6. Identifies the coatings and materials in 19.5 and cargoes for which they are suitable.

19.7. Explains measures which should be taken by crew members to ensure personal safety.

20. Recognises the problems associated with the carriage of various cargoes.

20.1. Summarises the conditions by arrangement of the loadline.

20.2. Sketches the loadline naming the lines.

20.3. Explains the problems involved in the carriage of the following cargoes:

a) deck timber;
b) grain;
c) iron ore;
d) concentrates.

20.4. Explains the precautions which must be taken when carrying the cargoes in 20.3.

Tonnage and Freeboard

21. Analyses the Loadline Rules with particular reference to the 'conditions of assignment'.

21.1. Distinguishes terminology, 'freeboard', 'freeboard deck', 'superstructure deck', 'Type A ship', 'Type B ship', 'superstructure'.

21.2. Enumerates the criteria used as a basis for assigning freeboards:

a) adequate ship strength;
b) adequate reserve buoyancy;
c) prevention of entry of water into hull;
d) safe height of working platform and protection of crew;
e) deck wetness in relation to bow height;
f) stability and compartmentation.

21.3. Explains various seasonal and fresh water loadline markings.

21.4. Enumerate conditions for assigning basic minimum freeboard to tankers.

21.5. Distinguishes main factors and describes maintenance required to maintain 'conditions of assignment':

a) hatchways;
b) machinery space openings;
c) openings in freeboard and superstructure decks;
d) vents, air pipes, cargo doors and other openings in hull below the freeboard deck;
e) side scuttles, freeing ports;
f) guard rails, gangways.

21.6. Distinguishes between tabular freeboard, basic freeboard, assigned freeboard.

21.7. Explains the conditions under which Type 'B' ship may be assigned a reduced freeboard

21.8. Distinguishes between gross and net tonnages

21.9. Determines the information required for tonnage measurement

21.10. Distinguishes between enclosed and excluded spaces.

21.11. Analyses the function of the tonnage certificate and discusses the statement of information given

Structural Materials

22. Integrates learning from different areas to explain the uses of materials other than mild steel for ships structures.

22.1. Identifies the advantages and disadvantages of higher tensile and other special steels, aluminium alloys and glass reinforced plastics as constructional materials.

22.2. Explains the uses of materials in 22.1 in ship construction.

22.3. Identifies the problems encountered in the connection of aluminium to steel in ship construction.

22.4. Illustrates a method used to overcome 22.3.

J CLASSIFICATION, STRUCTURAL FIRE PROTECTION, LIFE SAVING APPLIANCES AND POLLUTION CONTROL.

23. Analyses the function and influence of Classification Societies on the construction of ships.

23.1. Determines the role of Classification Society in the design, building and operation of ships.

23.2. Determines the nature of initial survey for award of class and intermediate/continuous surveys for retention of classification.

23.3. Distinguishes between surveys for the various ship types, ie oil tankers, dry cargo ships, refrigerated cargo ships, chemical tankers, gas carriers.

23.4. Shows an understanding of classification notation.

Structural Fire Protection

24. Identifies in general terms the methods of structural fire protection for passenger ships and cargo ships.

24.1. Explains that fire divisions are classified according to their degree of fire resistance.

24.2. Describes, in broad outline only, the structural arrangements for fire protection of passenger ships.

24.3. Outlines the requirements regarding:

a) openings in A-class divisions;
b) the protection of stairways, lift shafts and ventilation trunks.

24.4. Describes the structural arrangements for fire protection of:

a) dry cargo ships
b) oil tankers.

Life-Saving Appliances

25. Understands in broad outline the life-saving requirements for merchant ships.

25.1. Lists the following types of life-saving equipment:

a) lifeboats;
b) liferafts;
c) lifebelts;
d) life jackets;
e) buoyancy equipment.

25.2. Describes, with the aid of a sketch, a set of lifeboat gravity davits.

25.3. Describes, with the aid of a sketch, the braking arrangements for the davits described in 25.2.

25.4. Describes a launching procedure using the davits described in 25.2.

Pollution Control by Construction

26. Understands the facts and principles underlying the regulations for marine pollution control by construction.

26.1. Explains the following:

a) segregated ballast tanks;
b) clean ballast tanks;
c) protective locations;
d) slop tanks.

26.2. Explains the regulations relating to the items in 26.1,

26.3. Explains the crude oil washing (COW) system for cargo tank cleaning.

26.4. States the advantages and disadvantages of COW.

Vibration and Noise

27. Integrates learning from different areas to explain the causes and adverse effects of ship vibration and the methods used to prevent same.

27.1. Defines the terms:

a) frequency;
b) amplitude;
c) resonance;
d) mode;
e) node;
f) anti-node.

27.2. Explains that a ship will have natural frequencies of hull vibration.

27.3. Points out that vibration may be caused by:

a) the action of the sea;
b) out-of-balance forces in main or auxiliary machinery;
c) fluctuating forces on the propeller;
d) propeller-hull interaction;
e) operation of deck machinery.

27.4. Points out that vibration may cause:

a) structural failure;
b) failure of equipment;
c) discomfort to passengers and crew.

27.5. Explains the effect of the following with regard to preventing or reducing vibration:

a) stern design;
b) propeller design;
c) machinery seating arrangements;
d) alteration of ships loading condition.

