MODEL COURSE

7.04

OFFICER IN CHARGE OF AN ENGINEERING WATCH

2014 EDITION

ELECTRONIC EDITION

IMO INTERNATIONAL MARITIME ORGANIZATION

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INTERNATIONAL MARITIME ORGANIZATION

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Contents

Foreword

Since its inception the International Maritime Organization (IMO) has recognized the importance of human resources to the development of the maritime industry and has given the highest priority to assisting developing countries in enhancing their maritime training capabilities through the provision or improvement of maritime training facilities at national and regional levels. IMO has also responded to the needs of developing countries for postgraduate training for senior personnel in administrations, ports, shipping companies and maritime training institutes by establishing the World Maritime University in Malmö, Sweden, in 1983.

Following the adoption of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978 (STCW), a number of IMO Member Governments had suggested that IMO should develop model training courses to assist in the implementation of the Convention and in achieving a more rapid transfer of information and skills regarding new developments in maritime technology. IMO training advisers and consultants also subsequently determined from their visits to training establishments in developing countries that the provision of model courses could help instructors improve the quality of their existing courses and enhance their implementation of the associated Conference and IMO Assembly resolutions.

In addition, it was appreciated that a comprehensive set of short model courses in various fields of maritime training would supplement the instruction provided by maritime academies and allow administrators and technical specialists already employed in maritime administrations, ports and shipping companies to improve their knowledge and skills in certain specialized fields. With the generous assistance of the Government of Norway, IMO developed model courses in response to these generally identified needs and now keeps them updated through a regular revision process taking into account any amendments to the requirements prescribed in IMO instruments and any technological developments in the field.

These model courses may be used by any training institution and, when the requisite financing is available, the Organization is prepared to assist developing countries in implementing any course.

K. SEKIMIZU
Secretary-General

Introduction

■ Purpose of the model courses

The purpose of the IMO model courses is to assist maritime training institutes and their teaching staff in organizing and introducing new training courses or in enhancing, updating or supplementing existing training material where the quality and effectiveness of the training courses may thereby be improved.

It is not the intention of the model course programme to present instructors with a rigid "teaching package" which they are expected to "follow blindly". Nor is it the intention to substitute audio-visual or "programmed" material for the instructor's presence. As in all training endeavours, the knowledge, skills and dedication of the instructors are the key components in the transfer of knowledge and skills to those being trained through IMO model course material.

Rather, this document should be used as a guide with the course duration given as indicative of the expected time required to cover the required outcomes. The parties may modify this course to suit their respective training schemes.

For those following planned training schemes approved by the administration, it is intended that this training may form an integral part of the overall training plan and be complementary to other studies. The training may be undertaken in progressive stages; for such candidates, it is not appropriate to specify the duration of the learning, provided achievement of the specified learning outcomes is properly assessed and recorded.

The educational systems and the cultural backgrounds of trainees in maritime subjects vary considerably from country to country. For this reason the model course material has been designed to identify the basic entry requirements and trainee target group for each course in universally applicable terms, and to specify clearly the technical content and levels of knowledge and skill necessary to meet the technical intent of IMO conventions and related to recommendations.

This is the next major revision to this model course. In order to keep the training programme up to date in future, it is essential that users provide feedback. New information will provide better training in safety at sea and protection of the marine environment. Information, comments and suggestions should be sent to the Head of the STCW and Human Element Section at IMO, London.

■ Use of the model course

To use the model course the instructor should review the course plan and detailed syllabus, taking into account the information provided under the entry standards specified in the course framework. The actual level of knowledge and skills and the prior technical education of the trainees should be kept in mind during this review, and any areas within the detailed syllabus which may cause difficulties, because of differences between the actual trainee entry level and that assumed by the course designer, should be identified. To compensate for such differences, the instructor is expected to delete from the course, or reduce the

emphasis on, items dealing with knowledge or skills already attained by the trainees. He should also identify any academic knowledge, skills or technical training which they may not have acquired.

By analysing the detailed syllabus and the academic knowledge required to allow training in the technical area to proceed, the instructor can design an appropriate pre-entry course or, alternatively, insert the elements of academic knowledge required to support the technical training elements concerned at appropriate points within the technical course.

Adjustment of the course objective, scope and content may also be necessary if in your maritime industry the trainees completing the course are to undertake duties which differ from the course objectives specified in the model course.

Within the course plan the course designers have indicated their assessment of the time that should be allotted to each area of learning. However, it must be appreciated that these allocations are arbitrary and assume that the trainees have fully met all entry requirements of the course. The instructor should therefore review these assessments and may need to reallocate the time required to achieve each specific learning objective or training outcome.

■ Lesson plans

Having adjusted the course content to suit the trainee intake and any revision of the course objectives, the instructor should draw up lesson plans based on the detailed syllabus. The detailed syllabus contains specific references to the textbooks or teaching material proposed to be used in the course. Where no adjustment has been found necessary in the learning objectives of the detailed syllabus, the lesson plans may simply consist of the detailed syllabus with keywords or other reminders added to assist the instructor in making his presentation of the material.

■ Presentation

The presentation of concepts and methodologies must be repeated in various ways until the instructor is satisfied, by testing and evaluating the trainee's performance and achievements, that the trainee has attained each specific learning objective or training objective. The syllabus is laid out in learning objective format and each objective specifies a required performance or what the trainee must be able to do as the learning or training outcome. Taken as a whole, these objectives aim to meet the knowledge, understanding and proficiency specified in the appropriate tables of the STCW Code.

■ Implementation

For the course to run smoothly and to be effective, considerable attention must be paid to the availability and use of:

- properly qualified instructors
- support staff
- rooms and other spaces
- workshops and equipment

- suggested references, textbooks, technical papers
- other reference material.

Thorough preparation is the key to successful implementation of the course. IMO has produced a booklet entitled ‘Guidance on the implementation of IMO model courses’, which deals with this aspect in greater detail.

In certain cases, the requirements for some or all of the training in a subject are covered by another IMO model course. In these cases, the specific part of the STCW Code which applies is given and the user is referred to the other model course.

■ Course objective

This model course comprises four functions at the operational level. On successful completion of the training and assessment trainees should be competent to carry out safely the watchkeeping duties of an officer in charge of an engineering watch in a manned engine-room or designated duty engineer in a periodically unmanned engine-room, both at sea and in port. In particular, they will be fully conversant with the basic principles to be observed in keeping an engineering watch as per STCW regulation VIII/2 and STCW Code, chapter VIII.

■ Entry standards

Since the minimum age for certification is 18 years, it is expected that in most cases the entry age will be at least 16 years. It is envisaged that trainees will have been in full-time education up to the commencement of training, although in some instances entry will no doubt be made available to those who, having completed full-time education, follow other paths first. Administrations will wish to specify their own educational standards for entry. With this in mind, attention is drawn to the fact that while the mathematical standards of the courses to be followed are not high, trainees continually use fundamental mathematics as a tool throughout the whole of their training; also, as the principles of applied science and engineering are included at an early stage, it is essential to ascertain the potential and interest in this kind of work before entry. In a similar manner, trainees have to accomplish a range of engineering craft skills, and therefore an aptitude and interest in this direction are also necessary.

Where entrants have not reached the required standards in mathematics or physical science it will be necessary to provide a preparatory course or courses to bring them to the desired level before starting the professional studies. Conversely, topics which have been adequately covered during their general education can be omitted and the allotted time reduced accordingly.

No previous maritime or engineering training is assumed, but those entering the course should be following an approved programme of shipboard training.

■ Course intake limitations

Training to acquire engineering skills in workshops will be planned and implemented for a certain period of time. During these periods it is recommended that there are not more than

approximately ten trainees to each supervisor/instructor. Depending upon staffing levels and how the timetable and utilization of premises can be arranged, other subjects may be studied in class sizes of not more than 24 in order to allow the instructor to give adequate attention to individual trainees. Larger numbers may be admitted if extra staff and tutorial periods are provided to deal with trainees on an individual basis.

In addition, for scheduling access to learning facilities and equipment, attention to strict time management is necessary. In large classes students should have their own reference books, unless sufficient copies can be provided in a central library. Classrooms should be big enough to seat all students so they can see and hear the instructor.

■ Textbooks

A large number of books and publications may be used to study marine engineering. The framework in each function contains details of specified textbooks which are referred to in the syllabus by page number appropriate to the learning objectives. Other books may be considered equally suitable; the chosen books should help trainees to achieve the learning objectives.

Details of additional books which would provide useful library references and further background reading are included where appropriate in each subject.

References to books are made in the syllabuses of the individual subjects to aid both instructors and trainees in finding relevant information and to help in defining the scope and depth of treatment intended.

The mention of a particular textbook does not imply that it is essential to use that book, only that it appeared to be best suited to the course at the time of its design. In many instances there are a number of suitable books, and instructors are free to use whatever texts they consider to be most suited to their circumstances and trainees.

Every effort has been made to quote the latest editions of the publications mentioned but new editions are constantly being produced. Instructors should always use the latest edition for preparing and running their courses.

Full use should be made of technical papers and other publications available from maritime and other professional organizations. Such papers contain new developments in techniques, equipment, design, management and opinion, and are an invaluable asset to a maritime training establishment.

■ Training and the STCW Convention 1978, as amended

The standards of competence that have to be met by seafarers are defined in part A of the STCW Code in the Standards of Training, Certification and Watchkeeping for Seafarers Convention, as amended in 2010. This IMO model course has been revised and updated to cover the competences in STCW Code. It sets out the education and training to achieve those standards.

This course covers the minimum standard of competence for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room, see STCW Code, table A-III/1.

For ease of reference, the course material is organised in four separate functions as per the STCW Code. These functions are:

Function 1	Marine engineering at the operational level
Function 2	Electrical, electronic and control engineering at the operational level
Function 3	Maintenance and repair at the operational level
Function 4	Controlling the operation of the ship and care for the persons on board at the operational level.

Each function is addressed in five parts: Part A which is common for all functions, Part B, Part C, Part D and Part E, which again addresses all the functions.

Part A provides the framework for the course with its aims and objectives and notes on the suggested teaching facilities and equipment. A list of useful teaching aids, IMO references and textbooks is included which affects all four functions.

Part B provides an outline of lectures, demonstrations and exercises for the course. No detailed timetable is suggested. From the teaching and learning point of view, it is more important that the trainee achieves the minimum standard of competence defined in the STCW Code than that a strict timetable is followed. Depending on their experience and ability, some students will naturally take longer to become proficient in some topics than in others.

Part C gives the Detailed Teaching Syllabus. This is based on the theoretical and practical knowledge specified in the STCW Code. It is written as a series of learning objectives; in other words what the trainee is expected to be able to do as a result of the teaching and training. Each of the objectives is expanded to define a required performance of knowledge, understanding and proficiency. IMO references, textbook references and suggested teaching aids are included to assist the teacher in designing lessons.

Part D gives the Instructor Manual, which contains guidance notes for the instructor and additional explanations.

Part E provides the Evaluation which addresses all the functions. A separate IMO model course 3.12 also addresses Assessment of competence. This course explains the use of various methods for demonstrating competence and criteria for evaluating competence as tabulated in the STCW Code. An excerpt of this model course is also included in Part E to aid the instructors.

The Convention defines the minimum standards to be maintained in part A of the STCW Code. Mandatory provisions concerning Training and assessment are given in section A-I/6 of the STCW Code. These provisions cover: qualifications of instructors, supervisors and assessors; in-service training; assessment of competence; and training and assessment within an institution. The corresponding part B of the STCW Code contains guidance on training and assessment.

The criteria for evaluating competence of officers in charge of an engineering watch specified in the minimum standard of competence tables of part A of the STCW Code have to be used in the assessment of all competences listed in those tables.

■ Ships without steam boilers

The function Marine Engineering at the Operational Level includes competences concerned with the operation of steam boilers. These are addressed in the detailed teaching syllabus in Part C. Candidates for certification for service on ships in which steam boilers do not form part of their machinery may omit the relevant requirements. Certificates so awarded should not be valid for service on ships in which steam boilers form part of their machinery until the engineer officer meets the standard of competence in the items previously omitted. Such limitations are required to be shown on the certificate and in the endorsement.

■ Responsibilities of Administrations

Administrations should ensure that training courses delivered by colleges and academies are such as to ensure officers completing training do meet the standards of competence required by STCW regulation III/1, paragraph 2.

■ Validation

The information contained in this document has been validated by the Sub-Committee on Standards of Training and Watchkeeping for use by technical advisers, consultants and experts for the training and certification of seafarers so that the minimum standards implemented may be as uniform as possible. *Validation* in the context of this document means that no grounds have been found to object to its content. The Sub-Committee has not granted its approval to the document, as it considers that this work must not be regarded as an official interpretation of the Convention.

n Conventions, Regulations and Legislation

These are constantly being revised and updated. It is essential that the up-to-date version of these are being used and that all references to particular versions in this model course should be taken to include all future amendments and revisions.

Part A: Course Framework for all functions

■ Aims

This model course aims to meet the mandatory minimum requirements for knowledge, understanding and proficiency in table A-III/1 of STCW Code for the functions Marine Engineering, Electrical, Electronic and Control Engineering, Maintenance and Repair and Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level.

■ Objective

Function 1

This syllabus covers the requirements of the STCW Code, chapter III, section A-III/1. This functional element provides the detailed knowledge to support the training outcomes related to Marine Engineering at the Operational Level.

This section provides the background knowledge and practical work to support:

- maintaining a safe engineering watch
- using English in written and oral form
- using internal communication systems
- operating main and auxiliary machinery and associated control systems
- operating fuel, lubrication, ballast and other pumping systems and associated control systems.

Function 2

This syllabus covers the requirements of the STCW Code, chapter III, section A-III/1. This functional element provides the detailed knowledge to support the training outcomes related to Electrical, Electronic and Control Engineering at the Operational Level.

This section provides the background knowledge and practical work to support:

- the safety requirements for working on electrical tasks
- the ship's electrical engineering and electronics

control engineering

- power distribution systems.

Function 3

This syllabus covers the requirements of the STCW Code, chapter III, section A-III/1. This functional element provides the detailed knowledge to support the training outcomes related to Maintenance and Repair at the Operational Level.

This section provides the background knowledge and practical work to support:

- the use of hand and machine tools and measuring instruments
- marine engineering maintenance.

Function 4

This syllabus covers the requirements of the Manila Amendment of STCW Code, chapter III, section A-III/1. This functional element provides the detailed knowledge to support the training outcomes related to Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level.

This section provides the background knowledge to support:

- compliance with pollution prevention requirements
- maintaining the seaworthiness of the ship, including:
  - ship stability
  - ship construction
- prevention, control and fighting of fires on board ship*
- operation of life-saving appliances*
- provision of medical first aid on board ship*
- monitoring compliance with legislative requirements
- application of leadership and teamworking skills
- contributing to safety of personnel and ship.

This function includes topics such as ship stability, carriage of cargoes on deck, heavy lifts, containers, bulk cargoes, grain, dangerous goods, oil tankers and the IMO conventions.

■ Entry standards

This course is principally intended for candidates for certification as officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room. Those wishing to enter this course should be following an approved programme of on-board training.

■ Course certificate

On successful completion of the course and assessments, a document may be issued certifying that the holder has successfully completed a course of training which meets or exceeds the level of knowledge and competence specified in table A-III/1 of STCW Code, for the functions Marine Engineering, Electrical, Electronic and Control Engineering, Maintenance and Repair and Controlling the Operation of the Ship and Care for Persons on Board at the Operational level. A certificate may be issued only by centres approved by the Administration.

* These topics are covered in separate IMO model courses.

■ Staff requirements

Instructors shall be qualified in the task for which training is being conducted and have appropriate training in instructional techniques and training methods (STCW Code, section A-I/6). Depending on the complexity of the exercises set, an assistant instructor with similar experience is desirable for certain practical exercises. As well as instructors, additional staff will be required for the maintenance of machinery and equipment and for the preparation of materials, work areas and supplies for all practical work.

■ Teaching facilities and equipment

All functions

A classroom equipped with an overhead projector and a blackboard, whiteboard or flipchart should be provided for teaching the theory of the course and holding group discussions. The availability of appropriate engine room simulation equipment and/or replicated engines and engine-room equipment would be beneficial in developing the practical competence required by STCW Code.

Function 2

The following equipment is recommended for relevant laboratories:

- measuring/testing instruments (oscilloscope, voltmeters, ammeters, power meters, digital and analog multi meters, continuity testers, clamp meters, live-line testers, insulation testers, etc.)
- electrical circuit devices (various relays, switches, resistors, circuit breakers, fuses, lamps, transformers, connectors)
- examples of electrical diagrams (i.e. block, system, circuit and wiring diagrams)
- motors and several kinds of motor starters with starter circuits diagram
- model A.C. and D.C. generators
- a selection of marine cables, an earth lamp model system
- electronic circuit experiment equipment including electro circuit elements such as various semiconductor devices, thyristor, IGBT, MOSFET, LSI, LED), simple circuit diagrams and configurations
- various automatic control devices/equipment (PID controllers, sequencer, transducer, recorders, control valves, thermostats, pressure switches, level switches, iron-cored solenoid, resistance thermometer bulb, standard of adjustable resistance to create desired temperature signal, hydraulic testing equipment.
- PID control experiment equipment for temperature/level/pressure control system.

Function 3

A comprehensive workshop is required for the practical elements in the training objectives.

The workshop is required equipped with an overhead crane and a range of maintenance tools. Services such as compressed air and a water supply will be necessary, as well as access to workshops used for training in other marine engineering skills.

When starting a training programme in plant maintenance in a training institute, the acquisition of suitable marine engineering components and machinery can be difficult as the high cost would preclude the purchase of new equipment. The training centre can initially acquire scrap, discarded parts and equipment items, or seek donations of equipment from manufacturers or shipowners. Some financial annual provision must be made in the training centre's budget for updating and expanding the equipment each year.

The following equipment is recommended for workshops:

- pumps
- air compressors
- steam turbine
- diesel engine four and two stroke a
- wide range of valves
- pipework and fittings
- refrigerator components
- heat exchangers
- boiler mountings
- oil fuel burners
- deck machinery
- diesel engine cylinder heads, complete with fittings
- hydraulic pumps, motors, valves and fittings
- a turbocharger
- a thrust block
- oil purifiers.

Function 4

The following equipment is recommended:

- cut-away three-dimensional models showing the structure of parts of the ship
- photographs, drawings and plans illustrating various types of ship and constructional details
- a floating ship stability demonstration model and a flotation tank. The model should be capable of demonstrating the effects of adding or removing masses, shifting masses, suspending masses and free liquid surface
- a marine hydrometer.

■ Teaching aids (A)

The list of teaching aids and references are recommendations only and are intended to support the learning outcomes of the course.

Note: Other equivalent teaching aids may be used as deemed fit by the instructor.

A1 Instructor Manual (Part D of this course)
A2 Manufacturers' Manuals
Manufacturers' instruction manuals and handbooks are the main source of information in instructing the correct procedures in dismantling, inspection and assembly of the specific items of machinery listed.
A3 Video player/DVD player, personal computer
A4 *Marlins* English language Study Pack 1 and Study Pack 2 with audio cassette and teacher's notes (www.marlins.co.uk)

■ Videos (DVDs) & CDs

V1 Personal safety in the engine room (Code No. 556)
V2 Engine room resource management (Code No. 649)
V3 Basic marine lubrication series (Code No. 442-444)
V4 Handling and treatment of heavy fuels (Code No. 143)
V5 Fuel oil burner theory and diagnostics (Code No. 604)
V6 Internal care of marine boilers (Code No. 150)
V7 Centrifugal pumps - theory and operation (Code No. 9)
V8 Tanker practices - Part 1 & 2 Pumping cargo (Code No. 501, 502)
Available from: Videotel Marine International Ltd
84 Newman Street, London W1P 3LD, UK
Tel: 44 20 7299 1800
Fax: 44 20 7299 1818
Email: mail@videotelmail.com
URL: www.videotel.co.uk
V9 Engine-room resource management
V10 Marine steam turbine plant
Available from: The Maritime Human Resource Institute
Kaiji center building, 4-5 Kojimachi
Chiyoda-ku, Tokyo, Japan
Tel: 81 3 3265 5126
Fax: 81 3 3264 3808
URL: http://www.mhrij.or.jp
V11 Practical marine engineering knowledge series (Code No. 167.1-167.6)
V12 Machinery alarms and protection devices (Code No. 528)
V13 Welding safety (Code No. 495)
V14 Who needs it? Personal protective equipment (Code No. 597)
V15 Entering into enclosed spaces (Edition 2) (Code No. 682)

V16 Permit to work (Code No. 621)
Available from: Videotel Marine International Ltd
84 Newman Street, London W1P 3LD, UK
Tel: 44 20 7299 1800
Fax: 44 20 7299 1818
Email: mail@videotelmail.com
URL: www.videotel.co.uk

V17 DVD: IMO - Safe, Secure and Efficient Shipping on Clean Oceans (2006 Edition)
IMO Sales No. V010M, ISBN 978-92-801-70023
Available from: IMO Publications Section
4 Albert Embankment
London SE1 7SR, UK
Fax: +44 20 7587 3241
URL: www.imo.org

V18 MANUAL HANDLING TECHNIQUES, CODE NO: 703

V19 FIGHTING POLLUTION - PREVENTING POLLUTION AT SEA (EDITION 3) CODE NO: 755

V20 GOOD BUNKERING PRACTICE (EDITION 2) CODE NO: 962

V21 PERMIT TO WORK, CODE NO: 621

V22 SAFE GANGWAY AND LADDER OPERATIONS, CODE NO: 946

V23 SEVEN STEPS TO SHIP STABILITY PART 1, CODE NO: 622, SEVEN STEPS TO SHIP STABILITY PART 2, CODE NO: 623

V24 DEATH IN MINUTES - RESCUE TECHNIQUES FROM CONFINED SPACES, CODE NO: 750

V25 SAFE HOT WORK PROCEDURES, CODE NO: 701

V26 WASTE AND GARBAGE MANAGEMENT, CODE NO: 627

V27 MEDICAL FIRST AID (EDITION 2) CODE NO: 990

V28 HULL STRESS MONITORING, CODE NO: 550

V29 SURVIVAL, CODE NO: 681

V30 BASIC FIRE FIGHTING (EDITION 3) CODE NO: 674

V31 STCW AND FLAG STATE IMPLEMENTATION, CODE NO: 629

V32 SECURITY AT SEA, CODE NO: 484

V33 IMMERSION SUITS - THE DIFFERENCE BETWEEN LIFE AND DEATH, CODE NO: 947

V34 MUSTER LISTS, DRILLS & HELICOPTER OPERATIONS, CODE NO: 678

V35 MLC 2006, CODE NO: 986

V36 PORT STATE CONTROL - TIGHTENING THE NET (EDITION 2) CODE NO: 977

V37 SAFETY CONSTRUCTION SURVEY - PART 2, CODE NO: 545

V38 SAFETY EQUIPMENT SURVEY - PART 3, CODE NO: 546

V39 MANAGEMENT FOR SEAFARER SERIES, CODE NO: 607 - 612
Available from: Videotel Marine International Ltd
84 Newman Street, London W1T 3EU, UK
Tel: +44(0) 20 7299 1800
Fax: +44(0) 20 7299 1818
Email: mail@videotelmail.com
URL: www.videotel.co.uk

V40 BALLAST WATER MANAGEMENT

V41 MARPOL. THE NEW RULES

V42 STOWAWAYS A NEW VIEW ON PREVENTION
Available from: Walport International Ltd,
Riverside Business Centre, Fort Road, Tilbury
Essex RM18 7ND, United Kingdom
Tel: +44 (0)1375 489 790
Fax: +44 (0)1375 489 794
Email: sales@walport.com
URL: www.walport.com

V43 SOPEP (CBT # 0004)
V44 ISM CODE (CBT # 0005)
V45 VESSEL STRUCTURAL CONDITIONS (CBT # 0014)
V46 CORROSION PROTECTION I (CBT # 0015)
V47 CORROSION PROTECTION II (CBT # 0016)
V48 BALLAST WATER MANAGEMENT (CBT # 0027)
V49 PROTECTION AND INDEMNITY (CBT # 0028)
V50 OPERATION OF GENERATORS (CBT # 0041)
V51 STABILITY II, DAMAGE STABILITY (CBT # 0061)
V52 STOWAWAYS, MIGRANTS AND REFUGEES (CBT # 0155)
V53 INTRODUCTION TO THE MARITIME LABOUR CONVENTION (MLC 2006) (CBT # 0191)
V54 MLC 2006 - ONBOARD RESPONSIBILITIES (CBT # 0192)
V55 CULTURE MANAGEMENT (CBT # 0251)
V56 ACTIVE LISTENING (CBT # 0252)
V57 CORRECTIVE FEEDBACK (CBT # 0253)
V58 MEETING MANAGEMENT (CBT # 0254)
V59 QUESTION TECHNIQUES (CBT # 0255)
V60 TEAM LEADERSHIP (CBT # 0256)
V61 STRESS MANAGEMENT (CBT # 0257)
V62 PERSONAL SAFETY (DVD # 2001)
Available from: seagull AS
P.O. Box 1062
N-3194 Horten, Norway
Tel: +47 33 03 09 10
Fax: +47 33 04 62 79
Email: seagull@sgull.com

V63 COUNTING THE COST
Available from: UK P&I Thomas Miller P&I Ltd.
90 Fenchurch Street,
London EC3M 4ST, UNITED KINGDOM
Tel: +44 20 7283 464

■ IMO references (R)

CHECKS SHOULD BE MADE THAT THESE ARE THE LATEST EDITIONS AVAILABLE

R1 INTERNATIONAL CONVENTION ON STANDARDS OF TRAINING, CERTIFICATION AND WATCHKEEPING FOR SEAFARERS (STCW), 1978, as amended (2011 EDITION) (ISBN 978-92-801-15284)

R2 INTERNATIONAL CONVENTION FOR THE SAFETY OF LIFE AT SEA (SOLAS), AS AMENDED (IMO SALE AND NO. IE110E) SOLAS - CONSOLIDATED EDITION, 2009 (ISBN 9789280115055)
R3 INTERNATIONAL CONVENTION FOR THE PREVENTION OF POLLUTION FROM SHIPS, 1973 (MARPOL 1973) (IN IMO SALES NO. IC520E) (CONSOLIDATED EDITION, 2011) (ISBN 978-92-801-15321)
R4 REGULATIONS FOR THE PREVENTION OF POLLUTION BY OIL - ANNEX 1, MARPOL 73/78 (IN IMO SALES NO. 520)
R5 REGULATIONS FOR THE CONTROL OF POLLUTION BY NOXIOUS SUBSTANCES IN BULK - ANNEX II, MARPOL 73/78 (IN IMO SALES NO. 520)
R6 GUIDELINES FOR THE IMPLEMENTATION OF ANNEX V OF MARPOL 73/78 (IN IMO SALES NO. 520)
R7 MANUAL ON OIL POLLUTION, SECTION 1 - PREVENTION (IMO SALES NO. 557) OUT OF PRINT
R8 ASSEMBLY RESOLUTION A.665(16): PERFORMANCE STANDARDS FOR RADIO DIRECTION-FINDING SYSTEMS
R9 MEPC.14(20) AMENDMENTS TO ANNEX I OF MARPOL 73/78
R10 MEPC.16(22) AMENDMENTS TO ANNEX II OF MARPOL 73/78
R11 MEPC.21(22) AMENDMENTS TO PROTOCOL ITO MARPOL 73/78 AND THE TEXT OF THE PROTOCOL, AS AMENDED, ANNEXED THERETO
R12 MARPOL - HOW TO DO IT, 2002 EDITION. IMO SALES NO. IA636E, ISBN 978-92-801 41528
R13 POLLUTION PREVENTION EQUIPMENT UNDER MARPOL, 2006 EDITION. IMO SALES NO. IA646E, ISBN 978-92-801-14706
R14 MANUAL ON OIL POLLUTION - SECTION I - PREVENTION (2011 EDITION) ISBN 978-92-801-4244-0
MANUAL ON OIL POLLUTION - SECTION II - CONTINGENCY PLANNING, 1995 EDITION. IMO SALES NO. IA560E, ISBN 978-92-801-13303
MANUAL ON OIL POLLUTION - SECTION III - SALVAGE, 1997 EDITION. IMO SALES NO. IA566E, ISBN 978-92-801-14423
MANUAL ON OIL POLLUTION - SECTION IV - COMBATING OIL SPILLS, 2005 EDITION. IMO SALES NO. IA569E, ISBN 978-92-801-41771
MANUAL ON OIL POLLUTION - SECTION V: ADMINISTRATIVE ASPECTS OF OIL POLLUTION RESPONSE, 2009 EDITION. IMO SALES NO. IA572E, ISBN 978-92-801-15000

Details of distributors of IMO publications that maintain a permanent stock of all IMO publications may be found on the IMO website at http://www.imo.org

■ Textbooks (T)

T1 International Labour Office. Accident Prevention on Board Ship at Sea and in Port, 2nd ed. Geneva, ILO, 1996 (ISBN 92-21-09450-2)
T2 Jackson, L. and Morton, T.D., General Engineering Knowledge for Marine Engineers. 5th ed. London, Thomas Reed Publications Ltd, 1990 (ISBN 09-47-63776-1)
T3 Joel, R., Basic Engineering Thermodynamics in S.I. Units. 5th ed. Harlow, Longman, 1996 (ISBN 05-82-25629-1)
T4 Morton, T.D., Motor Engineering Knowledge for Marine Engineers. London, Thomas Reed Publications Ltd, 1994 (ISBN 09-01-2856-5)

T5 Taylor, D.A., Introduction to Marine Engineering. 2nd ed. London, Butterworth, 1990 (ISBN 07-50-6253-9)
T6 Blakey, T.N., English for Maritime Studies. 2nd ed. Hemel Hempstead, Prentice Hall International (UK) Ltd, 1987 (ISBN 0 13 281379-3)
T7 Hall, D.T., Practical Marine Electrical Knowledge. London, Witherby & Co Ltd, 1984 (ISBN 0-900886-87-0)
T8 Kraal, E.G.R., Basic Electrotechnology for Engineers. 3rd ed. London, Thomas Reed Publications Ltd, 1985 (ISBN 0-900335-96-3)
T9 Maritime and Coastguard Agency (MCA), Code of Safe Working Practices for Merchant Seamen, London. The Stationery Office Publications Centre, Consolidated Edition, 2009 (ISBN 9780115530784)
T10 Leslie Jackson, Reed's Instrumentation and Control System, Adlard Coles Nautical, London, 1992 (ISBN 0-7136-6731-1)
T11 Flood, C.R., Fabrication, Welding and Metal Joining Processes. London, Butterworth, 981 (ISBN 04-08-00448-7) OUT OF PRINT 1999
T12 Hannah-Hillier, J., Applied Mechanics. Harlow, Longman, 1995 (ISBN 05-82-25632-1)
T13 Pritchard, R.T., Technician Workshop Processes and Materials. London, Hodder and Stoughton, 1979 (ISBN 0-34022-100-3) OUT OF PRINT 1999
T14 Simmonds, C.H. and Maguire, D.E., Progressive Engineering Drawing for T.E.C. Students, London, Hodder and Stoughton Ltd, 1983 (ISBN 03-40-26196-x-0) OUT OF PRINT 1999
T15 Derrett, D.R., Ship Stability for Masters and Mates, 6th ed. Butteworth-Heinemann, 2006 (ISBN 0-7506-6784-2)
T16 Cornish, M., Ives. E., Reeds Maritime Meteorology, Reeds Professional. Revised edition, Adlard Coles, 2010 (ISBN 978-1408112069)
T17 International Safety Guide for Oil Tankers and Terminals. 5th ed. ICS/OCIMF. London, Witherby & Co. Ltd, 2006 (ISBN 978-1856-092-913)
T18 Swift, Capt A.J., Bridge Team Management - A Practical Guide. The Nautical Institute, London, 1993 (ISBN 1-870077-14-8)

n Bibliography (B)

B1 POUNDER'S MARINE DIESEL ENGINES AND GAS TURBINES 8TH EDITION. ISBN 0-7506-5846-0
B2 DIESEL ENGINES FOR SHIP PROPULSION AND POWER PLANTS VOLUME I & II. K. KUIKEN, TARGET GLOBAL ENERGY. ISBN 978-90-79104-02-4
B3 THE STEAM AND CONDENSATE LOOP. SPIRAX SARCO, 2007. ISBN 978-0-9550691-4-7
B4 STEAM TURBINES, DESIGN, APPLICATION AND RERATING. 2ND EDITION. 2009, H.P. BLOCH, M.P. SINGH. ISBN 978-0-07-164100-5
B5 SHIPS ELECTRICAL SYSTEMS. K. VAN DOKKUM, 1ST EDITION, DOKMAR. ISBN 978-90-71500-17-6
B6 HIGH VOLTAGE ENGINEERING FUNDAMENTALS. J. KUFFEL, 2ND EDITION, 2000, NEWNES. ISBN 978-0750636-34-6
B7 PRACTICAL TROUBLESHOOTING OF ELECTRICAL EQUIPMENT AND CONTROL CIRCUITS. M. BROWN, 2005 EDITION, NEWNES. ISBN 0-7506-6278-6
B8 ELECTRONICS FUNDAMENTALS. FLOYD SERIES, 7TH EDITION, 2006. ISBN 978-0132197-09-0

B9 COPENDIUM MARINE ENGINEERING. H. MEIER-PETER, 2009. ISBN 978-38774382-2-0
B10 SHIP KNOWLEDGE. K. VAN DOKKUM, 7TH EDITION, DOKMAR. ISBN 978-90-71500-18-3
B11 MARINE REFRIGERATION MANUAL. A.W.C. ALDERS, 1987, RMCA. ISBN 90-9001576-0
B12 PRACTICAL PID CONTROL. A. VISIOLI, 2010 EDITION, SPRINGER. ISBN 978-1-84628-586-8
B13 PNEUMATIC ACTUATING SYSTEMS FOR AUTOMATIC EQUIPMENT. I.L. KRIVTS, 2006 EDITION, CRC PRESS. ISBN 978-0-8493-2964-7
B14 OIL HYDRAULIC SYSTEMS, PRINCIPLES AND MAINTENANCE. S.R. MAJUMDAR, 2003, MCGRAW-HILL. ISBN 0-07-140669-7
B15 MACHINE SHOP TOOLS AND OPERATIONS. R. MILLER, 5TH EDITION, 2004, WILEY PUBLISHING. ISBN 0-764-55527-8
B16 ENGINEERING MATERIALS: PROPERTIES AND SELECTION. K.G. BUDINSKI, 9TH EDITION, 2009. ISBN 978-0137128-42
B17 SHIP STABILITY. K VAN DOKKUM, 4TH EDITION, DOKMAR. ISBN 978-90-71500-15-2

Officer in Charge of an Engineering Watch

Function 1:
Marine Engineering at the Operational Level

Officer in Charge of an Engineering Watch

Function 1: Marine Engineering at the Operational Level

INDEX

Part B1: Course Outline

■ Timetable

No formal example of a timetable is included in this model course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors
- workshop equipment available

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

■ Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees handouts contribute to the learning process.

■ Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
1.1 MAINTAIN A SAFE ENGINEERING WATCH		
1.1.1 THOROUGH KNOWLEDGE OF PRINCIPLES TO BE OBSERVED IN KEEPING AN ENGINEERING WATCH	7	
1.1.2 SAFETY AND EMERGENCY PROCEDURES	8	
1.1.3 SAFETY PRECAUTIONS TO BE OBSERVED DURING A WATCH AND IMMEDIATE ACTIONS TO BE TAKEN	8	
1.1.4 ENGINE-ROOM RESOURCE MANAGEMENT	8	31
1.2 USE ENGLISH IN WRITTEN AND ORALFORM		
1.2.1 THE ENGLISH LANGUAGE TO ENABLE THE OFFICER TO PERFORM ENGINEERING DUTIES AND TO USE ENGINEERING PUBLICATIONS		20
1.3 USE INTERNAL COMMUNICATION SYSTEMS		
1.3.1 OPERATION OF ALL INTERNAL COMMUNICATION SYSTEMS ON BOARD		5
1.4 OPERATE MAIN AND AUXILIARY MACHINERY AND ASSOCIATED CONTROL SYSTEMS		
1.4.1 BASIC CONSTRUCTION AND OPERATION PRINCIPLES OF MACHINERY SYSTEMS		
.1 Marine diesel engine	100	
.2 Marine steam turbine	50	
.3 Marine gas turbine	15	
.4 Marine boiler	40	
.5 Shafting installations and propeller	20	
.6 Other auxiliaries	120	
.7 Steering gear	20	
.8 Automatic control systems	20	
.9 Fluid flow and characteristics of major systems	15	
.10 Deck machinery	10	410
1.4.2 SAFETY AND EMERGENCY PROCEDURES FOR OPERATION OF PROPULSION PLANT MACHINERY INCLUDING CONTROL SYSTEMS		
.1 Main engine auto slow down and shut down	10	
.2 Main boiler auto shut down	10	
.3 Power failure	5	
.4 Emergency procedures for other equipment/installations	5	30

Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
1.4.3	PREPARATION, OPERATION, FAULT DETECTION AND NECESSARY MEASURES TO PREVENT DAMAGE FOR THE FOLLOWING MACHINERY ITEMS AND CONTROL SYSTEMS		
	.1 Main engine and associated auxiliaries	16	
	.2 Boiler and associated auxiliaries, and steam systems	16	
	.3 Auxiliary prime movers and associated systems	8	
	.4 Other auxiliaries	30	70
1.5	**OPERATE FUEL, LUBRICATION, BALLAST AND OTHER PUMPING SYSTEMS AND ASSOCIATED CONTROL SYSTEMS**		
1.5.1	OPERATIONAL CHARACTERISTICS OF PUMPS AND PIPING SYSTEMS INCLUDING CONTROL SYSTEMS		10
1.5.2	OPERATION OF PUMPING SYSTEMS		
	.1 Routine pumping operation	2	
	.2 Operation of bilge, ballast and cargo pumping system	20	22
1.5.3	OILY WATER SEPARATOR/SIMILAR EQUIPMENT REQUIREMENTS AND OPERATION		8
Total for Function 1: Marine Engineering at the Operational Level			**606 hours**

Teaching staff should note that the hours for lectures and exercises are suggestions only as regards sequence and length of time allocated to each objective. These factors may be adapted by lecturers to suit individual groups of trainees depending on their experience, ability, equipment and staff available for teaching.

Part C1: Detailed Teaching Syllabus

■ Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular,

- Teaching aids (indicated by A)
- IMO references (indicated by R) and
- Textbooks (indicated by T)

will provide valuable information to instructors.

■ Explanation of information contained in the syllabus tables

The information on each table is systematically organized in the following way. The text above the line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.*

In this model course there are four functions:

- Marine Engineering at the Operational Level
- Electrical, Electronic and Control Engineering at the Operational Level
- Maintenance and Repair at the Operational Level
- Controlling the Operation of the Ship and Care for the Persons on Board at the Operational Level

The header of the first column denotes the COMPETENCE concerned. Each function comprises several competences. For example, Function 1, Marine Engineering at the Operational Level, comprises a total of five COMPETENCES. Each competence is uniquely and consistently numbered in this model course.

* Morrison, W.S.G. Competent crews = safer ships. Malmo, WMU Press, 1997 (ISBN 91-973372-0-X).

The first is **Maintain a Safe Engineering Watch**. It is numbered 1.1, that is the first competence in Function 1. The term competence should be understood as the application of knowledge, understanding, proficiency, skills and experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the competence **Maintain a Safe Engineering Watch** comprises a total of four training outcomes. The first is in THOROUGH KNOWLEDGE OF PRINCIPLES TO BE OBSERVED IN KEEPING AN ENGINEERING WATCH. Each training outcome is uniquely and consistently numbered in this model course. Thorough knowledge of principles to be observed in keeping an engineering watch is numbered 1.1.1. For clarity, training outcomes are printed in black on grey, for example TRAINING OUTCOME.

Finally, each training outcome embodies a variable number of required performances as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified required performance.

Following each numbered area of required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process. For example, under the topic 1.1.1 Thorough knowledge of principles to be observed in keeping an engineering watch, to meet the required performance, the trainee should be able to:

- explain principles to be observed in an engineering watch at sea and in port, including the following based on the provisions concerned in the STCW Code, chapter VIII, section A-VIII/1, A-VIII/2 and B-VIII/2:
  - duties associated with taking over a watch and accepting a watch
  - routine duties undertaken during a watch
  - maintenance of the machinery space logs and the significance of the reading taken
  - duties associated with handing over a watch
- explain standards/regulations for watchkeeping in a national law if any
- state the importance, ordinance and arrangements of watchkeeping, and the need to:
  - wear appropriate clothes, safety shoes and a safety helmet
  - carry a torch lamp
  - maintain bodily functions
  - be awake and highly conscious

IMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performances are placed immediately following the TRAINING OUTCOME title.

It is not intended that lessons are organized to follow the sequence of required performances listed in the Tables. The Syllabus Tables are organized to match with the competence in the STCW Code, table A-III/1. Lessons and teaching should follow college practices. It is not necessary, for example, for Thorough knowledge of principles to be observed in keeping an engineering watch to be studied before Safety and emergency procedures. What is necessary is that all the materials are covered and that teaching is effective to allow trainees to meet the standard of the required performance.