Noise

28. Recognises the problems of noise on ships and the methods used to reduce same.

28.1. Discusses the sources of noise and how it is transmitted throughout a ship.

28.2. Discusses how structural and machinery arrangement can reduce noise levels.

Appendix 3: MCA Unit mapping

STCW95 Reg III/2 2nd Engineer Unlimited Applied Mechanics — MCA Mapping

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	**Marine Engineering: Statics and Strength of Materials**	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
A STATICS	**X**													
1 Solves problems involving forces in static equilibrium							**X**							
2 Discusses pin jointed frameworks and their solution.							**X**							
3 Solves problems involving centres of gravity and centroids.								**X**						

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	Marine Engineering: Statics and Strength of Materials	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
B FRICTION	**X**													
4 Discusses the effects of friction when one rigid body slides or tends to slide over another rigid body			**X**											
C KINEMATICS	**X**													
5 Solves problems involving linear, angular and relative motion.		**X**												

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	Marine Engineering: Statics and Strength of Materials	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
6 Describes the motion of projectiles and solves associated problems involving moving objects.		X												
7 Understands and uses the concept of relative velocity		X												
D DYNAMICS	X													
8 Discusses the concepts of force and energy and solves associated problems			X											
9 Discusses centripetal and centrifugal effects and solves associated problems.			X											
E MACHINES	X													

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	**Marine Engineering: Statics and Strength of Materials**	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
10 Discusses the principles of simple machines and solves associated problems.					**X**									

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	**Marine Engineering: Statics and Strength of Materials**	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
F STRENGTH OF MATERIALS	**X**													
11 Discusses the effects on a material caused by the application of external forces and solves associated problems.								**X**						
12 Discusses the effect of temperature change on materials														

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	**Marine Engineering: Statics and Strength of Materials**	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
13 Solves problems involving stresses in thin cylinders subjected to an internal pressure								**X**						
14 Solves problems involving stress in thin rotating rims.								**X**						
15 Solves problems involving canitlever and simply supported beams.								**X**						
16 Solves problems involving torsion on circular shafts.									**X**					
G HYDROSTATICS	**X**													

	Marine Engineering: Dynamics and Machines	Outcome 1: Explain and solve problems involving linear, angular and relative motion.	Outcome 2: Explain and solve problems involving dynamics for linear and angular systems.	Outcome 3: Explain and solve problems relating to fluids in motion.	Outcome 4: Explain the principles of simple machines and solve associated problems.	**Marine Engineering: Statics and Strength of Materials**	Outcome 1: Explain and solve problems involving forces and moments concerned with static equilibrium and framed structures.	Outcome 2: Explain and solve problems relating to compressive/tensile loading and bending of sections.	Outcome 3: Explain and solve problems relating to sections under shear and shafts under torsion.	Outcome 4: Derive and solve problems related to manometers and fluids at rest.				
17 Discusses the principle of Archimedes and solves associated problems.										**X**				
18 Solves problems involving hydrostatic forces on immersed areas.										**X**				
H HYDRODYNAMICS	**X**													
19 Solves problems related to liquids in motion.				**X**										

STCW95 Reg III/2 2nd Engineer Unlimited Electrics — MCA Mapping

	Marine Engineering: Electrical and Electronic Devices	Outcome 1 Discuss the physical construction and compare the characteristics of basic electrical/electronic components	Outcome 2 Demonstrate knowledge of simple linear dc and ac electrical circuits and solve related problems.	Outcome 3 Analyse the characteristics and marine applications of semiconductor devices used in rectification and small signal devices	Outcome 4 Describe secondary cells and batteries for marine applications	**Marine Engineering: Electrical Motors and Generators**	Outcome 1 Apply three phase circuits	Outcome 2 Apply the principles of magnetism and electromagnetic induction	Outcome 3 Explain the action of generators	Outcome 4 Explain the action of motors
Electric and Electronic Components										
Understands the physical construction and characteristics of basic components		X	X		X					
Electric Circuit Principles										
Understands the operation of simple linear dc and ac electrical circuits and solves related problems			X	X						
Electromagnetism										
Understands the principles of magnetism and electromagnetic induction								X	X	X

STCW95 Reg III/2 2nd Engineer Unlimited Electrics — MCA Mapping (cont)

	Marine Engineering: Electrical and Electronic Devices	Outcome 1 Discuss the physical construction and compare the characteristics of basic electrical/electronic components	Outcome 2 Demonstrate knowledge of simple linear dc and ac electrical circuits and solve related problems.	Outcome 3 Analyse the characteristics and marine applications of semiconductor devices used in rectification and small signal devices	Outcome 4 Describe secondary cells and batteries for marine applications	**Marine Engineering: Electrical Motors and Generators**	Outcome 1 Apply three phase circuits	Outcome 2 Apply the principles of magnetism and electromagnetic induction	Outcome 3 Explain the action of generators	Outcome 4 Explain the action of motors
Electrical Machines										
Understands the principles and applications of ac motors and generators							**X**		**X**	**X**

STCW95 Reg III/2 2nd Engineer Unlimited Heat — MCA Mapping

	Marine Engineering: Introduction to Marine Heat Engine Principles	Outcome 1: Determine the effect of applying heat energy to solids and liquids	Outcome 2: Apply the Gas Laws to non-flow systems and evaluate the work done	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	Outcome 5: Explain, using an analysis by mass, the combustion of marine grade fuels		**Marine Engineering: Auxiliary Thermodynamic Principles**	Outcome 1: Discuss and evaluate the use of single stage reciprocating air compressors	Outcome 2: Demonstrate the use of thermodynamic property tables and charts to evaluate the properties of vapours and gases.	Outcome 3: Determine the power of single stage steam turbine	Outcome 4: Discuss and evaluate vapour compression refrigeration plant
Pressure, Temperature, Energy	**X**											
Recognises and measures the effect of pressure in fluid.		**X**										
Defines and measures temperature		**X**										
Discusses heat as a form of energy, specific heat capacity, sensible heat, latent heat and solves associated problems		**X**										
Discusses the physical changes of solids and liquids associated with changes in temperature		**X**										

STCW95 Reg III/2 2nd Engineer Unlimited Heat — MCA Mapping

	Marine Engineering: Introduction to Marine Heat Engine Principles	Outcome 1: Determine the effect of applying heat energy to solids and liquids	Outcome 2: Apply the Gas Laws to non-flow systems and evaluate the work done	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	Outcome 5: Explain, using an analysis by mass, the combustion of marine grade fuels		**Marine Engineering: Auxiliary Thermodynamic Principles**	Outcome 1: Discuss and evaluate the use of single stage reciprocating air compressors	Outcome 2: Demonstrate the use of thermodynamic property tables and charts to evaluate the properties of vapours and gases.	Outcome 3: Determine the power of single stage steam turbine	Outcome 4: Discuss and evaluate vapour compression refrigeration plant
Heat Transfer	**X**											
Describes the way in which heat may be transferred and the factors which may influence heat transfer. Solves simple problems involving conduction, convection and radiation		**X**										

	Marine Engineering: Introduction to Marine Heat Engine Principles	Outcome 1: Determine the effect of applying heat energy to solids and liquids	Outcome 2: Apply the Gas Laws to non-flow systems and evaluate the work done	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	Outcome 5: Explain, using an analysis by mass, the combustion of marine grade fuels		**Marine Engineering: Auxiliary Thermodynamic Principles**	Outcome 1: Discuss and evaluate the use of single stage reciprocating air compressors	Outcome 2: Demonstrate the use of thermodynamic property tables and charts to evaluate the properties of vapours and gases.	Outcome 3: Determine the power of single stage steam turbine	Outcome 4: Discuss and evaluate vapour compression refrigeration plant
Internal Energy, Thermo-dynamic Systems, First Law	X											

STCW95 Reg III/2 2nd Engineer Unlimited Mathematics — MCA Mapping

	SQA Unit and Learning Outcome	**Marine Engineering: Mathematics**	Learning Outcome 1	Learning Outcome 2	Learning Outcome 3	**Marine Engineering: Auxiliary Thermoynamic Processes**	Learning Outcome 1	**Marine Engineering: Naval Architecture**	Learning Outcome 1	Marine Engineering: Statics and Strength of Materials	Learning Outcome 2
MCA Syllabus Topic											
Arithmetic							**x**				
Algebra			**x**								
Logarithms			**x**								
Graphs					**x**						**x**
Trigonometry					**x**						
Mensuration									**x**		
Calculus Differentiation				**x**							
Calculus Integration				**x**							

STCW95 Reg III/2 2nd Engineer Unlimited Naval Architecture — MCA Mapping

MCA STCW95 Reg III/2 2nd Engineer Unlimited Naval Architecture Syllabus	**Marine Engineering: HNC Naval Architecture**	Outcome 1 Perform calculations on Hydrostatic data	Outcome 2 Calculate small angle Stability	Outcome 3 Derive formulae and solve problems involving Ships propellers and Resistance
Hydrostatics				
Calculate Displacement and Buoyancy		**x**		
Tonnes Per Centimetre Immersion		**x**		
Change in Draught due to Density		**x**		
Coefficients of Form		**x**		
Wetted Surface Area		**x**		
Simpson's Rule				

MCA STCW95 Reg III/2 2nd Engineer Unlimited Naval Architecture Syllabus	**Marine Engineering: HNC Naval Architecture**	Outcome 1 Perform calculations on Hydrostatic data	Outcome 2 Calculate small angle Stability	Outcome 3 Derive formulae and solve problems involving Ships propellers and Resistance
Apply Simpson's rule to the determination of Areas, Volumes and Masses and First moments of Area, Volume and Mass		**x**		
Ships Stability				
Calculate the positions of the centre of gravity of a ship under any condition of loading			**x**	
Stability at Small Angles			**x**	
Change in Draughts due to Bilging			**x**	
Stability at Small Angles			**x**	
Ships Resistance				

MCA STCW95 Reg III/2 2nd Engineer Unlimited Naval Architecture Syllabus	**Marine Engineering: HNC Naval Architecture**	Outcome 1 Perform calculations on Hydrostatic data	Outcome 2 Calculate small angle Stability	Outcome 3 Derive formulae and solve problems involving Ships propellers and Resistance
Understands the basic factors involved in the resistance to motion exerted by water on a ship moving through it.				**x**
Propellers				**x**
Admiralty Coefficients				
Uses Admiralty Coefficient as an approximate method of estimating power				**x**
Fuel Consumption				
Calculates the variation in fuel consumption with speed and the fuel required to be loaded for a given voyage				**x**

STCW95 Reg III/2 2nd Engineer Unlimited Naval Architecture — MCA Mapping

MCA STCW95 Reg III/2 2nd Engineer Unlimited Naval Architecture Syllabus Ship Construction	Marine Engineering: HNC Naval Architecture Ship Construction	Outcome 1 Explain the Construction of a Ship	Outcome 2 Explain Ship Construction techniques
Ship Terminology		X	
Framing Systems		X	
Ship Types		X	
Construction of Structural Components		X	
Rudders and Stern-frames		X	
Anchor and Cable Arrangement		X	
Ship Stresses			X
Ventilation			X
Drainage of Compartments			X