COMPETENCE 1.1	Maintain a Safe Engineering Watch	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 1.1.1 THOROUGH KNOWLEDGE OF PRINCIPLES TO BE OBSERVED IN KEEPING AN ENGINEERING WATCH 1.1.2 SAFETY AND EMERGENCY PROCEDURES 1.1.3 sAFETY PRECAUTIONS TO BE OBSERVED DURING A WATCH AND IMMEDIATE ACTIONS TO BE TAKEN 1.1.4 ENGINE-ROOM RESOURCE MANAGEMENT (ERM)		STCW CODE table A-III/1

COMPETENCE 1.1	Maintain a Safe Engineering Watch	IMO Reference
1.1.1 THOROUGH KNOWLEDGE OF PRINCIPLES TO BE OBSERVED IN KEEPING AN ENGINEERING WATCH (7 hours) **Textbooks:** **Teaching aids:** A1, A3, V1, V2, V9 Required performance: - explains principles to be observed in an engineering watch at sea and in port, including the following based on the provisions concerned in the STCW Code, ch VIII, section A-VIII/1, A-VIII/2 and B-VIII/2: - duties associated with taking over a watch and accepting a watch - routine duties undertaken during a watch - maintenance of the machinery space logs and the significance of the reading taken - duties associated with handing over a watch - explains standards/regulations for watchkeeping in a national law if any – states the importance, ordinance and arrangements of watchkeeping, and the need to: - wear appropriate clothes, safety shoes and a safety helmet - carry a torch lamp - maintain bodily functions – be awake and highly conscious		STCW Code ch VIII section A-VIII/1 para 10 section A-VIII/2 part 4 para 9-12 part 4-2 para 52-83 part 5 para 90-97 part 5-2 para 100-101 part 5-4 para 103-104 section B-VIII/1 para 6-9 section B-VIII/2 part 4-2 para 6-8
1.1.2 SAFETY AND EMERGENCY PROCEDURES (8 hours) **Textbooks:** **Teaching aids:** A1, A3, V1, V2, V9 Required performance: - states what is meant by emergency in accordance with components of the machinery - states that the type of impact of the emergency should be promptly identified and countermeasures conforming to the emergency procedures and contingency plans established beforehand, should be taken - states that changeover of remote/automatic control to local operation of all systems has to be almost always done in case of emergency to take actions necessary for maintaining a safe operation - states that each component/installation constructing propulsion machinery can be isolated from the entire system and can be run manually - explains remedial/emergency procedures and conditions in accordance with components of the machinery in such an event of power failure - explains necessary procedures/measures with isolation of the component/ installation of major machinery, taking examples such as arrangements/ managements of piping systems, control systems and other elements concerned - states procedures for recovery and malfunctions considered to be likely occurred in steering gears in case of blackout and other causes including procedures for changeover of remote-auto to electric hydraulic driven at machine side and hand pump hydraulic driven at machine side respectively		R1

COMPETENCE 1.1	Maintain a Safe Engineering Watch	IMO Reference

1.1.3 SAFETY PRECAUTIONS TO BE OBSERVED DURING A WATCH AND IMMEDIATE ACTIONS TO BE TAKEN (8 hours)

R1

Textbooks:

Teaching aids: A1, A3, V1, V2, V9

Required performance:

- explains the importance of engine-room rounds before taking over the watch and periodic rounds during the watch
- explains the need to be at places where communication with bridge and chief engineer is always available except engine-room rounds or carrying communication means
- explains the need to have an incentive and positive mental attitude emphasizing that officers in charge of the engineering watch assume a great responsibility in the safe navigation
- explains the need to pay continuous attention to all the running parameters of machinery and to what tasks are being carried out by other personnel concerned
- explains the need to be well-versed in structure of the engine-room including evacuation route and installations/equipment for emergency
- states that arrangements of fire-extinguishing installations should be clearly understood including sorts and number of fire extinguishers in accordance with types of ship
- states immediate actions to be taken in the event of accidents such as fire, a person overboard, oil spill and flooded, emphasizing that the appropriate immediate actions minimize damage
- explains necessary measures to contain oil spreading in the event of oil spill including communicating information/report, preparation of the dedicated apparatus against oil spill, plugging of scupper pipes and stopping oil systems

1.1.4 ENGINE-ROOM RESOURCE MANAGEMENT (ERM) (8 hours)

R1

STCW Code ch VIII section A-VIII/2 part 3, para 8

Textbooks:

Teaching aids: A1, A3, V1, V2, V9

Required performance:

- explains ERM principles based on Bridge Resource Management (BRM)/ERM principles described in STCW Code, ch VIII, section A-VIII/2, part 3, para 8
- explains ERM in terms of maintaining the safe engineering watch including why ERM is necessary
- explains the resources considered to be included in ERM
- – explains the resource management in a specific manner taking examples such as personnel management, information management and management of installations/equipment
- explains what is necessary to practise ERM
- – explains what is meant by the following in practising ERM:
  - allocation, assignment and prioritization of the resources
  - effective communication
  - assertiveness and leadership
  - obtaining and maintaining situational awareness
  - – consideration of team experience

COMPETENCE 1.2	Use English in Written and Oral Form	IMO Reference
TRAINING OUTCOME: Demonstrates a knowledge and understanding of: 1.2.1 THE ENGLISH LANGUAGE TO ENABLE THE OFFICER TO PERFORM ENGINEERING DUTIES AND TO USE ENGINEERING PUBLICATIONS		STCW Code section A-III/1 IMO model course, 3.17

COMPETENCE 1.2	Use English in Written and Oral Form	IMO Reference
1.2.1 THE ENGLISH LANGUAGE TO ENABLE THE OFFICER TO PERFORM ENGINEERING DUTIES AND TO USE ENGINEERING PUBLICATIONS (20 hours) **Textbooks:** T6 **Teaching aids:** A4 Required performance: - use English in written and oral form to: - perform the officer's duties - use general maritime vocabulary - use marine technical terminology - use manufacturers' manuals - use shipboard drawings - use other engineering publications		IMO model course, 3.17 R1

COMPETENCE 1.3	Use Internal Communication Systems	IMO Reference
TRAINING OUTCOME: Demonstrates a knowledge and understanding of: 1.3.1 OPERATION OF ALL INTERNAL COMMUNICATION SYSTEMS ON BOARD		STCW Code section A-III/1

COMPETENCE 1.3	Use Internal Communication Systems	IMO Reference
1.3.1 OPERATION OF ALL INTERNAL COMMUNICATION SYSTEMS ON BOARD (5 hours) **Textbooks:** **Teaching aids:** A3, Practical exercises should be carried out where an equipped laboratory exists. Required performance: - states the importance of: - communicating effectively in all circumstances - orders, instructions, reports and exchange of information being clear, accurate and concise - using accepted marine terminology, and proper methods are employed - chief or second engineer being kept informed as required - the bridge being informed and consulted as required		STCW Code section A-III/1 R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 1.4.1 BASIC CONSTRUCTION AND OPERATION PRINCIPLES OF MACHINERY SYSTEMS 1.4.2 sAFETY AND EMERGENCY PROCEDURES FOR OPERATION OF PROPULSION PLANT MACHINERY INCLUDING CONTROL SYSTEMS 1.4.3 PREPARATION, OPERATION, FAULT DETECTION AND NECESSARY MEASURES TO PREVENT DAMAGE FOR THE FOLLOWING MACHINERY ITEMS AND CONTROL SYSTEMS		STCW Code section A-III/1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

1.4.1 BASIC CONSTRUCTION AND OPERATION PRINCIPLES OF MACHINERY SYSTEMS (410 hours)

Textbooks: T2, T3, T4, T5

Teaching aids: A1, A2, A3, V4, V5, V6, V7, V10

Required performance:

1.1 Marine diesel engine (100 hours)

1) Heat-engine cycle (20 hours) — R1

- defines “heat-engine cycle” as a number of thermodynamic processes arranged in a given sequence, and repealed over constant intervals of time
- states that real practical cycles are based on “ideal” theoretical cycles
- – states that most ideal cycles involve the following thermodynamic processes:
  - heating or cooling, at constant pressure
  - heating or cooling, at constant volume
  - adiabatic compression or expansion
- states that the cycle of thermodynamic processes (or operations) is called out on a “working fluid”
- states that ideally the working fluid is “perfect”, with its physical properties and structure remaining constant throughout the cycle
- states that working fluids used in practical engines change during the cycle of processes
- states that the function of a heat-engine cycle is to produce the maximum possible output of useful work from a given quantity of energy supplied to the working fluid
- states that, in the majority of practical heat-engine cycles, the energy input is obtained from the energy released by the combustion of a fuel with air
- states that the “efficiency” of the cycle is measured by the energy output obtained per unit of energy supplied to the working fluid
- states that, in the “ideal” case, the energy output will be the difference between the energy supplied during the cycle (Q1) and the energy remaining and rejected at the end of the cycle (Q2)
- deduces from the above objective that ideally the output energy is the difference between the energy supplied and the energy rejected,
  i.e. $W = Q1 - Q2$
- deduces from the above objective that the cycle efficiently is given by the ratio:
  $$\frac{\text{Energy output}}{\text{Energy input}} = \frac{W}{Q1} = \frac{\text{Energy supplied - Energy rejected}}{\text{Energy supplied}} = \frac{Q1 - Q2}{Q1}$$
- – solves simple numerical problems related to the equation in the above objective

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

2) Ideal gas cycle (15 hours) — R1

- defines ideal gas cycle as those which use a perfect (or ideal) gaseous working fluid
- defines the following cycles as a sketch on a plane of pressure-volume:
  - otto cycle
  - diesel cycle
  - dual cycle
  - joule cycle

  indicating where the thermodynamic processes given in the above objective have been used in each cycle
- names the practical engines whose cycle is modelled on the cycles listed in the above objective as:
  - otto, internal-combustion reciprocating engine, using gas or petrol as a fuel; ignition of fuel is by spark
  - diesel, compression-ignition reciprocating engine, using diesel or heavier fuel oil; ignition is by transfer of heat energy from compressed air
  - dual, modern development of the diesel cycle
  - joule, rotary turbine, using gaseous or light to medium fuels (“gas turbine”)
- explains the meaning of “single-and double-acting” as applied to reciprocating engines
- describes the processes which take place in each stroke of the two-stroke and four-stroke cycles in diesel and petrol engines
- lists the usual maximum temperatures and pressures for the cycles listed in the above objective
- sketches a diagram showing typical crank angles at which air and exhaust valves or ports open and close and the periods of air inlet, compression, combustion, expansion and exhaust in the above objective

3) Diesel engine fuel atomization and combustion (20 hours) — R1

- describes the combustion process in a boiler or an engine cylinder
- describes the chemical reaction in combustion as being between combustible materials such as hydrocarbon on fuels and the oxygen contained in atmospheric air
- states that, as a result of combustion, heat energy become available, enabling thermodynamic operations to be carried out
- states that the heat released during the combustion of a unit of a substance is termed calorific value (CV)
- states that calorific values for fuels are usually stated with respect to unit mass in the case of solid and liquid fuels and unit volume in the case of gaseous fuels
- states that the main combustible elements in marine fuels are carbon, hydrogen and sulphur
- states the appropriate calorific values of the elements given in the above objective
- states that sulphur is usually present in marine fuels
- states that the salts of sodium and vanadium are usually present in marine fuels
- states that sulphur, although combustible, is an undesirable element in a fuel

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– states that sodium and vanadium are also undesirable elements in a fuel – states typical percentages of carbon, hydrogen and sulphur for - fuel oil for a steam boiler - marine diesel fuel - states typical calorific values for marine fuels – states the average proportions, by percentage, of oxygen and nitrogen in atmospheric air - sketches a section through a typical injector nozzle assembly, including dual fuel injector - explains how atomization is produced by the injector nozzle – explains why swirl and penetration are important to the ignition and combustion of the fuel/air mixture - describes the care necessary with injector nozzle holes	
4)	**Engine types (10 hours)** - states that marine diesel engines are normally described in broad categories by the bore of their cylinders and their rotational speed - states that large-bore engines are normally fitted with piston rods and crossheads - states that smaller diesel engines normally have trunk pistons and gudgeon pin in the place of piston rods and crossheads - states that large-bore engines are normally directly connected to the propeller and therefore rotated at low speed - states that other diesel engines may run at medium speed or high speed, depending upon their duty - states that medium-speed and high-speed engines are often used as direct drives for generation of electrical power - states that medium-speed engines (and occasionally high-speed engines) are used, through some form of speed reduction, as main propulsion engines - states the approximate speed ranges related to the following engines: - low-speed - medium-speed - high-speed	R1
5)	**Engine principles (15 hours)** - sketches typical indicator diagrams for: - a two-stroke engine - a four-stroke engine - explains the problems of obtaining indicator diagrams from slow-speed, medium-speed and high-speed engines - states that peak pressures are sometimes measured which give an indication of engine power and performance - develops the expression: work = pressure × volume, to produce an expression for the power of a diesel engine in terms of m.e.p., number of cylinders, length of stroke, diameter of piston and r.p.m. - calculates indicated power, using given dimensions, r.p.m., m.e.p. and the expression developed in the above objective - states typical compressions and maximum pressures for slow-, medium- and high-speed engines	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– explains the reasons for supercharging, giving typical supercharge pressures – using the equation PV = mRT, shows the effect of varying P and T in a diesel-engine cylinder - sketches and labels a diagrammatic arrangement of a supercharging system – explains why high pressures are required for the injection of fuel into the cylinder - describes the essential features of a hydraulic fuel injector – states, as approximate percentages or fractions, a simple distribution of energy obtained from the fuel into: - output as useful work - heat to the cooling media - energy retained in the exhaust gases - energy absorbed in engine friction - energy lost through radiation - states, for a marine propulsion diesel engine, typical values of: - brake thermal efficiency - mechanical efficiency - fuel consumption in kg per kW hour	
6)	**Basic construction (20 hours)**	
	a) Large-bore (two-stroke) engine details (10 hours)	R1
	– describes with the aid of a simple single line sketch, naming the material of manufacture, the assembled construction of the principal components of a diesel engine, including: - the bedplate – a main bearing – an ‘A’ frame and entablature – guides – a liner – a cooling-water jacket – a cylinder head – a diaphragm – a turbocharger – the scavenge trunk – an air cooler – the crankshaft – a connecting rod – a crosshead – a piston – crankpin bearing – gudgeon/piston pin bearing – the camshaft – a push rod – a rocker – an exhaust valve or port	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– an air-inlet port - the chain or gear train driving the camshaft - sketches a section through a piston, showing the cooling arrangements – sketches a section through an engine bedplate, showing the longitudinal and transverse girders, the main-bearing and tie-bolt housings - describes, with the aid of simple sketches, the following valves, showing principal parts, materials and method of operation: - exhaust valve - cylinder lubricator - fuel valve - cylinder relief valve - air-starting valve - crankcase relief valve - jerk fuel pump including the pressures at which the two relief valves operate - with the aid of engine manufacturers' manuals, defines specified work clearances of all bearing and sliding surfaces and interference fits, where applicable - describes, with the aid of diagrams, the distribution of lubricating oil to the guides, piston pin, crankpin and main bearings when pistons are oil-cooled and when water-cooled	
	b) Medium-speed and high-speed (four-stroke) diesel engines (10 hours) – lists the services for which auxiliary diesel engines are used – name the materials used in the manufacture of the listed items, then describe, with the aid of sketches, the assembled construction of these items: - the bedplate – a cylinder block – a cylinder jacket – a cylinder liner – a cylinder head – the exhaust gas manifold – the air-inlet manifold – the air cooler – the engine crankcase – a bearing housing and shell – the lubrication-oil sump – a piston – a connecting rod – a gudgeon/piston pin – the crankshaft – the camshaft and chain – the push rods – the fuel injector – the air inlet and exhaust valves and rockers	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– describes in simple terms the principal features of a typical “V”-type medium-speed diesel engine - sketches a diagrammatic arrangement of a propeller drive from two medium-speed engines - sketches typical timing diagrams for medium-speed and high-speed diesel engines - describes a simple governor to maintain normal running speed under conditions of variable load - describes, with the aid of diagrams, a lubrication and piston-cooling system for a medium-speed diesel engine - identifies that the power starting of an auxiliary diesel engine can be pneumatic, hydraulic or electrical - explains why it is important to maintain the lubricating oil and fuel filters clean and in good condition - uses engine builders’ manuals to obtain working clearances specified by the instructor - describes how the diesel engine of an emergency generator is started – states the normal intervals between checking and testing the emergency generating engine	
1.2	**Marine steam turbine (50 hours)**	
1)	**Rankine cycle (20 hours)** - states that the Rankine cycle is the ideal cycle where the working fluid is used in both liquid and vapour phases, such as: - steam power plant - refrigeration plant - describes the four main components of steam plant as: - the steam boiler, which produces superheated steam from feed water, the required energy being supplied from the combustion of a fuel in air - the turbine(s), which adiabatically expand the high-pressure superheated steam to obtain useful output work (W) - the condenser, which receives the low-pressure exhaust steam from the turbine to cool it and condense it to water - the feed pump, which raises the pressure of the condensate to the boiler pressure and pumps it back into the boiler - states the Rankine cycle efficiency as the ratio: $\frac{\text{Energy derived from the cycle as useful work}}{\text{Energy supplied to the cycle}}$ - states that the output energy of the cycle is the turbine work (W) – states that the turbine work (W) is defined as the difference in energy contained in the superheated steam entering the turbine and the energy contained in the exhaust steam leaving the turbine - states that the energy input of the cycle is the energy transferred from the fuel during combustion in the boiler - states that because the working fluid is in both the liquid and vapour phases during the cycle, energy levels and other properties for the working fluid must be obtained from tables of thermodynamic properties	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

– draws and labels a simple line diagram of a steam plant, using “blocks” for the four main components and arrows to indicate flow of the working fluid and indicating energy values at important points in the cycle

- solves simple numerical problems related to the above objectives

2) Basic construction (10 hours)

- names the materials used in the manufacture of the listed items, then describes, with the aid of sketches, the assembled construction of these items:
  - high pressure turbine casing
  – low pressure turbine casing
  – astern turbine casing
  – low pressure turbine exhaust casing
  – high pressure turbine rotor
  – low pressure turbine rotor
  – receiver pipe
  – reduction gear
  – wheels
  – pinions
  – main condenser
  – gland condenser
  – gland packing steam reservoir
  – gland packing steam leak-off reservoir
  – gland packings
  – gland steam make-up valve, gland steam spill valve
  – manoeuvring valve
  – astern guardian valve
  – flexible coupling
  – thrust bearing
  – labyrinth packings
  – nozzles
  – blades (moving blade, stationary blade)
  – shroud
- states the feature of impulse turbine
- states the feature of reaction turbine
- sketches types of turbine plant arrangement
  - bleeder turbine (extraction turbine)
  - regenerative turbine
  - reheat turbine

3) Operation principles (20 hours)

- explains why main condenser is kept in vacuum
- explains how to keep main condenser in vacuum
- describes the importance of draining inside turbine casing
- describes, with the aids of a sketch/computer aided drawing, function of gland packing steam
- explains the function of manoeuvring valve

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– explains the role of extraction steam - describes that gland steam pressure is controlled by make-up valve and spill valve - describes how to keep the hotwell level of condenser - explains spinning operation - explains the meaning of throttle governing and nozzle governing, which is the way of control of turbine output - explains meaning of auto-spinning system - states that the main turbines are provided with a satisfactory emergency supply of lubricating oil, which will come into use automatically in case of failure of lubricating oil system	
1.3	**Marine gas turbine (15 hours)**	
1)	**Operation principles (8 hours)** - explains how a gas turbine is used for - describes the feature of a gas turbine - describes the operation principles in terms of four processes, compression, combustion (heating), expansion and exhaust - compares a gas turbine with a steam turbine in terms of advantages and disadvantages - describes the types of gas turbines	
2)	**Basic construction (7 hours)** - using visual aids, describes the three main components of gas turbine as: - compressor - combustion chamber - turbine - describes the types of compressors and their features - describes the types of combustion chambers and their features - describes the types of turbine and their features - lists the attached equipment and explains their feature and functions in simple terms	
1.4	**Marine boiler (40 hours)**	
1)	**Steam boiler fuel atomization and combustion (12 hours)** - states that the elements carbon and hydrogen combine chemically with oxygen during combustion to form the gaseous products carbon dioxide and water vapour - explains the part played by nitrogen in the combustion process - states that, to ensure that the combustion process is as compete as possible, excess air is normally supplied - states that the excess of air must be kept to a minimum, consistent with good combustion - states that either the percentage of carbon dioxide or the percentage of oxygen in the exhaust gas should be continuously recorded - states that although excess air is supplied, there may be some incomplete combustion of carbon to carbon monoxide (CO)	R1, R3

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– states that in practice the products of combustion are normally a gaseous mixture of carbon dioxide, sulphur dioxide, water-vapour, possibly carbon monoxide and an ash, possibly containing sodium and vanadium - states that poor combustion creates smoke, which pollutes the atmosphere and wastes fuel and reduces the efficiency of the engine or boiler - states that the production of smoke may lead to prosecution – explains why the proportion of CO_2 or O_2 in exhaust gases provides an indication of combustion efficiency - describes briefly the instruments available to indicate and record the percentage of CO_2 and O_2 in exhaust gas - states the ranges of percentages of CO_2 which indicate: - good combustion - poor combustion - bad combustion - explains the importance of atomization when it is required to mix a liquid fuel with air prior to combustion - explains why the viscosity of a fuel is important in its atomization – describes how the viscosity of a liquid fuel can be controlled by varying its temperature - states the theoretical air/fuel ratio for a typical boiler fuel – states the actual air/fuel ratio, allowing for normal excess air, in: - the furnace of a steam boiler - the cylinder of a diesel engine - states that if sulphur dioxide contacts a low-temperature surface, sulphuric acid will be produced, which will cause corrosion - explains how the effect of the above objective can be minimized – sketches a section through the nozzle assembly of a pressure-jet burner – states that in the above objective atomization is produced by the fuel, at high pressure, passing through a small orifice in the burner nozzle - describes the attention required by burner atomizer tips – describes, with a single line diagram, a combustion air register, identifying: - swirl vanes - the flame stabilizer - air-flow control valves - the burner - states typical values of the pressure drop and of the velocity of combustion air in the register - explains why the thorough and rapid mixing of atomized fuel and combustion air is important - describes furnace conditions which indicate good combustion – describes, with the aid of sketches, how pressure-jet, steam-jet and rotary-cup burners atomize fuel and promote adequate fuel/air mix ratio	
2)	**Marine boiler fundamentals (8 hours)** - describes, with the aid of diagrams, an auxiliary boiler steam system together with identifying the services supplied by steam	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– states typical pressures of steam produced in auxiliary boilers and average system supply pressures - states that auxiliary steam boilers range from simple fire-tube boilers to self-contained fully automated package units - explains simply and briefly, with the aid of diagrams, the principal differences between a fire-tube boiler, a water-tube boiler and a packaged boiler	
3)	**Marine boiler construction (10 hours)** - describes the material commonly used for construction in a fire-tube boiler – describes, with the aid of sketches, the general constructional details of a fire-tube boiler, showing how the parts are connected to form a complete structure - states that, for pressure vessels: - shells of cylindrical form give a higher strength/weight ratio than other shapes - the cylindrical shell can be sited vertically or horizontally - dished or spherical end-plates give a higher strength than flat end-plates of similar thickness - all flat surfaces must be properly stayed to resist deformation - stays can have the form of solid bars, thick tubes or plate girders - corrugated furnaces provide higher strength and flexibility than plain furnaces of similar thickness - states why boiler is usually installed on board diesel engine ships – explains and outlines a boiler system listing associated systems including their components - explains the relationship between a boiler and exhaust gas economizer – explains ignition system including the function of burner control – explains feed water system including the function of feed water control – explains steam temperature control system usually used for main boiler – states what is meant by ABC and ACC – describes how a tube is expanded into a tube plate – describes the principles of construction, operation and control of a packaged boiler	R1
4)	**Marine boiler mountings and steam distribution (10 hours)** - identifies the following boiler fittings and position on boiler shell (supply shell diagram for fitting to be married/drawn and identified): - main steam outlet (or “stop”) valve - auxiliary steam stop valve - safety valves and easing gear - water level gauges - feed inlet valve - blow-down valve - scumming valve - soot blowers - connections for pressure gauges - air release valve - sampling valve	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

– explains the importance of boiler mounted valves
– identifies the following internal boiler fitting and internal position within boiler shell:
  - feedwater distribution unit
  - scumming pan
  - blow-down dip pipe
- explains the purpose of the valves and fittings listed in the above objectives, comparing the differences, where applicable, between water-tube and fire-tube boilers
- explains the purpose of a reducing valve
– describes the operation of a reducing valve, using a single line sketch
– explains how steam pipes are supported
– explains how expansion and contraction are allowed for in steam pipes
– describes the different methods of joining lengths of a steam pipe
– explains the purpose of drains and steam traps
– describes the operation of steam traps
– describes the procedure for warming through a steam line and explains the cause, in simple terms, of water hammer and how water hammer can be avoided
- explains the outline of steam supply system including its components/ installations
- describes the means used to minimize the possibility of oil contaminating the boiler feed water

1.5 Shafting installations and propeller (20 hours)

1) Shafting installations (10 hours)

- describes the following installations/equipment constructing shafting:
  - propeller
  - rope guard
  - stern tube
  - stern tube bearing
  - shaft seal
  - propeller shaft
  - intermediate shaft
  - aft bearing
  - plumber block
  - thrust bearing
- describes the details of oil shaft seal and stern tube bearing including their components
- describes the details of thrust bearing

2) Propellers (10 hours)

- describes various types of propellers and their features
- describes structure and materials for propellers

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– defines the following parameters of propeller: - diameter - pitch - pitch ratio - boss ratio - pressure side - suction side - leading edge - trailing edge - blade section - blade rake	
	- explains briefly how propellers fit on propeller shafts	
	– describes a highly-skewed (skew back) propeller and its advantages	
	– describes a controllable pitch propeller (CCP) and its mechanism of changing blade angle	
	- states the advantages and disadvantages of a controllable pitch propeller in comparison with fixed pitch propeller (FPP)	
	- defines the cavitation of propellers and explains its generating mechanism	
	– defines the propeller singing and explains its generating mechanism and preventive measures	
1.6	**Other auxiliaries (120 hours)**	
1)	**Various pumps (20 hours)**	
	a) Principles (5 hours)	R1
	– states that the function of a pump is to transfer fluid between two given points	
	– lists the losses of head in a pumping system	
	– states that the viscosity of the fluid to be pumped must be within the range specified in the pump design	
	- states that permission should be obtained before any fluids are moved which might affect the stability of the ship and cause pollution overboard	
	b) Types of pump (15 hours)	R1
	– names the types of pump generally used on ships and the purposes for which they are normally used	
	- explains the basic action of a displacement pump	
	– explains the necessity for a relief valve to be fitted in the discharge of any displacement pump	
	- states that when a pump is handling oil or other hazardous material any discharge from the relief valve must be contained within the pumping system	
	- describes, with the aid of diagrams, how a reciprocating displacement pump works	
	- explains the purpose of an air vessel fitted to the discharge	
	– describes the characteristics of a reciprocating pump, referring to: - suction lift - priming - discharge pressure – vapour, or gas, in the fluid being pumped	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– explains the principle of rotary displacement pumps – sketches a single line diagram to show the principal parts of: - a gear pump - a rotary vane pump - a screw-displacement pump - describes the principles of operation of an axial-flow pump – describes the type of duty best suited to an axial-flow pump – explains the principles of a centrifugal pump, referring of the purpose of: - the impeller - the diffuser or volute - makes a single line sketch of a vertical single-entry centrifugal pump – explains what is meant by a ‘single-entry’ and a ‘double-entry’ impeller – describes the arrangement of a vertical multi-stage single-entry centrifugal – explains the purpose of a diffuser – describes the characteristics of a centrifugal pump, referring to: - suction lift - priming - discharge pressure - vapour or gas in the fluid being pumped - explains why and when priming and/or air extraction is necessary and makes single line sketches of: - a reciprocating air pump - a water-ring air pump - makes a single line sketch of a central priming system and explains its advantage - explains the principle of an ejector	
2)	**Refrigeration (40 hours)**	
	a) Marine refrigeration cycle (20 hours) – states that a refrigeration cycle operates on a reversed heat-engine cycle – describes the working fluids for this cycle as “refrigerants” – states that because working fluids are used in both the liquid and vapour phases during the cycle, energy levels and other properties for the working fluid must be obtained from tables of thermodynamic properties - describes the four main components of the plant as: - the evaporator, in which the low-pressure refrigerant enters as a cold liquid and is evaporated to a cold low-pressure vapour - the compressor, in which the low-pressure cold vapour is compressed to a high-pressure superheated vapour - the condenser, in which the hot-high-pressure vapour is cooled and condensed of a cool liquid - the expansion valve, where the cool high-pressure liquid is throttled and expanded to a low-pressure cold liquid - states that the energy required to evaporate the low-pressure liquid refrigerant to a low-pressure vapour at constant low temperature is transferred from the refrigerated chambers, either directly or through a secondary coolant such as brine	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– states that the transfer of energy from the refrigerated chamber is that which produces and maintains its low temperature - states that the refrigeration plant performance is measured by the quantity of energy extracted from the refrigerated chambers per unit energy supplied in compressor work - states that the input energy from the compressor is the difference between values of the refrigerant energy at the inlet to and at the exit from the compressor - using $\frac{\text{Energy extracted in the evaporator}}{\text{Energy input from compressor}}$, derived from the above objectives calculates the performance of a refrigerator - draws and labels a line diagram of a refrigeration plant, using “blocks” for the main components and arrows to indicate flow of the working fluid and indicating the energy values at important points of the cycle - applies simple numerical calculations related to, and making use of the above objectives - lists the refrigerants commonly used in marine refrigeration systems	
	b) Principles of refrigeration (8 hours)	R1

	– explains, in simple terms, the difference between refrigeration, air conditioning and ventilation
	- states that marine refrigerating systems operate on a reversed Rankine cycle, which is also termed the vapour-compression cycle
	- sketches a single line and block diagram of a refrigeration system, system components and arrows to indicate flow of refrigerant, showing the following components:
	  - compressor
	  - condenser
	  - regulator valve and controlling sensor
	  - evaporator
	  - oil separator
	  - drier
	- shows on the diagram in the above objective the part of the system where the following processes take place:
	  - removal of superheat
	  - condensation
	  - throttling
	  - evaporation
	  - compression
	  - expansion
	  - charging
	- describes the requirements of a primary refrigerant
	– names common primary refrigerants currently specified under IMO recommendation (ozone protection)
	- describes the purpose of a secondary refrigerant
	– names common secondary refrigerants	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	c) Refrigerating compressors (2 hours)	R1
	– states the types of compressor in common use	
	– describes in simple terms the applications of the types of compressor in the above objective	
	- states that cylinder blocks of a reciprocating compressor can be either in line or in a vee	
	- describes, with aid of simple sketches, a rotary gland seal	
	– describes how excessive pressure in the cylinder is relieved	
	d) Refrigerating system components (4 hours)	R1
	– states the function of the expansion valve	
	– describes how the expansion valve is controlled	
	– sketches an expansion valve in section as a single line diagram	
	– describes briefly how an oil separator works	
	– states the function of a liquid receiver	
	– describes how the system can be controlled automatically, using the temperature of the cold room	
	- describes in simple terms a condenser	
	– describes in simple terms an evaporator	
	e) Refrigerating system brines (4 hours)	
	– describes the composition of a brine	
	– explains how the density of a brine is varied to suit the temperature of operation	
	- determines the density of brine samples	
	– states that a brine density should be sufficient to give a freezing temperature below the lowest temperature required	
	- states that a brine should be maintained with an alkalinity between pH 8 and 9 to minimize corrosion	
	- determines the pH value of brine samples	
	– explains the precautions to be taken if a brine has to be made with sodium chloride	
	- describes the process of making a brine	
	f) Cold storage spaces (2 hour)	
	– describes the principles of insulation of storage spaces	
	– states that range of temperature for spaces containing:	
	- frozen meat and fish	
	- vegetables	
	- lobby	
3)	**Air conditioning and ventilation systems (5 hours)**	
	- sketches a single line and block diagram of an air conditioning system, system components and arrows to indicate flow of refrigeration, showing the following components:	
	- fan	
	- thermotank	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– thermostat - fresh air dumper - return air dumper - states how to control temperature and humidity in the air conditioning system	
4)	**Heat exchangers (10 hours)** - states that marine heat exchangers are normally of the surface heat-transfer type and that seawater is used for cooling and condensing steam for heating - describes surface heat transfer, referring to the relative direction of flow of fluid – defines 'contact heat transfer' as the heat flow between fluids initially at different temperatures when they are mixed together - sketches the principle of construction of the following surface heat-exchangers: - shell and tube - flat plate type - explains the meaning of single-pass, two-pass, etc. – lists the types of heat exchangers used for the following: - lubricating-oil coolers - fuel-oil heaters - fresh-water coolers - compressed-air coolers - fresh-water heaters - steam condensers - seawater evaporating and distilling plant - seawater heaters - evaporators and condensers in refrigerators - states the materials used for the shell, tubes and tube plates of heat exchangers - explains how: - differential expansion is allowed for - an effective seal is maintained between the fluids - leakage is detected - explains how temperature control is achieved in coolers – describes the effect of partially closing the cooling-water inlet valve – explains the effect of entrained air in cooling water and how it is removed	R1
5)	**Evaporators and distillers (15 hours)** - explains why 'fresh water' may have to be produced from seawater - lists the purposes for which the water might be used - explains the effect that distillation has on the dissolved solids in seawater - states that evaporators and distillers are pressure vessels and as such must conform to approved standards for materials, fittings and construction - states that there are two main methods of obtaining vapour from seawater: - by direct boiling, using boiling water evaporators - by the evolution of vapour when the seawater is 'supersaturated', using flash evaporators	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

	– describes in simple terms, using line sketches, the construction of a shell and coil evaporator, naming the materials of the principal parts
	- lists the mountings fitted to a simple shell and coil evaporator
	- explains why a reducing orifice is fitted in the steam supply line of such an evaporator
	- states that the heat transfer can be obtained from:
	  - a supply of steam or other hot fluid passing through coils
	  - tubes which are immersed in the seawater or
	  - an electrical element immersed in the seawater
	- explains why low-pressure evaporators are used
	- explains what is meant by single-effect and by double-effect evaporation
	(Flash evaporators)
	- explains the principle of flash evaporation
	- states that flash evaporators can use a number of stages, with seawater feed passing through each stage in succession
	- describes, with the aid of a simple sketch, a two-stage flash evaporator
	- explains the principle of operation of the evaporator in the above objective
	(Multiple-effect evaporation)
	- states that shell and coil evaporators can be connected in series, with the vapour produced in the first unit being used as the heating fluid in the next unit, the seawater passing through each unit in turn
	- states that production of vapour in the second and successive units occurs partly by boiling and partly by flash evaporation
	- states that such a system is termed 'multiple effect'
	- states that multiple-effect evaporation produces an increased quantity of fresh water compared to a single evaporator using a similar input of heat
	- describes, with the aid of a single line sketch, the arrangement of a two-stage flash-evaporation plant	

6)	**Air compressor and system principles (15 hours)**	
	a) Air compressors (10 hours) - describes an air compressor as a pump which takes air from the atmosphere and, with an input of energy, compresses it in one or more states to a smaller volume with higher pressure and temperature - explains the reason for cooling the air, during and after the compression - states that the compressed air is stored in steel reservoirs until required for some purpose, such as staring a diesel engine - states that, during the compression process, the relationship: PV^n = a constant will apply - states that air can be treated as an ideal gas and that the relationship: $\frac{PV}{T}$ = a constant will also apply	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– states that for the air storage tank the relationship: PV = mRT will apply, where: m = mass of air stored in the tank (kg) R = specific gas constant for air (= 8314 J/kg/K) T = temperature of air, in kelvin units P = air pressure, in Newtons per square metre V = volume of reservoir tank, in cubic metres	
	- solves simple numerical problems related to the above objectives	
	b) Air compressors and system principles (5 hours)	R1
	– lists shipboard uses of compressed air	
	– states the common pressure limit of single-stage compressors	
	– states that, in order to restrict the rise of air temperature during compression, the air is cooled by circulating water around the cylinder	
	- states that air compressor can be single-stage or multi-stage reciprocating or rotary machines	
	- describes the compression processes in a two-stage reciprocating compressor	
	– draws a line diagram of a two-stage air compressor. indicating stage air pressures and temperatures	
	– explains why intercoolers and after-coolers are used	
7)	**Purifier and fuel oil treatment (10 hours)**	
	- describes the following with the aid of sketches: - bowl assembly - operating water - seal water - gravity disk - valve cylinder - separation disk/plate	
	- states principles of purifying to eliminate water or dirt particles from oil	
	– explains why fuel oil treatment is necessary	
	– explains in simple terms, the purification by using gravity force and filters, and centrifugal separation	
	- describes the following types of filter, which are used in fuel oil lines: - mesh/gauze elements - magnetic elements - fibre assemblies	
	- explains how the force of gravity is used to separate out liquids and solids of different densities	
	- describes the operation principles of an oil purifier	
	– explains why the use of centrifugal separation is much faster and more effective than gravity in the separation process	
	- describes, with the aid of simple sketches, a bowl separator and a tube separator, showing the main components and the principal differences between the two	
	- states the rotation speeds used in the equipment described in the above objective	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
8)	**Thermal fluid heating systems (5 hours)**	
	- states the functions of a thermal fluid heating system on board ship	
	- states the differences between a thermal fluid heating system and an auxiliary steam system	
	- states the properties of thermal fluids used on board ship	
	- describes with the aid of diagrams and sketches the components and their functions, fittings and safety devices of a thermal fluid system	
	- explains the need for a minimum flow of the thermal fluid in the system	
	- describes the safety precautions and possible dangers when operating a thermal fluid heating system	
	- describes the operation of a thermal fluid heating system	
1.7	**Steering gear (20 hours)**	
1)	**Steering gear principles (10 hours)**	R1
	- states that the gear is vital to the safety of a ship; it must function correctly and be properly serviced and maintained	
	- states that there must be two independent means of steering	
	– states that alternative control of the steering gear must be provided in the steering gear compartment	
	- draws a line and block diagram, to represent the major components, of a steering system, showing:	
	- the steering-wheel transmitter located in the bridge space	
	- the rudder-control receiver unit located aft in the steering compartment	
	- the systems conveying the transmitter signal to the receiver	
	- the power system which moves the rudder	
	- the rudder-control feedback to the system	
	- states that the function of the receiver is to act on the signal, from the transmitter and, through a control element, to operate the rudder power system	
	- states that the transmitter and receiver system can be hydraulic or electrical	
	– states that the rudder power system can be hydraulic or electrical	
	– identifies the particular requirements of oil tankers	
2)	**Steering gear electrical control (2 hours)**	
	- describes the principles of operation of an electrical control system	
3)	**Hydraulic power-operated rudder systems (4 hours)**	
	- explains that the systems can be principally cylinders and rams or a radial-vane motor	
	- sketches, using lines and block diagrams, the system of cylinders and rams, showing how, with a pair of rams in line and two rams in parallel, hydraulic pressure actuates the rudder through a crosshead or trunnion and tiller-arm assembly	
	- states that, in a radial-vane-type system, hydraulic pressure acts on radial vanes attached to the rudder stock, this producing movement of the rudder	
	- describes normal operation of rudder drive pumps and system, indicating which valves are open and which are closed	
	- states the materials normally used in the main components in the above objectives	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

4) Hydraulic power rotary pumps (4 hours)

- states that a rotary positive-displacement pump is used to obtain displacement of fluid and produce movement of the rudder
- states that the pump in the above objective is driven by an electric motor
- describes the principle of operation of a radial cylinder pump
- describes the principle of operation of a swash-plate pump
- describes how the pumping action is controlled:
  - by linkage to the telemotor receiver and
  - by linkage to the rudder, for feedback control
- describes, with the aid of single line sketch, how the pump is controlled to move the rudder from one position to another
- states that the fluid in the system must be the correct mineral-base oil which is clean and free of moisture
- explains how shocks to the system from wave action on the rudder are absorbed

1.8 Automatic control systems (20 hours)

- names and describes each component constructing the following control methodologies:
  - ON-OFF control
  - sequential control
  - PID control
  - program control
- describes what control methodologies can be applied to which control systems taking examples such as automatic motor start/stop for ON-OFF control, automatic generator start/stop for sequential control, level/temperature/ pressure control for PID control and main engine speed multiplication/reducing program for program control
- describes in simple words, the construction and functions of each component for control systems
- describes operation principles of each component constructing automatic control systems taking examples such as:
  - pressure switch
  - temperature switch
  - resistance bulb
  - electric-pneumatic converter
  - electromechanical transducer
  - valve positioner
  - control valve
  - relay
  - pneumatic/electronic PID controller

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

1.9 Fluid flow and characteristics of major systems (15 hours)

- describes fluid flows of:
  - fuel oil
  - lubricating oil
  - cooling fresh water
  - cooling sea water

  systems in the diesel engine propulsion plant
- describes fluid flows of:
  - main steam
  - condensate water
  - and feed water
  - lubricating oil

  systems in the steam turbine propulsion plant
- describes what sorts of fittings are used to construct each plant system taking examples such as various types of valves, pipings, pressure regulator and the like
- describes characteristics appeared in the each piping system taking examples such as supplementary devices/pipings, pipe colouring and location of equipment/installations
- conduct a workshop meeting giving opportunities to the trainees to present their research activities on construction of piping systems
- describes the means by which lengths of pipe are joined together, naming the materials used to seal joints for:
  - steam pipes
  - seawater pipes
  - the fire main
  - bilge and ballast pipes
  - starting air pipes
  - control air pipes
- explains how pipes are supported to reduce vibration
- explains how expansion and contraction of pipes is catered for
- names the materials used for the construction pipes carrying the fluids listed in the above objective
- describes the principal construction of a cock and materials generally used
- explains how the arrangement of ports in the plug is displayed
- describes the main features of a globe valve
- explains the difference between a screw-lift valve, a screw-down non-return valve and a non-return valve
- describes the main features of a gate valve
- describes a typical relief valve
- lists and describes the applications of quick-closing valve
- describes the main features of a quick-closing valve
- makes a single line sketch of a change-over sea chest
- explains the purpose and applications of change-over sea chests

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– explains how pipelines are blanked off - describes the main features of a mud box **1.10 Deck machinery (10 hours)** **1) Windlass/mooring winch** - describes what components construct typical electric/hydraulic windlass/ mooring winch systems - explains the construction of windlass/mooring winch with visual aids/ illustrations of typical ones - explains the operation mechanism of windlass/mooring winch with visual aids/ illustrations of typical ones - explains in simple words, speed control mechanism used in windlass/mooring winch with visual aids/illustrations of typical ones **2) Winch** - describes components used in the construction of typical electric/hydraulic winch systems - explains the construction of a winch with visual aids/illustrations of typical ones - explains the operation mechanism of a winch with visual aids/illustrations of typical ones - explains in simple words, speed control mechanism used in winch with visual aids/illustrations of typical ones **3) Boat winch** - explains the construction of a boat winch with visual aids/illustrations of typical ones - explains the operation mechanism of a boat winch with visual aids/illustrations of typical ones	
	1.4.2 SAFETY AND EMERGENCY PROCEDURES FOR OPERATION OF PROPULSION PLANT MACHINERY INCLUDING CONTROL SYSTEMS (30 hours) **Textbooks:** T2, T3, T4, T5 **Teaching aids:** A1, A2, A3, V4, V5, V6, V7, V10 Required performance: **2.1 Main engine auto slow down and shut down (10 hours)** - explains main engine auto slow down and shut down taking a typical system as an example in terms of the following: - specific conditions - processes appeared until auto slow down/shut down - transient phenomenon of the plant - procedures for recovery (changeover of manoeuvring position, manoeuvring method, eliminating causes and etc.) - main engine control system - explains main engine manual emergency slow down and shut down in terms of the following, taking a typical system as an example - specific conditions - impacts on the plant - procedures for recovery	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
2.2	**Main boiler auto shut down (10 hours)** - explains main boiler auto shut down taking a typical system as an example in terms of the following: - specific conditions - processes appeared until shut down - impacts on the plant under way and in port - procedures for recovery (eliminating causes, reigniting burner and etc.) - main boiler control system (changeover of control system, position and etc.)	
2.3	**Power failure (blackout) (5 hours)** - explains briefly power supply system on board ships and its back-up system - explains specific conditions of blackout and procedures for recovery responding to their causes taking a typical system as an example, including the following: - transient phenomenon of the plant - equipment/installations to be promptly addressed - sequential restarting auxiliaries - auxiliaries to be manually restarted - generator control system and power distributing system	
2.4	**Emergency procedures for other equipment/installations (5 hours)**	
1)	**Emergency steering (1 hour)** - describes how the system can be controlled from: - a local position in the steering compartment at the rudder head - an emergency steering position on deck – describes alternative systems of steering that can be used in an emergency	R1
2)	**Others (4 hours)** - explains precautions/procedures to be taken for the following: - operation of purifiers in case of blackout - heat exchangers under blackout - back-up in case of control air failure - cooling seawater system in case of air ingress - clogged strainers/filters	
1.4.3	**PREPARATION, OPERATION, FAULT DETECTION AND NECESSARY MEASURES TO PREVENT DAMAGE FOR THE FOLLOWING MACHINERY ITEMS AND CONTROL SYSTEMS (70 hours)**	R1
Textbooks: T2, T3, T4, T5		
Teaching aids: A1, A2, A3, V4, V5, V6, V7, V10		
Required performance:		
3.1	**Main engine and associated auxiliaries (16 hours)** The following can be applied to diesel engine, steam turbine and gas turbine except for some of them - explains the outline of main machinery system listing associated systems including their components - states precautions, safety measures, checking procedures and points to be made as preparations before starting up main engine	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

– states the need for warming up/cooling down main engine or keeping it at hot condition unless cooling down has been done
- explains the standard of completing warming up/cooling down main engine
– explains precautions and typical procedures for warming up/cooling down main engine including theoretical rationale
- states precautions for starting associated auxiliaries to establish each system constructing propulsion machinery such as fuel oil, lubricating oil, cooling system and starting air system
- states particularly, precautions against auxiliaries which repair/overhaul was carried out
- states precautions to start main engine turning
– states the importance of carrying out all procedures in an orderly manner in order to prevent malfunction and damage
- states the need to carry out main engine trial run and necessary precautions
– states typical procedures for main engine trial run and checking points
– states procedures for changing over the propulsion machinery to the state of navigation
- explains the critical speed/revolution caused by torsional vibration of shafting system
- explains how the running conditions can be evaluated if it is in good working order in terms of running parameters, engine performance and operating range
- explains how running parameters such as temperatures, pressures and levels can be determined in normal range
- explains what malfunctions are likely to occur due to running parameters getting out of the normal range
- explains in simple words, how to calculate engine output
– explains how the engine revolution is controlled
– explains in simple words, the operating range including shaft revolution, ship's speed, engine output, engine torque and their relationships
- states the definition of torque rich
– explains in simple words, the difference of output characteristic between diesel engine and steam turbine
- explains the meanings of major running parameters to be strictly observed
– states the importance of engine-room rounds to detect sign of faults/ malfunctions, emphasizing that running sound, leaking and vibration can be detected through engine-room rounds and these factors cannot be detected with monitoring system
- describes how to carry out the cleaning of turbocharger under way
– explains how to keep running of main diesel engine under the condition of cutting fuel oil to one cylinder or more
- explains how to keep running of main diesel engine under the condition of reducing the number of turbochargers
- describes the conditions which create dangerous oil mists in crankcases
– describes the correct action to take when hazardous conditions are indicated in a crankcase
- explains the importance of keeping scavenge air spaces and supercharge air-spaces drained and clean

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference

– describes the correct procedure and actions to take if a fire occurs in the scavenge air space or in the supercharge air space when an engine is running
- describes the action to be taken if a turbocharger surges

3.2 Boiler and associated auxiliaries, and steam systems (16 hours)

- states procedures for igniting the burner manually and automatically
– states how to build up the steam pressure and to put boiler into service
– explains precautions and necessary measures to be taken when getting up steam
- explains the benchmark for building up steam pressure
– states the function of safety valve and how to adjust the setting point to blow
– explains operation methods of boiler and economizer under way
– explains precautions for using exhaust gas economizer
– describes the method used to ensure that all pipes, cocks, valves and other fittings used for indicating water level are clear and in good working order
- explains the treatment of boiler water including examination of properties of boiler water, surface and bottom blowing of boiler water
- states what is meant by soot blow including the function of soot blowers
– explains what malfunctions/troubles are likely to happen to boiler on its operation
- states precautions for opening high temperature steam valves
– explains how to keep boiler in cold condition while it is out of service
– describes the correct procedures for operating steaming boilers in parallel on load
- describes the correct procedures for checking the water level in steaming boilers
- describes the danger of oil entering a boiler with the feedwater
– explains what is meant by “blow-back”
– explains how blow-back can be avoided
– explains the need for, and the use of, soot blowers
– explains why the temperature of boiler exhaust gases should be maintained above a minimum value

3.3 Auxiliary prime movers and associated systems (8 hours)

(Diesel engine)

- states precautions before starting an engine such as confirming fuel oil line, starting air line, cooling sea/fresh water line established and amount of lubricating oil inside the sump tank
- describes briefly components constructing each associated system for an engine
- states preparations and procedures for manual start of an engine
- states the conditions of remote-auto start of an engine
- states the differences between manual start and remote-auto start of an engine
- describes briefly the control system and its components including their function
- states the safety devices and their functions

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– lists the normal operating pressures and/or temperatures for: - exhaust gas - inlet air - circulating water at inlet and outlet - lubricating oil - fuel	
	(Steam turbine) - states precautions before starting a steam turbine such as confirming steam line, gland steam line, lubricating oil line, condensate water line and circulating line - describes briefly components constructing each associated system for a steam turbine - states preparations and procedures for start of a steam turbine - describes briefly the control system and its components including their function - states the safety devices and their functions	
3.4	**Other auxiliaries (30 hours)**	
1)	**Purifier and fuel oil treatment (8 hours)** - states sequence of discharging sludge – states why oil purifier needs following data concerning oil: - temperature - quantity of flow - density/specific gravity - explains the function of gravity disk – explains the function of low and high pressure water – describes sludge discharging mechanism of an oil purifier – explains the difference between purifying and clarifying – describes the purification process of fuel oil, starting the approximate temperatures of the oil necessary both in the supply tank and immediately prior to centrifuging - explains precautions for starting purifier and checking points to ensure a good working order - describes the correct procedures for the disposal of waste oil, sludge residue, etc.	R1
2)	**Air compressor (4 hours)** - states that cylinder lubrication must be kept to a minimum consistent with correct and safe operation - states that cylinder lubricating oil should not have a flashpoint below 210°C and the use of synthetic lubricating oil to reduce a hazard - describes the attention required to keep the intake air filter working effectively - explains the reason for fitting drain valves after air coolers - describes the starting-up and stopping procedures – explains the principles upon which air compressors are run automatically	R1

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
	– describes the particular quality required for compressed air that is to be used in control systems	
	- explains how the required quality in the above objective is achieved	
3)	**Evaporators and distillers (10 hours)**	R1
	- describes the need for starting fresh water generator and the limitation of keeping its running	
	- explains the outlines of starting procedures in accordance with typical type of fresh water generators	
	(Control of water density and scale)	
	- explains how the formation of scale on the heating surfaces of coils, tubes and other heat-transfer elements is controlled	
	- states the limiting pressure and temperature in the shell in order to control the formation of scale	
	- states that the seawater in evaporator vessels is termed 'brine'	
	– explains that the density of this brine is sometimes measured relative to that of seawater, e.g. $\frac{0.5}{32}$ $\frac{2}{32}$ $\frac{2.5}{32}$ etc.	
	– explains why the density of the brine must be carefully controlled during the operation of an evaporator	
	- explains how, when an evaporator is operating normally, the brine is maintained at optimum density	
	- states that excessive density of the brine should be avoided as it will cause the metallic salts contained in seawater to carry over with the vapour	
	- states the effect of maintaining the density of the brine too low	
	– describes the type of scale deposited on the heating surfaces	
	– explains how the scale described in the above objective is removed	
	(Distillation)	R1
	- defines the term distillation as used in marine engineering practice	
	- describes the function of a distiller as that of condensing fresh water from the vapour produced in an evaporator	
	- states that cooling is usually achieved by heat exchange with seawater flowing through tubes or coils	
	(Drinking water)	R1
	- describes the quality necessary if the water being produced by a distiller is to be used for human consumption	
	- states that if, during the evaporation process, a temperature of 75°C is not achieved, chemical agents must be added to the water to destroy any harmful bacteria which may be present	
	- explains how the water is made palatable	
	- states that seawater should not be evaporated when sailing in areas where pollution may be present, i.e. in rivers and estuaries, particularly in the vicinity of land drains or of discharges of sewage or industrial effluents	

COMPETENCE 1.4	Operate Main and Auxiliary Machinery and Associated Control Systems	IMO Reference
4) Refrigerator (8 hours) - states the preparation and precautions for starting a refrigerator - states precautions and checking points on a refrigerator while it is running - states how the operating condition is identified in a good working order - states what malfunctions/troubles likely occur in refrigerators - describes the effect of variations in seawater temperature on the running of a refrigerating system - describes the effect in refrigeration unit of air, moisture and oil - explains how to charge refrigerant into a refrigerator and vice versa - explains how to charge lubricating oil into a refrigerator and vice versa - explains how to remove air from a refrigerator unit - states how to inspect leaking of refrigerant - states how to make a leak test for a refrigerator unit such as pressure test/ vacuum test		

COMPETENCE 1.5	Operate Fuel, Lubrication, Ballast and other Pumping Systems and Associated Control Systems	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 1.5.1 OPERATIONAL CHARACTERISTICS OF PUMPS AND PIPING SYSTEMS INCLUDING CONTROL SYSTEMS 1.5.2 OPERATION OF PUMPING SYSTEMS 1.5.3 OILY WATER SEPARATOR/SIMILAR EQUIPMENT REQUIREMENTS AND OPERATION		STCW Code table A-III/1

COMPETENCE 1.5	Operate Fuel, Lubrication, Ballast and other Pumping Systems and Associated Control Systems	IMO Reference

1.5.1 OPERATIONAL CHARACTERISTICS OF PUMPS AND PIPING SYSTEMS INCLUDING CONTROL SYSTEMS (10 hours) — R1

Textbooks: T2, T5

Teaching aids: A1, A2, A3, V3, V7, V8

Required performance:

- states that performance will deteriorate if the temperature of the liquid being handled approaches that at which vapour is produced at the pressure in the suction pipe
- states that performance deteriorates if the viscosity of the fluid increases
- states that, if there is no positive head at the inlet to a centrifugal pump, a priming device must be used
- describes or performs the correct procedure for starting up and stopping:
  - positive-displacement pumps
  - axial-flow pumps
  - centrifugal pumps

  making reference to:
  - suction valves
  - discharge valves
  - priming
- explains the attention necessary to ensure the satisfactory operation of:
  - an adjustable gland
  - a non-adjustable gland
- explains possible reasons for a loss of performance of a pump
- lists the ship's services which receive a supply of:
  - seawater
  - fresh water

1.5.2 OPERATION OF PUMPING SYSTEMS (22 hours)

Textbooks: T2, T5

Teaching aids: A1, A2, A3, V3, V7, V8

Required performance:

2.1 Routine pumping operations (2 hours)

- states the need to understand the pipe lines constructing pumping systems to be daily used in order to maintain the normal operation of the plant
- states that the status of valves concerned in both manual and automatic pumping systems must be periodically checked
- states that any operation of pumping systems should be recorded in such a routine works record book

2.2 Operation of bilge, ballast and cargo pumping systems (20 hours) — R1

(Bilge)

- explains the purpose of a bilge pumping system
- explains why non-return valves are fitted to bilge pipes in watertight compartments which contain the open end of the pipe

COMPETENCE 1.5	Operate Fuel, Lubrication, Ballast and other Pumping Systems and Associated Control Systems	IMO Reference

	- sketches a diagrammatic arrangement of a bilge pumping system, including the connections to other pumps
	- describes the purpose, siting and common principal connections of an emergency bilge suction
	- describes the principal features of an emergency bilge pump
	(Ballast)
	- explains the purpose of a ballast pumping system
	- explains the fittings necessary when a space may be used for:
	  - ballast or dry cargo
	  - ballast or oil
	- sketches a diagrammatic arrangement of a ballast system
	(Fresh water and seawater)
	- lists the main uses of fresh water and seawater
	- describes a domestic fresh-water pumping system, explaining how:
	  - the water pressure is maintained
	  - the pump is started and stopped
	  - the water is heated
	- describes a domestic seawater pumping system
	- describes the treatment necessary for water produced by evaporators for human consumption
	(Hydraulic system)
	- lists the machinery which might be controlled or driven by hydraulic motors
	- describes a hydraulic system
	- describes the properties of hydraulic fluid
	- explains the care necessary when topping up the fluid from a hydraulic system
	(Sewage system)
	- explains what is meant by a coliform count in sewage systems
	- explains what is meant by a sewage-retention system
	- explains the purpose of a sewage comminutor
	- describes the principles of a biological sewage treatment plant
	- states that the effluent from a sewage plant must not be discharged in certain specified areas and that permission to discharge sewage must be obtained from the officer in charge of a navigational watch
	(Incinerator)
	- explains briefly the purpose and operation of an incinerator for the disposal of:
	  - sludge
	  - refuse
	(Fire main)
	- explains, using a single line sketch, how a fire main is supplied with water, including the cross connections with other pumps
	- states that the minimum number of independently driven fire pumps is laid down by international law
		R1

COMPETENCE 1.5	Operate Fuel, Lubrication, Ballast and other Pumping Systems and Associated Control Systems	IMO Reference

	- states that, where installed, an independent fire pump, driven by a diesel engine, should be capable of being readily and repeatedly started
	- explains the purpose of the isolating valve in the machinery space fire-pump delivery main
	(Fuel oil)
	- states that fuel oil is stored in double-bottom tanks, wing tanks or special deep tanks
	- describes the venting arrangements for fuel tanks
	– states that the two properties which indicate fluidity are viscosity and pour point
	- explains how fluidity of the fuel is achieved when fuel is to be transferred
	– states the minimum closed flashpoint of marine fuels
	– states the maximum temperature to which fuel oil may be raised for transfer and when stored in a settling tank
	- states that:
	  - oil leaks should be remedied as soon as possible
	  - oil dips should be collected in a container, which must be emptied very frequently
	  - cleanliness is essential
	- lists the precautions to be taken to avoid spillage when bunkering	

1.5.3 OILY WATER SEPARATOR/SIMILAR EQUIPMENT REQUIREMENTS AND OPERATION (8 hours) **Textbooks:** T2, T5 **Teaching aids:** A1, A2, A3, V3, V7, V8 Required performance: - describes the requirements necessary for oily water separators/similar equipment - describes the structure of oily water separators/similar equipment – describes the oil separation principles of oily water separators/similar equipment - describes the components constructing oily water separators/similar equipment - states the reasons to use positive-displacement pump for oily water separators/similar equipment - states the principles of oil content meter attached to oily water separators/ similar equipment - explains how to prevent oil being mixed into discharging bilge when oil content exceeds 15 ppm - states that fluid going through inside the pipe lines and oily water separator/ similar equipment can be correctly checked with pressure gauges - states that pollution of the sea is an offence under international law – states that the dumping of oil or oil-water mixtures is strictly prohibited – states that there is a legal maximum oil content of water to be discharged overboard		R1

COMPETENCE 1.5	Operate Fuel, Lubrication, Ballast and other Pumping Systems and Associated Control Systems	IMO Reference
- states that any discharge which could be contaminated must be passed through an oily water separator which produces an effluent containing less than 100 ppm of oil under all inlet conditions - states that the effluent should be further filtered to give an output containing a maximum of 15 ppm of oil under all inlet conditions - describes, with the aid of a single line sketch, the operation of an automatic three-stage oily water separator/similar equipment - lists the information which must be entered in the Oil Record Book when pumping out bilges		

Part D1: Instructor Manual

The following notes are intended to highlight the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references.

This function is extensive and covers many different areas, including: the application of the principles to be observed in keeping an engineering watch as required by the STCW Code, chapter VIII; operating main and auxiliary machinery and associated control systems and operating pumping systems for fuel, lubrication, bilges, ballast and cargo.

Function 1: Marine Engineering at the Operational Level

1.1 MAINTAIN A SAFE ENGINEERING WATCH (30 hours)

1.1.1 THOROUGH KNOWLEDGE OF PRINCIPLES TO BE OBSERVED IN KEEPING AN ENGINEERING WATCH (7 hours)

The standards regarding watchkeeping to be adopted by engineer watchkeepers are contained in the relevant parts of chapter VIII of the STCW Code. Note that regulation VIII/1 contains new provisions concerned with hours of rest and prevention of drug and alcohol abuse for watchkeeping personnel.

1.1.2 SAFETY AND EMERGENCY PROCEDURES (8 hours)

This topic highlights what is necessary to maintain a safe engineering watch and to address an emergency situation. This is also based on the relevant parts of chapter VIII of the STCW Code.

1.1.3 SAFETY PRECAUTIONS TO BE OBSERVED DURING A WATCH AND IMMEDIATE ACTIONS TO BE TAKEN (8 hours)

More specific ways, manners and precautions to undertake an engineering watch can be learned in this topic. Instructors should teach trainees meaning of these elements/factors, taking into account the relevant parts of chapter VIII of the STCW Code as well.

1.1.4 ENGINE-ROOM RESOURCE MANAGEMENT (ERM) (8 hours)

Although there is no formal definition of ERM, the concept of ERM could be learned and the human elements specified in the table A-III/1 necessary for practising ERM should be learned. In this subject, ERM principles described in chapter VIII of the STCW Code should also be learned.

1.2 USE ENGLISH IN WRITTEN AND ORAL FORM (20 hours)

1.2.1 THE ENGLISH LANGUAGE TO ENABLE THE OFFICER TO PERFORM ENGINEERING DUTIES AND TO USE ENGINEERING PUBLICATIONS (20 hours)

(See IMO model course 3.17)

IMO model course 3.17 on Maritime English based on a clearly defined entry standard in general English, deals with maritime terminology and the use of English sufficient to allow the use of engineering publications and the performance of engineering duties concerned with the ship's safety and operation.

The course also includes the vocabulary needed to make use of and understand manufacturers' technical manuals and specifications to converse with technical shore staff concerning ship and machinery repairs.

1.3 USE INTERNAL COMMUNICATION SYSTEMS (5 hours)

1.3.1 OPERATION OF ALL INTERNAL COMMUNICATION SYSTEMS ON BOARD (5 hours)

Internal Communication Systems on Board

Instructors should refer to references for further guidance on this topic.

1.4 OPERATE MAIN AND AUXILIARY MACHINERY AND ASSOCIATED CONTROL SYSTEMS (510 hours)

1.4.1 BASIC CONSTRUCTION AND OPERATION PRINCIPLES OF MACHINERY SYSTEMS (410 hours)

1.1 Marine diesel engine

Heat-engine cycle

Instructors should read the training outcome (Appendix 3: Thermodynamics), which is based on the same textbook, in order to assist the continuity of the various subject areas.

In some cases the references in the textbook take the subject matter to a level which is more advanced than required in the watchkeeping certificate. Later study for the chief and second engineer officer certificates will take each subject further. The textbook references are intended to guide the instructor who will need to draw up notes for the use of trainees. Without such notes the trainees would probably be confused by the depth of treatment in the book. The specific training outcomes make a clear statement of the level to be achieved by the trainees.

It is not intended that the concept of entropy should be used. The use of P-V diagrams should give an adequate depth of understanding.

Ideal gas cycle

Trainees should already be able to explain the meaning of the processes described in training this function.

When covering the ideal gas cycles, the Carnot cycle may be included if thought necessary, although the main purpose is to relate theoretical cycles to real practice. The numerous pressure, volume and temperature relationships shown in the text should not be used.

There is no book reference to training outcome Single acting or Double acting. A simple explanation of the marine applications is all that is required.

Fuels

Trainees should have had an introduction to fuel oil in their earlier work. The chemical equations for the combustion of fuels are not included; marine engineers do not use these and it is questionable whether their use would add anything to the performance of a practising marine engineer.

Trainees need to know that hydrocarbons require oxygen, and hence air, for combustion and the elements involved. The combustion equations are not essential and would not be used in practice at sea. Knowledge of the incomplete combustion of carbon is important. The fact that hydrogen burns to produce steam is also important. The products of the combustion of sulphur need highlighting because of the harmful effects of the resultant sulphuric acid. This is dealt with when studying for more advanced certificates.

It will be necessary to explain that the salts of sodium and vanadium included can cause problems, and this is dealt with in later studies.

Combustion

Trainees should learn in combustion that this should be complete and there should be no carbon monoxide present. If there is good atomization of the fuel, it rapidly reaches its ignition temperature, there is adequate mixing of fuel with air and sufficient time is available. If there is evidence of unburnt fuel in the combustion chamber then obviously not all combustion has been complete.

In addition to the textbook reference it should be said that nitrogen reduces the flame temperature and, in a diesel engine, expands during the working stroke, transferring work to the piston.

For a diesel engine the air/fuel ratio used should be that at normal full power. At other loads the ratio could be quite high, depending on the matching of the turbo charger to the engine characteristics.

Engine types

Visits to a manufacturer’s premises can be an advantage but often these are too far away to be of use. Alternatively, such a visit by the instructor can be of considerable value. Ship visits might be more convenient and if used should be carefully planned; it should be decided

beforehand what training outcomes can be achieved and whether the expense of time and money is justified.

Marine diesel engines

Manufacturers of low- and medium-speed engines, of which there are many, are normally pleased to supply colleges with copies of their operation and maintenance manuals. It is recommended that colleges obtain manuals appropriate to the engines which trainees are likely to encounter. These manuals give precise details of bearing clearances, dismantling procedures, running temperatures and pressures, etc., and will encourage trainees to refer to manuals for expert guidance when they return to sea.

The training outcome *cycle dimensions, length of stroke, power and rotation speed* has attempted to place engines into two groups:

(1) large-bore, running at low speed, normally using direct drive, fitted with piston rods and guides;

(2) smaller bore, running at medium and high speeds and fitted with trunk pistons.

The purpose is to ensure that the rest of the subject is covered using descriptions and terminology which will be understood. The objectives are self-explanatory. They cover areas where overlaps occur and precise demarcation is not possible. Nevertheless, trainees will need to use and be aware of the use of these general descriptions because they are frequently used in the profession.

It would be beneficial if trainees could be given actual indicator diagrams. With a low-speed engine, access to the indicator position is sometimes difficult and the surroundings can be uncomfortably hot. This, along with the necessity to remove and re-fit the instrument to each cylinder in a series of sequential operations, can make the process arduous. Also, with the introduction of electronic power-measuring indicators, it is still important to be familiar with traditional methods of power measurement.

Mechanically operated indicators are unsuitable for higher speed engines and the more sophisticated instruments required are not normally carried on ships.

The compression and maximum pressures given in the textbook *Compression Pressures* are typical of many engines but for smaller bore engines, which also usually run at higher speeds, the maximum pressures can be in excess of 100 bar.

Supercharge air pressures vary with the make of engine and the age of its design, but generally pressures are in the region of 0.3 to 2.0 bar. Higher pressures are found in high-performance four-stroke engines.

Trainees should have records of all of the systems, pressures, temperatures, etc., referred to in objectives 1.4.1.1, 1.4.2.1 and 1.4.3.1 as a result of their seagoing assignments. It is recommended that such records are compared to the book references in order to check for accuracy and their acceptance for general application.

Although not applied to all engines, the principles of the jerk fuel pump are adequate to cover training outcomes for fuel pump injection systems.

It is important that the detector for indicating hazardous engine crankcase conditions is in good working order and is not giving false alarms, and frequent and careful maintenance is therefore essential. Check whether the Administration or shipowners have laid down their requirements and, if so, pass these onto the trainees. In the absence of company or other guidance, the procedure would be: inform the chief engineer immediately; piston cooling returns should be quickly checked and indications of local increase of temperature noted; inform the bridge and stop the engine; wait, to provide a long cooling period; open up the crankcase at the suspected unit.

For the training outcome referring to *scavenge spaces* it is necessary to emphasize that drains need to be kept clear of obstruction and opened regularly. Spaces need to be kept clear of oil, dust, water, unburnt fuel and any other deposits by regular inspection and, when necessary, cleaning. Failure to do this is likely to lead to an outbreak of fire.

A shipowner may issue standing instruction on the procedure to follow covering training outcome *scavenge fires*. The procedure might be: inform the chief engineer and the bridge; cut off the fuel to the unit in question (a small fire might burn itself out); reduce total engine power and finally inject fire-extinguishing media. If the trunking containing the fire is adjacent to other potential dangers, such as the crankcase, then cool it with water.

The procedures to meet training outcome *turbo charger surge* should include a statement that a turbo charger should not be allowed to continue surging. Also, the immediate remedy is to reduce the engine power and then slowly increase it again. Measures for the prevention of this occurrence are the responsibility of the chief engineer.

1.2 Marine steam turbine

Rankine cycle

This training outcome should be helped by a sketch of a P-V diagram. Again, entropy should not be included. Note that the steady-flow equation has not been covered and is not required at this stage.

Steam turbine construction

For this training outcome, as trainees must have difficulties to understand the construction of steam turbine, scraps of steam turbine and other visual aids should be prepared as much as possible for their better understanding. Trainees must have little opportunity to look through an actual steam turbine unit and not familiar with the steam turbine. Instructors therefore should note that only important parts of the construction should be emphasized at this stage including main components constructing the unit which produces power. It would be necessary for instructors to limit any item within a fundamental range. Design issues on nozzle, blade and other specific components would not be necessary.

Plant operation

Significance of sequence for each warming up and cooling down procedure should be noted and this helps trainees understand characteristics of steam turbine plant. Several points to be observed for maintaining steam turbine plant in an effective running condition should be emphasized including their theoretical background. The difference between a diesel engine

and a steam turbine in governing method should be identified. In addition, brief explanation about types of steam turbine, and regenerating and reheating cycle including main plant machinery would be desirable.

1.3 Marine gas turbine

Construction and operation

Visual aids showing operation mechanism and construction should be prepared to teach and hopefully an actual gas turbine unit would be installed. This type of main machinery must be something special and unique operation method must be necessary and trainees should learn these characteristics and it is essential that the trainees can make up their ideas/knowledge on the gas turbine system from this aspect.

1.4 Marine boiler

Marine boiler construction

When covering this objective, the instructor should note that trainees do not cover the stress in the shell of a pressure vessel until studying for more advanced certificates.

Trainees should have learned how to expand a tube when completing their training in marine engineering skills.

Boiler mountings and steam distribution

In this objective, most of the valves and internal fittings are essential to a steam boiler. However, in some cases scumming and soot-blowing facilities might not be provided.

Marine boiler operation

Raising steam and coupling a boiler into the steam system should have been covered in the seagoing phase. The important points are to:

- drain water from steam lines coming into use
- raise steam pressure slowly to that in the main to be supplied

open the main steam valve very slowly

- adjust the heat input to the other boiler(s)
- open the feed valve to the new boiler
- reduce the heat input and feedwater supply to the existing boiler.

The operation procedures may have been covered in the seagoing phase. The important points are to adjust the heat and feedwater inputs to each boiler according to the required share of the load.

In normal operation, with the boiler and feedwater quality as they should be, water-level gauge fittings should not become blocked. The movement of a ship at sea causes the level of the boiler water to rise and fall continuously, and this usually indicates that all is well; this

partly covers this objective. Also, as a regular check, and if any doubt arises, the procedures given in the textbook should be followed.

When covering the dangers of low level water, trainees should learn that if a shortage of water in a boiler causes parts to be uncovered which are exposed to heat from the combustion of fuel then the temperature of those parts will rise rapidly. Distortion will occur, due to excessive expansion of the metal. If the rise in temperature continues, the pressure in the boiler will cause serious distortion or rupture of the weakened metal. On the other hand a high water level in a boiler may lead to priming and to carry-over of water in the steam.

Administrations may have given instruction on the procedure to cover the event in this objective. If not, trainees should learn that if it can be determined without doubt that heat-transfer surfaces have not been exposed, then increasing the feedwater rate will raise the level of water in a boiler without damage. If there is the possibility that heat-transfer surfaces have been exposed then they should immediately extinguish the fire(s) in the boiler, reduce the boiler pressure by opening the safety valves and shut off the feedwater supply.

The Chief Engineer should be informed. Any exposed parts must be given time to return to their normal working temperature before re-opening the feedwater supply. In the meantime, all vulnerable parts should be inspected as far as possible to check for damage. If all is well, the boiler can be brought slowly back into service, with regular checks being made for leaks at joints and distortion of heating surfaces.

The purpose of settling tanks and the maintenance procedures for oil-burning equipment should have been covered during the seagoing phase. It should, therefore, only be necessary to ascertain that trainees can comply with the objectives as specified.

The maintenance of good combustion, avoidance of the accumulation of combustible deposits and adequate cleaning of uptake passages will avoid uptake fires.

Trainees should know that an uptake fire might be detected by a rise in the temperature of the combustion air from the air heater or a rise in the temperature of the steam from the superheater, if one is fitted. Alternatively, smell and smoke might be the first indication. Standing instructions should be followed; if there are none, a watchkeeping engineer should call the Chief Engineer and shut off all fuel and air supply to the boiler. If further action is necessary, smother the boiler's internal gas paths with CO_2, or similar, and cool the outside of the casing to prevent the external paint coatings, etc., catching fire.

Steam boiler fuel atomization and combustion

When covering the last objective in this section, it is important to emphasize that observation into the furnace should be through a dark glass filter. The atmosphere around the flame should be clear and the flame should be stable and bright.

1.5 Shafting installations and propeller

For trainees, it is almost impossible to look through the inside of shafting installations. Instructor therefore should give the trainees useful knowledge on the shafting installations for their seagoing phases. Although there are several types of the installations, this knowledge would help the trainee understand construction/structure of the shafting installations. There

are also several types of propellers and only fundamental knowledge should be given to the trainees at this stage. Introduction of some types of propeller and names of parts must be necessary: however, design issues concerning propelling and propeller efficiency would not be necessary.

1.6 Other auxiliaries

Principles of pumping

The engineer officer in charge of a watch is responsible for a variety of pumping operations about the ship. Many systems are continuous, with flow rates being controlled either manually or automatically, whereas others are brought into use according to demand, again either automatically or manually. It is, therefore, important that an engineer should know sufficient to ensure that the systems are used, or are working, correctly. The recommended equipment can be made up of used components obtained from shipping companies or from ship breakers. The dismantling and sectioning of this equipment are useful exercises for trainees when acquiring engineering skills.

Volume and mass flows are covered in Appendix 4, Mechanical science, but may need revision for this objective.

Types of pump

During their seagoing phase, trainees will have used a variety of pumps. Care is necessary to ensure that the correct names have been learned (V7 and V8).

In the early part of their training trainees will have practised dismantling various pumps and, therefore, should have some prior knowledge and record of the requirements of the objectives under this section. Sectioned or dismantled pumps or models would be of considerable benefit.

Instructors should note when describing this section, axial-flow pumps are not found in all ships and may not have been seen by trainees.

Trainees may experience the use of ejectors, for ballast-stripping purposes in bulk carriers.

Principles of refrigeration

Trainees may have had experience on ships with large-scale refrigeration plant. However, on the majority of ships, refrigeration is limited to domestic cold stores.

For objective 1.4.1.2, the Rankine cycle and its application to refrigeration will have been covered in Training outcome 1, **Marine Heat Engines**.

The basic circuit and its function, as required in this objective, are covered in Training outcome 1, **Marine Heat Engines**. It is unlikely that the practical aspects, such as oil separation and charging, would have been covered.

Refrigerating compressors and system components

These objectives are best covered by providing trainees with the actual parts, dismantled and sectioned where appropriate.

Heat exchangers

Trainees are not likely to encounter contact heat exchangers. The paragraph on ‘contact heat transfer’ is simply to create an awareness of their existence.

The two most common types of construction of heat exchangers are named in this section. If it is anticipated that trainees may experience other types then these should be added.

Evaporators and distillers

Depending on the type of ship and the trade patterns experienced during their seagoing phase, some trainees may have previously operated evaporators and therefore should already be in a position to accomplish some of the objectives laid down in the syllabus. Nevertheless it is important to ensure that all trainees, regardless of previous experience, understand the function and correct operation of evaporators sufficiently well to be able to follow instructions laid down by the chief engineer.

It may be possible to obtain instruction manuals from suppliers of evaporators, in which case these should be made available to trainees and be also used along with the recommended text.

Trainees should be able to complete a list of the purposes for which water might be used, as a result of their seagoing experience. Distillation can be demonstrated using water samples.

It should be possible to obtain used evaporator mountings etc., from shipowners or ship breakers. Administrations may issue more precise regulations regarding seawater than indicated, in which case they should be adopted.

Air compressors and system principles

Trainees will have had operational experience of air compressors during their seagoing phase which should have included some routine maintenance procedures.

Compressor manufacturers’ manuals should be easily obtainable and trainees should be encouraged to refer to these whenever appropriate. Trainees should be able to complete a list of shipboard uses for compressed air, as a result of their seagoing experience.

Thermal fluid heating systems (5 hours)

The trainee should already be familiar with the principles of heat transfer and the relation to fluid flow being either laminar or turbulent.

The instructor should emphasize that thermal fluid systems can be installed on board certain types of ship which do not need the additional operational use of steam to drive a turbine or other system for which pressure is required. Thermal fluid heating systems in general are very

user friendly as they need a minimum of maintenance and supervision as they are pressureless systems contrary to steam systems.

Emphasis should be given to the safety and health precautions when working with thermal fluid heating systems. The systems are working with oil heated up to high temperatures which may cause for instance serious safety hazards if the oil saturates insulation materials etc.

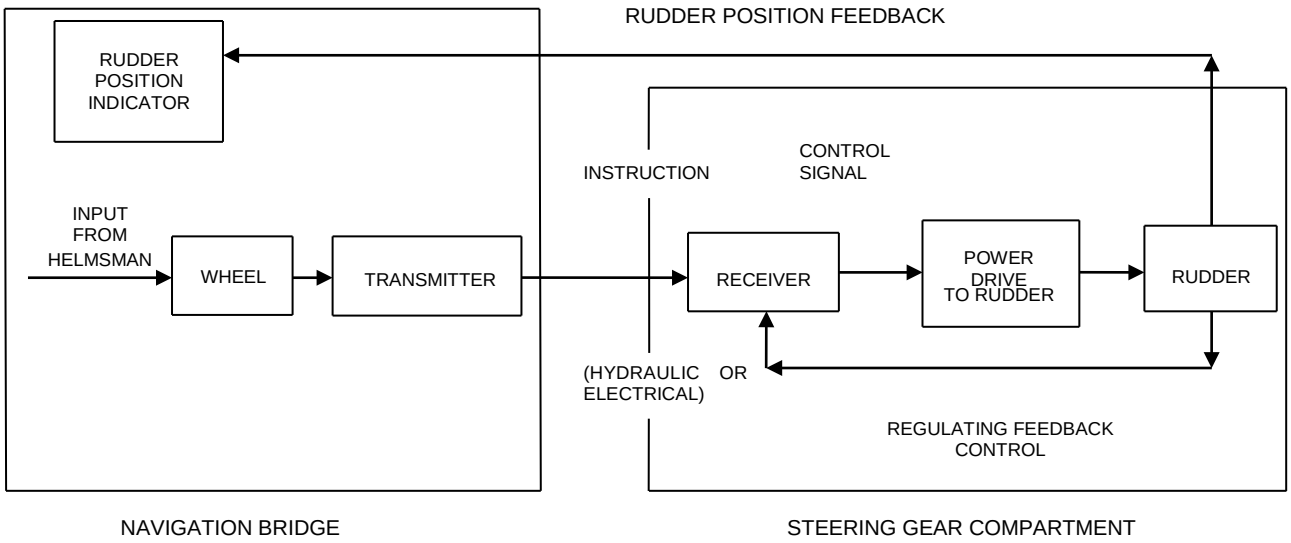
1.7 Steering gear

Steering gear principles

Trainees will have gained some experience of steering gears during their seagoing phase. Instructors should take care to ensure that this experience is enhanced by this subject and that trainees' observations and records are acceptable.

Many losses of ships and accidents have occurred through the malfunctioning of steering gears. It is, therefore, of great importance that the engineer officer in charge of a watch is competent to ensure the continual availability of steering control and power.

A simple diagram, similar to that shown below, would be quite adequate to meet this objective.



DIAGRAMMATIC ARRANGEMENT OF A MANUALLY OPERATED STEERING SYSTEM

1.8 Automatic control system

This subject should be limited to outline of automatic control and system components and detailed knowledge should be given to trainees in function 2. There are basically four kinds of methodologies to control machinery and process and these four basic control actions are executed in various means nowadays such as computer, PLC, sequencer, control unit with other several functions and the like. These details should be also given in function 2. The trainees should understand what is necessary to control machinery and process values in this subject and it is essential for the trainees to see actual control system components for their further study.

1.9 Fluid flow and characteristic of major systems

Fluid flow and characteristics of major systems

Trainees should have made joints and connected pipes during their skill training. It is, however, necessary for explaining the sealing of joints to ensure that they have retained the correct knowledge.

The arrangements of ports in a plug is not referred to in the textbooks but trainees must be made aware of the line markings indicating through-flow parts, right-angled ports and a 'tee' arrangement of ports.

The description of a hydraulic system should have been included in the skill-training period; nevertheless, it is important to ensure that trainees know of the use of both spectacle and tabbed or spade blanking plates.

1.10 Deck machinery

Trainees would have opportunities to handle deck machinery and in this subject, useful knowledge for handling the machinery should be given to the trainees to ensure their entire understanding. These are system components, their functions and operation mechanism. As far as hydraulic systems concerned in operation mechanism, it would be learned in function 2 in detail, which is the subject of a hydraulic control system. The most important mechanism to be learned is how to create a great power for the purpose of the machinery from a small input.

1.4.2 SAFETY AND EMERGENCY PROCEDURES FOR OPERATION OF PROPULSION PLANT MACHINERY INCLUDING CONTROL SYSTEMS (30 hours)

Safety and emergency procedures

There are so many safety/protective systems to protect machinery from damages. This is based on the idea that protection of the machinery leads safety of hull and on-board personnel. However, there may be a case that safety/protective systems have to be ignored in order to ensure human life. Trainees therefore should learn this subject from these aspects and be familiar with system components, their functions and operation mechanism. A watchkeeping officer has to be competent to take appropriate actions and procedures in an actual emergency. Instructor should give trainees the basic idea aforementioned taking up various cases as examples. These case studies would be an effective method to teach in this topic.

The instructor should encourage lateral thinking and it is important to have a discussion in order to find a better solution. This approach will cultivate the trainee's sense of engineering and assist in obtaining the information necessary to reach a solution.

1.4.3 PREPARATION, OPERATION, FAULT DETECTION AND NECESSARY MEASURES TO PREVENT DAMAGE FOR THE FOLLOWING MACHINERY ITEMS AND CONTROL SYSTEMS (70 hours)

Preparation and operation of propulsion plant

The purpose of this subject is to give trainees an insight into some of the activities which they will be trained to perform during the seagoing phase. Later, when they continue their studies ashore, trainees will cover each topic again, possibly in a classroom environment, to reach the standard required to qualify as engineer officer in charge of a watch.

Trainees will have had some experience of machinery maintenance during which they should have made sketches and taken notes. However, it will be necessary for instructors to prepare schematic arrangements, etc., to ensure that trainees understand the principles. Considerably more detailed knowledge will be gained later both on board ship and then when back in the training establishment.

Wherever possible, trainees should be encouraged to refer to the instructions given in manufacturers' manuals, which are normally easily obtainable direct or from their agents.

At this stage trainees cannot become competent in the operation of marine plant, this will come with further experience and training.

Principles should be applied which will enable trainees later during their seagoing phase to gain full advantage of the experience and training available on board ship.

It is important that trainees achieve the specific training outcomes. However, the order in which these are accomplished is not important. In some cases it will be necessary to rearrange the order printed in the syllabus to accommodate the sequence dictated by a particular job. In all cases, it must be ensured that trainees are competent in basic skills before proceeding to more advanced training outcomes.

Where running machinery cannot be used, trainees will have to describe the procedures. Extracts from manufacturers' manuals should be made wherever possible.

As machinery in a training establishment usually runs without abnormality, instructors will have to superimpose imaginary readings on those actually taken to meet objective 1.1, in order to indicate malfunctioning.

Trainees need to know of the basic symptoms of malfunction, i.e. those related to pressure, temperature, speed, noise, vibration, fume vapour, smoke and smell.

Trainees should not be given sole responsibility for overseeing the operation of machinery.

Their first priority is to report immediately suspected faults to an officer, who should then take appropriate action. Nevertheless, trainees should be made aware of the steps to be taken in simple cases.

For pressures and temperatures it is suggested that reference is made to the appropriate manuals; alternatively, data may be obtained for the type of engine that trainees are likely to encounter.

1.5 OPERATE FUEL, LUBRICATION, BALLAST AND OTHER PUMPING SYSTEMS AND ASSOCIATED CONTROL SYSTEMS (40 hours)

1.5.1 OPERATIONAL CHARACTERISTICS OF PUMPS AND PIPING SYSTEMS INCLUDING CONTROL SYSTEMS (10 hours)

Knowledge relating to this subject can be a theoretical background to handle pumps. There must be several types of pumps on board and these pumps are designed suitable for the purpose of the pumps and trainees should learn which types of pumps are applied to the specific purposes or fluids to be transferred and their running characteristics. Appropriate operation of pumps must be led by well-understood knowledge on pump characteristic depending on the types.

1.5.2 OPERATION OF PUMPING SYSTEMS (22 hours)

The trainees sometimes encounter large-sized pumps equipped with special starting methodologies. Most of them are electric driven pumps and these starting methodologies should be learned in function 2. In this topic, appropriate starting/stopping sequence depending on the specific piping systems and fluids should be emphasized.

As for bilge pumping system, it is quite important for trainees to figure out the systems since bilge, sludge and waste oil transfers are carried out and the system is connected ashore and overboard. Trainees therefore need to draw a diagram of the bilge pumping system during seagoing phase in order to have a complete understanding of the system and appropriate operation.

The fire main, as part of the fixed fire-fighting installation, is covered in the training on fire fighting. It is included in this module to ensure that the watchkeeping engineer is fully aware of the provision and of his responsibilities in making available an ample supply of water at all times.

Instructors need to be familiar with the relevant parts of reference R1 and/or national administration regulations. Trainees need to be aware of the existence of the regulations but at this stage do not need to quote detail other than that specified in learning these objectives.

1.5.3 OILY WATER SEPARATOR/SIMILAR EQUIPMENT REQUIREMENTS AND OPERATION (8 hours)

For this objective it is essential that instructors refer to the relevant parts of the reference book R3 and of the regulations of the national administration. Trainees need to be aware of these but should not be expected to quote text.

Trainees will have pumped bilges and probably used ballast systems during their seagoing phase. It follows, therefore, that they will have used an oily water separator/similar equipment and made entries in the Oil Record Book. However, the subject is so important that repetition is necessary to reinforce past experience and to ensure that correct procedures will be maintained in the future.

Officer in Charge of an Engineering Watch

Function 2:
Electrical, Electronic and Control Engineering at the Operational Level

Officer in Charge of an Engineering Watch

Function 2: Electrical, Electronic and Control Engineering at the Operational Level

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Part B2: Course Outline

■ Timetable

No formal example of a timetable is included in this model course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

■ Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees handouts contribute to the learning process.

■ Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
2.1 OPERATE ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS (280 hours)		
2.1.1 BASIC ELECTRICAL ENGINEERING		
.1 Electrical theory	25	
.2 Fundamentals of alternating current	40	
.3 Generators	30	
.4 Power distribution systems	15	
.5 Electrical motors	20	
.6 Electrical motor starting methodologies	10	
.7 High-voltage installations	5	
.8 Lighting	5	
.9 Cables	5	
.10 Batteries	10	165
2.1.2 BASIC ELECTRONICS		
.1 Electron theory	5	
.2 Basic electronic circuit elements	20	
.3 Electronic control equipment	15	
.4 Flowchart for automatic and control systems	5	45
2.1.3 BASIC CONTROL ENGINEERING		
.1 Fundamentals of automatic control	15	
.2 Various automatic controls	5	
.3 ON-OFF control	5	
.4 Sequential control	5	
.5 Proportional-Integral-Derivative (PID) control	10	
.6 Measurement of process value	20	
.7 Transmission of signals	5	
.8 Manipulator elements	5	70

Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
2.2	**MAINTENANCE AND REPAIR OF ELECTRICAL AND ELECTRONIC EQUIPMENT**		
2.2.1	SAFETY REQUIREMENTS FOR WORKING ON ELECTRICAL SYSTEMS	10	
2.2.2	MAINTENANCE AND REPAIR		
	.1 Principles of maintenance	(5 h)	
	.2 Generator	(5 h)	
	.3 Switchboard	5	
	.4 Electrical motors	5	
	.5 Starters	5	
	.6 Distribution system	20	
	.7 D.C. Electrical systems and equipment	5	50
2.2.3	DETECTION OF ELECTRIC MALFUNCTION AND MEASURES TO PREVENT DAMAGE		
	.1 Fault protection	15	
	.2 Fault location	5	20
2.2.4	CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT	10	
2.2.5	FUNCTION AND PERFORMANCE TEST AND CONFIGURATION		
	.1 Monitoring systems	5	
	.2 Automatic control devices	10	
	.3 Protective devices	10	25
2.2.6	ELECTRICAL AND SIMPLE ELECTRONIC DIAGRAMS	5	
Total for Function 2: Electrical, Electronic and Control Engineering at the Operational Level			**400 hours**

Part C2: Detailed Teaching Syllabus

■ Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been achieved.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular,

- Teaching aids (indicated by A)
- IMO references (indicated by R) and
- Textbooks (indicated by T)

will provide valuable information to instructors.

■ Explanation of information contained in the syllabus tables

The information on each table is systematically organized in the following way. The line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

In this model course there are four functions:

- Marine Engineering at the Operational Level
- Electrical, Electronic and Control Engineering at the Operational Level
- Maintenance and Repair at the Operational Level
- Controlling the Operation of the Ship and Care for the Persons on Board at the Operational Level

The header of the first column denotes the **COMPETENCE** specified in the table A-III/1. Each function comprises several competences. For example, Function 2, Electrical, Electronic and Control Engineering at the Operational Level, comprises two COMPETENCES. These competences are uniquely and consistently numbered in this model course.

The first competence in FUNCTION 2 is **Operate Electrical, Electronic and Control Systems** and it is numbered 2.1. The second competence is **Maintenance and Repair of Electrical and Electronic Equipment** and it is numbered 2.2. The term 'competence' should be understood as the application of knowledge, understanding, proficiency, skills, experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the competence **Operate Electrical, Electronic and Control Systems** comprises a total of three training outcomes. The first is in BASIC ELECTRICAL ENGINEERING. Each training outcome is uniquely and consistently numbered in this model course. Basic electrical engineering is numbered 2.1.1. For clarity, training outcomes are printed in black on grey, for example TRAINING OUTCOME.

2.1.1 Basic electrical engineering

Finally, each training outcome embodies a variable number of Required performances as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified Required performance.

Following each numbered area of Required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process. For example, under the topic 2.1.1.2 Fundamentals of Alternating Current, to meet the Required performance, the trainee should be able to:

- explain how alternating current is produced in a simple loop rotating in a magnetic field
- by means of sketches, relate the position of the loop in the above objective to the voltage wave form for one cycle at 90° intervals of rotation
- explain the relationship between:
  - instantaneous voltage
  - conductor velocity
  - the sine of the displaced angle θ
- sketch the wave form of an A.C. voltage

  and so on.

IMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performances are placed immediately following the TRAINING OUTCOME title.

It is not intended that lessons are organized to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organized to match with the competence in the STCW Code, table A-III/1. Lessons and teaching should follow college practices. It is not necessary, for example, for Basic electrical engineering to be studied before Basic electronics. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of the required performance.

COMPETENCE 2.1	**Operate Electrical, Electronic and Control Systems**	**IMO Reference**
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 2.1.1 BASIC ELECTRICAL ENGINEERING 2.1.2 BASIC ELECTRONICS 2.1.3 BASIC CONTROL ENGINEERING		STCW Code table A-III/1

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

2.1.1 BASIC ELECTRICAL ENGINEERING (165 hours) — R1

Textbooks: T7, T8

Teaching aids: A1, A2, A3, V11

Required performance:

1.1 Electrical theory (25 hours)

1) Ohm's law

- describes the effect of resistors in a circuit and uses the symbol R
- names and uses the symbol Ω
- defines the unit of resistance
- defines Ohm's law
- defines Ohm's law to find current, voltage and resistance in simple problems
- describes how the current through and the voltage across resisters are affected in series and in parallel circuits

2) Kirchhoff's law

- states and applies Kirchhoff's:
  - voltage law
  - current law
- calculates the current flowing and the voltage drop across resistors in simple circuits
- constructs and uses a Wheatstone Bridge
- – given the voltage and total current, calculates the total (or equivalent) resistance of a parallel circuit
- given the values of the resistances in a parallel circuit, calculates the total resistance
- compares the effect of adding a further resistance to:
  - a parallel circuit
  - a series circuit
- explains how the objective affects the e.m.f. and the terminal potential difference of a supply, demonstrating the effect by calculations and by experiment
- explains the effect of internal resistance in the supply source
- – determines current flows, resistance values and voltages in:
  - series circuits
  - parallel circuits by calculation

3) Electrical circuit

- states that current can only flow in a closed circuit
- explains why some materials are:
  - conductors
  - insulators
  - and names commonly used materials in each group
- names the different sources of electricity and explains their effect when connected to a conductor
- explains potential difference and electromotive force, stating the units and the symbols used
- explains the current flow, stating its symbol (I)

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– states that current strength is measured in amperes, represented by A
- states that a steady current flowing in a single direction is called a direct current (D.C.)
- states that when the direction of flow of a current is continually reversing it is called an alternating current (A.C.)
- states that in modern ships the main supply is usually A.C. but that D.C. has many uses
- describes what is meant by static electricity
- describes electrostatic charging and the principles of overcoming potential hazards

4) Impedance and inductance

- explains what is meant by “impedance” and uses the correct symbol
– compares impedance of an A.C. circuit with resistance of a D.C. circuit
– states the relationship between impedance, voltage and current
– compares the effect in an A.C. circuit and in a D.C. circuit:
  - of a simple resistance
  - the same resistance wound in the form of a coil
  - the same coiled resistance, into which an iron core is inserted
- describes what is meant by “reactance” and uses the correct symbol
– sketches the impedance triangle, indicating R, X, Z and the phase angle (φ)
– states that the cosine of the phase angle is called the power factor
– calculates impedances and power factors, given the resistance and reactance of coils
- explains the effect of changing current and its associated magnetic flux on the induced e.m.f.
- explains why, in a circuit containing only reactance, there is a difference in phase of 90° between the applied voltage and the current
- sketches graphs showing the variation of current, applied voltage and back e.m.f. over one cycle when an A.C. is applied to:
  - a circuit containing only pure resistance
  - a choke having inductance only
- superimposes a curve representing the power dissipated in both cases in the above objective
- states the value of the power factor in both cases in the above objective
– states that, in practice, an inductor will always have a resistance
– sketches a phasor diagram for a circuit containing an inductance which has resistance, indicating the resultant applied voltage and the phase angle
- states that in cases such as those in the above objective, i.e. in inductive circuits, the current always lags the applied voltage
- states that shipboard installations produce power demand with a lagging power factor
- explains the effect of varying power factor on the power consumed
– states that power = $V \times I \times \frac{R}{Z}$ or $V \times I \times \cos\phi$
– solves simple problems concerning power, current, resistance, impedance, reactance and power factor and verifies the solutions, using laboratory equipment

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

1.2 Fundamentals of alternating current (40 hours)

1) Alternating current

- explains how alternating current is produced in a simple loop rotating in a magnetic field
- by means of sketches, relates the position of the loop in the above objective to the voltage wave form for one cycle at 90° intervals of rotation
- explains the relationship between:
  - instantaneous voltage
  - conductor velocity
  - the sine of the displaced angle θ
- sketches the wave form of an A.C. voltage
- shows diagrammatically a simple circuit for a three-phase supply from an alternator
- develops the expression $e = BIv$ to produce $e = E_{max} \sin\theta$, where e is the instantaneous voltage, E_{max}, is the maximum voltage and θ is the displaced angle
- projects the vertical components of a rotating vector to draw one complete cycle of a sine wave
- states that the rotating vector is called a phasor
- using a triangle produced from the above objective, confirms that $\frac{e}{E_{max}} = \sin\theta$
- superimposes degrees and radians on the sine wave drawn in the above objective
- uses the correct symbols and conventions for:
  - rotation
  - angular velocity
  - periodic time
  - frequency
  - peak value
  - amplitude
- deduces the expression $e = E_{max} \sin\theta\ 2\pi ft$
- calculates instantaneous voltages, given the unknown quantities
- explains what is meant by phase difference between voltage and current values
- explains why root mean square (r.m.s.) values are used
- given a series of values of instantaneous voltage or current for a hall cycle, calculates r.m.s. value
- states that the r.m.s. value for a sine wave is 0.707 of the peak value

2) Electromagnetic induction

- describes the principle of electromagnetic induction and states its main applications
- explains how the following factors affect the induced voltage:
  - flux density
  - number of turns in the coil
  - conductor/flux cutting rate
- explains Faraday's law of electromagnetic induction

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– explains Lenz's law

- explains in simple terms the principle of static induction, to include mutual induction and self-induction

3) Work, energy and power

- explains the difference between work, energy and power, giving the units and symbols commonly used
- states that work = current × time × voltage, giving the units used
- makes simple calculations to determine energy and work
- defines power, giving the units and symbols used
- from the above objective, derives the expression
  power = voltage × current (P = VI), giving the units used
- using the equations from above objectives, derives $P = I^2 R$ and $P = \frac{V^2}{R}$

1.3 Generators (30 hours)

1) A.C. generators

- uses Fleming's hand rules to determine the directions of magnetic field, motion and current
- on an actual machine, or by using a given diagram that shows the arrangement of a simple generator, identifies and explains the function of:
  - the armature
  - slip rings
  - brushes and springs
  - field poles
  - field coils
- sketches a graph showing the variation of e.m.f. when a simple loop generator coil is rotated between two poles
- states the range of voltage and frequency at which ships' electrical power is generated
- states that the A.C. voltages normally given are root mean square values and that all equipment is rated in these terms
- states that peak values are 2 times larger than r.m.s. values

– describes in simple terms an A.C. generator with three-phase windings, stating the phase difference

- sketches a schematic arrangement of a three-phase alternator with star connection
- in the terminal box of a stator field winding, identifies the outlets of the three phases and the common neutral connection
- explains how excitation of the rotor is produced and supplied

– describes how a generator is cooled

– lists the parts of a generator fitted with temperature alarms

– explains why heaters are fitted to a generator

– explains the function of an automatic voltage regulator

– sketches a block diagram of an automatic voltage regulator, naming the main components and explaining the purpose of the hand trimmer

- explains such sources of supply can be run in parallel and those which cannot

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– performs or describes the synchronizing sequence to bring a generator into service in parallel with a running generator, using both a synchroscope and lamps

- adjusts, or describes how to adjust, the load sharing of two generators running in parallel
- either performs the procedure, or describes how, to reduce the load on a generator and takes it out of service
- states that load sharing can be automatically controlled

– states that the emergency generator feeds its own switchboard and that both are usually installed in the same compartment above the waterline

- describes the connections between the emergency and main switchboards and the necessary safeguards
- describes the situation where the emergency generator would be started up automatically and the methods of starting
- describes the regular “no load” running and the occasional “on load” running of the emergency generator

2) D.C. generators

- sketches, in diagrammatic form, the basic circuit for a D.C. generator

– on a given drawing or an actual generator, identifies the field poles, yoke, shoe, field windings and interpoles

- describes the differences in appearance of shunt coils and series coils

– on a given drawing or an actual generator, identifies the windings, commutator, commutator insulation, laminations, clamping arrangement, ventilation holes, coil-retaining arrangements, brushes, tails, brush loading arrangement and bearings

- names the two types of winding used on armatures

– on an actual machine or by using a given diagram that shows the arrangement of a simple direct-current generator, identifies and explains the function of:

  - the armature
  - the commutator
  - brushes and springs
  - field poles
  - field coils

1.4 Power distribution systems (15 hours)

1) Distribution

- explains the basic purposes of switches, circuit breakers and fuses
- describes briefly the principle of the various types of closing mechanism of circuit breakers
- lists the ways in which a circuit breaker can be tripped
- explains the purpose of interlocks fitted to circuit breakers
- lists the essential services which are supplied by electrical power
- explains the purpose of an emergency power supply
- states the possible sources of emergency power supply and how they are brought into use

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– draws a system diagram of a typical distribution system, showing:
  - main generators
  - emergency generators
  - shore supply
  - battery charging
  - 440 volt supply
  – 220 volt supply
  – circuit breakers
  – transformers
– by means of simple sketches, shows the difference between insulated systems and earthed-neutral systems

2) Insulation

- explains what is meant by an insulator and the purpose of insulation
- describes leakage in an insulated cable
- explains why the insulation resistance of large installations is normally relatively lower than those of small installations
- describes the factors which affect the value of insulation resistance
- explains why the current-carrying capacity of a machine is governed by its insulation
- describes what is meant by insulation resistance and explains how it often deteriorates
- describes the materials and general physical characteristics of insulation materials and the factors and conditions which cause deterioration
- states the maximum temperature which common insulation materials can withstand and the maximum ambient air temperature used in design
- explains why the ventilation and cooling of insulation is essential

3) Transformers

- states that transformers on ships are usually air-cooled
- shows diagrammatically the connections between the main switchboard and the main distribution board through:
  - delta-delta transformers
  - delta-star transformers
  - delta-star transformers with an earthed neutral
- describes the procedure when connecting up to a shore supply

1.5 Electrical motors (20 hours)

1) A.C. motors

- states the normal supply for three-phase induction motors
- names the types of motor commonly used on board ships, giving their applications
- given the actual components from a three-phase induction motor, identifies:
  - rotor
  - bearings
  - fan
  - stator
  - field windings

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– rotor cage
- method of lubrication
- terminals

- explains the differences between the following motor enclosure, describing how cooling is achieved in each case:
  - drip-proof
  - totally enclosed
  - deck watertight
  - flameproof
- sketches a graph showing the relationship between speed and load and between current and load, from no load to full load
- given a motor name plate, explains the meaning of all of the information displayed
- explains in simple terms how the driving torque is produced in an induction motor
- explains why slip is essential

2) D.C. motor

- explains what is meant by the back e.m.f. (E_b) of a motor
– relates the supply voltage to the back e.m.f. and to the voltage drop in the armature ($V = E_b + I_a R_a$)
- explains why the starting current is high compared to the load current
– explains why a starter is required and the principle involved
– states that rotational speed (N) is approximately proportional to:
- $\frac{\text{applied voltage}}{\text{field flux}}$ or $N \propto \frac{V}{\Phi}$
– from the above objective, explains how the rotational speed is affected by:
  - varying the voltage
  - varying the strength of the magnetic field
- describes typical applications of:
  - shunt motors
  - series motors
- in compound motors, explains what is meant by:
  - long shunt
  - short shunt
  - cumulatively connected

1.6 Electrical motor starting methodologies (10 hours)

- explains the following starting methods for D.C. motors and its characteristics:
  - starting rheostat
  - automatic starter
- explains the following starting methods for A.C. motors and its characteristics:
  - direct on line starting
  - star-delta starting
  - compensator starting

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– states what should be taken into consideration when selecting starting methods for A.C. motors
- explains the basic reason for the provision of motor protection
– explains the principles of the most common overcurrent relays
– explains the difference between the largest possible overload current and a fault current
- describes the function of the overcurrent trip, time delays and fuses with both overload and fault currents
- explains the basis upon which fuses are chosen
– explains the principle of a thermal relay, including the means of its adjustment
– explains what is meant by single phasing and its effect on a motor:
  - when running
  - when starting
  - if continued attempts to start are made
- describes in principle the protection against running with a phase open circuited
- explains why under voltage trips are necessary
– states applications where the following speeds are suitable:
  - single fixed speed
  - two or three fixed speeds
  - infinitely variable speed
- describes briefly how stepped speeds can be provided
– lists the means of producing variable speed
– describes the principle of the Ward-Leonard drive
– explains the principle of a variable-frequency motor

1.7 High-voltage installations (5 hours)

- states that more than 1,000 V is usually called high voltage
- states how and why high-voltage installations are used on board ships
- states what voltages are mostly used as high voltage on board ships
- describes equipment/installations in high-voltage systems such as high-voltage generator, distribution board, motors, etc.
- states the special characteristics and features of high-voltage installations in comparison with less than 1,000 V
- states that high-voltage systems are normally earthed via a resistor
- explains how the presence of earth faults is indicated in a high-voltage system with an earthed neutral
- states safety precautions to be strictly observed to prevent accidents when working on high-voltage electrical equipment
- states that any operation of high-voltage installations must be carried out remotely at places where a certain distance is being kept from the installations

1.8 Lighting (5 hours)

- states that correct levels of lighting are vital to safety, efficiency and comfort
- describes the principle of the incandescent lamp
- explains the difference between lamps for general lighting and for rough service

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– describes briefly the principle, application and care when handling tungsten-halogen lamps
- explains the principle of discharge lamps
- explains how fluorescent tubes are started up
- explains how the power factor of fluorescent tubes is improved
- explains how radio interference is suppressed in a fluorescent tube
- explains the effect of variation in voltage on both incandescent and gas-discharge lamps
- explains how energy lights are marked
- states which emergency lights are on the emergency switchboard system and which lights may be on the battery circuit
- explains why the correct power of lamp should be used

1.9 Cables (5 hours)

- names materials commonly used for the following part of cables:
  - conductors
  - insulation
  - sheathing
- describes the reaction of electric cables to a fire
- explains why cable sockets need to be securely attached and locked on to the terminal

1.10 Batteries (10 hours)

- describes the principle of the voltaic cell
– quotes an example of and explains the difference between:
  - primary cells
  - secondary cells
- lists the routine and emergency services normally supplied by batteries
– states the range of voltages and/or alkaline batteries which are used
– states that lead-acid and/or alkaline batteries are used
– explains the effect on current and voltage when connecting cells:
  - in series
  - in parallel
- states that 12 lead-acid or 20 alkaline cells connected in series produce a nominal 24 volts
- explains how cells or batteries are connected to increase their capacity
– explains how capacity is stated and what it means
– describes the dangers which may exist in a battery compartment and explains how they are overcome
- explains the topping up procedure for batteries
– describes how batteries are recharged and the periods during which gassing takes place
- describes how a battery is connected for recharging
– explains how the condition of an alkaline battery is determined
– explains the effect of the internal resistance of a battery on its terminal voltage
– demonstrates the above objective by means of simple examples

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference
	– describes the first-aid necessary if parts of the body and eyes are in contact with electrolyte from: - a lead-acid battery - an alkaline battery - states that the appropriate first-aid equipment should be available in the place where the batteries are housed	
2.1.2 BASIC ELECTRONICS (45 hours)		R1
Textbooks: T7, T8, T10		
Teaching aids: A1, A3, V1		
Required performance:		
2.1 Electron theory (5 hours)		
	- explains what is meant by: - an atom - an element - a compound - a molecule - explains the composition of an atom in terms of electrons, protons and neutrons and the balance of electrons and protons - states that electrons orbit the nucleus, their increasing energy level being proportional to their distance from it - describes the effect of applying energy to an atom – describes the flow of current in a conductor subjected to a potential difference, referring to: - electron flow - conventional flow - explains the significance of the number of electrons in the outer shell, with reference to: - inert elements - positive ions - negative ions - ionization	
2.2 Basic electronic circuit elements (20 hours)		
1) Semiconductor		
	- defines the semiconductor - describes how semiconductors are utilized - explains the current and the free electrons in the semiconductor - explains what types of intrinsic/extrinsic semiconductor are - explains the following characteristics of semiconductors: - photoelectric effect - thermoelectric effect - communicating action - hall effect	

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– explains the following with regard to semiconductors:
  - P-N junction and its properties
  - semiconductor diode rectification
  - structure of diode
  - function principle
  - transistor amplification effect

2) Thyristor

- defines the thyristors
- lists various types of thyristors and describes their actions and characteristics
- describes how thyristors are utilized, taking some applications as examples
- states advantages and disadvantages when using thyristors

3) IC and LSI

- defines Integrated Circuit (IC) and Large Scale Integrated Circuit (LSI) as circuit elements
- describes the structures of IC
- describes briefly the functions of the following types of IC:
  - Transistor Transistor Logic (TTL)
  - Emitter-Coupled Logic (ECL)
  - Complementary Metal-Oxide Semiconductor (CMOS)
  - Erasable Programmable Read-Only Memory (EP-ROM)
  - Random Access Memory (RAM)
  - Central Processing Unit (CPU)

2.3 Electronic control equipment (15 hours)

- defines the following electronic control equipment and states briefly their control mechanism
  - relay circuit unit
  - digital sequential control devices
  - Integrated Automation Control and Monitoring System (IACMS)
  - Programmable Logic Controller (PLC)
  - analogue/digital/computer PID Controller
  - computer programmable controller
- states how control equipment cited above are utilized for main engine, CPP, generator, boiler and auxiliaries in terms of the following:
  - main engine; start/stop, revolution, injection timing, electronic governor and the others (auto-load, crash astern, automatic shut down, automatic slow down, etc.)
  - controllable Pitch Propeller (CPP); autoload/blade angle control
  - generator; generator automatic control (GAC) (auto-synchro, load sharing, etc.) primary mover start/stop sequence
  - boiler; Automatic Combustion Control (ACC), burner control, Feed Water Control (FWC)
  - Steam Temperature Control (STC)
  - auxiliary machinery; purifier automatic control (automatic sludge discharge), temperature/level/pressure/viscosity control

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference
2.4	**Flowchart for automatic and control systems (5 hours)** - explains symbol marks used in flow charts such as terminal, processing, determination, input/output, etc. - states what is understood with flow charts - explains flow charts indicating automatic control system for main engine, generator control system and others taking some of them as examples - describes briefly the major components in relation to the function found in the flow charts	
2.1.3	BASIC CONTROL ENGINEERING (70 hours) **Textbooks:** T7, T8, T10 **Teaching aids:** A1, A2, A3, V11 Required performance:	R1
3.1	**Fundamentals of automatic control (15 hours)** - defines an automatic control and states its purpose – describes what devices/equipment construct control systems and their role/ functions - relates sensing unit, controller, controlled variable, manipulating variable and controlled object to each of them in the control system - describes what sort of devices are included in the sensing unit – describes variety of controllers such as electronic (PID, PLC, computer) controller and pneumatic controller - defines setting value, input value, deviation and output value/controlled variable in the controller - describes what sort of devices are included as manipulators – describes variety of controlled object – describes how automatic controls are utilized in the ship's propulsion machinery, taking examples of temperature and level control systems, including control parameters such as time lag, time constant, dead time, first/ second-order lag element, disturbance and offset	
3.2	**Various automatic controls (5 hours)** - classifies systematically automatic controls in terms of control methodologies - states what an optimal control means - explains briefly feedback control and feedforward control - describes briefly ON-OFF control, sequential control, PID control and program control - explains how these automatic controls are applied to the control systems - explains briefly program control and how the control is realized - describes the applications of program control in the ship's propulsion machinery	
3.3	**ON-OFF control (5 hours)** - explains what ON-OFF control means - explains the characteristics of ON-OFF control - explains how ON-OFF control is utilized - lists components comprising ON-OFF control system - describes ON-OFF control taking some applications as examples	

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

3.4 Sequential control (5 hours)

- explains what a sequential control means
- explains the characteristics of a sequential control
- explains how a sequential control is utilized
- lists components comprising a sequential control system
- describes sequential controls taking some applications as examples

3.5 Proportional-Integral-Derivative (PID) control (10 hours)

- explains the principles/theory of PID control
- – explains how P, I and D actions can be electrically/pneumatically available showing simple electronic circuits and pneumatic diagrams
- states that PID control is classical control methodology but even now, it is still firm basis for controlling any physical/process value
- states that PLC and computer controller produces the same actions as analog PID controller when controlling physical/process value
- explains P, I, D, PI, PD and PID actions respectively using step or ramp input
- – explains the characteristics of P action as well as proportional band (PB)
- – explains the characteristics of I and D actions
- – explains how P, I and D actions contribute to control systems, stating that P value contributes to strength of control, I value contributes to accuracy of control and D value contributes to speed of control
- describes the step response test to PID action and what can be understood by its results
- explains how P, I, and D parameters for optimal control can be determined
- – describes the components comprising PID control systems including sensing unit, transducer, manipulator and controller

3.6 Measurement of process value (20 hours)

1) Temperature

(Mechanical)

- states that it is common practice to call the measuring instrument for temperatures:
  - above 500°C a pyrometer
  - below 500°C a thermometer
- states the temperature range for which mercury is used
- names the fluids which can be used for the measurement of lower temperatures
- describes the principal features of thermometers based on the filled system, including:
  - mercury in steel
  - vapour-pressure
  - gas-filled
- describes the principal features of a bimetallic thermometer

(Electrical)

- states that the range and accuracy varies according to the material used in the detecting element
- sketches and describes a resistance-type measuring instrument based on the Wheatstone bridge

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– describes the characteristics of a thermistor and the conditions for which it is suitable
- sketches a circuit used in a thermocouple and describes its operation
- describes the principles of an optical pyrometer

2) Pressure

- describes the principal features of, and compares, the following:
  - manometers:
    - simple water
    - wide-cistern or well
    - inclined-tube
    - mercury
  - pressure gauges:
    - Bourdon
    - diaphragm-sealed gauge
    - twin-bellows differential-pressure cell
    - strain gauge
- describes how pressure gauges can be tested on board ship

– tests a pressure pump

– sketches calibration curves for a Bourdon pressure gauge, showing the effect of:
  - zero adjustment
  - multiplication adjustment
  - angularity adjustment

- states that calibration and testing are normally performed by specialists

3) Level

(Direct methods)

- describes the principle of a float-operated level-measuring device
- describes the principle of a probe element
- describes a displacement gauge

(Inferential methods)

- explains the principle of inferential methods
- describes a level sensor based on immersed resistors
- describes a level indicator based on a bubbler system
- describes a pneumercator gauge

4) Flow

- explains the difference between a quantity metre and a rate-of-flow metre
- explains that a quantity metre is basically a rate-of-flow metre combined with an integrator
- describes the function of the two elements of a flow metre
- sketches a graph to show the relationship between velocity of a fluid and its pressure difference
- from the above objective, shows the velocity is proportional to the square root of pressure
- explains the situations in which extractions of square roots are necessary

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

– describes the principal features of:
  - a rotormeter
  - an electrical flowmeter
  - a rotameter
- sketches an orifice and a Venturi, showing the direction of flow and the pressure-measuring points
- explains how a manometer can be used as a square-root extractor when measuring the pressure difference in an orifice or Venturi
- states that extraction of a square root can also be accomplished pneumatically and electrically

5) General measurement of processes

- explains the principles of a tachometer
– explains the principles of A.C. and D.C. electric tachometers
– explains the principles of a torque metre based on the effect of stress in a magnetic field
- explains how the above objective can be developed to measure power
– explains the principal features of a viscometer
– describes the application of a photoelectric cell to:
  - an oil-in-water
  - a smoke-density detector
  - an oil-mist detector
  - a flame detector
- describes the common types of fire detector
– describes the principal features of:
  - an explosive-gas detector
  - a vibration monitor
  - an oxygen analyser
  - a CO_2 analyser
  - a relative humidity metre
  - salinity measurement
  - a dissolved-oxygen metre
  - a pH metre
- describes or performs routine setting up, testing and maintenance of the measuring devices included in the above objectives

3.7 Transmission of signals (5 hours)

1) Transmitters

- describes the function of a transducer

2) Controlling elements

(Pneumatic)

- describes the flapper and nozzle arrangement
- explains what is meant by negative feedback and by positive feedback
- sketches a flapper and nozzle arrangement with negative feedback
- explains the function of a force-balance transducer
- describes the principal features of an electro pneumatic transducer

COMPETENCE 2.1	Operate Electrical, Electronic and Control Systems	IMO Reference

(Electrical)

- uses a Wheatstone bridge used as a transducer
- describes the principles of a variable-inductance
- describes the principles of a variable-capacitance transducer
- describes the principles of an electronic force-balance system
- describes the principles of a voltage-current transducer

(Receivers)

- describes the principal features of:
  - a pneumatic receiver integrator
  - a potentiometric pen recorder
- explains the function of an X-Y recorder
- describes the basic principles of A.C. and D.C. servo motors

3.8 Manipulator elements (5 hours)

1) Pneumatic

- states that the final controller might be operated pneumatically, hydraulically or electrically
- sketches a diaphragm-operated control valve
- describes the characteristics of the motor element and the correcting element in the above objective
- describes or, preferably, determines by experiment the flow characteristics and applications of:
  - mitre valves
  - vee-ported valves
- explains what is meant by “turn-down ratio”
- describes the conditions which may dictate the need for a positioner
- describes the principal features of a positioner
- explains the circumstances when piston actuators might be used
- describes the conditions where butterfly valves might be used
- describes the wax-element temperature-control valve and states its normal temperature range

2) Electrical servomotors

- describes a D.C. servomotor and explains how it varies from the common motor
- explains the problems of using a three-phase A.C. machine as a servomotor
- describes the applications of a two-phase A.C. servomotor, explaining how its characteristics can be varied

3) Hydraulic servomotor

- describes the principles of a swash plate pump
- explains the advantage of using high pressures
- explains the applications of a hydraulic ram servomotor

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 2.2.1 SAFETY REQUIREMENTS FOR WORKING ON ELECTRICAL SYSTEMS 2.2.2 MAINTENANCE AND REPAIR 2.2.3 DETECTION OF ELECTRIC MALFUNCTION AND MEASURES TO PREVENT DAMAGE 2.2.4 CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT 2.2.5 FUNCTION AND PERFORMANCE TEST AND CONFIGURATION 2.2.6 ELECTRICAL AND SIMPLE ELECTRONIC DIAGRAMS		STCW Code table A-III/1

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference
2.2.1 SAFETY REQUIREMENTS FOR WORKING ON ELECTRICAL SYSTEMS (10 hours) **Textbooks:** T7, T8, T9 **Teaching aids:** A1, A3, V11 Required performance: - describes the cause of electric shock, giving the level of current which could be fatal - states the voltage range which is considered safe – applies safety precautions necessary when working on electrical equipment in practice - states the isolation procedures required for electrical equipment – states the safety and isolation precautions necessary before commencing work – explains the purpose of interlocks fitted to circuit breakers – explains the danger associated with the spaces in the vicinity of busbars – explains the potential danger of instrument voltage/current transformer circuits and the safe procedure for working on such circuits - describes the protection normally provided on the doors of switchboard cubicles - explains that safety and emergency procedures are documented in the ship's safety management system		R1 R2 ch. IX
2.2.2 MAINTENANCE AND REPAIR (50 hours) **Textbooks:** T7, T8, **Teaching aids:** A1, A2, A3, V11 Required performance: **2.1 Principles of maintenance (5 hours)** - explains the need for maintenance - describes briefly what is meant by: - breakdown maintenance - planned maintenance - condition monitoring **2.2 Generator (5 hours)** - states the safety and isolation precautions necessary before commencing work - lists the parts to be inspected, their common faults and the necessary remedial action - tests and records values of insulation resistance - performs routine maintenance and testing of a generator **2.3 Switchboard (5 hours)** - describes or carries out a maintenance routine on main circuit breakers - describes the care to be taken when handling circuit breakers - detects and corrects faults implanted in circuit breakers		R1

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference

2.4 Electrical motors (5 hours)

- lists the principal maintenance equipment for motors
- carries out the maintenance necessary for a cage electric motor, paying particular attention to:
  - damp, condensation and air flow
  - dust and oil
  - external and internal surfaces
  - frequency of maintenance
  - deterioration of insulation
  - cleaning, inspection, renewal and lubrication of bearings
- describes the most common causes of failure of insulation
- checks the insulation resistance of a three-phase induction motor

2.5 Starters (5 hours)

- carries out the maintenance necessary, and completes reports on, starters and controllers, with specific reference to:
  - casings, corrosion and bonding
  - contactors, magnet faces, pitting, overheating, spring force, lubrication
  - connections, cables and leads
  - correct operation when in use
- detects and rectifies faults implanted in motors, starters and protection equipment

2.6 Distribution system (20 hours)

(Transformer)

- describes the maintenance checks required by a transformer

(Distribution)

- explains what is meant by the following faults:
  - open-circuit
  - earth
  - short-circuit
- estimates the current flowing during given fault conditions
- explains how earth faults occur and the potential danger
- explains the effects of an earth fault with an insulated distribution system
- given a diagram showing earth-fault lamps, describes the appearance of the lamps when an earth fault occurs
- explains the principle of using earth-fault instruments
- on a given distribution circuit, carries out a logical procedure to detect the location of an earth, using earth-fault lamps and an insulation-testing instrument
- explains why the circuit must be switched off when replacing a lamp
- describes the deterioration common in both lamp holders and their wire connections
- explains the care necessary when working on fluorescent lamp circuits
- describes how failed lamps are disposed of

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference
	– describes the care necessary when maintaining: - exposed watertight fittings - portable hand lamps - carries out routine testing and maintenance of lighting circuits and fittings - detects and rectifies implanted faults likely to be encountered at sea (high voltage) - states that high-voltage systems are normally earthed via a resistor - explains how the presence of earth faults is indicated in a high-voltage system with an earthed neutral - states routine maintenances and inspection/testings to be needed **(Cables)** - fits cables through glands into a terminal box, earthing the armouring as appropriate - solders and crimps terminal sockets to conductors - measures resistance of cables - explains the limitation of temporary repairs to insulation - carries out temporary repairs to insulation	
	2.7 D.C. electrical systems and equipment (5 hours) **(Battery system)** - states that emergency lights and back-up power supply lines for the ship's propulsion machinery must be tested at frequent intervals - demonstrates or describes the maintenance of batteries, taking all necessary precautions - names the gases given off when recharging a lead-acid battery, explaining the effect on the electrolyte and how it is remedied - checks the specific gravity of the electrolyte of a lead-acid battery and of an alkaline battery and explains its significance **(Remote/automatic control equipment)** - states that the presence of back-up power for remote/automatic control equipment should be continuously monitored and must be checked at frequent intervals - states how back-up power for monitoring systems can be tested and its built-in battery must be renewed at a certain intervals - states that back-up power for safety/protective devices is supplied from emergency D.C. line and it must be tested carefully at a certain intervals - states that the power for safety/protective devices is isolated from control systems and other power sources	
2.2.3	DETECTION OF ELECTRIC MALFUNCTION AND MEASURES TO PREVENT DAMAGE (20 hours) **Textbooks:** T7, T8, **Teaching aids:** A1, A2, A3, V11 Required performance: **3.1 Fault protection (15 hours)** - explains why fault protection is essential – names the component parts of fault-protection equipment	R1

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference
	– explains why fault currents can be extremely high – names the three types of overcurrent-protection relay and describes the principles of operation of each - explains the advantages and disadvantages of high-rupturing capacity fuses – names the protection provided against: - short circuits - small overloads - describes the procedure when replacing a blown fuse – explains in simple terms, preferential tripping when overload occurs – explains the purpose of under voltage protection of generators and of motors – explains the purpose of reverse power protection – sketches the layout of a typical main switchboard, indicating the function of the main parts - explains the danger associated with the spaces in the vicinity of busbar – explains the use of transformers for switchboard instruments, stating the voltages and current produced - describes the earthing of instruments – explains the potential danger of instrument voltage/current transformer circuits and the safe procedure for working on such circuits - explains how status indicator lamps are usually supplied with power – describes the procedure if a fault develops with a miniature circuit breaker – adjusts, maintains and tests the types of fault protection normally encountered	
	3.2 Fault location (5 hours) - describes the essential requirements for the automatic operation of marine machinery - uses control and instrumentation terminology in its correct context - compares pneumatic, hydraulic and electronic-electrical control systems - describes a simple control loop - names analog and digital devices - locates faults in simple control systems - on locating fault takes actions to best prevent damage - states what is necessary to prevent damage from electrical malfunctions such as burned circuit elements, poor contacts, breaking and faulty limit/micro switches	
2.2.4	CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT (10 hours)	R1
Textbooks: T7, T8,		
Teaching aids: A1, A2, A3, V11		
Required performance:		
	(Insulation tester)	
	- states the operation principles of an insulation tester - states the precautions when using an insulation tester – states the range of voltages used for testing ships' equipment	STCW Code B-III/1 pa.1

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference
	– uses an insulation tester: - to check the zero reading - to check that the equipment is dead - to measure values of phase-to-phase insulation - to measure values of phase-to-earth insulation **(Continuity tester)** - uses a continuity tester to: - check that the equipment is dead - measure the resistance of circuits - enters test readings and relevant comments on an appropriate record card - explains the significance of individual and comparative test readings **(Multi-tester)** - uses digital and analog multimeters, taking the necessary precautions, to: - check the accuracy of the meter - check for battery failure - measure resistance - measure voltage - measure current - test diodes **(Clampmeter)** - states the operation principles of a clampmeter - states the precautions when using a clampmeter - uses a clampmeter to measure current - uses a live-line tester to determine whether equipment is live or dead	
	2.2.5 FUNCTION AND PERFORMANCE TEST AND CONFIGURATION (25 hours) **Textbooks:** T7, T8, T10 **Teaching aids:** A1, A2, A3, V11 Required performance: **5.1 Monitoring systems (5 hours)** - states what a monitoring system or data logger is - explains how a monitoring system is constructed showing its system configuration - explains functions of the following system components for a monitoring system: - CPU unit - I/O interface - monitoring display - log printer - alarm printer - lamp driver - extension alarm system	R1

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference

– explains briefly how each system component works and its operation mechanism
- explains how measured/monitored values can be confirmed if it is correct
- explains how alarm setting values in a monitoring system can be changed
- explains how function/performance tests can be carried out taking a typical system as an example

5.2 Automatic control devices (10 hours)

(Process control)

- states what components are comprised in various automatic control systems showing their system configurations
- explains briefly the functions of the following components and their operation mechanism:
  - sensor
  - controller
  - transducer/converter
  - positioner
  - regulator
  - control valve
  - actuator
  - relay
  - servomotor
- explains how function/performance tests for each component cited above can be carried out
- describes testing equipment for function/performance of each component cited above
- explains what is meant by mechatronics and how it is utilized in automatic control systems

(System control)

- describes how functions/performances of automatic control systems incorporated in the following operation systems can be tested:
  - main engine
  - power generation and distribution
  - boiler
  - auxiliary machinery

5.3 Protective devices (10 hours)

- states what is meant by protective/safety devices and how they work in simple terms
- explains how protective/safety devices are incorporated in each system in a ship's propulsion machinery stating that protective/safety devices are isolated from their control systems
- explains briefly the following protective/safety devices and operation mechanism
  - main engine shut down such as over speed, lubricating oil low pressure, etc.
  - prime mover of generator shut down

COMPETENCE 2.2	Maintenance and Repair of Electrical and Electronic Equipment	IMO Reference
	– boiler shut down such as low water, non-detect flame eye etc. - purifier shut down - describes briefly how functions/performances of protective/safety devices can be tested - explains the need for testing functions/performances of protective/safety devices in the ship's statutory survey	
2.2.6 ELECTRICAL AND SIMPLE ELECTRONIC DIAGRAMS (5 hours) **Textbooks:** T7, T8, T10 **Teaching aids:** A1, A2, A3, V11 Required performance: - explains major electrical and electronic symbols used in their circuit diagrams – describes the function of circuit elements presented by the symbols in their circuit diagram - explains briefly the flow of electrical/electronic current and functions of their circuit diagrams taking simple circuits containing major electrical/electronic symbols as examples - explains the basic differences between the following electrical diagrams: - block diagram - system diagram - circuit diagram - wiring diagram - using a given simple wiring diagram, sketches a circuit diagram – from given simple circuit or wiring diagrams, sketches schematic or system diagrams, using correct letter and circuit symbols – uses the diagrams named in the above objective		R1

Part D2: Instructor Manual

The following notes are intended to highlight the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references. These notes have been included to provide additional information where appropriate

Function 2: Electrical, Electronic and Control Engineering at the Operational Level

2.1 OPERATE ELECTRICAL, ELECTRONIC AND CONTROL SYSTEMS 280 hours

2.1.1 BASIC ELECTRICAL ENGINEERING

Merchant ships may not carry specialized electrical engineers in their officer complement. In such cases it is common practice to delegate responsibilities for electrical engineering work to engineers qualified to keep watches. Even in cases where electrical engineers are on board, the watchkeeping engineer is still responsible for the safe and efficient operation of the electrical equipment during his duty periods. He is responsible for the generation and distribution of all electrical power and for the utilization of most of the load. He is also responsible for ensuring the availability of all of the protective and safety devices and for isolating machinery and equipment to allow inspection, maintenance and repair to take place. It is therefore important that trainees gain sufficient knowledge from theoretical studies, practical work and operational experience to become competent watchkeeping engineers.

The training in this topic provides the knowledge and skill to meet the requirements specified in table A-III/1 of STCW 2010, which are knowledge and skills relating to generators, power distribution systems, electrical motors and electrical motor starting methodologies. It is noted that high-voltage installation has been added giving necessary precautions for handling high-voltage that was introduced into the competence table by the 2010 amendments to STCW.

It is intended that the subject should be practically based, that is, containing only enough theory to give an adequate understanding of the principles applying to operational practices. Wherever possible, actual equipment should be made available for trainees to work on. In cases where this cannot be works visits, ships' visits, colour slides, videos or illustrations may have to suffice; at least this will provide some level of familiarity.

All of the practical work should be performed by individual trainees, although it is recognized that in some cases small groups of two or three may be necessary.

Most modern, large ships have A.C. electrical supplies. Even so, some ships may have D.C. motors, fed by a rectified supply, for certain variable-speed applications. For these reasons, A.C. and D.C. practice must also be included.

Some revision will be necessary at the commencement of training outcome *alternating current* to re-establish the expression e = BIv as a starting point. The expression $e = E_{max} \sin\theta$ is a most important contribution to the understanding of the principles of alternating current.

The inclusion of R.M.S. current for half cycle is to assist the understanding of r.m.s. value calculations.

Either a terminal box or a photograph of one will be necessary to complete training outcome *identifies outlets of three phases* and common neutral connection.

The variety and complexity of a.v.r.'s are such that trainees can be expected only to reach the level indicated by the training outcome.

Trainees may never come into contact with D.C. machines. Nevertheless, it is thought necessary to include at least the basic principles, which would prove to be essential knowledge if at some later date such machines were found to be installed. On some modern ships, where variable-speed drives are required, D.C. motors may be used with a rectified A.C. supply.

2.1.2 BASIC ELECTRONICS

This topic provides knowledge and skills relating to theory of electronic circuits and control equipment made by electronic technologies. It is noted that semiconductor and thyristor technologies should be understood by trainees in terms of basic theoretical knowledge as these subjects have become more essential than before due to a widespread use of high-voltage applications on board ships. The control equipment made by electronics is also highlighted due to the rapid advancement of computer and relevant technologies.