Mapping HND Marine Engineering Syllabus to MCA Class 1 Applied Heat Syllabus

	Marine Engineering: Marine Heat Engine Principles	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	**Marine Engineering: Advanced Marine Heat Engine Principles**	Outcome 1: Apply the fundamental properties of thermodynamics to a process	Outcome 2: Evaluate and apply Marine heat engine cycles	Outcome 3: Evaluate heat transfer through complex systems	Outcome 4: Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume	**Marine Engineering: Advanced Marine Thermodynamic Principles**	Outcome 1: Analyse the use of multistage reciprocating air compressors	Outcome 2: Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants	Outcome 3: Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine
Thermodynamic Systems	**X**											
Defines and Applies the fundamental concepts of thermodynamic properties to a system.		**X**										
Thermodynamic Processes				**X**								
Defines and applies the fundamental properties of thermodynamics to a process.					**X**							
Heat Engine Cycles				**X**								
Discusses the concept of heat engine cycles.						**X**						
IC Engine Performance	**X**											
Discusses internal combustion engines and performance.			**X**									

	Marine Engineering: Marine Heat Engine Principles	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	**Marine Engineering: Advanced Marine Heat Engine Principles**	Outcome 1: Apply the fundamental properties of thermodynamics to a process	Outcome 2: Evaluate and apply Marine heat engine cycles	Outcome 3: Evaluate heat transfer through complex systems	Outcome 4: Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume	**Marine Engineering: Advanced Marine Thermodynamic Principles**	Outcome 1: Analyse the use of multistage reciprocating air compressors	Outcome 2: Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants	Outcome 3: Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine
Reciprocating Air Compressors									**X**			
Discusses and describes the use of reciprocating air compressors.										**X**		
Combustion				**X**								
Discusses combustion of solid, liquid and gaseous fuels by mass and by volume in terms of air requirements, excess air and products of combustion.								**X**				
Heat Transfer				**X**								
Discusses modes of heat transfer by conduction, radiation, convection.							**X**					

Mapping HND Marine Engineering Syllabus to MCA Class 1 Applied Heat Syllabus (cont)

	Marine Engineering: Marine Heat Engine Principles	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	**Marine Engineering: Advanced Marine Heat Engine Principles**	Outcome 1: Apply the fundamental properties of thermodynamics to a process	Outcome 2: Evaluate and apply Marine heat engine cycles	Outcome 3: Evaluate heat transfer through complex systems	Outcome 4: Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume	**Marine Engineering: Advanced Marine Thermodynamic Principles**	Outcome 1: Analyse the use of multistage reciprocating air compressors	Outcome 2: Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants	Outcome 3: Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine
Properties of Steam and Steam Cycles									**X**			
Understands constant pressure steam formation, and the use of thermodynamic tables and charts.												**X**
Nozzles and Steam Turbines									**X**			
Understands the use of steam as a working fluid and discusses its behaviour during flow through nozzles under equilibrium conditions.												**X**

Mapping HND Marine Engineering Syllabus to MCA Class 1 Applied Heat Syllabus (cont)

	Marine Engineering: Marine Heat Engine Principles	Outcome 3: Apply the First Law of Thermodynamics to closed and open systems	Outcome 4: Describe the Ideal cycles associated with Marine Engines and use practical cycles to evaluate power and efficiency	**Marine Engineering: Advanced Marine Heat Engine Principles**	Outcome 1: Apply the fundamental properties of thermodynamics to a process	Outcome 2: Evaluate and apply Marine heat engine cycles	Outcome 3: Evaluate heat transfer through complex systems	Outcome 4: Calculate the combustion of solid, liquid and gaseous marine fuels by mass and volume	**Marine Engineering: Advanced Marine Thermodynamic Principles**	Outcome 1: Analyse the use of multistage reciprocating air compressors	Outcome 2: Apply the concept of reverse heat engine to refrigeration and recognise the properties of common refrigerants	Outcome 3: Determine the efficiency of steam plant and power from a velocity and a pressure compound steam turbine
Refrigeration									**X**			
Understands the concepts of the reversed heat engine cycle and its applications to refrigeration plant and heat pump, and recognises the properties of common refrigerants											**X**	

Mapping HND Marine Engineering Syllabus to MCA Class 1 Electro-technology Syllabus

	Marine Engineering: Electrical Power	Outcome 1: Analyse dc linear and non-linear circuits	Outcome 2: Analyse single phase and three phase ac circuits	Outcome 3: Evaluate and describe the use of electronic devices in power circuits	**Marine Engineering: Electrical Distribution Systems**	Outcome 1: Discuss and evaluate the construction and operation of ac generators	Outcome 2: Describe and evaluate distribution systems and transformers	Outcome 3: Evaluate the operation of three phase motors
Electric Circuit Principles	X							
Solves dc linear circuit problems under steady and transient conditions		X						
Solves dc non-linear circuit problems under steady state conditions		X						
Understands operation of single-phase and three-phase ac circuits.			X					
Electronic Circuit Principles	X							
Understands the operation of junction diodes in rectification circuits.				X				
Understands the operation of the Thyristor as a controlled rectifier				X				
Understands the function of a Zener Diode as a dc voltage stabilizer.				X				
Understands the action of a transistor and its function as a switch and signal amplifier device				X				
Generation.					X			
Understands the principles of operation of ac generators						X		
Distribution					X			
Understands typical arrangements of marine ac and dc distribution systems							X	
Understands the principles of operation of a transformer.							X	

	Marine Engineering: Electrical Power	Outcome 1: Analyse dc linear and non-linear circuits	Outcome 2: Analyse single phase and three phase ac circuits	Outcome 3: Evaluate and describe the use of electronic devices in power circuits	**Marine Engineering: Electrical Distribution Systems**	Outcome 1: Discuss and evaluate the construction and operation of ac generators	Outcome 2: Describe and evaluate distribution systems and transformers	Outcome 3: Evaluate the operation of three phase motors
Utilisation					**X**			
Understands the principles and operation of the three-phase induction motor.								**X**
Understands principles of operation of 3-phase synchronous motor								**X**

Mapping HND Marine Engineering Syllabus to MCA Class 1 Applied Mechanics Syllabus

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Vector Representation						**X**						
Understands the use of vectors for graphical solutions								**X**				
Statics						**X**						
Understands the conditions of equilibrium of a body subject to a system of coplanar and non-coplanar forces and/or moments, and applies the conditions of equilibrium to solve relevant practical problems.							**X**					

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Friction						**X**						
Discusses the effect of friction when one rigid body slides or tends to slide over another rigid body, and applies the principles established to the solution of practical problems.							**X**					
Kinematics.						**X**						
Solves problems involving linear, angular and relative motion								**X**				

Mapping HND Marine Engineering Syllabus to MCA Class 1 Applied Mechanics Syllabus (cont)

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Dynamics						**X**		**X**				
Applies the laws of motion to translational dynamics.								**X**				
Applies the laws of motion to rotational dynamics								**X**				
Describes centripetal and centrifugal effects and solves associated problems								**X**				
Describes and solves problems involving simple harmonic motion SHM									**X**			

Mapping HND Marine Engineering Syllabus to MCA Class 1 Applied Mechanics Syllabus

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Machines						**X**						
Understands the principles involved in the determination of movement ratio for geared mechanisms												
Strength of Materials	**X**							**X**				
Revises the terminology and solves simple problems in strength of materials		**X**										

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Discusses the effect of temperature change on the physical dimensions of components		**X**										
Solves problems involving shear forces and bending moments on simply supported and cantilever beams			**X**									
Solves problems related to the Theory of Simple Bending			**X**									
Solves problems relating to the stability of axially loaded columns				**X**								

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Derives and uses the simple theory of torsion for members of circular sections				**X**								
Applies the theory of torsion to close coiled helical springs					**X**							
Solves problems relating to the concept of elastic strain energy		**X**			**X**							
Solves problems involving the concept of stresses on oblique planes of stressed material					**X**							
Hydrostatics						**X**					**X**	

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Solves problems involving hydrostatic forces on immersed areas										**X**		
Applies Archimedes Principle to solve problems												**X**
Hydrodynamics						**X**						
Discusses the concepts of energy related to the steady flow motion of liquids and solves associated problems										**X**		
Solves problems related to changes in momentum of liquids in motion										**X**		

	Marine Engineering: Advanced Strength of Materials	Outcome 1: Explain the terminology and solve problems in strength of materials. *Also* solve problems on the effect of temperature change on the physical dimensions of components	Outcome 2: Explain and solve problems relating to shear forces and bending moments on simply supported and cantilever beams. *Also* explain and solves problems relating to the theory of bending	Outcome 3 Explain and solve problems relating to the stability of axially loaded columns. *Also* explain and solve problems on the theory of torsion for members of circular sections	Outcome 4: Explain and solve problems on torsion with regards to close coiled helical springs. *Also* explain and solve problems on elastic strain energy. *Also* explain and solve problems on stresses on oblique planes of stressed material	**Marine Engineering: Advanced Applied Mechanics**	Outcome 1: Explain and solve equilibrium problems related to bodies subjected to coplanar and non coplanar force systems	Outcome 2: Explain and solve problems involving combinations of linear, angular and relative motion	Outcome 3: Explain and solve problems involving simple harmonic motion	Outcome 4: Explain and solve problems involving fluid mechanics	**Marine Engineering: Advanced Naval Architecture**	Outcome 2: Trim/Bilging, Rudders
Mathematical Solutions of Control System Problems.												
Derives equations and in certain cases solves mathematical problems related to control												

Mapping HND Marine Engineering Syllabus to MCA Class 1 Naval Architecture Syllabus

	Marine Engineering: Advanced Naval Architecture	Outcome 1 1. Explain and use Simpsons First Rule. 2. Free surface effect 3. Large angle Stability	Outcome 2 1. Trim/Bilging 2. Rudders	Outcome 3 1. Ship Resistance Shear Force and Bending Moments	**Marine Engineering: Advanced Ship Construction and Survey**	Outcome 1: Analyse the construction of various specialised vessels	Outcome 2: Analyse Propeller and Rudder construction and operation	Outcome 3: Analyse ship's structure with reference to fire protection, vibration and noise	Outcome 4: Analyses the Loadline Rules with particular reference to the conditions of assignment	**Marine Engineering Management**	Outcome 1: Interpret and apply marine legislation and safety management systems to shipboard operations
Simpsons Rule	**X**										
Applies Simpson's first rule (including subdivided intervals) to the determination of second moments of area		**X**									
Free Surface Effect	**X**										
Understands the effect of free surface liquids on transverse stability and solves problems involving free surface effect.		**X**									
Stability	**X**										
Uses cross-curves of stability to produce curves of statical stability.		**X**									
Makes use of particular features of wall-sided vessels to obtain an approximation to the stability of a ship.		**X**									