For the outcome referring to power, current, resistance, impedance, reactance power factor problems should be kept as simple as possible, for they are intended to enhance the training knowledge of operational practice and to emphasize the effect of inductance, inductive loads and their effect on the power factor. At this level, reactance is not obtained by using $X_L = 2\pi fL$; this comes in later studies. If reactance is needed to solve a problem, the value should be given.

2.1.3 BASIC CONTROL ENGINEERING

More specific subjects concerning control engineering should be strengthened in consideration of the diversity of control systems. Basic knowledge and understanding of PID control is most important since PID control is still utilized even in computer controls. In this topic, understanding of PID control actions is the most important issue to be learned and trainees' complete understanding enables them to obtain optimum control results in an actual control system. For this objective, experimental step response test by using actual control equipment and control objectives is desirable. As far as sequential control is concerned, at least trainees need to be able to interpret motor starter circuits. Practical training by using actual starter circuits would be most effective. Nowadays, in motor starter circuits, a printed circuit board has been introduced for control circuits; however, it is necessary for the trainees to have practical training using various relays to understand visually what is taking place in the control circuits at this stage.

With regard to measurements of process value referred to so far, the knowledge and skills should be maintained in this section. This subject helps trainees understand the mechanism of sensing process values. It is essential for trainees to understand transmission of signals from various sensors. In the process of the transmission, signal conversion is taking place

until the signal enters a controller and an experiment using some testing equipment must be effective for the trainees to understand visually the transmission. Pressure testing equipment and an adjustable standard resistance can be applied to the experiment for the transmission of pressure, level and temperature signal.

2.2 MAINTENANCE AND REPAIR OF ELECTRICAL AND ELECTRONIC EQUIPMENT 120 hours

2.2.1 SAFETY REQUIREMENTS FOR WORKING ON ELECTRICAL SYSTEMS

Useful safety precautions, rules and practices may be found in T7 and T9. It is essential that the trainee is keen to understand these precautions and follows them routinely when engaged in fault finding or repairs.

As such, trainees need to acquire an awareness for safety precautions for working on electrical tasks. Particularly, the special precautions for high-voltage installations must be acquired since the characteristics of high voltage are quite different from the less than 1,000 V that has been usually used on board ships.

2.2.2 MAINTENANCE AND REPAIR

This topic includes knowledge and skills to carry out maintenance and repair on major electrical equipment in the machinery space and power distribution system (electrical wiring and D.C. line). It must be effective for trainees to have opportunities to practise maintenance and repair as much as possible utilizing various practical materials concerning this subject.

2.2.3 DETECTION OF ELECTRIC MALFUNCTION AND MEASURES TO PREVENT DAMAGE

In this topic, fault protection and location have come (from the previous version of this model course.) also provides necessary knowledge and skills to carry out maintenance and repair and trainees should acquire them as well as from 2.2.2 MAINTENANCE AND REPAIR.

2.2.4 CONSTRUCTION AND OPERATION OF ELECTRICAL TESTING AND MEASURING EQUIPMENT

This topic deals with electrical testing and measuring equipment usually used on board ships and does not include special testing and measuring equipment. Trainees need to acquire complete knowledge and skills for using this kind of equipment. Trainees should have as many opportunities as possible to use them.

2.2.5 FUNCTION AND PERFORMANCE TEST AND CONFIGURATION

This topic has been introduced due to a widespread use of remote/automatic control in the operation of ship’s propulsion machinery and monitoring systems. Except for safety/ protective devices, most equipment relating to monitoring and control systems in recent years are made by computer or relevant technologies and many functions have become available. Although the software for these systems cannot be updated or modified on board ships according to the IACS regulations, minimum knowledge and skills related to configurations and mechanism of monitoring and control systems need to be acquired.

2.2.6 ELECTRICAL AND SIMPLE ELECTRONIC DIAGRAMS

This topic provides trainees with interpretation of electrical and simple electronic diagrams and helps the trainees understand the functions and control mechanism of electrical/electronic equipment. In maintenance and repair, the ability to interpret electrical circuit diagrams and functions of electronic diagrams is required before commencing the work.

Officer in Charge of an Engineering Watch

Function 3:
Maintenance and Repair at the Operational Level

Officer in Charge of an Engineering Watch

Function 3: Maintenance and Repair at the Operational Level

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Part B3: Course Outline

■ Timetable

No formal example of a timetable is included in this model course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

■ Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees handouts contribute to the learning process.

■ Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
3.1 APPROPRIATE USE OF HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS FOR FABRICATION AND REPAIR ON BOARD (184 hours)		
3.1.1 CHARACTERISTICS AND LIMITATIONS OF MATERIALS USED IN CONSTRUCTION AND REPAIR OF SHIPS AND EQUIPMENT		
.1 Basic metallurgy, metals and processes	6	
.2 Properties and uses	6	
.3 Non-metallic materials	3	15
3.1.2 CHARACTERISTICS AND LIMITATIONS OF PROCESS USED FOR FABRICATION AND REPAIR		
.1 Process	5	
.2 Heat treatment of carbon steel	5	10
3.1.3 PROPERTIES AND PARAMETERS CONSIDERED IN THE FABRICATION AND REPAIR OF SYSTEMS AND COMPONENTS		
.1 Materials under load	5	
.2 Vibration	3	
.3 Self-secured joints	1	
.4 Permanent joints	1	
.5 Bonding plastics	1	
.6 Adhesives and bonding	3	
.7 Pipework	5	19
3.1.4 METHODS FOR CARRYING OUT SAFE EMERGENCY/ TEMPORARY REPAIRS	5	5
3.1.5 SAFETY MEASURES TO BE TAKEN TO ENSURE A SAFE WORKING ENVIRONMENT AND FOR USING HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS	5	5
3.1.6 USE OF HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS		
.1 Hand tools	15	
.2 Powered hand tools	5	
.3 Machine tools	95	
.4 Measuring instruments	10	125
3.1.7 USE OF VARIOUS TYPES OF SEALANTS AND PACKINGS	5	5

Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
3.2	**MAINTENANCE AND REPAIR OF SHIPBOARD MACHINERY AND EQUIPMENT (218 hours)**		
3.2.1	SAFETY MEASURES TO BE TAKEN FOR REPAIR AND MAINTENANCE INCLUDING THE SAFE ISOLATION OF SHIPBOARD MACHINERY AND EQUIPMENT REQUIRED BEFORE PERSONNEL ARE PERMITTED TO WORK ON SUCH MACHINERY OR EQUIPMENT		
	.1 ISM Code	1	
	.2 SMS	2	
	.3 Safety measures to be taken	2	5
3.2.2	APPROPRIATE BASIC MECHANICAL KNOWLEDGE AND SKILLS	5	5
3.2.3	MAINTENANCE AND REPAIR SUCH AS DISMANTLING, ADJUSTMENT AND REASSEMBLING OF MACHINERY AND EQUIPMENT		
	.1 Fastening		
	.2 Centrifugal pumps		
	.3 Reciprocating pumps		
	.4 Screw and gear pumps		
	.5 Valves		
	.6 Air compressors		
	.7 Heat exchangers		
	.8 Diesel engine		
	.9 Turbocharger		
	.10 Boiler		
	.11 Shafting system		
	.12 Refrigerator		
	.13 Oils fuels and lubricating system		
	.14 Deck machinery		145
3.2.4	THE USE OF APPROPRIATE SPECIALIZED TOOLS AND MEASURING INSTRUMENTS	5	5
3.2.5	DESIGN CHARACTERISTICS AND SELECTION OF MATERIALS IN CONSTRUCTION OF EQUIPMENT		
	.1 Selection of materials in construction of equipment	6	
	.2 Design characteristics	6	
	.3 Design characteristics of bearings	3	15

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
3.2.6 INTERPRETATION OF MACHINERY DRAWINGS AND HANDBOOKS		
.1 Types of drawing	2	
.2 Line work	4	
.3 Pictorial projection	4	
.4 Development	4	
.5 Dimensioning	5	
.6 Geometrical tolerances	2	
.7 Limits and fits	2	
.8 Engineering drawing practice	15	38
3.2.7 THE INTERPRETATION OF PIPING, HYDRAULIC AND PNEUMATIC DIAGRAMS	5	5
Total for Function 3: Maintenance and Repair at the Operational Level		**402 hours**

Part C3: Detailed Teaching Syllabus

■ Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the proficiency in specified knowledge or skill has been acquired.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular,

- Teaching aids (indicated by A)
- IMO references (indicated by R) and
- Textbooks (indicated by T)

will provide valuable information to instructors.

■ Explanation of information contained in the syllabus tables

The information in each table is systematically organized in the following way. The line at the top of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

In this model course there are four functions:

- Marine Engineering at the Operational Level
- Electrical, Electronic and Control Engineering at the Operational Level
- Maintenance and Repair at the Operational Level
- Controlling the Operation of the Ship and Care for the Persons on Board at the Operational Level

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises several competences. For example, Function 3, Maintenance and Repair at the Operational Level comprises two **competences**. These competences are uniquely and consistently numbered in this model course.

The first competence in FUNCTION 3 is **Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair On Board** and it is numbered 3.1. The second competence is **Maintenance and Repair of Shipboard Machinery and Equipment** and it is numbered 3.2. The term 'competence' should be understood as the application of knowledge, understanding, proficiency, skills, experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the competence **Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair On Board** comprises a total of seven training outcomes. The first is in CHARACTERISTICS AND LIMITATIONS OF MATERIALS USED IN CONSTRUCTION AND REPAIR OF SHIPS AND EQUIPMENT. Each training outcome is uniquely and consistently numbered in this model course and the first training outcome is numbered 3.1.1. For clarity, training outcomes are printed in black on grey, for example TRAINING OUTCOME.

Finally, each training outcome embodies a variable number of Required performances as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified Required performance. For the training outcome Characteristics and limitation of materials used in construction and repair of ships and equipment, there are three areas of performance. For example:

3.1.1.1 Basic metallurgy, metals and processes

3.1.1.2 Properties and uses

3.1.1.3 Non-metallic materials

Following each numbered area of Required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process. For example, under the topic 3.1.1.1 Basic metallurgy, metals and processes, to meet the Required performance, the trainee should be able to:

- Describe in simple terms the production of pig iron from iron ore
- Describe the principles of the open-hearth, the Bessemer and more modern processes used in the production of steel from pig iron
- Explain the principal differences between sand casting, die casting, centrifugal casting, forgings, cold working and hot-rolled plate, bars and other sections and so on.

IMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performances are placed immediately following the TRAINING OUTCOME title.

It is not intended that lessons are organized to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organized to match with the competence in the STCW Code, table A-III/1. Lessons and teaching should follow college practices. It is not necessary, for example, for Characteristics and limitations of materials used in construction and repair of ships and equipment to be studied before Characteristics and limitations of process used for fabrication and repair. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of the Required performance.

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 3.1.1 CHARACTERISTICS AND LIMITATIONS OF MATERIALS USED IN CONSTRUCTION AND REPAIR OF SHIPS AND EQUIPMENT 3.1.2 CHARACTERISTICS AND LIMITATIONS OF PROCESSES USED FOR FABRICATION AND REPAIR 3.1.3 PROPERTIES AND PARAMETERS CONSIDERED IN THE FABRICATION AND REPAIR OF SYSTEMS AND COMPONENTS 3.1.4 METHODS FOR CARRYING OUT SAFE EMERGENCY/TEMPORARY REPAIRS 3.1.5 sAFETY MEASURES TO BE TAKEN TO ENSURE A SAFE WORKING ENVIRONMENT AND FOR USING HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS 3.1.6 USE OF HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS 3.1.7 USE OF VARIOUS TYPES OF SEALANTS AND PACKINGS		STCW CODE table A-III/1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
3.1.1 CHARACTERISTICS AND LIMITATIONS OF MATERIALS USED IN CONSTRUCTION AND REPAIR OF SHIPS AND EQUIPMENT (15 hours) **Textbooks:** T2, T12 **Teaching aids:** A1 Required performance:		
1.1	**Basic metallurgy, metals and processes (6 hours)** - describes in simple terms the production of pig iron from iron ore - describes the principles of the open-hearth, the Bessemer and more modem processes used in the production of steel from pig iron - explains the principal differences between sand casting, die casting, centrifugal casting, forgings, cold working and hot-rolled plate, bars and other sections - states the normal range of carbon content in mild steel, tool steel, cast steel and cast iron - describes the principal difference between ferrous and non-ferrous metals - gives examples of applications of non-ferrous metals in marine engineering - states the purpose of the alloying elements nickel, chromium and molybdenum in steels used in marine engineering - identifies the metals used in non-ferrous alloys commonly employed in marine engineering	R1
1.2	**Properties and uses (6 hours)** - explains in simple terms what influences the choice of material for a marine engineering component - describe in simple terms what is meant by the following mechanical properties: - elasticity - brittleness - hardness - strength - toughness - ductility - malleability - plasticity - explains what is meant by low-, medium- and high-carbon steels – compares the tensile strength, ductility and hardness of low-, medium- and high-carbon steels - states the uses of low-, medium- and high-carbon steels – describes the properties of cast iron and gives examples of its use – defines an alloy – states the uses of aluminium, copper, zinc, lead, tin and antimony – states the component metals of brass, bronze and white metal – states the uses of the above alloys – explains why the above alloys are suitable for the uses in the above objective – identifies samples of metals described in the above objectives	R1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
1.3 Non-metallic materials (3 hours) - explains the reasons for using the following fillers in polymers: - glass fibre - mica - states that polymers can be plastic, rigid, semi-rigid or elastomeric - states the properties and limitations of polymers - lists polymers and other non-metallic materials in common use – states applications of polymers and other non-metallic materials on board ship		R1
3.1.2 CHARACTERISTICS AND LIMITATIONS OF PROCESSES USED FOR FABRICATION AND REPAIR (10 hours) **Textbooks:** T2, T11, T13 **Teaching aids:** A1 Required performance: **2.1 Process (5 hours)** - explains the purpose of heat treatment - describes the following heat treatment processes and the types of steel to which they might be applied: - annealing - normalizing - hardening - tempering		R1
.2.2 Heat treatment of carbon steel (5 hours) - states how low-carbon steels can be cases hardened – states why low-carbon steels are sometimes cases hardened – describes in basic terms a suitable heat-treatment process for common carbon steels, given the properties required - completes items of information in a table which gives the following details for the tempering of high-carbon steel: - temperatures (230 to 320°C) - colour - application conditions - typical tool applications - explains how a component is tempered throughout its whole cross-section – carries out the heat treatments listed in the above objective – tests a hardened and tempered cutting edge, taking the necessary safety precautions		

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference

3.1.3 PROPERTIES AND PARAMETERS CONSIDERED IN THE FABRICATION AND REPAIR OF SYSTEMS AND COMPONENTS (19 hours)

Textbooks: T2, T11, T12, T13

Teaching aids: A1, A3, V13

Required performance:

3.1 Materials under load (5 hours)

- defines stress as the internal resistance per unit area of a material to an externally applied load
- defines strain as the deformation produced in a material by an externally applied load
- describes three types of loading as:
  - tensile
  - compressive
  - shear
- illustrates with the aid of simple sketches, a material under each of the applied loadings given in the above objectives, using arrows to indicate load and stress and dotted lines to indicate deformation
- explains how stress and strain can be calculated in terms of loading and material dimensions, for the cases in the above objectives
- defines, for an elastic material subjected to a tensile load:
  - elastic limit
  - yield point
  - ultimate strength
  - breaking strength
- states that, within the elastic limit, Hooke's law will apply
- defines Hooke's law as:

$$\frac{\text{stress}}{\text{strain}} = \text{a constant}$$

- defines the constant contained in Hooke's law as the Modulus of Elasticity
- applies the above objectives with simple numerical calculations
- shows, on a sketched graph of load to a base of corresponding extension values, the behaviour of an elastic materials under tensile loading and indicates the condition points listed above
- states the significance in engineering practice of the four physical properties in the above objectives

3.2 Vibration (3 hours) R1

- states that vibration is caused by the effect of a single force or a succession of forces applied suddenly to elastic materials
- states that the forces causing vibration in a ship usually result from an imbalance in the machinery
- describes the main sources of ship vibration as:
  - machinery with reciprocating components (e.g. pistons, etc.)
  - ship's propeller blades rotating through water of varying pressure and velocity
  - rotating machinery which has not been balanced (e.g. some crankshafts)

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
	- rotating machinery becoming unbalanced through damage, erosion, corrosion or deposits (e.g. dirt, scale, etc.) - unbalanced power in the cylinders of a diesel engine - worn bearings in rotating machinery - states that a ship's structure and machinery are constructed largely of materials which are elastic - states that vibrations are transmitted from one elastic material or component to another - states that anti-vibration materials are sometimes placed between connecting parts in order to reduce vibration - states that if a component is vibrating a reversing stress is present in the material - states that in normal working conditions the stresses due to vibrations are well within limits allowed for in the design - states that vibrations in a component may be from different sources, which can cause resonance and magnify the effect - states that if vibrations become excessive the stresses induced can cause permanent damage - states that excessive vibration should not be allowed to continue – states that when varying the rotational speed of machinery, stages may be encountered where vibrations become excessive - explains that the condition described in the above objective is normally due to a resonance of vibrations which occurs at what is known as 'critical speeds' - states that excessive vibration within machinery is not always apparent – states that critical speeds are predictable and should be clearly marked on controls and known to engineer officers - states that machinery should not be allowed to operate either at or close to a critical speed - states that critical speed ranges should be passed through as quickly as possible - states that in addition to including stress, vibration may cause securing devices to work loose - explains how vibration may be reduced	
3.3	**Self-secured joints (1 hour)** - sketches the stages of making self-secured joints - makes self-secured joints	R1
3.4	**Permanent joints (1 hour)** – lists the different ways of making permanent joints	
3.5	**Bonding plastics (1 hour)** - describes the principle of bonding plastics - states the range of softening temperature for plastics – explains the care and safeguards necessary when heating plastics	R1

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3.6	**Adhesives and bonding health and safety (3 hours)**
	- explains the care necessary when using adhesives, to include:
	  - skin protection
	  - storage
	  - fire
	  - toxicity
	- states the advantages and disadvantage of adhesive bonding
	– describes the basic principles of joining by using an adhesive
	– sketches the four joint configurations
	– states the purpose of an activator when using an epoxy resin
	– states the significance of pot life
	– explains the limitations on the service conditions of epoxy resins
	– states that special epoxy resins are made to meet particular service conditions
	– lists the steps necessary when bonding together:
	  - two metal components
	  - friction material to steel
	- describes briefly metal-to-metal bonding and applications using:
	  - liquid or paste
	  - beads or dry film
	Joining plastics
	- states the three methods of joining plastics
	- states the need to use the correct adhesive for the plastic to be joined
	- selects and uses the correct adhesive for a variety of applications for a variety of strength tests included in the above objectives	

3.7	**Pipework (5 hours)** - determines minimum bend radius with regard to pipe diameter, thickness, material and process to be used - selects pipe filters/strainers in piping systems - observes safety precautions - bends pipes, using both cold and hot techniques - removes bulk filler and residue - checks for ovality, thinning and other defects – anneals, normalizes or stress-relieves as necessary	R1
3.1.4	METHODS FOR CARRYING OUT SAFE EMERGENCY/TEMPORARY REPAIRS (5 hours) **Textbooks:** T2, T13 **Teaching aids:** A1 Required performance: - explains what is meant by an emergency/temporary repair - explains the differences between an emergency/temporary repair and a permanent repair	R1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
	- explains what should be taken into account when carrying out emergency/ temporary repair - explains how to carry out emergency/temporary repairs in accordance with situations and materials - explains what sort of materials can be used for emergency/temporary repairs of pipings - explains what sort of materials can be used for emergency/temporary repairs of valves - explains what sort of materials can be used for emergency/temporary repairs of coolers - explains what sort of materials can be used for emergency/temporary repairs of boiler smoke tubes - explains methods for emergency/temporary repairs of overboard/sea water suction valves in case of leaking. - explains how to replace overboard/sea water suction valves under afloat condition	
3.1.5	sAFETY MEASURES TO BE TAKEN TO ENSURE A SAFE WORKING ENVIRONMENT AND FOR USING HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS (5 hours) **Textbooks:** T9, T13 **Teaching aids:** A1, A3, V1, V14 Required performance: - states that a well-organized workshop must be most effective to ensure a safe working environment and for using hand tools, machine tools and measuring instruments - states the importance that all the tools and measuring instruments should be kept in good order and shape to avoid accidents and to ensure safety of life - states that proper use of tools enables successful completion of the tasks – states the importance that a careful attitude is necessary when working on any tasks - states that first-aid box, fire extinguishers, appropriate lighting and ventilation should be in the workshop - describes the necessary control over the power supply to a machine tool – describes the basic differences between ‘stop’ and ‘start’ buttons – describes the purpose and siting of ‘emergency stop’ buttons – describes the situations where the following should be worn: - safety helmets - eye protection - protective footwear - skin protection - states when hands and arms should be washed with soap and water – describes the care necessary for hands, including for any cuts or abrasions	R1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
3.1.6 USE OF HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS (125 hours) **Textbooks:** T11, T13 **Teaching aids:** A1, A3, V13 Required performance:		R1

6.1	**Hand tools (15 hours)**
	- lists hand tools usually used for fabrication and repair on board ships, showing actual hand tools such as various types of spanners, wrenches, pliers, drivers, nippers, benders, cutters, hacksaws, vices, gear pullers, files, drills, reamers, hammers, tap and dies, brushes, anvil, swage block, punches, scrapers, chisels, scissors and chucks
	- explains and demonstrates how to use hand tools usually used for fabrication and repair
	- explains and demonstrates correct selections of specific hand tools in accordance with their purposes of use
	- among others, describes the following with regard to thread cutting:
	  - the purpose of taper, second and plug taps
	  - what governs the diameter of the hole to be drilled prior to tapping
	  - the difference in use of a die nut and a stock and die
	  - the different techniques used when cutting:
	  - small-diameter threads
	  - large-diameter and fine threads
	  - internal threads in open-ended and blind holes and external threads on small- and large-diameter rod
	- explains and demonstrates safety precautions necessary when using specific hand tools
	(Supervised student activity)
	- uses various hand tools to acquire the fundamental skills of using them with sample materials provided
		R1
		STCW Code
		B-III/1 pa.1

6.2	**Powered hand tools (5 hours)** - lists powered hand tools usually used for fabrication and repairs on board ships, showing actual powered hand tools such as various types of electrical/ air driven grinders, sanders, drills, impact wrenches, portable jig saw, hand shear and nibbler - explains and demonstrates how to use powered hand tools usually used for fabrication and repair - explains and demonstrates safety precautions necessary in general when using electric/air driven hand tools - explains and demonstrates specific difficulties and necessary precautions when using electric/air driven hand tools **(Supervised student activity)** - uses various powered hand tools to acquire the fundamental skills of using them with sample materials provided	R1 STCW Code B-III/1 pa.1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
6.3	**Machine tools**	R1
1)	**Drilling machines (10 hours)**	STCW Code
	- lists the uses of a drilling machine	B-III/1 pa.1
	- explains briefly how drills are held in a machine	
	- explains how a work piece is held in place, emphasizing dangerous practice and the particular problem when drilling thin plate	
	- describes the procedure for inserting and removing drills with parallel and with tapered shanks	
	- describes the care necessary to avoid accidents when using a drilling machine	
	(Supervised student activity)	
	- uses drilling machines to acquire the fundamental skills of using them with sample materials provided	
2)	**Grinding machine (5 hours)**	
	- explains the purpose of a grinding machine	
	- explains how to use a grinding machine	
	- demonstrates an awareness of the dangers which exist when using a grinding machine	
	- describes the procedure to ensure safety when using a grinding machine	
	(Supervised student activity)	
	- uses grinding machine to acquire the fundamental skills of using it with sample materials provided	
3)	**Centre lathe (20 hours)**	R1
	- explains the primary purpose of a centre lathe, its construction and functions	
	- explains the roles of each part, performing their functions of chucks, centres, face plates, material removal, thread cutting and taper turning	
	- on a given diagram or machine, identifies the main features of a modern lathe	
	- on a given diagram or machine, indicates the features and dimensions which govern the capacity of a lathe	
	- demonstrates an awareness of the dangers which exist when using a lathe	
	(Cutting tools)	
	- explains various cutting tools in terms of materials	
	- explains various cutting tools in terms of figures	
	- explains various cutting tools in terms of functions	
	(Supervised student activity)	
	- uses a centre lathe to acquire the fundamental skills of using it with sample materials provided	
4)	**Welding and soldering**	R1
	a) Principles of electric arc welding (5 hours)	STCW Code
	- explains the suitability of low-, medium- and high-carbon steels for welding	B-III/1 pa.1
	- sketches the relative positions of the electrode and the base metal when metallic arc welding manually	
	- states that A.C. welding is more common than D.C. welding	
	- sketches the components and circuit necessary in arc welding –	
	describes how welding electrodes are classified	

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
	- describes the purpose of the electrode covering – explains how electrodes should be stored – explains how damp electrodes can be detected – states how damp electrodes can be dried – identifies the tools commonly used when welding – describes the principle of metal arc gas-shielded welding – describes the principle of tungsten inert-gas welding	
	b) Principles of gas welding (5 hours) – explains the basic principles of gas welding – describes the principal features of a low-pressure system – explains what is meant by a high-pressure system – lists the fuel-oxygen/air mixtures – describes the flame produced when using oxygen and acetylene – explains the effect on the flame of mixing different proportions of oxygen and acetylene - describes the dangers of handling acetylene gas and the methods used for its storage in cylinders - explains why the maximum discharge rate should not be exceeded – identifies the safety fittings for an acetylene gas cylinder – compares the need for control of gas pressure for: - welding – cutting - states that a two-stage gas pressure regulator gives a more precise control than a single-stage regulator - identifies the safety features of gas pressure gauges – states that high-pressure blowpipes are unsuitable for use in a low-pressure system - identifies the principal parts of a high-pressure blowpipe – explains the care necessary for: - blowpipe - hoses - explains the purpose of hose check valves and flashback arresters – describes the sequence to be followed if a flashback arrester is triggered – explains the basic purpose of a cylinder manifold system – names the gas, states its approximate pressure and describes the cylinder outlet thread, given the colours of cylinders likely to be encountered - sketches the relative positions of the base metal, the filler wire and the welding nozzle when using: - the leftward technique - the rightward technique - demonstrates the welding procedure for both techniques in the above objective – explains the limitations of leftward welding – explains the advantage of the rightward technique	R1 STCW Code B-III/1 pa.1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
	c) Welded joints in low-carbon steel (20 hours)	R1
	– describes a butt weld	STCW Code
	– explains why plate edges are prepared	B-III/1 pa.1
	– sketches cross-sections:	
	- of typical plate-edge preparations	
	- indicating the features of a good weld	
	- of a typical multi-run weld	
	- describes a fillet weld	
	– sketches cross-sections of fillet joints, showing:	
	- throat length with concave and convex reinforcement	
	- tee joint plate-edge preparations	
	- corner joints	
	- lap joint	
	(Supervised student activity)	
	- makes welded butt and fillet joints, using manual electric arc and gas welding techniques	
	d) Common faults in welded joints (1 hour)	
	– identifies the errors which can occur when lining up joints prior to welding	
	– explains the cause of distortion	
	– sketches a butt-welded and a fillet-welded joint, showing the effect of distortion	
	e) Thermal cutting (10 hours)	R1
	– states the applications of flame and plasma-arc cutting	STCW Code
	– explains the principle upon which oxygen is used to cut iron	B-III/1 pa.1
	– describes the conditions necessary in order to cut when using an oxygen-fuel gas mixture	
	- identifies the common engineering metals which can and cannot be cut using an oxygen-fuel gas mixture	
	- lists the gases commonly used as fuels	
	– identifies the controls on a gas cutting blowpipe and demonstrates their purpose	
	- explains the factors which affect the quality of cutting	
	– states the basic principles of plasma-arc cutting	
	(Supervised student activity)	
	- uses an oxygen-fuel gas cutting torch to cut straight lines and curves in mild steel plate up to 10 mm thick to crop mild steel sections	
	f) Inspection (5 hours)	R1
	- constructs a checklist for visual inspection during:	
	- electric welding	
	- gas welding	
	- constructs a list of the points to check visually after welding is completed – explains the limitations of visual inspection	

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
	- carries out the following destructive tests on welded joints: - bend - macroscopic - nick-break - carries out penetrant tests on welded joints – describes the principle of: - ultrasonic inspection - microscopic inspection - lists common weld defects and their causes	
	g) Soldering (10 hours) – explains why brazing is used – describes the basic principles of soldering **Soft soldering** - explains the limitations of soft-soldered joints and the reasons – explains how soft-soldered joints might be strengthened – with the aid of a simple sketch, describes the uses of a soldering iron – states the main hazards and precautions necessary when soldering – tin is a soldering iron and makes soft-soldered joints – describes the process of sweating joints – explains the need for a flux, its application and its removal – explains the differences between and the uses of the following fluxes: - passive - active – explains the characteristics and uses of plumber's solder **Hard soldering** - states the reason for hard soldering - identifies the metals which can be joined by: - silver solder - brazing - bronze welding - states the processes to be followed, stating the approximate melting point when: - silver solder - brazing - bronze welding **(Supervised student activity)** - makes soft- and hard-soldering joints	R1
	h) Safety and health when welding - states the protective clothing to be worn when welding on a bench - states the additional protection necessary when welding in more difficult situations - states the measures necessary to protect other personnel when welding – states the precautions related specifically to gas welding	R1

COMPETENCE 3.1	Appropriate Use of Hand Tools, Machine Tools and Measuring Instruments for Fabrication and Repair on Board	IMO Reference
	- explains the effect of radiation from welding on the eyes and skin - describes the dangers of fumes from welding and how this should be dealt with - explains the principles of the precautions to be taken when welding or when a similar heating process is to be performed in tanks which have contained combustibles - states the precautions to be taken when working in confined spaces - states the care and precautions necessary when handling and storing compressed gas cylinders, with particular reference to acetylene and oxygen	
6.4	**Measuring instruments (10 hours)** - lists measuring instruments usually used for fabrication and repair on board ships, showing measuring instruments such as various types of scales, callipers, protractors, square and straight edge, vernier callipers, depth gauges, micrometers, dial indicators, thickness gauges, radius gauges and screw pitch gauges - explains and demonstrates how to use measuring instruments including their accuracy - explains and demonstrates correct selections of specific measuring instruments in accordance with their purposes of use **(Supervised student activity)** - uses various measuring instruments to acquire skills of using them with sample materials provided	R1 STCW Code B-III/1 pa.1
3.1.7	USE OF VARIOUS TYPES OF SEALANTS AND PACKINGS (5 hours) **Textbooks:** T2, T5 **Teaching aids:** A 1 Required performance: - explains what is meant by sealant, gasket and packing - explains the differences between gasket and packing - explains how packings are used showing actual packings such as various types of O-rings, gland packings, mechanical seals, oil seals and labyrinth packings - explains how gaskets are used showing actual gaskets such as various types of non-metallic gaskets, non-ferrous metallic gaskets, metallic gaskets and semi-metallic gaskets - explains how sealants are used showing actual sealants such as various types of sealants, liquid packings and seal tapes **(Supervised student activity)** - uses various sealants and packings to acquire skills of using them with sample materials provided	R1

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 3.2.1 sAFETY MEASURES TO BE TAKEN FOR REPAIR AND MAINTENANCE INCLUDING THE SAFE ISOLATION OF SHIPBOARD MACHINERY AND EQUIPMENT REQUIRED BEFORE PERSONNEL ARE PERMITTED TO WORK ON SUCH MACHINERY OR EQUIPMENT 3.2.2 APPROPRIATE BASIC MECHANICAL KNOWLEDGE AND SKILLS 3.2.3 MAINTENANCE AND REPAIR SUCH AS DISMANTLING, ADJUSTMENT AND REASSEMBLING OF MACHINERY AND EQUIPMENT 3.2.4 THE USE OF APPROPRIATE SPECIALIZED TOOLS AND MEASURING INSTRUMENTS 3.2.5 DESIGN CHARACTERISTICS AND SELECTION OF MATERIALS IN CONSTRUCTION OF EQUIPMENT 3.2.6 INTERPRETATION OF MACHINERY DRAWINGS AND HANDBOOKS 3.2.7 THE INTERPRETATION OF PIPING, HYDRAULIC AND PNEUMATIC DIAGRAMS		STCW CODE table A-III/1

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference
3.2.1 sAFETY MEASURES TO BE TAKEN FOR REPAIR AND MAINTENANCE INCLUDING THE SAFE ISOLATION OF SHIPBOARD MACHINERY AND EQUIPMENT REQUIRED BEFORE PERSONNEL ARE PERMITTED TO WORK ON SUCH MACHINERY OR EQUIPMENT (5 hours) **Textbooks:** T9, T13 **Teaching aids:** A1, A3, V1, V14 Required performance: **1.1 ISM Code (1 hour)** - explains the outline of ISM Code (International Safety Management) including the background and process of establishment **1.2 SMS (2 hours)** - explains briefly how a SMS (Safety Management System) should be established and what sorts of documents are included - lists documents, checklists and others for safety measures for fabrication and repair and explains their specific purposes **1.3 Safety measures to be taken (2 hours)** - states that safety measures to be taken for repair and maintenance can be identified through proper risk assessment - states that safety measures based on SMS should be applied to identified risks - explains that tool box talks prior to repair and maintenance are effective for taking necessary safety measures - explains that safety measures include use of protective equipment, preparation of proper lighting, antislipping measures, preparation of safety procedures, setting up a safety barrier, preparation of a safe working platform, mechanical/ electrical isolation of machinery to be repaired/maintained, and prior checks based on SMS - explains that particular safety measures in accordance with machinery feature may be necessary		R1
3.2.2 APPROPRIATE BASIC MECHANICAL KNOWLEDGE AND SKILLS (5 hours) **Textbooks:** T2, T5 **Teaching aids:** A1 Required performance: - states that knowledge concerned in operation mechanism and construction of machinery equipment depending on Function 1 has to be necessary to carry out maintenance and repair (Refer to function 1) - states that details of the construction of intended machinery/equipment/ components have to be confirmed with their drawings/instruction books before working on the tasks - states that understanding/interpretation of drawings and instruction books is required to carry out maintenance and repair		R1

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference

3.2.3 MAINTENANCE AND REPAIR SUCH AS DISMANTLING, ADJUSTMENT AND REASSEMBLING OF MACHINERY AND EQUIPMENT (145 hours) — R1

Textbooks: T9, T13

Teaching aids: A1, A2, A3, V14, V15, V16

Required performance:

3.1 Fastening

- identifies types of threaded fastener
- states that bolts/nuts should be equally tightened in correct sequence when fastening plates/blocks with more than two bolts/nuts
- explains why studs are used

(Supervised student activity)

- fits studs and bolts and uses correct tightening procedures
- removes studs (intact and broken) and split nuts
- demonstrates how to protect finished surfaces

3.2 Centrifugal pumps

(Supervised student activity)

- dismantles:
  - casing
  - impeller
  - wear rings
  - shaft
  - bearings
  - gland/seal
  - air pump
  - float chamber
- examines and measures all parts for wear and deterioration
- re-fits, checking, clearances
- replaces and adjusts seals

3.3 Reciprocating pumps

(Supervised student activity)

- dismantles:
  - cylinders
  - piston/buckets
  - rings
  - valves
  - joins
  - glands
  - relief valves
- measures wear in cylinders, neck rings and rods; checks ring gaps
- machines and/or grinds in valves and seats
- removes gland packing
- selects and fits new gland packing

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference

3.4 Screw and gear pumps

(Supervised student activity)

- dismantles:
  - rotors and gears
  - seals
  - bearings
  - relief valve
- examines for wear and deterioration
- reassembles, checking end clearances and backlash
- replaces and adjusts seals

3.5 Valves

(Supervised student activity)

The following are applied to typical stop valves and safety/relief valves:

- examines seats, valves, spindles, glands
- machines valves and seats
- beds in valves on seats, using grinding paste
- removes old gland packing
- selects correct gland packing
- repacks glands
- tests

3.6 Air compressors

(Supervised student activity)

- dismantles, examines and replaces or repairs as found necessary:
  - suction and delivery valves and seats
  - piston and rings
  - glands/seals
  - relief valves and bursting discs
  - coolers and cooling passages
  - lubricating oil system
  - drains

3.7 Heat exchangers

(Supervised student activity)

- dismantles and examines:
  - for leakage
  - for corrosion
  - for erosion
  - for fouling
- checks provision for tube expansion:
  - descales
  - replaces tubes
  - plugs tubes
  - secures tube tightness in tube plates
  - checks means of reducing corrosion
  - fills and tests

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference

3.8 Diesel engine

(Supervised student activity)

- dismantles and inspects all parts for wear and deterioration, including:
  - pistons
  - rings
  - liners
  - bearings
  - valves
  - cooling passages
  - crankshaft alignment
  - lubrication system
- refurbishes diesel engine components:
  - cylinder heads
  - exhaust valves
  - air-start valves
  - fuel injector
  - relief valve
  - fuel injection pump
- reassembles
- – checks timing and ascertains freedom of movement
- – checks condition of lubrication oil
- – purges air from fuel system
- – test runs

3.9 Turbocharger

(Supervised student activity)

- dismantles:
  - air filter
  - air casing
  - inducer (if fitted)
  - impeller
  - volute
  - diffuser
  - gas inlet grid
  - nozzle ring
  - rotor
  - bearings
- examines all parts for wear and deterioration, paying particular attention to:
  - erosion in the air side
  - erosion in the turbine nozzles and in the blades
  - corrosion of the gas casing
  - hard deposits
  - condition of bearings
  - condition of labyrinths
  - lubrication system
- reassembles and checks clearances

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference

3.10 Boiler

- explains the need for cleaning the fire side of a boiler and how to do it
- describes how to inspect the fire side of a boiler and repair/maintenance
- explains the need of cleaning up the water side of a boiler and how to do it
- describes how to inspect the water side of a boiler and the repair/maintenance
- describes how to restore the boiler after cleaning up the fire/water side
- describes how to repair the firebrick wall of a furnace

3.11 Shafting system

(Supervised student activity)

- thrust block
- stern tube
- shaft bearings
- shaft sealing equipment

3.12 Refrigerator

(Supervised student activity)

- compressors
- evaporator
- condenser
- expansion valve
- oil separator

3.13 Oils, fuels and lubricating system

(Supervised student activity)

- filters
- purifiers
- bearings
- settling-tanks
- tank contents gauges

3.14 Deck machinery

(Supervised student activity)

- lifeboat davits and gear
- mooring winch
- windlass
- winch
- crane

3.2.4 THE USE OF APPROPRIATE SPECIALIZED TOOLS AND MEASURING INSTRUMENTS (5 hours)

Textbooks: T11, T13

Teaching aids: A1

Required performance:

- states that some machinery/equipment are installed with specialized tools and measuring instruments for their repair and maintenance
- explains what sort of specialized tools and measuring instruments are supplied

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference
	– explains how to use specific specialized tools and measuring instruments showing for overhauling diesel engine and steam turbine - explains how to use wear gauge for stern tube bearing	
	3.2.5 DESIGN CHARACTERISTICS AND SELECTION OF MATERIALS IN CONSTRUCTION OF EQUIPMENT (15 hours)	
	Textbooks: T2, T12, T5	
	Teaching aids: A1	
	Required performance:	
5.1	**Selection of materials in construction of equipment (6 hours)** - explains what materials are used for constructing major parts of the following equipment: - diesel engines: crank shaft, cylinder liner and head, piston, exhaust valve, bearing - steam turbines: turbine casing, rotor, blade, nozzle, reduction gear - gas turbine: turbine casing, rotor, compressor, gas generator - boilers: water tube, furnace, steam, water drum, superheater - shafting: propeller shaft, stern tube bearing, propeller - pumps: impeller, casing, shaft, casing ring, sleeve, gear, screw, piston/ bucket ring - heat exchangers: heating tube, cooling tube, shell - compressors: piston ring, valve, cylinder block, cylinder liner - purifiers: spindle, gravity disc/ring dam, bowl body - high pressure/temperature valve: body, valve, valve seat	R1
5.2	**Design characteristics (6 hours)** - explains design characteristics developed to improve performance in: - highly skewed propeller - construction of diesel engines - construction of steam turbine - construction of gas turbine - construction of boiler	R1
5.3	**Design characteristics of bearings (3 hours)** **(Plain bearings)** - explains the limitations of direct-lined bearings - describes solid and lined inserts - describes briefly: - thick-walled liners - medium-walled liners - thin-walled liners - wrapped bushes - lists the ideal properties of a lubrication oil for plain bearings - describes the reasons for using white metal, copper-lead alloys, lead bronzes, tin bronzes, gun metals and aluminium-based alloys for plain bearings	R1

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	(Ball and roller bearings) - compares the load-carrying abilities of ball and roller bearings - compares the ability of ball and roller bearings to carry radial and axial loads - states the type of bearing suitable for shafts subject to angular misalignment - describes how ball and roller bearings are lubricated - states the proportion of available volume to be filled when using grease - states the maximum height of lubricant in a stationary bearing when using oil	
3.2.6	INTERPRETATION OF MACHINERY DRAWINGS AND HANDBOOKS (38 hours) **Textbooks:** T14 **Teaching aids:** A1 Required performance:	
6.1	**Types of drawing (2 hours)** - explains the purpose of a general arrangement - explains the purpose of assembly drawings - explains the purpose of component drawings - explains the use of collective single-part drawings - explains the use of pictorial drawings - lists the standard/routine information and references commonly given on drawings	R1
6.2	**Linework (4 hours)** - relates examples of lines to applications and vice-versa – draws tangents as required in practice – demonstrates what is meant by: - first-angle projection - third-angle projection and sketches the correct symbol for both cases - using given examples, completes first- and third-angle projections with: - missing lines - missing views - simple plotted curves - prepares a sketch given simple components and provides sufficient dimensions for their manufacture - completes orthographic projections of solids – completes sectional views in orthographic projection – draws a third-angle projection with hidden detail – explains the use of auxiliary projection	R1
6.3	**Pictorial projection (4 hours)** - draws isometric projections of simple solids – draws oblique projections of simple solids	R1

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference
6.4	**Development (4 hours)** - draws the development of a 90° intersection of circular trunking - draws the development of a cone - draws the development of a square pyramid – draws the development of a square-to-round transition piece	R1
6.5	**Dimensioning (5 hours)** - dimensions a simple component, applying all correct standards – explains the advantage of datum dimensioning	R1
6.6	**Geometrical tolerances (2 hours)** - explains briefly what is meant by geometrical tolerance - relates symbols for geometrical tolerance to the intended characteristics - using given reference material, applies tolerance data to engineering drawings, to include examples of: - straightness - flatness - roundness - cylindricity - concentricity - squareness - parallelism - angularity - position	R1
6.7	**Limits and fits (2 hours)** - explains the need for limits and fits – given various ways of indicating limits of size, explains their meaning – explains the meaning of: - tolerance - actual size - basic size - nominal size - explains hole basis fits – explains shaft basis fit – explains, using examples: - clearance fits - transition fits - interference fits - describes, using examples, the cumulative effect of tolerances – explains what is meant by selective assembly – lists the factors which influence the selection of tolerances	R1
6.8	**Engineering drawing practice (15 hours)** - makes engineering drawings employing the following: - sections in two parallel planes - revolved sections	R1

COMPETENCE 3.2	Maintenance and Repair of Shipboard Machinery and Equipment	IMO Reference
	– thin sections – part sections – half sections – hidden detail – machinery symbols – surface finish – angular dimensions – arrow heads – auxiliary dimensions – centre lines – pitch-circle diameters – threads – thick chain-lines – enlarged views – hatching – leader lines – using reference material, applies abbreviations to drawings – applies conventional representation of the following features: - external and internal threads - squares on shafts - serrated and splined shafts - holes on a linear and on a circular pitch - bearings - interrupted views - tension and compression springs	
3.2.7 THE INTERPRETATION OF PIPING, HYDRAULIC AND PNEUMATIC DIAGRAMS (5 hours) **Textbooks:** T2, T14, T5 **Teaching aids:** A1 Required performance: - states that piping diagrams indicate all the information necessary for ship's machinery fittings - explains that piping diagrams include design characteristics of the system and propulsion plant - explains how to interpret piping diagrams taking a major system as an example - explains major symbol marks used in piping diagrams - explains major symbol marks used in hydraulic and pneumatic diagrams - explains operation mechanism of the major devices used in the hydraulic and pneumatic systems and how they work		R1

Part D3: Instructor Manual

The following notes are intended to highlight the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references.