	Marine Engineering: Advanced Naval Architecture	Outcome 1 1. Explain and use Simpsons First Rule. 2. Free surface effect 3. Large angle Stability	Outcome 2 1. Trim/Bilging 2. Rudders	Outcome 3 1. Ship Resistance Shear Force and Bending Moments	**Marine Engineering: Advanced Ship Construction and Survey**	Outcome 1: Analyse the construction of various specialised vessels	Outcome 2: Analyse Propeller and Rudder construction and operation	Outcome 3: Analyse ship's structure with reference to fire protection, vibration and noise	Outcome 4: Analyses the Loadline Rules with particular reference to the conditions of assignment	**Marine Engineering Management**	Outcome 1: Interpret and apply marine legislation and safety management systems to shipboard operations
Understands the effects of form on stability.		**X**									
Stability information supplied to ships.		**X**									
Trim	**X**										
Understands how to calculate the effects on the end draughts of addition, removal, or longitudinal movement of small masses			**X**								
Understands how to use hydrostatic data to determine end draught of a ship			**X**								
Solves problems on the change in end draughts of a box-shaped vessel due to bilging a compartment which is not at midships			**X**								
Understands the elements in ship design which are included in order to reduce the effects of bilging.			**X**								

	Marine Engineering: Advanced Naval Architecture	Outcome 1 1. Explain and use Simpsons First Rule. 2. Free surface effect 3. Large angle Stability	Outcome 2 1. Trim/Bilging 2. Rudders	Outcome 3 1. Ship Resistance Shear Force and Bending Moments	**Marine Engineering: Advanced Ship Construction and Survey**	Outcome 1: Analyse the construction of various specialised vessels	Outcome 2: Analyse Propeller and Rudder construction and operation	Outcome 3: Analyse ship's structure with reference to fire protection, vibration and noise	Outcome 4: Analyses the Loadline Rules with particular reference to the conditions of assignment	**Marine Engineering Management**	Outcome 1: Interpret and apply marine legislation and safety management systems to shipboard operations
Rudders						**X**					
Understands the principal forces acting on a ship and rudder, when helm is applied to a vessel.							**X**				
Ship Resistance	**X**										
Calculates the power required to drive a ship from the resistance to motion exerted by the water on a ship at any given speed				**X**							
Understands the relationships between powers measured at points between the ship's engines and the propeller				**X**							
Understands the phenomenon of propeller cavitation, its causes and its effects							**X**				
Understands the reasons for carrying out ships' trials, and the value of the data obtained from them				**X**							

	Marine Engineering: Advanced Naval Architecture	Outcome 1 1. Explain and use Simpsons First Rule. 2. Free surface effect 3. Large angle Stability	Outcome 2 1. Trim/Bilging 2. Rudders	Outcome 3 1. Ship Resistance Shear Force and Bending Moments	**Marine Engineering: Advanced Ship Construction and Survey**	Outcome 1: Analyse the construction of various specialised vessels	Outcome 2: Analyse Propeller and Rudder construction and operation	Outcome 3: Analyse ship's structure with reference to fire protection, vibration and noise	Outcome 4: Analyses the Loadline Rules with particular reference to the conditions of assignment	**Marine Engineering Management**	Outcome 1: Interpret and apply marine legislation and safety management systems to shipboard operations
Shear Force and Bending Moments in Still Water				**X**							
Ship Stresses	**X**										
Recognises the causes and effects of stresses acting on ships				**X**							
Ship Construction					**X**						
Recognises the problems associated with and the structural arrangements for the carriage of liquified gases						**X**					
Recognises the problems associated with and the structural arrangements for the carriage of chemical cargoes						**X**					
Recognises the problems associated with the carriage of various cargoes						**X**					

Mapping HND Marine Engineering Syllabus to MCA Class 1 Naval Architecture Syllabus (cont)

	Marine Engineering: Advanced Naval Architecture	Outcome 1 1 Explain and use Simpsons First Rule. 2 Free surface effect 3 Large angle Stability	Outcome 2 1 Trim/Bilging 2 Rudders	Outcome 3 1 Ship Resistance Shear Force and Bending Moments	**Marine Engineering: Advanced Ship Construction and Survey**	Outcome 1: Analyse the construction of various specialised vessels	Outcome 2: Analyse Propeller and Rudder construction and operation	Outcome 3: Analyse ship's structure with reference to fire protection, vibration and noise	Outcome 4: Analyses the Loadline Rules with particular reference to the conditions of assignment	**Marine Engineering Management**	Outcome 1: Interpret and apply marine legislation and safety management systems to shipboard operations
Tonnage and Freeboard					**X**						
Analyses the Loadline Rules with particular reference to the conditions of assignment									**X**		
Classification, Structural, Fire protection, Life Saving Appliances and pollution Control.					**X**					**X**	
Analyses the function and influence of Classification Societies on the construction of ships											**X**
Identifies in general terms the methods of structural fire protection for passenger ships and cargo ships								**X**			

	Marine Engineering: Advanced Naval Architecture	Outcome 1 1 Explain and use Simpsons First Rule. 2 Free surface effect 3 Large angle Stability	Outcome 2 1 Trim/Bilging 2 Rudders	Outcome 3 1 Ship Resistance Shear Force and Bending Moments	**Marine Engineering: Advanced Ship Construction and Survey**	Outcome 1: Analyse the construction of various specialised vessels	Outcome 2: Analyse Propeller and Rudder construction and operation	Outcome 3: Analyse ship's structure with reference to fire protection, vibration and noise	Outcome 4: Analyses the Loadline Rules with particular reference to the conditions of assignment	**Marine Engineering Management**	Outcome 1: Interpret and apply marine legislation and safety management systems to shipboard operations
Understands in broad outline the life-saving requirements for merchant ships											**X**
Understands the facts and principles underlying the regulations for marine pollution control by construction											**X**
Integrates learning from different areas to explain the causes and adverse effects of ship vibration and the methods used to prevent same								**X**			
Recognises the problems of noise on ships and the methods used to reduce same								**X**			

Appendix 4: Core Skills

Oral Communication — SCQF level 6

a) Use vocabulary and a range of spoken language structures consistently and effectively at an appropriate level of formality.
b) Convey all essential information, opinions, or ideas with supporting detail accurately and coherently, and with varied emphasis as appropriate.
c) Structure communication to take full account of purpose and audience.
d) Take account of situation and audience during delivery.
e) Respond to others, taking account of their contributions.

Units	**Developed/ assessed**	a	b	c	d	e
Marine Engineering: Electrical and Electronic Devices	Developed	✓				✓
Marine Engineering: Marine Heat Engine Principles	Developed		✓	✓	✓	
Marine Engineering: Marine Management	Developed					✓

Written Communication (Reading) — SCQF level 6

a) Identify and summarise all significant information, ideas and supporting details in a complex written communication.
b) Evaluate fully the effectiveness of a communication in meeting its purpose and the needs of its intended readership.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b
Marine Engineering: Propulsion	Developed	✓	
Marine Engineering: Ship Construction	Developed		✓
Marine Engineering: Electrical Motors and Generators		✓	
Marine Engineering: Electrical Distribution Systems	Developed	✓	
Marine Engineering: Pneumatics and Hydraulic Systems	Developed	✓	
Marine Engineering: Marine Management	Developed		✓

Written Communication (Writing) — SCQF level 6

a) Present all essential ideas/information and supporting detail in a logical and effective order.
b) Use a structure which takes account of purpose and audience and links major and minor points in ways which assist the clarity.
c) and impact of the writing.
d) Use conventions which are effective in achieving the purpose of the piece and adapted as necessary for the target audience.
e) Use spelling, punctuation, and sentence structures which are consistently accurate.
f) Vary sentence structure, paragraphing, and vocabulary to suit the purpose and target audience.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c	d	e
Marine Engineering: Statics and Dynamics	Developed	✓				✓
Marine Engineering: Propulsion	Developed	✓	✓		✓	
Marine Engineering: Naval Architecture	Developed	✓		✓		
Marine Engineering: Ship Construction	Developed		✓		✓	
Marine Engineering: Electric Motors and Generators	Developed	✓				
Marine Engineering: Advanced Applied Mechanics	Developed	✓				✓
Marine Engineering: Advanced Marine Heat Engine Principles	Developed			✓		
Marine Engineering: Advanced Naval Architecture	Developed	✓		✓		
Marine Engineering: Advanced Strength of Materials	Developed	✓				✓
Marine Engineering: Electrical Distribution Systems	Developed		✓	✓		
Marine Engineering: Pneumatics and Hydraulic Systems	Developed			✓		
Marine Engineering: Advanced Ship Construction and Survey	Developed			✓		
Marine Engineering: Advanced Marine Thermodynamic Principles	Developed			✓		

Using Graphical Information — SCQF level 6

a) Extract, analyse, and interpret graphical information.
b) Select an appropriate form of complex table, chart, diagram, or qualitative form, and communicate complex information in that form.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b
Marine Engineering: Dynamics and Machines	Developed	✓	✓
Marine Engineering: Auxiliary Thermodynamic Principles	Developed	✓	
Marine Engineering: Electrical and Electronic Devices	Developed	✓	✓
Marine Engineering: Marine Heat Engine Principles	Developed	✓	
Marine Engineering: Electrical Motors and Generators	Developed	✓	✓
Marine Engineering: Advanced Marine Heat Engine Principles	Developed	✓	
Marine Engineering: Electrical Distribution Systems	Developed	✓	✓
Marine Engineering: Advanced Marine Thermodynamic Principles	Developed	✓	

Using Number — SCQF level 6

a) Work confidently with numerical or statistical methods.
b) Decide on the steps and operations to be carried out to solve a complex problem.
c) Carry out a number of sustained, complex calculations.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c
Marine Engineering: Statics and Strength of Materials	Developed	✓		✓
Marine Engineering: Dynamics and Machines	Developed	✓	✓	
Marine Engineering: Auxiliary Thermodynamic Principles	Developed	✓		
Marine Engineering: Electrical and Electronic Devices	Developed	✓	✓	✓
Marine Engineering: Marine Heat Engine Principles	Developed			✓
Marine Engineering: Naval Architecture	Developed		✓	✓
Marine Engineering: Electrical Motors and Generators	Developed	✓	✓	✓
Marine Engineering: Mathematics	Assessed	✓	✓	✓
Marine Engineering: Advanced Applied Mechanics	Developed		✓	✓
Marine Engineering: Advanced Marine Heat Engine Principles	Developed	✓		
Marine Engineering: Advanced Strength of Materials	Developed	✓		✓
Marine Engineering: Electrical Distribution Systems	Developed	✓	✓	✓
Marine Engineering: Advanced Marine Thermodynamic Principles	Developed	✓		

Accessing Information — SCQF level 6

a) Use a range of ICT equipment, observing security procedures.
b) Carry out complex searches for information.
c) Evaluate reliability of information using given criteria.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c
Marine Engineering: Propulsion	Developed		✓	✓
Marine Engineering: Ship Construction	Developed	✓		