This function is extensive and covers many different areas, including: properties and characteristics of materials in propulsion machinery; emergency/temporary repairs; safety measures; hand and machine tools and measuring instruments; maintenance and repairs of propulsion machinery; engineering drawings; piping, hydraulic and pneumatic diagrams.

Trainees will acquire practical skills and gain experience in:

- the use of hand and machine tools, and measuring instruments;
- using and wearing correct protective clothing and equipment;
- maintenance and repairs of propulsion machinery including proper dismantling/ reassembling procedures, proper use of sealants and packings, specialized tools and measuring instrument, inspection and test running;
- making engineering drawings of simple components of machinery.

Function 3: Maintenance and Repair at the Operational Level

Before any work commences, trainees should receive clear instructions about the job in hand. This can be taken place in a classroom but often it is appropriate and more convenient to do this in the workshop. Job cards should be prepared giving information and instruction together with the questions and the data required.

Whilst the work is in progress and after completion, sketches will need to be made and a report, with recommendations, drawn up.

3.1 APPROPRIATE USE OF HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS FOR FABRICATION AND REPAIR ON BOARD

3.1.1 CHARACTERISTICS AND LIMITATIONS OF MATERIALS USED IN CONSTRUCTION AND REPAIR OF SHIPS AND EQUIPMENT

Basic metallurgy, metals and processes

Trainees were introduced to marine engineering materials, in prerequisites at the time they were acquiring basic engineering skills. The purpose of this training outcome is to increase the trainees' knowledge of materials sufficiently to carry out the duties of a watchkeeping engineer. The topics are therefore limited in depth, as indicated by the training outcomes, which need not be exceeded.

Trainees will not be involved in the manufacture of any metals, but some knowledge of the production processes is necessary in order to understand the behaviour and performance of materials in operational conditions.

It is sufficient to refer to the basic constituents, relative strengths, resistance to corrosion, welding ability, magnetic properties and electrical conduction properties of materials.

Properties and uses

The graph in textbook T2 could be used as a helpful reference but note that the training outcome referring to ductility, tensile stress, etc., simply requires a comparison of those named properties of three kinds of carbon steel.

If small samples of the various metals are not available, then trainees will need to identify those materials from colour photographs or, preferably, by examining machinery and components.

Non-metallic materials

Trainees should be made aware that the variety of plastics available is increasing rapidly; therefore only the basic properties and reactions are covered.

3.1.2 CHARACTERISTICS AND LIMITATIONS OF PROCESS USED FOR FABRICATION AND REPAIR

Process

For training outcome Processes, it is suggested that examples such as heat treatment of knives, chisels, files, saws and drills are used.

3.1.3 PROPERTIES AND PARAMETERS CONSIDERED IN THE FABRICATION AND REPAIR OF SYSTEMS AND COMPONENTS

Vibration

Vibration is covered to a level which requires trainees to be able to state or describe various aspects of the source and effects of shipboard vibration. The topic has not been extended to include any theory as this tends to become too academic without being beneficial to a watchkeeping engineer.

Instructors should note that trainees at this level are not likely to be familiar with the theory of dynamic balancing of rotational forces. Nevertheless, they should be able to cope with the concept of unbalanced rotational and reciprocating forces, having observed the effect of these. Trainees should learn that anything which creates an imbalance in a rotating mass will produce vibration and also that the removal of uneven deposits on rotating components normally restores balance.

Instructors should indicate to trainees that machinery mounting pads are good examples of a means of reducing the transmission of vibrations.

Instructors should indicate to trainees that torsional vibrations can occur within components and are not always transmitted to either the engine frame or the ship structure. Critical speed ranges designated by designers are speeds where dangerous vibrations occur and might not be apparent; therefore they should be avoided. Designers attempt to avoid a critical speed

occurring in the normal operating range, but sometimes this is unavoidable. These problems have been known to cause crankshaft failures.

Instructors should indicate to trainees that it may be necessary to change over to stand-by machinery while the cause of vibration is investigated. Attention to stays, pipe clips and other means of securing components and also removing deposits from impellers, etc., or renewing worn bearings often reduces vibration.

Self-secured joints

Trainees may have to repair items incorporating self-secured joints at sea.

Bonding plastics

It is impossible to cover all available plastics, but the main principles should be studied.

Pipework

Trainees will most certainly have to bend copper pipes on board ships and, in extenuating circumstances, might have to bend mild steel pipes.

Training outcome Heat treatment is in Hand and power tools, but there the treatment is principally applied to tools whereas training outcome Annealing and normalizes applies to pipes, etc.

3.1.4 METHODS FOR CARRYING OUT SAFE EMERGENCY/TEMPORARY REPAIRS

Emergency/temporary repairs on board ships are sometime necessary in case of water leakage, oil leakage, gas leakage and the like. Trainees therefore need to learn how to address these situations including case studies and materials made available.

3.1.5 SAFETY MEASURES TO BE TAKEN TO ENSURE A SAFE WORKING ENVIRONMENT AND FOR USING HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS

Safety measures to be taken should be taught before working on tasks using all kinds of tools and measuring instruments. Trainees should learn about safety precautions, dangers caused by the features of hand tools, powered hand tools and machine tools when using such tools, and the need to keep tools in good order.

3.1.6 USE OF HAND TOOLS, MACHINE TOOLS AND MEASURING INSTRUMENTS In

this section trainees will acquire practical skills and gain experience in:

- using hand and machine tools and measuring instruments for fabrication, maintenance and repair;
- the maintenance of tools, machine tools and measuring instruments to be in good order and ready to use;
- selecting the correct tools and measuring instruments;

- using safe practices at all times;
- wearing and using proper protective clothing and equipment.

On completion of this section, trainees will possess sufficient skill and knowledge in the use of hand and power tools to carry out and/or supervise the work normally encountered as maintenance or repair work on board ship. Trainees will be able to select and use the correct tools in any given situation and carry out the necessary maintenance to ensure that they are kept in good order and ready for use. Trainees will also know how to apply the correct heat treatment to carbon steels in order to manufacture or repair simple tools. They will be able to select and use the correct adhesives for bonding of metals and plastics.

Hand tools

In the workshop or classroom, each hand tool should be shown to trainees and demonstrated how to use the tools and their purposes. Appropriate materials should be provided for trainees in order to develop skills in using hand tools.

Powered hand tools

The common powered hand tools on board ship are electrically driven drilling, grinding and shear machines. Trainees need to be able to use these powered hand tools and opportunities should be given to acquire skills in using these tools in the workshop.

Machine tools

(Centre lathe)

Safe working practices are to be applied at all times.

To satisfy training outcome for centre lathe, trainees will see a guide mechanism probably for the first time. As similar systems are used in various applications on board ships, it is important that particular attention is paid. In addition, it should be explained that cast iron is sometimes used on board ships where machinability and rigidity are required, for example in machinery foundations such as pumps, winches or small engine bedplates.

There is no need for trainees to be able to sketch lathes, etc., but there is a need to be able to identify various features.

On board ships, speed of machining might not be the prime criterion, but preservation of the geometry of the workpiece usually is important. Trainees should be able to plan and perform one setting operation for simple jobs.

Many ships have shaping machines installed; very few have milling machines. Most manufacturing or repair work on board ship can be accomplished without a milling machine and the expense of installing such a machine is often considered not justified. It is important, therefore, that trainees become skilful in the versatility of a shaping machine. (Ref. STCW 2010 Code, chapter III, sec. B-III/4)

(Soldering)

Practical soldering will also be covered in training outcomes within Marine electrotechnology. Applications should be restricted to sheet work and to pipework within these training outcomes.

(Safety and health when welding)

It is not necessary to cover the additional protection referred to in Protective measures in detail.

(Principles of arc welding)

Trainees will learn how to weld low-carbon steels and need to be aware of the problems of welding steels with higher carbon contents.

(Principles of gas welding)

Trainees need to know the technique of tungsten inert-gas (TIG) and MIG welding, but not necessarily be competent to carry out TIG and MIG welding.

It is possible that a low-pressure system, supplied by several cylinders discharging into a manifold, might be installed in the training establishment. On board ship a high-pressure system, fed from two gas cylinders, is likely to be used and training outcome High-pressure blow pipe, which is unsuitable for low-pressure systems, is intended to clarify the different equipment required.

Acetylene is probably the gas available on board ships, but trainees need to be aware of other gases.

(Thermal cutting)

Plasma arc cutting is included so that trainees will be aware of it; the process will not be used personally by trainees on board ships.

(Inspection)

Training outcome inspection has been included because inspection of welding work is often a very important part of an engineer officer’s duties.

Measuring instruments

Trainees need to learn how to use measuring instruments for carrying out fabrication, maintenance and repair. Particularly the use of various vernier callipers, micrometers and dial indicators need to be learned since these are usually used as precision instrument on board ships.

3.1.7 USE OF VARIOUS TYPES OF SEALANTS AND PACKINGS

Trainees need to know about sealants and packings including their definition and effects.

3.2 MAINTENANCE AND REPAIR OF SHIPBOARD MACHINERY AND EQUIPMENT

3.2.1 SAFETY MEASURES TO BE TAKEN FOR REPAIR AND MAINTENANCE INCLUDING THE SAFE ISOLATION OF SHIPBOARD MACHINERY AND EQUIPMENT REQUIRED BEFORE PERSONNEL ARE PERMITTED TO WORK ON SUCH MACHINERY OR EQUIPMENT

Every topic will require instructions and guidance before practical work commences. Each time, opportunity should be taken to ensure that safe operation remains prominent in every process.

The potential hazards present in a workshop cannot be over-emphasized. It is essential that trainees are fully aware of the dangers and the precautions necessary before commencing any activity. The main issue is to ensure that trainees consider the aspects of safety and care as an integral part of everything they do.

The ship's safety management system should provide safe practices in ship operation and a safe working environment, with safeguards against all identified risks in compliance with the ISM Code.

Safety precautions, rules and practices may also be found in T9 and these topics are addressed in V1, V13 and V14.

3.2.2 APPROPRIATE BASIC MECHANICAL KNOWLEDGE AND SKILLS

Trainees need to learn about basic mechanical knowledge concerning construction and operation mechanisms of ship's machinery and acquire basic skills in order to carry out their maintenance and repair. This knowledge and skills can be referred to Function 1 with the understanding mentioned in this section.

3.2.3 MAINTENANCE AND REPAIR SUCH AS DISMANTLING, ADJUSTMENT AND REASSEMBLING OF MACHINERY AND EQUIPMENT

The programme of practical training is progressive. The early part should cover the acquisition of skills such as the use of hand tools, machine tools, welding, etc.; the later part is concerned with the techniques of inspection, maintenance and repair.

It is necessary to complete basic skills first, before commencing the remainder of the work.

An adequate knowledge and understanding of the procedures necessary to maintain marine machinery installations in a safe and efficient working order can only be obtained through actual experience.

To ensure that all aspects are covered, and a good understanding is gained, training must be under close supervision and should consist of a progressive and controlled series of activities and projects.

As well as instructing trainees in the classroom, it is advisable to reinforce matters such as safe practice immediately before starting and at frequent intervals during practical work.

Posters relating to safe practices are sometimes available from Administrations, and video recordings or films, if available on similar subjects, can be useful.

First-aid equipment and staff trained in first aid should always be available when trainees are in workshops. There should also be a means of transport and communication available for emergency use in case of an accident.

It is important that trainees achieve the training outcomes. However, the order in which these are accomplished is not important. In some cases it will be necessary to rearrange the order printed in the syllabus to accommodate the sequence dictated by a particular job. In all cases, it must be ensured that trainees are competent in basic skills before proceeding to more advanced work.

Plant maintenance training should include, wherever possible, lectures and discussions covering:

- the basic principles of the components to be worked on;
- the application of safe practices at all times;
- the isolation of units and/or systems prior to dismantling;
- the security of all personnel and materials during a maintenance operation;
- the dangers inherent in systems which contain fluids under pressure, or are of a hazardous nature;
- the basics of maintenance technology in terms of:
  - planned maintenance systems
  - condition monitoring
  - diagnostic testing
  - preventative maintenance
  - predictive maintenance

In the training utilizing the equipment/facilities in the workshop, the instructor should set up training exercises to be done by trainees so as to make full use and consideration of their features.

At all times trainees should wear adequate protective clothing and footwear appropriate to the work in hand. Safe working practices should be enforced at all times, see video V15.

It is important that training objectives are achieved during this part of the course. Most of the training outcomes will, as a natural outcome, be covered several times in various forms and applications.

3.2.4 THE USE OF APPROPRIATE SPECIALIZED TOOLS AND MEASURING INSTRUMENTS

Major installations on board ships have specialized tools and measuring instruments for their maintenance and repair. These tools and instruments have special shapes to apply only to

their specific installations. Trainees need to learn about what sort of tools and instruments are available and how to use them.

3.2.5 DESIGN CHARACTERISTICS AND SELECTION OF MATERIALS IN CONSTRUCTION OF EQUIPMENT

Materials in construction of equipment

Suitable materials are used to construct ship's machinery installations and trainees need to learn the features of the materials in specific parts of the installations in terms of strength, corrosion and other aspects. The first part of this function can also be applied.

Design characteristics of bearing

Trainees need to learn about basic design characteristics to understand what improvements in the design of ship's machinery installations have been made to improve performance. The first part of this function can also be applied.

Bearings

All types of bearings are used on board ship and a marine engineer spends considerable time on their inspection, maintenance and renewal. Bearings are also dealt with both practically and theoretically in other training outcomes, and there is therefore no need to exceed the training outcome requirements.

Large, thin-walled or shell bearings are in common use in modern large-bore diesel engines. The shell of such a bearing might be 600 mm in diameter and 15 mm thick.

In general, it can be said that in marine practice ball and roller bearings are used for small diameter applications such as in electric motors, etc.; they are also used for turbo-charger rotors. Although not directly part of this subject, the opportunity should be taken to make trainees aware of the need, in the case of certain high-speed applications, to renew bearings when the running hours prescribed by the manufacturer have been reached.

Trainees should not be expected to give details of which types of bearing are suitable for given applications; however, evidence of awareness of different bearings for different conditions is essential.

Lubrication of ball and roller bearings

Bear in mind that lubricating oil is dealt with elsewhere in the course. In addition to this objective, the lubrication of ball and roller bearings is covered briefly in other training outcomes.

Lubrication in general is covered elsewhere but the question of maximum quantities to be used in ball and roller bearings is unique to training outcome, Lubrication of ball and roller bearings.

3.2.6 INTERPRETATION OF MACHINERY DRAWINGS AND HANDBOOKS

On completion of this section, trainees will be competent to obtain any required information from engineering drawings produced to international standards and conventions. Should the need arise they will also be able to produce drawings of an adequate standard to manufacture of equipment components. In addition, they will possess knowledge of design principles.

Types of drawing

A marine engineer officer is a user of drawings; he has to be competent in reading drawings so as to carry out maintenance, repair, identification of components and their replacement. From time to time replacements will have to be made on board ship or ashore, either from original drawings supplied to the ship or occasionally from engineering drawings or sketches produced on board. It is not necessary, therefore, for trainees to become expert draughtsmen but they do require a thorough understanding of drawings and they also should have the ability to produce sketches and, if necessary, engineering drawings for use by others.

In addition to being able to obtain information from drawings, a marine engineer should have a good understanding of design concepts. This will assist in decision-making processes. For example, when machinery is malfunctioning it is often necessary to consider the possible design principles as part of an analysis of the problem as a basis for correcting the fault.

Linework

Engineering drawing practice appears in the syllabus as the last subject area, and it carries a time allocation of 15 hours. This does not mean that actual drawing should be delayed until the end; in fact there is much to be gained from trainees producing drawings from the early stages of the subject, for example, as required in Linework. The production of engineering drawings should be a continuing part of the training outcomes, with successive drawings including newly covered topics as the work progresses. In a similar manner the time allocated to various topics is mutually interchangeable according to how the instructor envisages his teaching plan.

Useful and meaningful exercises would be to produce drawings from which trainees can manufacture items as part of the engineering workshop skills.

Linework is the introduction to drawing skills. Trainees should be encouraged to use correct linework right from the beginning

Discretion should be used when teaching the drawing of tangents. Trainees will need to draw tangents when producing drawings but they are not expected to become expert draughtsman. They need to become aware of the special care necessary so that when the time comes they can refer to the method required.

Both of the projection styles mentioned in the training outcomes are in common use and it is therefore very important that trainees establish the method used before taking information from drawings. The level of examples given in the book reference against the training outcome is adequate and should not be exceeded.

Trainees should not be expected to produce auxiliary views but they do need to know what they are and to be competent to obtain information from them.

Pictorial projection

Instructors are referred to the recommended textbooks for guidance. In this area the use of simple CAD programs may be introduced.

Development

Development has been kept as simple as possible so as to obtain an insight into the principles. If, later during their career, trainees have to produce development drawings they will need to build on the principles.

Dimensioning

Instructors are referred to the recommended textbook, T14 for guidance.

Geometrical tolerancing

It is unlikely that trainees will use geometrical tolerances, but they will see such references on drawings, and they therefore need to know their meaning.

Limits and fits

The interchangeability of spare parts is very important. Spare parts may have to be obtained from a variety of sources and may, in some cases, have to be manufactured on board ship. A marine engineer must therefore be familiar with the allowable tolerances which might apply to components.

Trainees should not be expected to select fits but they need to know that the information is available. They should be able to quote the approximate dimensions.

Engineering drawing practice

Although engineering drawing practice appears last, it is expected that trainees will have been producing drawings throughout the training outcomes for this area. The purpose of engineering drawing practice is to specify the work which needs to be included. The examples printed in textbook T14 are adequate to cover the training outcome. However, instructors may wish to add others more obviously associated with marine engineering. This being so, consideration should be given to the possibility of including drawings of components and machinery situated in the college's marine engineering maintenance or operations workshops.

3.2.7 THE INTERPRETATION OF PIPING, HYDRAULIC AND PNEUMATIC DIAGRAMS

As aforementioned, understanding engineering drawings and obtaining necessary information from them are essential abilities for trainees and the symbols used in these diagrams should be taught as part of the training to interpret an engineering drawing.

Officer in Charge of an Engineering Watch

Function 4:
Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

Officer in Charge of an Engineering Watch

Function 4: Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

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Part B4: Course Outline

■ Timetable

No formal example of a timetable is included in this model, course.

Development of a detailed timetable depends on the level of skills of the trainees entering the course and the amount of revision work of basic principles that may be required.

Lecturers must develop their own timetable depending on:

- the level of skills of trainees
- the numbers to be trained
- the number of instructors

and normal practices at the training establishment.

Preparation and planning constitute an important factor which makes a major contribution to the effective presentation of any course of instruction.

■ Lectures

As far as possible, lectures should be presented within a familiar context and should make use of practical examples. They should be well illustrated with diagrams, photographs and charts where appropriate, and be related to matter learned during seagoing time.

An effective manner of presentation is to develop a technique of giving information and then reinforcing it. For example, first tell the trainees briefly what you are going to present to them; then cover the topic in detail; and, finally, summarize what you have told them. The use of an overhead projector and the distribution of copies of the transparencies as trainees handouts contribute to the learning process.

■ Course outline

The tables that follow list the competencies and areas of knowledge, understanding and proficiency, together with the estimated total hours required for lectures and practical exercises. Teaching staff should note that timings are suggestions only and should be adapted to suit individual groups of trainees depending on their experience, ability, equipment and staff available for training.

COURSE OUTLINE

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence:		
4.1 ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS		
4.1.1 PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT		
.1 MARPOL 73/78	14	
Technical Annexes: Annex I to VI of MARPOL 73/78 in detail		
.2 Conventions and legislations adopted by various countries	4	18
4.1.2 ANTI-POLLUTION PROCEDURES AND ASSOCIATED EQUIPMENT		
.1 Control of discharge of oil	2	
.2 Oil Record Book (Part I - Machinery Space Operations) and Part II - Cargo/Ballast operations)	1	
.3 Shipboard Oil Pollution Emergency Plan (SOPEP) including Shipboard Marine Pollution Emergency Plans (SMPEP) for Oil and/or Noxious Liquid Substances and Vessel Response Plan (VRP)	1	
.4 Operating procedures of anti-pollution equipment, sewage plant, incinerator, comminutor, ballast water treatment plant	1	
.5 Volatile Organic Compound (VOC) Management Plan, Garbage Management System, Anti-fouling systems, Ballast Water Management and their discharge criteria	3	8
4.1.3 PROACTIVE MEASURES TO PROTECT THE MARINE ENVIRONMENT		
.1 Proactive measures to protect the marine environment	1	1
4.2 MAINTAIN THE SEAWORTHINESS OF THE SHIP		
4.2.1 STABILITY, TRIM AND STRESS TABLES		
.1 Displacement	4	
.2 Buoyancy	2	
.3 Fresh water allowance	3	
.4 Statical stability	3	
.5 Initial stability	4	
.6 Angle of loll	1	
.7 Curves of statical stability	4	
.8 Movement of centre of gravity	4	
.9 List and its correction	6	
.10 Effect of slack tanks	3	
.11 Trim and draft calculations	6	
.12 Action to be taken in the event of partial loss of intact buoyancy	1	
.13 Stress tables and stress calculating equipment	3	44

Knowledge, understanding and proficiency		Total hours for each topic	Total hours for each subject area of Required performance
4.2.2	THE PRINCIPAL STRUCTURAL MEMBERS OF A SHIP		
	.1 Ship dimensions and form	12	
	.2 Ship stresses	8	
	.3 Hull structure	11	
	.4 Bow and stern regions	6	
	.5 Fittings	10	
	.6 Rudders and propellers	11	
	.7 Load lines and draught marks	5	63
4.3	**PREVENT, CONTROL AND FIGHT FIRES ON BOARD**		
	See IMO model course 2.03 and STCW Convention 1978, as amended regulation VI/3		
4.4	**OPERATE LIFE-SAVING APPLIANCES**		
	See IMO model course 1.23, and STCW Convention 1978, as amended regulation VI/2, paragraph 1-4		
4.5	**APPLY MEDICAL FIRST AID ON BOARD SHIP**		
	See IMO model course 1.14, and STCW Convention 1978, as amended regulation VI/4, paragraph1-3		
4.6	**MONITOR COMPLIANCE WITH LEGISLATIVE REQUIREMENTS**		
4.6.1	BASIC WORKING KNOWLEDGE OF THE RELEVANT IMO CONVENTIONS CONCERNING SAFETY OF LIFE AT SEA, SECURITY AND PROTECTION OF THE MARINE ENVIRONMENT		
	.1 Introduction to Maritime Law	1	
	.2 Law of the Sea	5	
	.3 Safety:		
	International Convention on load Lines,1966	2	
	SOLAS, 1974 as amended	2	
	SOLAS - Subdivision and stability	2	
	SOLAS - Fire protection, detection and extinction	2	
	SOLAS - LSA and arrangements (LSA Code)	2	
	SOLAS - Carriage of grain	1	
	SOLAS - Carriage of dangerous goods	1	
	Code of Safe Working Practices for Merchant Seamen	4	
	STCW Convention 1978, as amended	2	
	The International Ship and Port Facility Security Code (ISPS Code)	1	25

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
4.7 APPLICATION OF LEADERSHIP AND TEAMWORKING SKILLS 4.7.1 SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING 4.7.2 RELATED INTERNATIONAL CONVENTIONS AND RECOMMENDATIONS, AND NATIONAL LEGISLATION .1 Maritime Labour Convention (MLC) 2006 4.7.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT 4.7.4 EFFECTIVE RESOURCE MANAGEMENT 4.7.5 DECISION MAKING TECHNIQUES *See IMO model course 1.39 on Leadership and Teamwork* **4.8 CONTRIBUTE TO THE SAFETY OF PERSONNEL AND SHIP** *See IMO model course 1.19 - Personal Survival Techniques (PST) and IMO model course 1.21 - Personal Safety and Social Responsibilities (PSSR)*	2	
Total for Function 4: Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level		**161 hours**

Part C4: Detailed Teaching Syllabus

■ Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the *Required performance* expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed teaching syllabus; in particular,

- Teaching aids (indicated by A)
- IMO references (indicated by R) and
- Textbooks (indicated by T)

will provide valuable information to instructors.

■ Explanation of information contained in the syllabus tables

The information on each table is systematically organized in the following way. The line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

In this model course there are four functions:

- Marine Engineering at the Operational Level
- Electrical, Electronic and Control Engineering at the Operational Level
- Maintenance and Repair at the Operational Level
- Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

The header of the first column denotes the COMPETENCE concerned. Each function comprises several competences. For example, Function 4, Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level, comprises a total of eight COMPETENCES. Each competence is uniquely and consistently numbered in this model course.

The first competence in FUNCTION 4 is **Ensure Compliance with Pollution Prevention Requirements** and it is numbered 4.1. The term competence should be understood as the application of knowledge, understanding, proficiency, skills and experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the above competence comprises three training outcomes. The first is concerned with the PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT. Each training outcome is uniquely and consistently numbered in this model course. That concerned with precautions to be taken to prevent pollution of the marine environment is uniquely numbered 4.1.1. For clarity training outcomes are printed in black on grey, for example TRAINING OUTCOME.

Finally, each training outcome embodies a variable number of Required performances - as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified Required performance. For the training outcome concerned with precautions to be taken to prevent pollution of the marine environment, there are two areas of performance. They are:

4.1.1.1 MARPOL 73/78 (14 hours)
Technical Annexes: Annex I to VI of MARPOL 73/78 in detail

4.1.1.2 Conventions and legislations adopted by various countries (4 hours)

Following each numbered area of Required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process. For example, under the topic 4.1.1.1, to meet the Required performance, the trainee should be able to:

- define for the purpose of MARPOL 73/78: a harmful substance, a discharge, and ship and an incident
- state that violations of the Convention are prohibited and that sanctions should be established for violations
- describes the inspections which may be made by port State authorities and outlines actions which they may take and so on.

IMO references (Rx) are listed in the column to the right hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and required performance are placed immediately following the TRAINING OUTCOME title.

It is not intended that lessons are organized to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organised to match with the competence in the STCW Code, table A-III/1. Lessons and teaching should follow college practices. It is not necessary, for example, for shipbuilding materials to be studied before stability. What is necessary is that all the material is covered and that teaching is effective to allow trainees to meet the standard of the Required performance.

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.1.1 PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT 4.1.2 ANTI-POLLUTION PROCEDURES AND ALL ASSOCIATED EQUIPMENT 4.1.3 PROACTIVE MEASURES TO PROTECT THE MARINE ENVIRONMENT		STCW Code table A-III/1

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
4.1.1 PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT		R3
Textbooks: T17		
Teaching aids: A1, A3, V15, V17, V18, V19, V20, V21, V22, V24, V25, V26, V27, V28, V29, V30, V31, V32, V33, V34, V35, V36, V37, V38, V39, V40, V41, V42, V43, V44, V48, V49, V50, V51, V52, V53, V54, V55		
Required performance:		
1.1 International Convention for the Prevention of Pollution from Ships,1973, and the Protocol of 1978 relating thereto (MARPOL 73/78) Technical Annexes: Annex I to VI of MARPOL 73/78 in detail (14 hours)		
- defines, for the purpose of MARPOL 73/78:		R3, R4, R5,
- harmful substance		R6, R7, R9,
- discharge		R10, R11, R12,
- ship		R13, R14
– incident		
- states that violations of the Convention are prohibited and that sanctions should be established for violations, wherever they occur by the Administration of the ship concerned		
- describes the inspections which may be made by port State authorities and outlines actions which they may take		
- describes the provisions for the detection of violations and enforcement of the Convention		
- states that reports on incidents involving harmful substances must be made without delay		
Annex I - Oil		R3, R4
- defines, for the purposes of Annex I:		
- oil		
- oily mixture		
- oil fuel		
- oil tanker		
- combination carrier		
- nearest land		
- special area		
- instantaneous rate of discharge of oil content		
- wing tank		
- centre tank		
- slop tank		
- clean ballast		
- segregated ballast		
- describes the surveys and inspections required under the provisions of MARPOL 73/78		
- describes the steps which may be taken if a surveyor finds that the condition of the ship or its equipment is unsatisfactory		
- states that the condition of the ship and its equipment should be maintained to conform with the provisions of the Convention		

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
	– states that the certificate issued after survey is the International Oil Pollution Prevention (IOPP) Certificate - states that the IOPP Certificate should be available on board the ship at all times - lists the conditions under which oily mixtures may be discharged into the sea from an oil tanker - lists the conditions under which oily mixtures from machinery-space bilges may be discharged into the sea - states that the provisions do not apply to the discharge of clean or segregated ballast - describes the conditions under which the provisions do not apply to the discharge of oily mixtures from machinery spaces where the oil content without dilution does not exceed 15 parts per million - states that residues which cannot be discharged into the sea in compliance with the regulations must be retained on board or discharged to reception facilities - list the special areas for the purposes of Annex I – states that any discharge into the sea of oil or oily mixtures from an oil tanker or other ships of 400 tons gross tonnage and above is prohibited while in a special area - describes the conditions under which an oil tanker may discharge oily mixtures through ODMCS - describes the conditions under which a ship, other than an oil tanker, may discharge oily mixtures in a special area - states that the regulation does not apply to the discharge of clean or segregated ballast - describes conditions in which processed bilge water from machinery spaces may be discharged in a special area - describes the exceptional circumstances in which the regulations on the discharge of oil or oily mixtures do not apply - states that ballast water should not normally be carried in cargo tanks of tankers provided with segregated ballast tanks - explains the exceptions in which ballast may be carried in cargo tanks – states that every oil tanker operating with crude oil washing systems should be provided with an Operations and Equipment Manual - states that, in new ships of 400 tons gross tonnage and above and in new oil tankers of 150 tons gross tonnage and above, no ballast water should normally be carried in any oil fuel tank - explains that a new chapter 8 - STS operations has been added to MARPOL Annex 1 to prevent marine pollution during some ship-to-ship (STS) oil transfer operations - states that as per the above amendment to Annex I of MARPOL, Tankers of 150 GT and above involved in STS operations are required to have on board by the date of the first periodical survey after 1 January 2011 (but not later than 1 April 2012) an STS operations plan approved by the ship flag Administration, describing how STS operations are to be conducted	

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
	Annex II - Noxious Liquid Substances in Bulk	R3, R5
	- describes the requirements of Annex II apply to all ships carrying noxious liquid substances in bulk	
	- states that noxious liquid chemicals are divided into four categories, X, Y, Z and OS such that substances in category X pose the greatest threat to the marine environment and those in category Z the least	
	- states that the conditions for the discharge of any effluent containing substances falling in those categories are specified	
	- states that more stringent requirements apply in special areas, which for the purposes of Annex II are the Antarctic area	
	- states that pumping and piping arrangements are to be such that, after unloading, the tanks designated for the carriage of liquids of categories Z do not retain more than certain stipulated quantities of residue	
	- states that the discharge operations of certain cargo residues and certain tank cleaning and ventilation operations may only be carried out in accordance with approved procedures and arrangements based on standards developed by IMO	
	- states that each ship which is certified for the carriage of noxious liquid substances in bulk should be provided with a Procedures and Arrangements Manual	
	- states that the Manual identifies the arrangements and equipment needed to comply with Annex II and specifies the operational procedures with respect to cargo handling, tank cleaning, slops handling, residue discharging, ballasting and deballasting which must be followed in order to comply with the requirements of Annex II	
	- states that each ship should be provided with a Cargo Record Book which should be completed, on a tank-by-tank basis, whenever any operations with respect to a noxious liquid substance take place	
	- states that a surveyor appointed or authorized by the Government of a Party to the Convention to supervise any operations under this Annex should make an appropriate entry in the Cargo Record Book	
	- describes the surveys required for ships carrying noxious liquid substances in bulk	
	- states that the certificate issued on satisfactory completion of the survey is an international Pollution Prevention Certificate for the Carriage of Noxious Liquid Substances in Bulk	
	Annex III - Harmful Substances Carried by Sea in Packaged Forms, or in Freight Containers, Portable Tanks or Road and Rail Tank Wagons	R3
	- states that for the purpose of this Annex, empty receptacles, freight containers and portable road and rail tank wagons which have been used previously for the carriage of harmful substances are treated as harmful substances themselves unless precautions have been taken to ensure that they contain no residue that is hazardous to the marine environment	
	- states that packaging, containers and tanks should be adequate to minimize hazard to the marine environment	
	- describes the requirements for marking and labelling packages, freight containers, tanks and wagons	

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
	– describes the notification procedures for loading/unloading harmful substances as per MARPOL Annex III - describes the documentation relating to the carriage of harmful substances by sea - states that certain harmful substances may be prohibited for carriage or limited as to the quantity which may be carried aboard any one ship - states that jettisoning of harmful substances is prohibited except for the purpose of securing the safety of the ship or saving life at sea	
	Annex IV - Sewage - states that Annex IV contains a set of regulations regarding the discharge of sewage into the sea, ships' equipment and systems for the control of sewage discharge, the provision of facilities at ports and terminals for the reception of sewage, and requirements for survey and certification - describes the provisions regarding the discharge of sewage into the sea – states that an International Sewage Pollution Prevention Certificate is issued by national shipping administrations to ships under their jurisdiction showing compliance - states that the Annex requires ships to be equipped with either a sewage treatment plant or a sewage comminuting and disinfecting system or a sewage holding tank - states that the discharge of sewage into the sea is prohibited, except when the ship has in operation an approved sewage treatment plant or is discharging comminuted and disinfected sewage using an approved system at a distance of more than three nautical miles from the nearest land; or is discharging sewage which is not comminuted or disinfected at a distance of more than 12 nautical miles from the nearest land	R3
	Annex V - Garbage - defines, for the purposes of Annex V: - garbage - nearest land - special area - states that the provisions of Annex V apply to all ships - states that the disposal into the sea of all plastics is prohibited - states the regulations concerning the disposal of other garbage - states that the special areas for the purposes of Annex V as the Mediterranean sea, Baltic Sea, Black Sea, Red Sea, "Gulfs" area, North Sea, Antarctic area (south of latitude 60 degrees south), Wider Caribbean region including the Gulf of Mexico and the Caribbean Sea	R3
	Annex VI - Air Pollution - defines, for the purposes of Annex VI: - continuous feeding - emission control area (ECA) - new installations - nitrogen oxide (NO_x) technical code - ozone-depleting substances - sludge oil	R3

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
	– shipboard incineration - shipboard incinerator - particular matter (PM) - volatile organic compounds (VOCs) - describes the types of inspection required under Annex VI – describes the provision for the issuance of International Air Pollution Prevention certificate - describes the duration of validity of the certificate – describes the regulation regarding NO_x in regulation 13 of Annex VI – describes the requirement for SO_x emission control area (SECA) - describes the requirement for fuel oil quality in regulation 18 of Annex VI – states that the special areas for the purposes of Annex VI as the Baltic Sea (SOx), North Sea (SOx), North American (SOx, NOx and PM), United States Caribbean Sea ECA (SOx, NOx and PM)	
	1.2 Conventions and legislations adopted by various countries (4 hours) The trainee is expected to have a basic working knowledge of the conventions and legislations adopted by various countries such as, but not limited to:	
	- Convention of the Prevention of Marine Pollution by Dumping of Waste and Other Matter (London Dumping Convention) (LDC)	R8
	- International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969	R8
	- International Convention on Civil Liability for Oil Pollution Damage, 1969 (CLC 1969)	R8
	- Oil Pollution Preparedness, Response & Cooperation Convention (OPRC) as amended (OPRCHNS Protocol) – OPA-90 and other US legislation	
	4.1.2 ANTI-POLLUTION PROCEDURES AND ALL ASSOCIATED EQUIPMENT **Textbooks:** **Teaching aids:** A1, A3, V15, V17, V18, V19, V20, V21, V22, V25, V26, V27, V28, V29, V30, V31, V32, V33, V34, V35, V36, V37, V38, V39, V40, V41, V42, V43, V44, V48, V49, V50, V52, V53, V54, V62 Required performance: **2.1 Control of discharge of oil (2 hours)** - explains the control of discharge of oil as stated in regulation 9 of MARPOL 73/78 - explains Particularly Sensitive Sea Areas (PSSA) - explains methods for prevention of oil pollution and discharge provisions for oil and oily waste from machinery spaces outside special areas and within special areas - explains bilge water holding tank - explains oily water separator - explains oil discharge monitoring and control system and oil filtering equipment as stated in regulation 16 of MARPOL 73/78	

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference

– explains in brief the prevention of oil pollution as stated in regulation 13F in the event of collision or stranding and regulation 13G in the event of collision or stranding measures for existing tankers of MARPOL 73/78

- explains the retention of oil on board as stated in regulation 15 of MARPOL 73/78

2.2 Oil Record Book (Part I - Machinery Space Operations and Part II - Cargo/ Ballast Operations) (1 hour)

- describes the requirements for the provision of Oil Record Books, which is, oil tankers of 150 tons GT and every ship of 400 tons GT and above other than an oil tanker to carry an Oil Record Book Part I (Machinery space operations)
- describes that every oil tanker of 150 tons GT and above shall also be provided with an Oil Record Book Part II (Cargo/ballast operations)
- describes the various operations when the Oil Record Book has to be completed
- lists the various entries that need to be made in the Oil Record Book with respect to above for following operations:
  - for machinery space operations (all ships)
  - for cargo/ballast operations (oil tankers)
- describes the entries required for accidental or other exceptional discharge of oil
- explains that each completed operation shall be signed by the officer or officers in charge of the operations concerned and each completed page shall be signed by the master of ship
- states that the Oil Record Book should be kept on board readily available for inspection and should be preserved for a period of three years after the last entry has been made
- explains that the competent authority of the Government of a Party to the Convention may inspect the Oil Record Book on board any ship to which Annex I applies while the ship is in its port or offshore terminals and may make a copy of any entry in that book and may require the master of the ship to certify that the copy is a true copy of such entry

2.3 Shipboard Oil Pollution Emergency Plan (SOPEP) including Shipboard Marine Pollution Emergency Plans (SMPEP) for Oil and/or Noxious Liquid Substances and Vessel Response Plan (VRP) (1 hour)

- states that the Shipboard Oil Pollution Emergency Plan (“SOPEP”) is to be seen as an information from the owners to the Master of a particular ship
- states it is an advice to the Master how to react in case of an oil spill to prevent or at least mitigate negative effects on the environment
- states that the Plan contains operational aspects for various oil spill scenarios and lists communication information to be used in case of such incidents
- states that it is compulsory for all ships of more than 400 gross tons (oil tankers of more than 150 GT) to carry a SOPEP on board
- states that the required contents is described in MARPOL Convention Annex I, reg. 26
- explains that “Guidelines for the Development of a Shipboard Oil Pollution Emergency Plan” are published by IMO under MEPC.54(32) 1992 as amended by MEPC.86(44) 2000
- states that the SOPEP forms an integral part of the IOPP certificate and its existence is verified in the Supplement to the IOPP Certificate

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference

– describes that the Plan consists generally of 4 sections with the mandatory contents and its appendices with additional information as contact addresses and data plus a set of certain drawings for easy reference for the Master

- describes that the SOPEP consists of the following chapters:
  1. Ship identification data
  2. Table of Contents
  3. Record of Changes
  4. Section 1: Preamble
  5. Section 2: Reporting Requirements
  6. Section 3: Steps to control Discharges
  7. Section 4: National and Local Coordination
  8. Minimum Appendices:
     - List of Coastal State Contacts
     - List of Port Contacts
     - List of Ship Interest Contacts
  9. Ship's drawings:
     - General Arrangement Plan
     - Tank Plan
     - Fuel Oil Piping Diagram
  10. Further appendices on owners' decision
- explains that according to MARPOL following appendices should be added to the SOPEP:
  - Coastal State Contacts (as annually published but quarterly updated in the Internet by IMO)
  - Blank form for listing of Port Contact Addresses to be kept up-to-date by the Master
  - Ship Interest Contact List (communication data incl. 24hours contact phone numbers to owners/managers, data abt. charterer, insurance, P&I Club, etc.)