Providing/Creating Information — SCQF level 6

a) Use a range of ICT equipment, observing security procedures and needs of other users.
b) Resolve simple hardware or software problems.
c) Use software in unfamiliar contexts.
d) Evaluate information.
e) Present findings in an appropriate format.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c	d	e
Marine Engineering: Dynamics and Machines	Developed		✓	✓	✓	✓
Marine Engineering: Ship Construction	Developed	✓				

Critical Thinking — SCQF level 6

a) Identify the factors involved in the situation or issue.
b) Assess the relevance of these factors to the situation or issue.
c) Develop and justify an approach to deal with the situation or issue.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c
Marine Engineering: Statics and Strength of Materials	Developed			✓
Marine Engineering: Dynamics and Machines	Developed	✓	✓	
Marine Engineering: Auxiliary Thermodynamic Principles	Developed		✓	✓
Marine Engineering: Electrical and Electronic Devices	Developed		✓	
Marine Engineering: Marine Heat Engine Principles	Developed			✓
Marine Engineering: Advanced Applied Mechanics	Developed			✓
Marine Engineering: Advanced Marine Heat Engine Principles	Developed		✓	✓
Marine Engineering: Advanced Strength of Materials	Developed			✓
Marine Engineering: Pneumatics and Hydraulic Systems	Developed	✓		
Marine Engineering: Marine Management	Developed	✓		
Marine Engineering: Advanced Ship Construction and Survey	Developed		✓	✓
Marine Engineering: Advanced Marine Thermodynamic Principles	Developed		✓	✓

Planning and Organising — SCQF level 6

a) Develop a plan.
b) Identify and obtain resources to carry out the plan.
c) Carry out the task.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c
Marine Engineering: Dynamics and Machines	Developed	✓	✓	✓
Marine Engineering: Naval Architecture	Developed	✓		
Marine Engineering: Marine Management	Developed	✓		

Reviewing and Evaluating — SCQF level 6

a) Evaluate the effectiveness of the strategy/strategies.
b) Identify and gather appropriate evidence.
c) Draw conclusions and make recommendations.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c
Marine Engineering: Statics and Strength of Materials	Developed			✓
Marine Engineering: Propulsion	Developed	✓	✓	
Marine Engineering: Advanced Applied Mechanics	Developed			✓
Marine Engineering: Advanced Strength of Materials	Developed			✓
Marine Engineering: Marine Management	Developed	✓		

Working Co-operatively with Others — SCQF level 6

a) Analyse own role and the roles that make up the activity and/or activities and the relationship between them.
b) Organise own role to contribute effectively to the activity and/or activities, adapting own role as necessary.
c) Negotiate working methods.
d) Promote co-operative working with others, progress towards shared goal.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c	d
Marine Engineering: Dynamics and Machines	Developed			✓	✓
Marine Engineering: Electrical Motors and Generators	Developed	✓	✓		
Marine Engineering: Electrical Distribution Systems	Developed	✓	✓		
Marine Engineering: Pneumatics and Hydraulic Systems	Developed		✓		
Marine Engineering: Marine Management	Developed				✓

Reviewing Co-operative Contribution — SCQF level 5

a) Evaluate overall co-operative working, considering own involvement and the involvement of others, referring to supporting evidence.
b) Draw conclusions and justify them with reference to supporting evidence.
c) Identify own learning and objectives for future co-operative working.

Knowledge/Skills/Evidence	**Developed/ assessed**	a	b	c
Marine Engineering: Electrical and Electronic Devices	Developed	✓	✓	✓

Appendix 5: Preferred order of Unit delivery

HNC and HND 1st Year Marine Engineering		
Block 1	**Block 2**	**Block 3**
F910 33 Marine Engineering: Mathematics	F912 34 Marine Engineering: Propulsion	F914 34 Marine Engineering: Graded Unit 1
F90R 34 Marine Engineering: Statics and Strength of Materials	F90T 34 Marine Engineering: Auxiliary Thermodynamic Principles	DR2D34 Safety Engineering and the Environment
DR1W 34 Engineering Drawing	F90V 34 Marine Engineering: Dynamics and Machines	F911 34 Marine Engineering: Naval Architecture
F90W 34 Marine Engineering: Electrical and Electronic Devices	F913 34 Marine Engineering: Ship Construction	FT29 34 Marine Engineering: Auxiliary Systems
Workshop Skills	DN3Y 34 Fundamentals of Control Systems	F90X 34 Marine Engineering: Electrical Motors and Generators
	Workshop Skills	

HND Marine Engineering — Year 2		
Block 1	**Block 2**	**Block 3**
DG4L 34 Mathematics for Engineering 2	H0EB 35 Marine Engineering: Advanced Marine Heat Engine Principles	H0EL 35 Marine Engineering: Electrical Distribution Systems
H0EJ 35 Marine Engineering: Marine Management		H0EH 34 Marine Engineering: Electrical Power
H0EG 35 Marine Engineering: Advanced Strength of Materials	H0EC 35 Marine Engineering: Advanced Marine Thermodynamic Principles	DX4K 34 Process Control
H0EA 35 Marine Engineering: Advanced Applied Mechanics	H0ED 35 Marine Engineering: Advanced Naval Architecture	H0EK 34 Marine Engineering: Pneumatics and Hydraulic Systems
	H0EF 35 Marine Engineering: Advanced Ship Construction and Survey	
FW56 35 Marine Engineering: Graded Unit 2		