Shipboard Marine Pollution Emergency Plan (SMPEP)

- explains IMO has adopted a requirement for ships above 150 GRT certified to carry noxious liquid substances in bulk and that these ships shall carry an additional emergency plan called "Shipboard Marine Pollution Emergency Plan for noxious liquid substances"
- explains that this plan is to be seen as an information from the owners to the Master of a particular ship advising the Master how to react in case of a spill of noxious liquid substances to prevent or at least mitigate negative effects on the environment
- explains that the Plan is compulsory since 1 January 2003

– describes that the Plan contains operational aspects for various spill scenarios and lists communication information to be used in case of such incidents

- explains that as the contents is mainly similar to the contents of the Shipboard Oil Pollution Emergency Plan (SOPEP) which is compulsory, IMO recommends to prepare a combined plan called "Shipboard Marine Pollution Emergency Plan" ("SMPEP")

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference

– explains that such plan has to fulfil the requirements for the SOPEP and additionally for the Shipboard Marine Pollution Emergency Plan for noxious liquid substances according to the IMO Guideline

- states that the required contents is described in MARPOL 73/78 as amended Annex II, Reg. 16
- explains that "Guidelines for the Development of a Shipboard Marine Pollution Emergency Plan for noxious liquid substances" are published by IMO under MEPC.85(44) adopted in March 2000
- explains that the Certificate of Chemical Fitness or Substances in Bulk respectively can only be issued if the said plan is available on board
- explains that If a combined plan "Shipboard Marine Pollution Emergency Plan" (SMPEP) is carried, it has to be in accordance with the guidelines MEPC.85(44) and MEPC.54(32) as amended by MEPC.86(44)

Vessel Response Plan (VRP)

- explains that the VRP - Vessel Response Plan is a plan required for vessels trading to/from/in USA and this US Coast Guard's new regulations to improve pollution-response preparedness for vessels carrying or handling oil upon the navigable waters of the United States came into effect from 22 February 2011
- explains that the Oil Pollution Act of 1990 (OPA-90) and the international treaty, MARPOL 73/78, require owners/operators of certain vessels to prepare Vessel Response Plans (VRP) and/or Shipboard Oil Pollution Emergency Plans (SOPEP) and in addition, for certain vessels carrying noxious liquid substances a Shipboard Marine Pollution Emergency Plan (SMPEP), effective from 1 January 2003

2.4 Overview of anti-pollution equipment, sewage plant, incinerator, comminutor, ballast water treatment plant (1 hour)

- describes the operating procedures of anti-pollution equipment such as:
  - sewage plant
  - incinerator
  - comminutor
  - ballast water treatment plant

2.5 Volatile Organic Compound (VOC) Management Plan, Garbage Management System, Anti-fouling systems, Ballast Water Management and their discharge criteria (3 hours)

Volatile Organic Compound (VOC) Management Plan

- describes that Volatile Organic Compounds (VOC) are organic chemicals that easily vaporize at normal conditions and enter into the atmosphere
- explains that VOC may include a very wide range of individual substances, such as hydrocarbons (e.g. methane, ethane, benzene, toluene, etc.), oxidized hydrocarbons (or fuel oxygenates, such as methyl tert-butyl ether (MTBE)) and by-product organic compounds from chlorination in water treatment (such as chloroform)
- explains that VOC emissions from the fuel/petroleum industry sources occur during extraction of oil at the platform, tanker transportation of oil, loading and discharging at terminals, oil processing at refineries, tanking at filling stations and leakage from pipelines as well as oil spills
- explains that VOC emissions from ships can be due to incomplete combustion processes and include crankcase, exhaust and evaporation emissions

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference

– explains that tankers emit VOC during cargo loading and crude oil washing operations as well as during sea voyages

- explains that the amount of VOC emissions depends on many factors including the properties of the cargo oil, the degree of mixing and temperature variations during the sea voyage
- explains that to control this emission, there are four criteria that impact the extent and rate of evolution of gaseous non-methane VOC from crude oils and its subsequent release to the atmosphere. These are:
  - the volatility or vapour pressure of the crude oil
  - the temperature of the liquid and gas phases of the crude oil tank
  - the pressure setting or control of the vapour phase within the cargo tank
  - the size or volume of the vapour phase within the cargo tank
- describes that regulation 15.6 of MARPOL requires a tanker carrying crude oil shall have on board and implement a VOC Management Plan (Management Plan) approved by the Administration in accordance with IMO resolution MEPC.185(59) “Guidelines for the Development of a VOC Management Plan”
- explains that this VOC Management Plan is specific to each ship

– explains that the aim of the VOC Management Plan is to identify the arrangements and equipment required to enable compliance with regulation 15.6 of the Revised Annex VI and to identify for the ship’s officers the operational procedures for VOC emission control

Garbage Management System:

Garbage Management Plan

- explains that as per MARPOL 73/78, Annex V, regulation 9 every ship of 400 gross tonnage and above and every ship which is certified to carry 15 persons or more are to be required to carry a Garbage Management Plan which the crew are required to follow
- describes the content of the Garbage Management Plan

Garbage Record Book

- explains that every ship of 400 gross tonnage and above and every ship which is certified to carry 15 persons or more engaged in voyages to ports or offshore terminals under the jurisdiction of other Parties to the Convention and every fixed and floating platform engaged in exploration and exploitation of the seabed are to be provided with a Garbage Record Book
- describes the various operations when the Garbage Record Book has to be completed
- lists the various entries that needs to be made in the Garbage Record Book
- explains the disposal criteria for cargo residues/cargo hold washing water residues

Anti-fouling systems

- states that IMO adopted a new International Convention on the Control of Harmful Anti-fouling Systems on Ships, on 5 October 2001 which will prohibit the use of harmful organotins in anti-fouling paints used on ships and will establish a mechanism to prevent the potential future use of other harmful substances in anti-fouling system
- states that the convention entered into force on 17 September 2008

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference

Ballast Water Management Convention 2004

- states that The International Convention for the Control and Management of Ships Ballast Water & Sediments (BWM convention) was adopted by consensus at a diplomatic Conference at IMO in London on Friday 13 February 2004 and expected to be ratified
- defines the following:
  - ballast water
  - ballast water management
  - sediments
- describes the application of this convention
- states that in order to show compliance with the requirements of the Convention each vessel shall have on board a valid Certificate, a Ballast Water Management Plan and a Ballast Water Record Book
- describes the conditions where the application of this convention may be exempted
- describes the management and control requirement based on Section B Regulation B1 to B6
- describes the Annex - Section A, B, C, D and E briefly
- describes the various methods of ballast exchange
- describes the standards that need to be observed in ballast water exchange
- states under regulation B-4 Ballast water exchange, all ships using ballast water exchange should:
  - whenever possible, conduct ballast water exchange at least 200 nautical miles from the nearest land and in water at least 200 metres in depth, taking into account Guidelines developed by IMO
  - in cases where the ship is unable to conduct ballast water exchange as above, this should be as far from the nearest land as possible, and in all cases at least 50 nautical miles from the nearest land and in water at least 200 metres in depth
- states as per Annex - Section B Management and control requirements for ships:
  - ships are required to have on board and implement a Ballast Water Management Plan approved by the Administration (regulation B-1). The Ballast Water Management Plan is specific to each ship and includes a detailed description of the actions to be taken to implement the Ballast Water Management requirements and supplemental Ballast Water Management practices.
- states that a new paragraph, 4, has been added with effect from July 1, 2010 to SOLAS chapter V, regulation 22 - Navigation bridge visibility. Some changes are operational and others introduce new requirements applicable to navigation records
- states that as a consequence of this amendment, any increase in blind sectors or reduction in horizontal fields of vision resulting from ballast water exchange operations is to be taken into account by the Master before determining that it is safe to proceed with the exchange

COMPETENCE 4.1	Ensure Compliance with Pollution Prevention Requirements	IMO Reference
– states that as an additional measure, to compensate for possible increased blind sectors or reduced horizontal fields of vision, the Master must ensure that a proper lookout is maintained at all times during the exchange. Ballast water exchange must be conducted in accordance with the ship's ballast water management plan, taking into account the recommendations adopted by the IMO - explains that in accordance with SOLAS chapter V, regulation 28 - Records of navigational activities and daily reporting, the commencement and termination of the operation should be recorded - explains that the navigational records generated during ballast water exchange may be reviewed during ISM Audits and port State control inspections 4.1.3 PROACTIVE MEASURES TO PROTECT THE MARINE ENVIRONMENT **Textbooks:** **Teaching aids:** A1, A32, V15, V17, V19, V20 V21, V22, V25, V26, V27, V28, V29, V30, V31, V32, V33, V34, V35, V36, V37, V38, V39, V40, V41, V42, V43, V44, V48, V49, V50, V52, V53, V54, V62 Required performance: **3.1 Importance of proactive measures to protect the marine environment (1 hour)** - explains the need for taking proactive measures to protect the marine environment - describes the proactive measures that can be taken on board the ships to protect the marine environment for shipboard operations, including: - bunkering - loading/discharging oil, chemicals and hazardous cargoes - tank cleaning - cargo hold washing - pumping out bilges (hold and engine-room) - ballast water exchange - purging and gas freeing - disposal of other garbage - discharge of sewage		

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.2.1 sTABILITY, TRIM AND STRESS TABLES 4.2.2 THE PRINCIPAL STRUCTURAL MEMBERS OF A SHIP		STCW Code table A-III/1

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference

4.2.1 STABILITY, TRIM AND STRESS TABLES

Textbooks: T15

Teaching aids: A1, A3, V23, V45, V46, V47, V51

Required performance:

SHIP STABILITY

1.1 Displacement (4 hours) — R1

- states that, for a ship to float, it must displace a mass of water equal to its own mass
- explains how, when the mass of a ship changes, the mass of water displaced changes by an equal amount
- states that the displacement of a vessel is its mass and it is measured in tonnes
- states that displacement is represented by the symbol Δ
- explains the relationship between the displacement and mean draught of a ship by using the graph or scale
- given a displacement/draught curve, finds:
  - displacements for given mean draughts
  - mean draughts for given displacements
  - the change in mean draught when given masses are loaded or discharged
  - the mass of cargo to be loaded or discharged to produce a required change of draught
- defines 'light displacement' and 'load displacement'
- defines 'deadweight'
- uses a deadweight scale to find the deadweight and displacement of a ship at various draughts in seawater
- defines 'tonnes per centimetre immersion' (TPC)
- explains why TPC varies with different draughts
- uses a deadweight scale to obtain TPC at given draughts
- uses TPC obtained from a deadweight to find:
  - the change of mean draught when given masses are loaded or discharged
  - the mass of cargo to be loaded or discharged to produce a required change of draught
- defines 'block coefficient' (C_b)
- calculates C_b from given displacement and dimensions
- calculates displacement from given C_b and dimensions

1.2 Buoyancy (2 hours) — R1

- explains what is meant by 'buoyancy'
- states that the force of buoyancy is an upward force on a floating object created by the pressure of liquid on the object
- states that the buoyancy force is equal to the displacement of a floating object
- describes reserve buoyancy
- explains the importance of reserve buoyancy
- explains how freeboard is related to reserve buoyancy –

explains the purpose of load lines

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference
	- explains the requirements for maintaining watertight integrity - demonstrates an understanding of damage stability requirements for certain vessels - explains reasons for damage stability requirements - identifies damage stability requirements for Type A vessels, Type (B-60) and Type (B-100) vessels - identifies equilibrium condition after flooding for Type A, and all Type B vessels - identifies damage stability requirements for passenger vessels	
1.3	**Fresh water allowance (3 hours)** - explains why the draught of a ship decreases when it passes from fresh water to seawater and vice versa - states that when loading in fresh water before proceeding into seawater, a ship is allowed a deeper maximum draught - describes what is meant by the fresh water allowance (FWA) – given the FWA and TPC for fresh water, calculates the amount which can be loaded after reaching the summer load line when loading in fresh water before sailing into seawater - describes the uses a hydrometer to find the density of dock water – describes the effect of changes of tide and rain on dock water density – explains how to obtain the correct dock water density – given the density of dock water and TPC for seawater, calculates the TPC for dock water - given the density of dock water and FWA, calculates the amount by which the appropriate load line may be submerged - given the present draught amidships and the density of dock water, calculates the amount to load to bring the ship to the appropriate load line in seawater	R1
1.4	**Statical stability (3 hours)** - states that weight is the force of gravity on a mass and always acts vertically downwards - states that the total weight of a ship and all its contents can be considered to act at a point called the centre of gravity (G) - states that the centre of buoyancy (B) as being the centre of the underwater volume of the ship - states that the force of buoyancy always acts vertically upwards – explains that the total force of buoyancy can be considered as a single force acting through B - states that when the shape of the underwater volume of a ship changes the position of B also changes - states that the position of B will change when the draught changes and when heeling occurs - labels a diagram of a midship cross-section of an upright ship to show the weight acting through G and the buoyancy force acting through B - states that the buoyancy force is equal to the weight of the ship – labels a diagram of a midship cross-section of a ship heeled to a small angle to show the weight acting through G and the buoyancy force acting through B - describes stability as the ability of the ship to return to an upright position after being heeled by an external force	R1

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference
	- states that the lever GZ as the horizontal distance between the vertical forces acting through B and G - states that the forces of weight and buoyancy form a couple – states that the magnitude of the couple is displacement × lever, $\Delta \times GZ$ – explains how variations in displacement and GZ affect the stability of the ship – on a diagram of a heeled ship, shows: - the forces at B and G - the lever GZ - states that the length of GZ will be different at different angles of heel – states that if the couple tends to turn the ship toward the upright, the ship is stable - states that for a stable ship: - $\Delta \times GZ$ is called the righting moment – GZ is called the righting lever	
1.5	**Initial stability (4 hours)** - states that it is common practice to describe the stability of a ship by its reaction to heeling to small angles (up to approximately 10°) - defines the transverse metacentre (M) as the point of intersection of successive buoyancy force vectors as the angle of heel increases by a small angle - states that, for small angles of heel, M can be considered as a fixed point on the centreline on a diagram of a ship heeled to a small angle, indicates G, B, Z and M - shows on a given diagram of a stable ship that M must be above G and states that the metacentric height GM is taken as positive - shows that for small angles of heel, $GZ = GM \times \sin\theta$ – states that the value of GM is a useful guide to the stability of a ship – describes the effect on a ship's behaviour of: - a large GM (stiff ship) - a small GM (tender ship) - uses hydrostatic curves to find the height of the metacentre above the keel (KM) at given draughts - states that KM is only dependent on the draught of a given ship – given the values of KG, uses the values of KM obtained from hydrostatic curves to find the metacentre heights, GM - states that, for a cargo ship, the recommended initial GM should not normally be less than 0.15 m	R1
1.6	**Angle of loll (1 hour)** - shows that if G is raised above M, the couple formed by the weight and buoyancy force will turn the ship further from the upright - states that in this condition, GM is said to be negative and $\Delta \times GZ$ is called the upsetting moment or capsizing moment - explains how B may move sufficiently to reduce the capsizing moment to zero at some angle of heel - states that the angle at which the ship becomes stable is known as the angle of loll – states that the ship will roll about the angle of loll instead of the upright	R1

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference
	- states that an unstable ship may loll to either side - explains why the condition described in the above objective is potentially dangerous	
1.7	**Curves of statical stability (4 hours)** - states that for any one draught the lengths of GZ at various angles of heel can be drawn as a graph - states that the graph described in the above objective is called a curve of statical stability - states that different curves are obtained for different draughts with the same initial GM - identifies cross curves (KN curves and MS curves) – derives the formula GZ = MS + GM sinθ – derives the formula GZ = KN - KG sinθ – derives GZ curves for stable and initially unstable ships from KN curves – from a given curve of statical stability obtains: - the maximum righting lever and the angle at which it occurs - the angle of vanishing stability - the range of stability - shows how lowering the position of G increases all values of the righting lever and vice versa - states that angles of heel beyond approximately 40° are not normally of practical interest because of the probability of water entering the ship at larger angles	R1
1.8	**Movement of the centre of gravity (4 hours)** - states that the centre of gravity (G) of a ship can move only when masses are moved within, added to, or removed from the ship - states that: - G moves directly towards the centre of gravity of added masses - G moves directly away from the centre of gravity of removed masses - G moves parallel to the path of movement of masses already on board - calculates the movement of G (GG_1) from: $GG_1 = \frac{\text{mass added or removed} \times \text{distance of mass from G}}{\text{new displacement of the ship}}$ $GG_1 = \frac{\text{mass moved} \times \text{distance mass is moved}}{\text{displacement of the ship}}$ – performs calculations as in the above objective to find the vertical and horizontal shifts of the centre of gravity resulting from adding, removing or moving masses - states that if a load is lifted by using a ship's derrick or crane, the weight is immediately transferred to the point of suspension - states that if the point of suspension is moved horizontally, the centre of gravity of the ship also moves horizontally	R1

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference

	- states that if the point of suspension is raised or lowered, the centre of gravity of the ship is raised or lowered
	- calculates, by using moments about the keel, the position of G after loading or discharging given masses at stated positions
	- calculates the change in KG during a passage resulting from:
	  - consumption of fuel and stores
	  - absorption of water by a deck cargo
	  - accretion of ice on decks and superstructures given the masses and their positions	

1.9	**List and its correction (6 hours)** - shows on a diagram the forces which cause a ship to list when G is to one side of the centreline - states that the listing moment is given by displacement × transverse distance of G from the centreline - shows on a diagram that the angle of list (θ) is given by $\tan\theta = \frac{GG_1}{GM}$ where GG_1 is the transverse shift of G from the centreline – states that in a listed condition the range of stability is reduced – given the displacement, KM and KG of a ship, calculates the angle of list resulting from loading or discharging a given mass at a stated position, or from moving a mass through a given transverse distance - explains, with reference to moments about the centreline, how the list may be removed - given the displacement, GM and the angle of list of a ship, calculates the mass to load or discharge at a given position to bring the ship upright - given the displacement, GM and angle of list of a ship, calculates the mass to move through a given transverse distance to bring the ship upright - given the draught, beam and rise of the floor, calculates the increase in draught resulting from a stated angle of list	R1
1.10	**Effect of slack tanks (3 hours)** - states that if a tank is full of liquid, its effect on the position of the ship's centre of gravity is the same as if the liquid were a solid of the same mass - explains by means of diagrams how the centre of gravity of the liquid in a partly filled tank moves during rolling - states that when the surface of a liquid is free to move, there is a virtual increase in KG, resulting in a corresponding decrease in GM - states that the increase in KG is affected mainly by the breadth of the free surface and is not dependent upon the mass of liquid in the tank - states that in tankers the tanks are often constructed with a longitudinal subdivision to reduce the breadth of free surface	R1

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference
1.11	**Trim and draught calculations using trim tables (6 hours)** - states that “trim” is the difference between the draught aft and the draught forward - states that trim may be changed by moving masses already on board forward or aft, or by adding or removing masses at a position forward of or abaft the centre of flotation - states that ‘centre of flotation’ is the point about which the ship trims, and states that it is sometimes called the tipping centre - states that the centre of flotation is situated at the centre of area of the waterplane, which may be forward of or abaft amidships - demonstrates the uses hydrostatic data to find the position of the centre of flotation for various draughts - states that a trimming moment as mass added or removed × its distance forward or aft of the centre of flotation; or, for masses already on board, as mass moved × the distance moved forward or aft - states that the moment to change trim by 1 cm (MCT 1 cm) as the moment about the centre of flotation necessary to change the trim of a ship by 1 cm - demonstrates the uses hydrostatic curves or deadweight scale to find the MCT 1 cm for various draughts - given the value of MCT 1 cm, masses moved and the distances moved forward or aft, calculates the change in trim - given the value of MCT 1 cm, the position of the centre of flotation, masses added or removed and their distances forward of or abaft the centre of flotation, calculates the change of trim - given initial draughts and the position of the centre of flotation, extends the calculation in the above objective to find the new draughts - given initial draughts and TPC, extends the calculation in the above objective to find the new draughts - given initial draughts and TPC, extends the calculation to find the new draughts – demonstrates the uses of a trimming table or trimming curves to determine changes in draughts resulting from loading, discharging or moving weights - states that in cases where the change of mean draught is large, calculation of change of trim by taking moments about the centre of flotation or by means of trimming tables should not be used - calculates final draughts and trim for a planned loading by considering changes to a similar previous loading	R1
1.12	**Actions to be taken in the event of partial loss of intact Buoyancy (1 hour)** - states that flooding should be countered by prompt closing of watertight doors, valves and any other openings which could lead to flooding of other compartments - states that cross-flooding arrangements, where they exist, should be put into operation immediately to limit the resulting list - states that any action which could stop or reduce the inflow of water should be taken	R1

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference

1.13 Stress tables and stress calculating equipment (loadicator) (3 hours)

- states that each ship above a specified length is required to carry a loading manual, in which are set out acceptable loading patterns to keep shear forces and bending moments within acceptable limits
- states that the classification society may also require a ship to carry an approved means of calculating shear forces and bending moment at stipulated stations
- demonstrates the basic knowledge and use of a stress table
- demonstrates the basic knowledge and use of a stress calculating equipment (loadicator)
- states the information available from loadicator
- states that the loading manual and instrument, where provided, should be used to ensure that shear forces and bending moments do not exceed the permissible limits in still water during cargo and ballast handling
- describes the likelihood of overstressing the hull structure when loading certain bulk cargoes

4.2.2 THE PRINCIPAL STRUCTURAL MEMBERS OF A SHIP

Textbooks: T15

Teaching aids: A1, A3, V23, V45, V46, V47, V51

Required performance:

SHIP CONSTRUCTION

The trainees should have a knowledge of the principal structural members of a ship and the proper names of the various parts. Their knowledge should be such that they are capable of intelligent observation during the ordinary course of their work and could make adequate reports describing the location and nature of faults or minor damage discovered.

2.1 Ship dimensions and form (12 hours)

- illustrates the general arrangement of the following ship types:
  - general cargo
  - oil, chemical and gas tankers
  - bulk carriers
  - combination carriers
  - container
  - RO-RO
  - passenger
- sketches an elevation and plan views of various ship types such as a general cargo ship, crude oil carrier, and bulker showing the arrangement and illustrate a general knowledge of the primary structural members and indicate the proper names for the various parts to include holds, engine-room, peak tanks, doublebottom tanks, hatchway, tween deck and position of bulkheads, cofferdams, pump-room, cargo tanks, slop tank and permanent ballast tanks:
  - camber
  - rise of floor
  - tumblehome
  - flare
  - sheer

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference

- rake
– parallel middle body
– entrance
– run
– defines:
  - forward perpendicular (FP)
  - after perpendicular (AP)
  - length between perpendiculars (LBP)
  - length on the waterline (LWL)
  - length overall (LOA)
  - base line
  - moulded depth, beam and draught
  - extreme depth, beam and draught

2.2 Ship stresses (8 hours)

- describes in qualitative terms shear force and bending moments
– explains what is meant by ‘hogging’ and by ‘sagging’ and distinguishes between them
- describes the loading conditions which give rise to hogging and sagging stresses
- describes how hogging and sagging stresses are caused by the sea state
– explains how hogging and sagging stresses result in tensile or compressive forces in the deck and bottom structure
- describes water pressure loads on the ship’s hull
– describes liquid pressure loading on the tank structures
– calculates the pressure at any depth below the liquid surface, given the density of the liquid
- describes qualitatively the stresses set up by liquid sloshing in a partly filled tank
- describes racking stress and its causes
– explains what is meant by ‘pounding’ or ‘slamming’ and states which part of the ship is affected
- explains what is meant by ‘panting’ and states which part of the ship is affected
- describes stresses caused by localized loading
– describes corrosion
– describes the causes of corrosion on board
– describes the various methods that are being used to minimize the effect of corrosion

(**Note:** The following knowledge is not required under part A, chapter III, table A-III/1 of the STCW Code. However, it is recommended that the trainee have basic knowledge of the following:)

2.3 Hull structure

- identifies structural components on ships’ plans and drawings:
  - frames, floors, transverse frames, deck beams, knees, brackets
  - shell plating, decks, tank top, stringers

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference

- bulkheads and stiffeners, pillars
- hatch girders and beams, coamings, bulwarks
- bow and stern framing, cant beams, breasthooks

- describes the types of materials that are used in the construction of a ship
– describes and illustrates standard steel sections:
  - flat plate
  - offset bulb plate
  - equal angle
  - unequal angle
  - channel
  - tee
- describes with aids of sketches the longitudinal, transverse and combined systems of framing on transverse sections of the ships
- sketches the arrangement of frames, webs and transverse members for each system
- illustrates double-bottom structure for longitudinal and transverse framing
– illustrates hold drainage systems and related structure
– illustrates a duct keel
– sketches the deck edge, showing attachment of sheer strake and stringer plate
– sketches a radiused sheer strake and attached structure
– describes the stress concentration in the deck round hatch openings
– explains compensation for loss of strength at hatch openings
– sketches a transverse section through a hatch coaming, showing the arrangement of coamings and deep webs
- sketches a hatch corner in plain view, showing the structural arrangements
– sketches deck-freeing arrangements, scuppers, freeing ports, open rails
– illustrates the connection of superstructures to the hull at the ship's side
– sketches a plane bulkhead, showing connections to deck, sides and double bottom and the arrangement of stiffeners
- sketches a corrugated bulkhead
– explains why transverse bulkheads have vertical corrugations and for-and-aft bulkheads have horizontal ones
- describes the purpose of bilge keels and how they are attached to the ship's side

2.4 Bow and stern regions

- describes the provisions of additional structural strength to withstand pounding
- describes and illustrates the structural arrangements forward to withstand panting
- describes the function of the stern frame
- describes and sketches a stern frame for a single-screw ship
- describes and illustrates the construction of a transom stern, showing the connections to the stern frame

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference

2.5 Fittings

- describes and sketches an arrangement of modern weather-deck mechanical steel hatches
- describes how watertightness is achieved at the coamings and cross joints
– describes the cleating arrangements for the hatch covers
– describes the arrangement of portable beams, wooden hatch covers and tarpaulins
- sketches an oiltight hatchcover
– describes roller, multi-angle, pedestal and Panama fairleads
– sketches mooring bitts, showing their attachment to the deck
– sketches typical forecastle mooring and anchoring arrangements, showing the leads of moorings
- describes the construction and attachment to the deck of tension winches and explains how they are used
- describes the anchor handling arrangements from hawse pipe to spurling pipe
– describes the construction of chain lockers and how the bitter-ends are secured in the lockers
- explains how to secure anchors and make spurling pipes watertight in preparation for a sea passage
- describes the construction and use of a cable stopper
– describes the construction of masts and Sampson posts and how they are supported at the base
- describes the construction of derricks and deck cranes
– describes the bilge piping system of a cargo ship
– states that each section is fitted with a screw-down non-return suction valve
– describes and sketches a bilge strum box
– describes a ballast system in a cargo ship
– describes the arrangement of a fire main and states what pumps may be used to pressurize it
- describes the provision of sounding pipes and sketches a sounding pipe arrangement
- describes the fitting of air pipes to ballast tanks or fuel oil tanks
– describes the arrangement of fittings and lashings for the carriage of containers on deck

2.6 Rudder and propellers

- describes the action of the rudder in steering a ship
- reproduces drawings of modern rudders: semi-balanced, balanced and spade
- explains the purpose of the rudder carrier and pintles
- explains how the weight of the rudder is supported by the rudder carrier
- describes the rudder trunk
- describes the arrangement of a watertight gland round the rudder stock
- explains the principle of screw propulsion
- describes a propeller and defines, with respect to:
  - boss
  - rake

COMPETENCE 4.2	Maintain the Seaworthiness of the Ship	IMO Reference
	- skew - face - back - tip - radius - pitch - compares fixed-pitch with controllable-pitch propellers – sketches the arrangement of an oil-lubricated sterntube and tailshaft – describes how the propeller is attached to the tailshaft – sketches a cross-section of a shaft tunnel for water cooled and oil cooled type – explains why the shaft tunnel must be of watertight construction and how water is prevented from entering the engine-room if the tunnel becomes flooded **2.7 Load lines and draught marks** - explains where the deck line is marked – defines ‘freeboard’ – explains what is meant by ‘assigned summer freeboard’ – draws to scale the load line mark and the load lines for a ship of a given summer moulded draught, displacement and tonnes per centimetre immersion in salt water - explains how the chart of zones, areas and seasonal periods is used to find the applicable load line - demonstrates how to read draughts – explains that the freeboard, measured from the upper edge of the deck line to the water on each side, is used to check that the ship is within its permitted limits of loading - lists the items in the conditions of assignment of freeboard – describes why the height of sill varies between different type of vessels based on Load Line Rules	

COMPETENCE 4.3	Prevent, Control and Fight Fires on Board	IMO Reference
TRAINING OUTCOMES:		
Demonstrates a knowledge and understanding of:		STCW Code section A-VI/3
4.3.1 FIRE PREVENTION		
4.3.2 ORGANIZING FIRE DRILLS		
4.3.3 CHEMISTRY OF FIRE		
4.3.4 FIREFIGHTING SYSTEMS		
4.3.5 ACTION TO BE TAKEN IN THE EVENT OF FIRE, INCLUDING FIRES INVOLVING OIL		
See IMO model course 2.03 and the requirements of STCW table A-VI/3 for Competence in advanced firefighting		STCW Code table A-VI/3

COMPETENCE 4.4	Operate Life-saving Appliances	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.4.1 ORGANIZING ABANDON SHIP DRILLS AND THE OPERATION OF SURVIVAL CRAFT AND RESCUE BOATS, THEIR LAUNCHING APPLIANCES AND ARRANGEMENTS,THEIR EQUIPMENT, INCLUDING RADIO LIFE-SAVING APPLIANCES, SATELIITE EPIRBs, SARTs, IMMERSION SUITS AND THERMAL PROTECTIVE AIDS 4.4.2 SURVIVAL AT SEA TECHNIQUES *See IMO model course 1.23, and the requirements of STCW table A-VI/2-1 for Competence in survival craft and rescue boats other than fast rescue boats*		STCW Code section A-VI/2 para 1-4 STCW Code table A-VI/2-1

COMPETENCE 4.5	Apply Medical First Aid on Board Ship	IMO Reference
TRAINING OUTCOME: Demonstrates a knowledge and understanding of: 4.5.1 PRACTICAL APPLICATION OF MEDICAL GUIDES AND ADVICE BY RADIO, INCLUDING THE ABILITY TO TAKE EFFECTIVE ACTION BASED ON SUCH KNOWLEDGE IN THE CASE OF ACCIDENTS OR ILLNESSES THAT ARE LIKELY TO OCCUR ON BOARD SHIP *See IMO model course 1.14 and the requirements of STCW table A-VI/4-1 for Proficiency in medical first aid*		STCW Code section A-VI/4 STCW Code table A-VI/4

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference
TRAINING OUTCOME: Demonstrates a knowledge and understanding of: 4.6.1 BASIC WORKING KNOWLEDGE OF THE RELEVANT IMO CONVENTIONS CONCERNING SAFETY OF LIFE AT SEA, SECURITY AND PROTECTION OF THE MARINE ENVIRONMENT		STCW Code table A-III/1 R1

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

4.6.1 BASIC WORKING KNOWLEDGE OF THE RELEVANT IMO CONVENTIONS CONCERNING SAFETY OF LIFE AT SEA, SECURITY AND PROTECTION OF THE MARINE ENVIRONMENT

Textbooks: T17

Teaching aids: A1, A3, V15, V17, V18, V19, V20, V21, V22, V24, V25, V26, V27, V28, V29, V30, V31, V32, V33, V34, V35, V36, V37, V38, V39, V40, V41, V42, V43, V44, V48, V49, V50, V52, V53, V54, V62

Required performance:

1.1 Introduction to Maritime Law (1 hour)

- states that maritime law is based partly on generally accepted customary rules developed over many years and partly on statute law enacted by states
- states that matters of safety, protection of the marine environment and conditions of employment are covered by statute law
- states that the main sources of maritime law are international conventions
- states that the adoption of international conventions and agreements is intended to provide uniform practice internationally
- states that a convention is a treaty between the States which have agreed to be bound by it to apply the principles contained in the convention within their sphere of jurisdiction
- states that, to implement a convention or other international agreement, a State must enact national legislation giving effect to and enforcing its provisions
- states that recommendations which are not internationally binding may be implemented by a State for ships flying its flag
- lists the main originators of international conventions concerned with maritime law are:
  - International Maritime Organization (IMO)
  - International Labour Organization (ILO)
  - Comite Maritime International (CMI)
  - United Nations
- describes:
  - flag State jurisdiction
  - coastal State jurisdiction
  - port State jurisdiction
- describes main elements of relevant IMO Conventions, e.g. SOLAS, MARPOL and STCW
- explains the significance of the ‘no more favourable treatment’ clause in the SOLAS, MARPOL, STCW and ILO Minimum Standards in Merchant Ships Conventions
- distinguishes between private and public international law
- explains that public maritime law is enforced through:
  - surveys, inspection and certification
  - penal sanctions (fines, imprisonment)
  - administrative procedures (inspection of certificates and records, detention)
- states that the operation of a ship is governed by the national laws and regulations of the flag State, including those laws and regulations giving effect to international conventions

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

– states that differences of detail usually exist in the national laws of different states implementing the same convention

- states that, when serving in a ship flying a foreign flag, it is essential that the master and chief mate familiarize themselves with the laws and regulations of the flag State
- states that, when in port, a ship must also comply with the appropriate laws and regulations of the port State
- describes the importance of keeping up to date with developments in new and amended legislation

1.2 Law of the Sea (4 hours)

- Conventions on the Law of the Sea
- Territorial Sea and the Contiguous Zone
- International Straits
- Exclusive Economic Zone and Continental Shelf
- High Seas
- Protection and Preservation of the Marine Environment

1.3 Safety (27 hours)

International Convention on Load Lines, 1966 (LL 1966), as amended

- states that no ship to which the Convention applies may proceed to sea on an international voyage unless it has been surveyed, marked and provided with an international Load Line Certificate (1966) or an international Load Line Exemption Certificate, if appropriate
- explains to which ships the Convention applies

– describes the duration of validity of an International Load Line Certificate (1966)

– explains the circumstances in which an International Load Line Certificate (1966) would be cancelled by the Administration

- stales the control to which ships holding an international Load Line Certificate (1966) are subject when in the ports of other Contracting Governments
- describes for the purposes of the Regulations concerning:
  - freeboard
  - freeboard deck
  - superstructure
- describes the position, dimensions and marking of:
  - the deck line
  - the Load Line Mark
  - lines to be used with the Load Line Mark
- states that the circle lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground and that they should be permanently marked on the sides of the ship
- states that the international Load Line Certificate (1966) will not be delivered to a ship until the surveyor has certified that the marks are correctly and permanently indicated on the ship's sides
- describes the requirements concerning the provision of closing appliances for ventilators

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

– states that means, permanently attached, should be provided for closing the openings of air pipes to ballast tanks and other tanks
- describes the provisions for the protection of the crew
- states that deck cargo should be so stowed as to allow for the closing of openings giving access to crew's quarters, machinery space and other parts used in the necessary work of the ship

Code of Safe Working Practices for Merchant Seamen

- explains that this Code of Safe Working Practices or its equivalent is intended primarily for merchant seamen
- explains that there should always be an adequate number of copies to allow the Master, Safety Officer and any members of the Safety Committee to have their own, leaving at least one available for general reference
- explains that this Code is addressed to everyone on a ship regardless of rank or rating because the recommendations can be effective only if they are understood by all and if all cooperate in their implementation
- explains that the Code is arranged in sections which deal with broad areas of concern
- states that the introduction gives the regulatory framework for health and safety on board ships and overall safety responsibilities under that framework
- states that Section 1 is largely concerned with safety management and the statutory duties underlying the advice in the remainder of the Code. All working on board are required to be aware of these duties and of the principles governing the guidance on safe practice which they are required to follow
- states that Section 2 begins with a chapter setting out the areas that should be covered in introducing a new recruit to the safety procedures on board. It goes on to explain what individuals can do to improve their personal health and safety
- states that Section 3 is concerned with various working practices common to all ships
- states that Section 4 covers safety for specialist ship operation

– outlines and describes the contents of the COSWP for merchant seaman
– describes safe working practices and personal shipboard safety including:
  - working aloft
  – working over the side
  – working in enclosed spaces
  – permit to work systems such as:
    - hot work permit
    - cold work permit
    - entry in enclosed space pemit
    - working aloft permit
    - working overside permit
    - electrical isolation permit
  - line handling
  – lifting techniques and methods of preventing back injury
  – electrical safety
  – mechanical safety

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference
	– chemical and biohazard safety - personal safety equipment - describes the role of a safety officer - explains the topics discussed in the safety committee meeting - explains the importance of personal health and hygiene on board - describes the use of: - portable O_2 analysers - explosimeter - multi gas detectors - other portable gas measuring instruments	
	International Convention for the Safety of Life at Sea, 1974 as amended (SOLAS) - General Provisions - states that unless expressly provided otherwise, the regulations apply only to ships engaged on international voyages - defines 'international voyage' – defines: - passenger - passenger ship - cargo ship - tanker - age of a ship - explains who may carry out surveys for the enforcement of the provisions of SOLAS - describes the powers of a nominated surveyor – describes the procedures which apply if the surveyor finds that the ship does not comply with the provisions or is in such a condition that it is not fit to proceed to sea without danger to the ship or to persons on board - lists the surveys to which a passenger ship must be subjected – describes the extent of the surveys of passenger ships – describes the requirements for surveys of life-saving appliances and other equipment of cargo ships, including mandatory annual surveys - describes the requirements for surveys of radio and radar installations of cargo ships - describes the requirements for surveys of hull, and their extent, machinery and equipment of cargo ships, including mandatory annual surveys - describes the extent of the surveys of hull, machinery and other equipment of cargo ships - states that the condition of the ship and its equipment must be maintained to conform with the provisions of the regulations - states that after any survey of a ship required by SOLAS, no change should be made in the structural arrangements, machinery, equipment or other items covered by the survey without the sanction of the Administration - states that any accident to a ship or defect affecting the safety of the ship or the efficiency or completeness of the life-saving appliances or equipment should be reported to the Administration or organization responsible for issuing the relevant certificate, who will decide whether a survey is required	R2

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference
	– lists the surveys and their extent to which a passenger ship must be subjected – states that an accident or defect should also be immediately reported, by the master or owner, to the appropriate authorities of the port State when the ship is in a port of another Party to the SOLAS Convention - lists the certificates, including attachments and supplements, where appropriate, issued after survey to ships satisfying the requirements of SOLAS - states the period of validity of each of the certificates – states that no Exemption Certificate is not valid for longer than the period of validity of the certificate to which it refers - states that no extension of the five-year period of validity of the Cargo Ship Safety Construction Certificate is permitted - explains the circumstances under which other certificates may be extended and states the maximum extension permitted - describes the circumstances in which certificates cease to be valid – states that all certificates or certified copies of them should be posted up in a prominent and accessible place in the ship - states that certificates issued under the authority of a contracting Government should be accepted by other contracting Governments - states that a ship in the port of another Party is subject to control by officers authorized by that Government so far as verifying that the SOLAS Convention certificates are valid - describes the procedures which may be followed by officers authorized by a port State in exercising control regarding SOLAS Convention Certificates or Load Line Convention Certificates - states that the surveyor should also take into account the requirements of SOLAS reg. V/13 that all ships should be sufficiently and efficiently manned - states that, at the conclusion of a control exercise the master should be provided with a document giving the results of the control exercise and details of any action taken - states that Parties to the Protocol of 1978 to the SOLAS Convention, 1974, should apply the requirements of the Convention and Protocol as may be necessary to ensure that no more favourable treatment is given to ships of non-parties to the Convention and Protocol **SOLAS - Subdivision and Stability, Machinery and Electrical Installation** - defines, with reference to chapter II-1: - subdivision load line - deepest subdivision load line - length - breadth - draught - bulkhead deck - margin line - permeability of a space - machinery space - passenger spaces - watertight	R2

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

– explains what is meant by ‘floodable length’
– explains what is meant by ‘factor of subdivision’
– explains the application of the factor of subdivision to a passenger ship’s ability to withstand the flooding of adjacent main compartments
- describes the requirements regarding unsymmetrical flooding
– states that the master should be supplied with suitable information concerning the use of cross-flooding fittings
- describes the final conditions of the ship after assumed critical damage
– states that the master should be supplied with the data necessary to maintain sufficient intact stability under service conditions to enable the ship to withstand the critical damage
- states that the conditions of stability on which the calculations of heel are based should be supplied to the master of the ship
- states that excessive heeling might result should the ship sustain damage when in a less favourable condition
- states that water ballast should not in general be carried in tanks intended for oil fuel and describes the arrangement for ships which cannot avoid putting water in oil fuel tanks
- describes the marking of subdivision load lines on passenger ships
– states that details of the subdivision load lines assigned and the conditions of service for which they are approved should be clearly indicated on the Passenger Ship Safety Certificate
- states that a ship should not be loaded so as to submerge the load line mark appropriate to the season and locality, as determined in accordance with the international Convention on Load Lines, whatever the position of the subdivision load line marks may be
- states that a ship should not be loaded so as to submerge the subdivision load line mark appropriate to the particular voyage and condition of service
- classifies watertight doors as:
  - class 1 - hinged doors
  - class 2 - hand-operated sliding doors
  - class 3 - sliding doors which are power-operated as well as hand-operated
- describes the provisions regarding the fitting of watertight doors in passenger ships
- states that watertight doors in bulkheads dividing cargo between deck spaces must be closed before the voyage commences and must be kept closed during navigation
- states that the time of opening between-deck doors in port and the time of closing them before leaving port should be entered in the logbook
- states that all watertight doors should be kept closed during navigation except when necessarily opened for the working of the ship, in which case they should always be ready to be immediately closed
- states that in passenger ships carrying goods vehicles and accompanying personnel indicators are required on the navigating bridge to show automatically when each door between cargo spaces is closed and all door fastenings are secured

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference
	– states that sidescuttles the sills of which are below the margin line, should be of such construction as will effectively prevent any person opening them without the consent of the master - states that certain sidescuttles in between-deck spaces must be closed watertight and locked before the ship leaves port and must not be opened before arrival at the next port - describes the requirements for deadlights – states that sidescuttles and deadlights which will not be accessible during navigation must be closed and secured before the ship leaves port - states that the closing and locking of sidescuttles and deadlights in spaces used alternatively for the carriage of passengers or cargo should be recorded in a logbook when carrying cargo - states the requirements for the closure of cargo loading doors in passenger ships - describes the requirements for drills, operation and inspection of watertight doors and other openings in passenger ships - states that valves, doors and mechanisms should be suitably marked to ensure that they may be properly used to provide maximum safety - lists the entries which should be made in the logbook regarding the opening and closing of doors, sidescuttles and other openings and the drills and inspections required by the regulations - states that every passenger ship and every cargo ship of 24 metres and upwards must be inclined upon its completion and the elements of its stability determined - states that the master should be supplied with such information as is necessary to obtain accurate guidance as to the stability of the ship under varying conditions of service - describes the contents of damage control plans for passenger ships – states that booklets containing the damage control information should be made available to the ship's officers - describes the recommendations on damage control for dry cargo ships – describes the indicator system which must be provided on the navigating bridge of passenger ro-ro ships to show if shell doors, loading doors and other closing appliances are not fully closed or not secured - states the requirements for the detection of water leakage through shell doors or vehicle loading doors which could lead to major flooding of special category spaces or ro-ro cargo spaces - states the requirements for ro-ro cargo spaces to be monitored whilst the ship is under way	

	SOLAS - Fire Protection, Fire Detection and Fire Extinction
	- outlines the basic principles of the regulations on fire protection
	- explains briefly the properties of class 'A' and class 'B' divisions
	- defines:
	  - main vertical zones
	  - accommodation spaces
	  - public spaces
	  - service spaces
		R2

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference
	– cargo spaces - ro-ro cargo spaces, open and closed - special category spaces - machinery spaces of category A - control stations - states that fire hoses should be used only for the purposes of extinguishing fires or testing the apparatus at fire drills and surveys - outlines the content of the SOLAS training manual and maintenance manual – describes the information included in fire control plans or booklets – states that instructions concerning the maintenance and operation of all fire-fighting equipment and installations on board should be kept under one cover in an accessible position - states that a duplicate set of fire control plans or booklet should be permanently stored in a prominently marked weathertight enclosure outside the deckhouse for the assistance of shoreside fire-fighting personnel - states that all fire-extinguishing appliances must be kept in good order and available for immediate use at all times during the voyage - states that passenger ships must at all times when at sea, or in port , be so manned or equipped that any initial fire alarm is immediately received by a responsible member of the crew - states that a special alarm, operated from the navigating bridge or from the fire control station, should be fitted to summon the crew and should be capable of being sounded independently of the alarm to the passenger spaces - states that an efficient patrol system must be maintained for ships carrying more than 36 passengers - describes the training required by the fire patrol – states that there are special requirements for ships carrying dangerous goods – states that a ship should have a document provided by the Administration as evidence of compliance of construction and equipment with the requirements for the carriage of dangerous goods	
	SOLAS - Life-Saving Appliances and Arrangements	R2, R11
	- defines with reference to chapter III of SOLAS - certificated person - float-free launching - inflatable appliance - inflated appliance - launching appliance or arrangement - rescue boat - survival craft - states that life-saving appliances and arrangements required by chapter III of SOLAS must be approved by the Administration - states the requirements for exhibiting muster lists – describes the illustrations and instructions to be displayed in passenger cabins and other spaces - lists the items to be included in muster lists and emergency instructions – describes the provision of operating instructions for life-saving appliances	

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference
	– explains how the crew should be assigned to survival craft to ensure satisfactory manning and supervision of survival craft - states that the person in charge of a survival craft should have a list of its crew and should see that they are acquainted with their duties - states the requirement for the provision of training manuals – lists the items which should be contained in the training manuals – lists the items which should be contained in the maintenance manual – describes the frequency of abandon ship drills and fire drills and how they should be conducted - describes the guidelines for training crews for the purpose of launching lifeboats and rescue boats from ships making headway through the water - describes the on-board training which should be given in the use of life-saving appliances and in survival at sea - details the records which should be made of abandon ship drills and fire drills, other drills of life-saving appliances and on-board training - states that before leaving port and at all times during the voyage, all life-saving appliances must be in working order and ready for immediate use - describes the instructions for on-board maintenance of life-saving appliances which should be carried - describes the regulation regarding the maintenance of falls – describes the weekly and monthly tests and inspections required and the entries which should be made in the logbook - describes the requirements regarding the periodic servicing of inflatable liferafts, inflatable lifejackets, inflated rescue boats and hydrostatic release gear - describes the requirements for passenger muster stations – states that, on passenger ships, an abandon ship drill and a fire drill must take place weekly **SOLAS - Carriage of Grain** - lists the intact stability requirements for a ship carrying bulk - lists the contents of the grain loading information referred to in the document of authorization **SOLAS - Carriage of Dangerous Goods** - states that the regulations concerning the carriage of dangerous goods in packaged form or in solid bulk form apply to all ships to which the SOLAS regulations apply and to cargo ships of less than 500 gross tons - states that the provisions do not apply to ships' stores and equipment - states that the carriage of dangerous goods is prohibited except in accordance with the provisions of the regulations - states that the provisions should be supplemented by detailed instructions on safe packaging and stowage, which should include the precautions necessary in relations to other cargo, issued by each Contracting Government - classifies dangerous goods according to the IMDG Code - states that the correct technical name of goods, and not trade names, should be used in all documents relating to the carriage of dangerous goods	R2

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

– states that the documents prepared by the shipper should include or be accompanied by a signed certificate or declaration that the shipment offered for carriage is properly packaged and marked and in proper condition for carriage

- states the requirements for a special list or manifest of dangerous goods on board and their location or a detailed stowage plan showing the same information
- outlines the stowage requirements for dangerous goods

– states that substances which are liable to spontaneous heating or combustion should not be carried unless adequate precautions have been taken to minimize the likelihood of the outbreak of fire

- lists the explosives which may be carried in a passenger ship

– defines:
  - International Bulk Chemical Code (IBC Code)
  - chemical tanker

- states that the regulations apply to chemical tankers constructed on or after 1 July 1986, including those of less than 500 gross tons
- states that a chemical tanker must comply with the survey requirements for a cargo ship and, in addition, be surveyed and certified as provided for in the IBC Code
- states that the IBC Code prescribes the design and construction standards of such ships, the equipment they should carry and marine pollution aspects
- states that the requirements of the IBC Code are mandatory and subject to port State control
- defines:
  - International Gas Carrier Code (IGC Code)
  - gas carrier

1.4 International Ship and Port Facility Security Code (ISPS Code)

- describes that the International Ship and Port Facility Security Code (ISPS Code) is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port facilities in the wake of the 9/11 attacks in the United States
- explains that the ISPS Code is implemented through chapter XI-2 Special measures to enhance maritime security in the International Convention for the Safety of Life at Sea (SOLAS)
- explains that the Code has two parts, one mandatory and one recommendatory
- explains that the purpose of the Code is to provide a standardized, consistent framework for evaluating risk, enabling Governments to offset changes in threat with changes in vulnerability for ships and port facilities through determination of appropriate security levels and corresponding security measures
- explains that the ISPS Code is part of SOLAS so compliance is mandatory for the 148 Contracting Parties to SOLAS

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

– explains that International Code for the Security of Ships and Port Facilities contains mandatory provisions to which reference is made in chapter XI-2 of the International Convention for the Safety of Life at Sea, 1974 as amended

- describes the objectives of the ISPS Code

– defines Ship security plan as a plan developed to ensure the application of measures on board the ship designed to protect persons on board, cargo, cargo transport units, ship's stores or the ship from the risks of a security incident

- defines Company security officer as the person designated by the Company for ensuring that a ship security assessment is carried out; that a ship security plan is developed, submitted for approval, and thereafter implemented and maintained and for liaison with port facility security officers and the ship security officer
- defines Security level 1 as the level for which minimum appropriate protective security measures shall be maintained at all times
- defines Security level 2 as the level for which appropriate additional protective security measures shall be maintained for a period of time as a result of heightened risk of a security incident
- defines Security level 3 as the level for which further specific protective security measures shall be maintained for a limited period of time when a security incident is probable or imminent, although it may not be possible to identify the specific target
- explains that a ship that is compliant to the ISPS Code should have an International Ship Security Certificate (ISSC)
- explains that the Declaration of Security addresses the security requirements that could be shared between a port facility and a ship (or between ships) and shall state the responsibility for each
- explains that contracting Governments shall determine when a Declaration of Security is required by assessing the risk the ship/port interface or ship to ship activity poses to persons, property or the environment
- outlines that a ship can request completion of a Declaration of Security when:
  1. the ship is operating at a higher security level than the port facility or another ship it is interfacing with;
  2. there is an agreement on a Declaration of Security between Contracting Governments covering certain international voyages or specific ships on those voyages;
  3. there has been a security threat or a security incident involving the ship or involving the port facility, as applicable;
  4. the ship is at a port which is not required to have and implement an approved port facility security plan; or
  5. the ship is conducting ship to ship activities with another ship not required to have and implement an approved ship security plan
- explains that the Declaration of Security shall be completed by:
  1. the master or the ship security officer on behalf of the ship(s); and, if appropriate,
  2. the port facility security officer or, if the Contracting Government determines otherwise, by any other body responsible for shore-side security, on behalf of the port facility

COMPETENCE 4.6	Monitor Compliance with Legislative Requirements	IMO Reference

– explains that each ship shall carry on board a ship security plan approved by the Administration

- lists that the ship security plan addresses, at least, the following:
  1. measures designed to prevent weapons, dangerous substances and devices intended for use against persons, ships or ports and the carriage of which is not authorized from being taken on board the ship;
  2. identification of the restricted areas and measures for the prevention of unauthorized access to them;
  3. measures for the prevention of unauthorized access to the ship;
  4. procedures for responding to security threats or breaches of security, including provisions for maintaining critical operations of the ship or ship/ port interface;
  5. procedures for responding to any security instructions Contracting Governments may give at Security level 3;
  6. procedures for evacuation in case of security threats or breaches of security;
  7. duties of shipboard personnel assigned security responsibilities and of other shipboard personnel on security aspects;
  8. procedures for auditing the security activities;
  9. procedures for training, drills and exercises associated with the plan;
  10. procedures for interfacing with port facility security activities;
  11. procedures for the periodic review of the plan and for updating;
  12. procedures for reporting security incidents;
  13. identification of the ship security officer;
  14. identification of the company security officer including 24-hour contact details;
  15. procedures to ensure the inspection, testing, calibration and maintenance of any security equipment provided on board;
  16. frequency for testing or calibration of any security equipment provided on board;
  17. identification of the locations where the ship security alert system activation points are provided; and
  18. procedures, instructions and guidance on the use of the ship security alert system, including the testing, activation, deactivation and resetting and to limit false alert
- explains the role of Ship Security Alert System (SSAS) is to raise the alarm ashore in reaction to security threats or security incidents by notifying the flag State of the ship without alerting ships or coastal States in the vicinity or giving any indication on board
- explains that the use of the ship security alert system is a recognition that security is political and requires different response to a distress or emergency situation on board
- explains that operation of AIS in certain sea areas would cause security concern because information broadcast through AIS could be collected by pirates or terrorists
- explains that because of this concern, the last Assembly adopted resolution A956(23) ship masters are allowed to switch off the AIS in specific areas where threat of attack by pirates or terrorists are imminent

COMPETENCE 4.7	Application of Leadership and Teamworking Skills	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of: 4.7.1 SHIPBOARD PERSONNEL MANAGEMENT AND TRAINING 4.7.2 RELATED INTERNATIONAL CONVENTIONS AND RECOMMENDATIONS, AND NATIONAL LEGISLATION .1 Maritime Labour Convention (MLC) 2006 (2 hours) 4.7.3 APPLICATION OF TASK AND WORKLOAD MANAGEMENT 4.7.4 EFFECTIVE RESOURCE MANAGEMENT 4.7.5 DECISION-MAKING TECHNIQUES *See IMO model course 1.39 on Leadership and teamwork*		STCW Code table A-III/1

COMPETENCE 4.8	Contribute to the Safety of Personnel and Ship	IMO Reference
TRAINING OUTCOMES: Demonstrates a knowledge and understanding of:		STCW Code section A-VI/1 para 2
4.8.1 KNOWLEDGE OF PERSONNEL SURVIVAL TECHNIQUES *See IMO model course 1.19, and the requirements of STCW Code table A-VI/1-1 for Competence in personal survival techniques*		STCW Code table A-VI/1-1
4.8.2 knOWLEDGE OF FIRE PREVENTION AND THE ABILITY TO DISTINGUISH AND FIGHT FIRES *See IMO model course 1.20, and the requirements of STCW Code table A-VI/1-2 for Competence in fire prevention and fire fighting*		STCW Code table A-VI/1-2
4.8.3 KNOWLEDGE OF ELEMENTARY FIRST AID *See IMO model course 1.13, and the requirements of STCW Code table A-VI/1-3 for Competence in elementary first aid*		STCW Code table A-VI/1-3
4.8.4 KNOWLEDGE OF PERSONAL SAFETY AND SOCIAL RESPONSIBILITIES *See IMO model course 1.21, and the requirements of STCW Code table A-VI/1-4 for Competence in personal safety and social responsibility*		STCW Code table A-VI/1-4

Part D4: Instructor Manual

The following notes are intended to highlight the main objectives or training outcomes of each part of the function. The notes also contain some material on topics which are not adequately covered in the quoted references.

Trainees will be aware of the need and the practical measures required by law to prevent pollution of the environment. They will understand the requirements of MARPOL 73/78, (R3) the technical annexes, control of oil from machinery spaces and the Oil Record Book.

Function 4: Controlling the Operation of the Ship and Care for Persons on Board at the Operational Level

On completion of training for this function trainees will be able to use plans and tables or diagrams of stability and trim data to calculate the ship's initial stability, draughts and trim for any given disposition of cargo and other weights. They will also be able to determine whether stresses on the ship are within permitted limits by the use of stress data, calculating equipment or software. The fundamental actions to take in the event of partial loss of intact buoyancy will be understood.

They will have knowledge of the principal structural members of a ship and the proper names of the various parts.

Training concerned with Advanced training in firefighting is covered in IMO model course 2.03.

Training concerned with Proficiency in survival craft and rescue boats other than fast rescue boats is covered in IMO model course 1.23.

Training concerned with Proficiency in medical first aid on board ship is covered in IMO model course 1.14.

4.1 ENSURE COMPLIANCE WITH POLLUTION PREVENTION REQUIREMENTS

4.1.1 PRECAUTIONS TO BE TAKEN TO PREVENT POLLUTION OF THE MARINE ENVIRONMENT

In implementing this section of the course, the instructor should bear in mind that any officer of the watch aboard tankers will have completed a tanker familiarization course which should include the relevant requirements on pollution prevention related to tanker operations. Additional specialized instruction for service aboard tank vessels may be required as specified in chapter V of the STCW Code. This section is intended to provide an outline knowledge of the MARPOL Convention. In the following sections, detailed treatment should be confined to those requirements of the Convention which apply to all ships.

MARPOL technical annexes

The annexes set out the rules for the construction and equipment of ships and for ships' operations which may result in marine pollution.

4.1.2 ANTI-POLLUTION PROCEDURES AND ASSOCIATED EQUIPMENT

Annex I

Oil is defined in Annex I as any mineral oil and includes petrochemical products other than those listed in Annex II.

Compliance with construction and equipment requirements is enforced through the International Oil Pollution Prevention (IOPP) Certificate and regular surveys to ensure that the ship continues to comply with the requirements of the certificate. Port States verify that a ship has a certificate and may, if necessary, carry out a survey and demand rectification of deficiencies. The port State also inspects the Oil Record Book to check that the ship is adhering to the required operating procedures. Coastal States may enforce Annex I by regular air patrols which keep a watch for oil slicks.

Control of oil from machinery spaces

Waste oil is generated in lubricating oil and fuel oil purifiers. Under Annex I, discharge of this sludge into the sea is not permitted.

Oil and water leakages in machinery spaces give rise to oil and water mixtures in bilges which have to be disposed of from time to time to prevent them becoming a fire or stability hazard. Many ships have bilge-water holding tanks to enable bilges to be kept clean and dry in port. The contents of the tank can then be discharged at sea, using a separator. The separated oil is dealt with in the same way as other waste oil. The need to retain this on board until arrangements can be made for disposal requires the provision of a tank for oil residues. Annex I makes provision for this.

The equipment required for machinery spaces is set out in the regulations. The discharge provisions are similarly governed.

Oil Record Book (Part I, Machinery space operations)

The requirements for keeping records and the form of the Oil Record Book are set out in the relevant regulations.

Precautions which should be taken to prevent accidental pollution by oil

Officers who are to serve in oil, chemical or gas tankers will undertake specialized courses which include pollution prevention precautions applicable to those specialized ships. The precautions in this section apply to bunkering and the discharge of oily wastes, which are operations common to all ships, and are similar to those to be taken when loading or discharging an oil cargo (V6).

Sewage

Under Annex IV ships are not permitted to discharge sewage within four miles of the nearest land, unless they have in operation an approved treatment plant. Between 4 and 12 miles from land, sewage must be comminuted and disinfected before discharge.

4.1.3 IMPORTANCE OF PROACTIVE MEASURES TO PROTECT THE MARINE ENVIRONMENT

Importance of proactive measures to protect the marine environment encourages engineer officers to observe regulations concerned in the actual tasks on board ships which give direct impacts on the marine environment. Trainees, therefore, need to learn that careful treatment of pollution substances is strictly required.

4.2 MAINTAIN THE SEAWORTHINESS OF THE SHIP

4.2.1 STABILITY, TRIM AND STRESS TABLES

A ship's hydrostatic information is given for the even keel condition, so the true mean draught should be used to enter the tables or graphs. Since a ship is rarely on an even keel when draughts are read, either a calculation to correct the arithmetical mean draught must be made or the arithmetical mean draught may be used as an approximation.

Unless trim angles are excessive, the errors resulting from using arithmetical mean draught are small. In cases where complex accuracy is essential, draught surveys for example, the calculations would not be left to the officer of the watch. For the purposes of this course the arithmetical mean draught may be used when working with hydrostatic curves or tables. Data suitable for the preparation of exercises are contained in the Annex to these guidance notes.

Displacement

Archimedes' law and the principles of flotation should have been covered in physical science before starting this subject.

Buoyancy

Buoyancy in general should have been covered in physical science. The concept of reserve buoyancy and its importance to the safety of the ship should be emphasized.

Fresh water allowance

This should be developed by considering the relationship between buoyancy and water density. Calculations on box-shaped vessels can be used to show how the TPC for fresh water or dock water is related to the tabulated value for seawater.

Statical stability

This section introduces the lever GZ as the horizontal separation between the equal and opposite forces through G and B. The tendency for a stable ship to return to the upright is shown to depend upon the resulting couple.

Initial stability

The transverse metacentre is introduced and the way in which GZ is related to the metacentric height for small angles of heel is derived. A comparison of the behaviour of stiff and tender

ships in a seaway is included. A floating model can be used to demonstrate the effect on rolling period.

Angle of loll

The fact that an initial capsizing moment results if G is above M is to be shown. It may be possible to show an angle of loll by using a floating model although it is difficult to avoid large angles of list, due to slight displacement of the model's centre of gravity, confusing the experiment. Even so, the experiment demonstrates the unsatisfactory condition of a ship with a GM of nearly zero.

Curves of statical stability

Trainees should construct some curves of statical stability, using KN curves and given values of KG, including a curve for a ship with a negative GM.

Movement of the centre of gravity

Trainees should be able to deduce that adding masses above, or removing masses below, the original centre of gravity causes an increase in KG. Both processes can occur during a passage as water is absorbed by deck cargo and fuel is consumed from double-bottom tanks.

When dealing with the point of suspension, point out that lowering or raising the weight has no effect on the ship's centre of gravity. Only movement of the point of suspension, where the weight is acting, has any effect on KG.

List and its correction

Trainees should be reminded that the equation for angle of list applies only for small angles of list, up to about 10, for which the position of M can be taken as fixed.

Effect of slack tanks

It should be pointed out that any free liquid surface, such as water trapped on the weather deck or water used for fire fighting, will cause a similar increase in the value of KG.

Trim

The calculation of trim and final draughts after large changes in deadweight is not included. The lecturer should explain why trim tables should not be used for large changes in deadweight. The theory behind a vessel's change in trim due to a change in water density may also be covered.

In tankers and bulk carriers, the quantity and disposition of cargo is often similar to that of a previous loading. When planning the loading of such a cargo, the final draughts and trim can be obtained by making the necessary small adjustments to the actual draughts recorded for the previous cargo.

Actions to be taken in the event of a partial loss of intact buoyancy

The immediate actions which should be taken by the officer in charge of the watch are aimed at limiting the volume of lost buoyancy to the minimum. At the same time, if cross-flooding arrangements are required, they should be put into operation immediately to restrict the angle of list. Whether anything can be done to stop or reduce the inflow of water will depend upon the circumstances. In the event of loss of buoyancy due to damage to a hatch cover, a prompt reduction in speed or alteration of course, or both, may be effective.

4.2.2 SHIP CONSTRUCTION

The trainees should have knowledge of the principal structural members of a ship and the proper names of the various parts. Their knowledge should be such that they are capable of intelligent observation during the ordinary course of their work and can make adequate reports describing the location and nature of faults or minor damage discovered.

Ship dimensions and form

Particulars of constructional details of the various ship types are not intended. A knowledge of the general arrangement of various ship types is also applicable to other areas, such as cargo work and pollution prevention.

Ship stresses

A mathematical treatment of shear force and bending moments is not required at this stage. A qualitative description to explain the forces which the ship must be designed to withstand and the parts mainly involved in resisting them is needed.

When dealing with liquid pressure in tanks, attention should be drawn to the high forces on tank tops resulting from filling tanks until there is a head of liquid in air pipes and sounding pipes.

Hull structure

This section deals with the main structure of the hull, the names of the principal parts and how they are connected. Models and three-dimensional drawings are valuable aids to understanding the various connections and stiffening arrangements shown on the usual plan and elevation drawings.

Bow and stern

Details of construction have been limited to the transom stern since that is the commonest construction at present.

Fittings

The closing of hatches with wooden covers and tarpaulins has been included because there are still a number of older ships with that arrangement or a similar one using pontoon covers.

When dealing with bilge or ballast piping systems, show how the non-return valves are placed to prevent flooding of adjacent spaces through fractured pipelines. When dry cargo is carried in deep tanks, the ballast lines have blanks fitted to prevent accidental filling of the tanks. A similar arrangement is provided in cargo holds which are connected to the ballast system.

Rudders and propellers

Knowledge of the method of operation of controllable-pitch propellers is not required. Trainees should be aware that the amount and direction of thrust are controlled by altering the pitch of the propeller. They should also realize that when going astern a controllable-pitch propeller acts as an opposite-handed propeller to when going ahead. Many controllablepitch propellers are made left-handed going ahead so that they behave in the same way as the usual right-handed propellers when acting astern.

Load lines and draught marks

It is not intended that trainees should know how the summer freeboard is assigned. They should know that it is the minimum freeboard permitted when loading in seawater in a summer zone and that it is assigned to the ship by, or on behalf of, the Administration in accordance with the Load Line Regulations. They should also know that the load line mark is placed at that distance below the deck line.

It should be impressed upon trainees that, when loading to the minimum permitted freeboard, checks should be made of the actual freeboard amidships on each side. Even a barely perceptible list can produce a difference of several centimetres in the readings from opposite sides.

4.3 PREVENT, CONTROL AND FIGHT FIRES ON BOARD

The requirements of the STCW Convention are covered by IMO model course, Basic firefighting. That course is based on the recommendations set out in IMO Assembly resolution and the IMO/ILO Document for Guidance (R28).

Trainees should undertake this course as soon as possible in their career, preferably during the pre-sea stage at a shore-based establishment.

IMO Assembly resolution states “Masters, officers and as far as practicable key personnel who may wish to control firefighting operations should have advanced training in techniques for fighting fire with particular emphasis on organization, tactics and command”.

IMO model course 2.03, Advanced training in firefighting is suitable for this purpose and Administrations may wish this course to be completed before trainees qualify as officer in charge of a watch.

4.4 OPERATE LIFE-SAVING APPLIANCES

The requirements of the STCW Convention are fully covered by IMO model course 1.23, Proficiency in survival craft and rescue boats other than fast rescue boats, which is based on the requirements of the STCW Convention. Trainees who have successfully completed that

course and have been issued with a certificate of proficiency in survival craft have demonstrated the ability and knowledge necessary to satisfy the requirements of the regulations.

4.5 APPLY MEDICAL FIRST AID ON BOARD SHIP

The requirements of the STCW Convention are covered by IMO model course 1.14.

4.6 MONITOR COMPLIANCE WITH LEGISLATIVE REQUIREMENTS

4.6.1 BASIC WORKING KNOWLEDGE OF THE RELEVANT IMO CONVENTIONS CONCERNING SAFETY OF LIFE AT SEA, SECURITY AND PROTECTION OF THE MARINE ENVIRONMENT

The extent and depth of knowledge required of the IMO Conventions and implementation by flag state law is greater than was required by the 1978 Convention. A working knowledge of IMO Conventions concerning safety of life and protection of the marine environment is required. This includes Load Line, Tonnage, PAL, STP, SOLAS, MARPOL, STCW and ILO Minimum Standards in Merchant Ships Conventions. A knowledge of UNCLOS and international maritime law is also required.

Relatively new additions to maritime law should be noted including the ISM Code (incorporated as chapter IX of SOLAS, Management for the safe operation of ships); MARPOL 73/78 Annex I, regulation 26 that requires every oil tanker of 150 GT and above and every ship other than a tanker of 400gt and above to have a shipboard oil pollution emergency plan and amendments to MARPOL Annex V that require garbage management plans to be in place.

Introduction to maritime law

Maritime questions are not confined to one country and therefore maritime law has always had an international bias. Historically, customary codes recognized in several countries were applied by the courts. In more recent years their place has been taken by international conventions, which are given force by national legislation enacted by the contracting States. Most maritime law is now statute law, particularly in the areas of safety and prevention of pollution.

Jurisdiction in public international law has been designed to allocate and delimit national sovereign powers. Each State has the right to legislate and enforce legislation on its own territory, subject to respecting other States' sovereignty and international law.

Ships spend much time on the high seas, over which no one has sovereignty, but these are treated as extensions of the flag State, which should exercise its jurisdiction and control in administrative, technical and social matters. The flag State has exclusive jurisdiction over those matters on the high seas. This is referred to as flag State jurisdiction. In general, international conventions specify the rights and duties of the flag State so that a State accepting a convention must enact legislation applicable to its own ships to give it the powers to enforce the provisions of the convention.

A State's power to control the activities of foreign ships in its territorial waters and contiguous zone is called coastal State jurisdiction. For example, a State may enforce rules regarding

traffic separation schemes and anti-pollution measures within its territorial waters. The International Convention Relating to Intervention on the High Seas in Cases of Oil Pollution Casualties, 1969, gives a coastal State powers to take action in respect of a foreign ship on the high seas in special circumstances.

Port State jurisdiction refers to the power of a State to enforce rules and prosecute violations occurring within the jurisdiction of the port State. Many of the IMO conventions and a few ILO conventions include provisions giving rise to port State jurisdiction. The powers of the port State include inspection of certificates, inspection of the ship and in some cases detention of the ship.

The “no more favourable treatment” clause, mentioned in objective 4.6.1.1 provides that State parties are under the obligation to apply the relevant convention in the same manner to foreign ships flying the flag of a State which is not a party as to ships sailing under the flag of a State party to the convention. The result is that ships flying the flags of non-party States will have to comply with the standards of those conventions when calling at ports of a State party.

Law of the sea - on the high seas

In 1958, four conventions were drawn up at the United Nations Conference on the Law of the Sea at Geneva. They were the Conventions on the Territorial Sea and the Contiguous Zone, on the High Seas, on the Continental Shelf, and on Fishing and Conservation of the Living Resources of the High Seas, all of which are currently in force.

The syllabus is concerned only with those parts of the first three of the conventions mentioned above which are relevant to the master in conducting a voyage.

The United Nations Convention on the Law of the Sea, 1982 (UNCLOS) embraces all aspects of the uses and resources of the oceans.

The Convention establishes a comprehensive framework for the regulation of all ocean space. Its provisions govern, amongst other things, the extent of national sovereignty or jurisdiction, the safety of navigation and the protection of the marine environment from pollution. It provides for the establishment of territorial seas up to 12 miles and an exclusive economic zone of up to 200 miles in breadth over which the coastal State has certain sovereign rights. Many States have given effect to these provisions. It also provides for special regimes that apply to navigation through straits and archipelagic waters.

The Convention entered into force on 16 November 1994. It will of course influence future international maritime conventions and recommendations to the extent that conflict with UNCLOS will be avoided and other measures may be introduced to give substance to certain of its provisions.

Force majeure is an exceptional circumstance which is irresistible, beyond anyone’s power to resist even with foreknowledge. See the International Convention on Civil Liability for Oil Pollution Damage (1969), article III, paragraph 2(a), which uses the expression “an act of war, hostilities, civil war, insurrection or a natural phenomenon of an exceptional, inevitable and irresistible character.” They would be examples of force majeure, but this list is not necessarily exhaustive.

The expression “generally accepted international regulations, procedures and practices”, or one of several similar expressions, is used in a number of the provisions. The Convention on the Law of the Sea does not give formal definitions for these expressions, and no clear guidelines are provided as to how the “international regulations and rules, etc.”, referred to in the articles, may be identified. However, it appears to be generally accepted that the international regulations and standards adopted by IMO constitute a major component of the “generally accepted” international regulations and standards in matters relating to safety of navigation and the prevention and control of marine pollution from ships and by dumping.

Formal and authoritative interpretations of the provisions of UNCLOS can only be undertaken by the States party to that Convention or, in appropriate cases, by the judicial or arbitral tribunals envisaged for that purpose in the Convention itself.

Safety

Of all the international conventions dealing with maritime safety the most important is the International Convention for the Safety of Life at Sea, better known as SOLAS which covers a wide range of measures designed to improve the safety of shipping.

The Convention is also one of the oldest of its kind: the first version was adopted in 1914 following the sinking of the SS Titanic with the loss of more than 1,500 lives. Since then there have been four more versions of SOLAS. The present version was adopted in 1974 and entered into force in 1980.

Reference should be made to the International Safety Management (ISM) Code, which sets out the master’s responsibility with regard to safety and environmental protection and in which the watchkeeping officer has a crucial role in discharge of these responsibilities.

International Convention on Load Lines

The Load Lines Protocol of 1988 entered into force on 3 February 2000.

SOLAS - LSA Code

Instructors should note that the International Life-Saving Appliance (LSA) Code was adopted in 1996 and is now in force and mandatory. The Code gives technical and other details of personal life-saving appliances, visual signals, survival craft, rescue boats and other life-saving appliances.

IMO has introduced amendments to harmonize the periods between surveys which will result in equal periods of validity of the different certificates in the near future. The Annex to these Guidance Notes shows bar diagrams of the harmonized system.

The first survey that a cargo ship undergoes by the flag State Administration is the initial survey. When the period of validity of a certificate expires, a renewal survey is required for the new certificate. The annual surveys have different names depending on the certificate involved.

In the future, the Cargo Ship Safety Construction, Safety Equipment and Safety Radio Certificates may be combined into the Cargo Ship Safety Certificate. This is an option under the SOLAS 1988 protocol which came into force in February 2000.

Under 4.6.1.3, SOLAS sub-division and stability, trainees should only be expected to know the meaning and application of 'floodable length' and 'factor of subdivision', not the technical details of calculations.

In the section concerned with the SOLAS requirements for life-saving equipment, details of life-saving appliances, their equipment and their use are covered in IMO model courses 1.19, Proficiency in personal survival techniques, and 1.23, Proficiency in survival craft and rescue boats other than fast rescue boats.

Amendments to the 1974 SOLAS Convention and its Protocol of 1978 were adopted in 1988 to introduce the global maritime distress and safety system. The amendments entered into force, under the 'tacit acceptance' provisions of the SOLAS Convention and its 1978 Protocol, on 1 February 1992. Training requirements for the GMDSS general operator's certificate, see STCW reg. IV/2, are covered in IMO model course 1.25.

SOLAS - Carriage of grain

In many countries, the ship must also obtain a grain loading certificate, attesting that the ship has been loaded in accordance with the regulations, before sailing. Such certificates would be issued by an organization authorized by the Administration.

SOLAS - Carriage of dangerous goods

Details of the IBC and IGC codes are not required, but trainees should be aware of the survey and certification requirements. Officers who are to serve in chemical tankers or gas carriers will undertake appropriate specialized training.

STCW Code

The regulations and recommendations regarding the keeping of safe watches are fully covered in the STCW Convention, chapter VIII. Trainees should be aware of the requirements concerning the certificates needed by ship's officers and other personnel and the port State control which may be applied.

Passengers

Both the Special Trade Passenger Ships Agreement and the Protocol on Space Requirements refer to the International Health Regulations. The relevant sections are Article 84 and Annex V.

The Athens Convention entered into force on 28 April 1987.

Part E: Evaluation

The effectiveness of any evaluation depends to a great extent on the precision of the description of what is to be evaluated. The detailed teaching syllabus is thus designed, to assist the instructors, with descriptive verbs, mostly taken from the widely used Bloom's taxonomy.

Evaluation/Assessment is a way of finding out if learning has taken place. It enables the assessor (instructor), to ascertain if the learner has gained the required skills and knowledge needed at a given point towards a course or qualification.

The purpose of evaluation/assessment is to:

- To assist student learning.
- To identify students' strengths and weaknesses.
- To assess the effectiveness of a particular instructional strategy.
- To assess and improve the effectiveness of curriculum programmes.

To assess and improve teaching effectiveness.

The different types of evaluation/assessment can be classified as:

Initial/Diagnostic assessment

This should take place before the trainee commences a course/qualification to ensure they are on the right path. Diagnostic assessment is an evaluation of a trainee's skills, knowledge, strength and areas for development. This can be carried out during an individual or group setting by the use of relevant tests.

Formative assessment

Is an integral part of the teaching/learning process and hence is a "Continuous" assessment. It provides information on trainees' progress and may also be used to encourage and motivate them.

Purpose of formative assessment

- To provide feedback to students.

To motivate students.

- To diagnose students' strengths and weaknesses.

To help students to develop self-awareness.

Summative assessment

It is designed to measure trainee's achievement against defined objectives and targets. It may take the form of an exam or an assignment and takes place at the end of a course.

Purpose of summative assessment

- To pass or fail a trainee
- To grade a trainee

Evaluation for Quality assurance

Evaluation can also be required for quality assurance purposes.

Purpose of assessment with respect to quality assurance

- To provide feedback to instructors on trainee's learning.

To evaluate a module's strengths and weaknesses.

- To improve teaching.

Assessment Planning

Assessment planning should be specific, measurable, achievable, realistic and timebound (SMART). Some methods of assessment that could be used depending upon the course/ qualification are as follows and should all be adapted to suit individual needs.

- Observation (in Oral examination, Simulation exercises, Practical demonstration).

Questions (written or oral).

- Tests.
- Assignments, activities, projects, tasks and/or case studies.
- Simulations (also refer to section A-I/12 of the STCW Code).
- CBT.

Validity

The evaluation methods must be based on clearly defined objectives, and they must truly represent what is meant to be assessed, for example only the relevant criteria and the syllabus or course guide. There must be a reasonable balance between the subject topics involved and also in the testing of trainees' KNOWLEDGE, UNDERSTANDING AND PROFICIENCY of the concepts.

Reliability

Assessment should also be reliable (if the assessment was done again with a similar group/ learner, would you receive similar results). We may have to deliver the same subject to different groups of learners at different times. If other assessors are also assessing the same course/ qualification as us, we need to ensure we are all making the same decisions. To be reliable an evaluation procedure should produce reasonably consistent results no matter which set of papers or version of the test is used.

If the instructors are going to assess their own trainees, they need to know what they are to assess and then decide how to do this. The *what* will come from the standards/learning outcomes of the course/qualification they are delivering. The *how* may already be decided for them if it is assignments, tests or examinations.

The instructors need to consider the best way to assess the skills, knowledge and attitudes of our learners, whether this will be formative and/or summative and how the assessment will be valid and reliable.

All work assessed should be valid, authentic, current, sufficient and reliable; this is often know as VACSR - “valid assessments create standard results”.

- Valid - the work is relevant to the standards/criteria being assessed.

Authentic - the work has been produced solely by the learner.

- Current - the work is still relevant at the time of assessment.
- Sufficient - the work covers all the standards/criteria.
- Reliable - the work is consistent across all learners, over time and at the required level.

It is important to note that no single method can satisfactorily measure knowledge and skill over the entire spectrum of matters to be tested for the assessment of competence.

Care should therefore be taken to select the method most appropriate to the particular aspect of competence to be tested, bearing in mind the need to frame questions which relate as realistically as possible to the requirements of the officer’s job at sea.

STCW Code

The training and assessment of seafarers, as required under the Convention, are administered, supervised and monitored in accordance with the provisions of section A-I/6 of the STCW Code.

Column 3 - Methods for demonstrating competence and Column 4 - Criteria for evaluating competence in table A-III/1 (Specification of minimum standard of competence for officers in charge of an engineering watch in a manned engine-room or designated duty engineers in a periodically unmanned engine-room) of STCW Code 2010, set out the methods and criteria for evaluation. Instructors should refer to this table when designing the assessment.

instructors should also refer to the Guidelines for evaluating competence as given in part B-III/1 of STCW Code, as given below.

n Evaluation of competence

17. The arrangements for evaluating competence should be designed to take account of different methods of assessment which can provide different types of evidence about candidates' competence, e.g.:

1. *direct observation of work activities (including seagoing service);*
2. *skills/proficiency/competency tests;*
3. *projects and assignments;*
4. *evidence from previous experience; and*
5. *written, oral and computer-based questioning techniques.*

18. One or more of the first four methods listed should almost invariably be used to provide evidence of ability, in addition to appropriate questioning techniques to provide evidence of supporting knowledge and understanding.

Assessment is also covered in detail in another IMO model course; however, to assist and aid the instructors, some extracts from the model course are used to explain in depth.

When evaluation consists of calculations, the following should be taken into consideration: n

Calculations

To carry out their duties, officers in charge of an engineering watch must be able to solve technical problems by performing calculations in various subject areas such as fuel oil, machinery performance and technical management.

The ability to perform such calculations and to resolve such problems can be tested by having the candidates carry out the calculations in their entirety. Since a large variety of technical calculations is involved and the time necessary for their complete solution is considerable, it is not possible to completely test the abilities of candidates within a reasonable examination time.

Resort must therefore be made to some form of sampling technique, as is the case with the assessment of knowledge, comprehension and application of principles and concepts in other subject fields.

In examinations conducted on a traditional essay-type basis, the sampling technique that is applied in respect of calculation requirements is to attempt to cover as much of the subject area as possible within the examination time available. This is frequently done by using questions involving shorter calculations and testing in depth on one or two topics by requiring the completion of more complex calculations. The employment of this 'gross sampling' technique reduces the reliability of the examination as compared with what can be achieved with a more detailed sampling technique.

A greater breadth of sampling can be achieved by breaking down calculations into the various computational steps involved in their solution. This technique can only be applied to calculations in which the methodology is standardized. Fortunately, most calculations follow a standard format; where alternative methods of solution exist, the examination can be developed so as to allow candidates an appropriate freedom of choice. Such freedom of choice must be a feature of examinations of all types, in any event.

In order to develop a series of 'step test items', covering an entire calculation, it is necessary to identify each intermediate step in each calculation involved by all methods which are accepted as being correct in principle. These questions, after they have been reviewed for clarity and conciseness, form the standard 'step test items' in that calculation topic.

This approach allows questions to be posed which sample the candidate's knowledge and ability to perform parts of various calculations, which process takes up less time than having him perform entire calculations. The assumption is made that if the candidate can or cannot correctly complete a calculation step leading to the solution, then he can or cannot successfully carry out the entire calculation. Such detailed sampling allows a larger number of questions to be answered by the candidate within the time allotted for the examination, thus allowing a broader sampling of the candidate's knowledge and abilities, thereby increasing the reliability of the examination.

It must be pointed out that because of the greater number of test items used more time will be spent by candidates in reading the questions and in appreciating the precise step which each question involves.

However, the ability to answer correctly questions that are based on each intermediate step leading to the solution does not necessarily indicate competence in the application of the calculation methodology nor in the interpretation of the intermediate or final results. Further questions must therefore be developed which are of a 'procedural' and principle nature.

Such 'step test' and 'procedural' items may be drawn up as 'essay-type' items, supply-type items or multiple-choice items. Marking or scoring is easier if multiple-choice test items are used, but in some cases difficulties may arise in creating plausible distracters.

Detailed sampling allows immediate identification of errors of principle and those of a clerical nature. It must be emphasized that this holds true, in general, only if the test item is based on a single step in the overall calculation. Multiple-choice items involving more than one step may, in some cases, have to be resorted to in order to allow the creation of a sufficient number of plausible distracters, but care must be exercised to ensure that distracters are not plausible for more than one reason if the nature of the error made (and hence the distracter chosen) is to affect the scoring of the test item.

n Compiling tests

Whilst each examining authority establishes its own rules, the length of time which can be devoted to assessing the competence of candidates for certificates of competency is limited by practical, economic and sociological restraints. Therefore a prime objective of those responsible for the organization and administration of the examination system is to find the most efficient, effective and economical method of assessing the competency of candidates.

An examination system should effectively test the breadth of a candidate's knowledge of the subject areas pertinent to the tasks he is expected to undertake. It is not possible to examine candidates fully in all areas, so in effect the examination samples a candidate's knowledge by covering as wide a scope as is possible within the time constraints and testing his depth of knowledge in selected areas.

The examination as a whole should assess each candidate's comprehension of principles, concepts and methodology; his ability to apply principles, concepts and methodology; his ability to organize facts, ideas and arguments and his abilities and skills in carrying out those tasks he will be called upon to perform in the duties he is to be certificated to undertake.

All evaluation and testing techniques have their advantages and disadvantages. An examining authority should carefully analyse precisely what it should be testing and can test. A careful selection of test and evaluation methods should then be made to ensure that the best of the variety of techniques available today is used. Each test shall be that best suited to the learning outcome or ability to be tested.

Quality of test items

No matter which type of test is used, it is essential that all questions or test items used should be as brief as possible, since the time taken to read the questions themselves lengthens the examination. Questions must also be clear and complete. To ensure this, it is necessary that they be reviewed by a person other than the originator. No extraneous information should be incorporated into questions; such inclusions can waste the time of the knowledgeable candidates and tend to be regarded as 'trick questions'. In all cases, the questions should be checked to ensure that they measure an objective which is essential to the job concerned.

SCORING TESTS

Scoring subjective tests

The assessment of seafarers is concerned with judging whether they are competent, in terms of meeting sufficient specified learning objectives, to perform the tasks required by the qualification they are seeking. That is, they should be tested against predetermined criteria rather than against the performance of other examinees or the norm for the group as a whole, as is the case in many examinations.

To achieve that end in subjective tests, an analytical scoring scheme should be drawn up in which a complete model answer, which would attract full marks, is produced for each question. The model answer is then analysed for the definitions, facts, explanations, formulae, calculations, etc., contained in it and marks are allocated to each item, the aim being to make the scoring as objective as possible. A subjective element will still exist in the original allocation of marks to the various sections and, to some extent, in the scoring of incomplete or partially correct sections.

Either credit scoring or deductive scoring may be used. In credit scoring, marks are awarded, in accordance with the scoring scheme, for each correctly completed part of the answer, no marks being credited for incorrect parts or omissions. With deductive scoring, marks are deducted for errors and omissions from the total mark for the question or part question (where a question has been divided into two or more sections). When applied to essay

questions, the two methods should produce virtually the same score. Deductive scoring is usually confined to the marking of calculations.

Deductive scoring can be weighted to take account of the relative seriousness of different types of error. Errors are commonly classed and weighted as follows:

.1 errors of principle; for example, using the formula for righting moment in a calculation of list; deduct 50% of the mark for the question or part question;

.2 major errors; for example, extracting data for the wrong value or information from a publication; deduct 30% of the mark for the question or part question; and

.3 clerical errors; for example, transposition of numbers from tables or question paper, careless arithmetic; deduct 10% of the mark for the question or part question for each error.

In the case of clerical errors, only one deduction for a single error should be made. No deductions are made for incorrect answers which follow through from the original error. If deductions exceed the total mark for a question or part question it is given a zero score; negative scores are not carried over to other parts.

The different types of error can be taken into account in credit scoring schemes by suitably weighting the marks allocated to method, to the extraction of data and to clerical accuracy at each step of the calculation. The steps need to be smaller and more detailed than the division into parts used in deductive marking. As a result, the marks lost for errors of principle tend to be smaller in credit scoring than in deductive scoring.

A small percentage of the total mark, to be credited only for the correct final answer, is sometimes included in a credit scoring scheme. The answer must lie within stated accuracy limits to qualify for that credit. In deductive schemes, an answer that has otherwise been correctly calculated but which falls outside the accuracy limits are treated as a clerical error.

Where tests are to be marked locally at more than one test centre, a well-defined scoring scheme, which will give the same score when applied to the same paper by different markers, is essential for the uniform and fair treatment of candidates. To aid in any subsequent review of marks, possibly resulting from an appeal, the marker should make brief marginal notes on the paper to indicate the reasons for deductions.

Guidance on the treatment of answers produced by pocket calculators is needed. Examination rules usually warn candidates that all working must be shown to gain full marks for a question. The marks to deduct when insufficient working is shown but a correct answer is produced, or when all working is correctly shown but the answer is wrong, need to be known by the marker.

In papers in which all questions are to be answered, the marks may be weighted to reflect the importance or difficulty of individual questions or the length of time which will be needed to answer them. When this is done, it is usual to indicate the mark for each question on the question paper. Optional questions should all be of similar standard and carry equal marks, so that the standard of the complete test is the same regardless of the questions chosen.

Use can be made of a compulsory and an optional section in the same paper. Questions on which it is felt that all candidates should be tested can be placed in the compulsory section and suitably weighted, while the remainder of the paper offers a choice of questions each of similar standard.

A problem that arises with optional papers is how to deal with cases where more than the required number of questions is answered. Various solutions are adopted by different examining boards. Many mark all questions and discard the lowest marked question or questions, although that fact is not generally advertised as it may encourage candidates to attempt extra questions. Others take the requisite number of answers in the order in which they are on the question paper and ignore the remainder. A similar problem arises in papers in which candidates are required to answer a given number of questions and including at least some stated number from each of several sections.

The pass mark should be set at the lowest score for which sufficient skills and knowledge is demonstrated for competency in each subject. In practice, that score is difficult to determine exactly for an individual paper and could vary slightly from one examination to another. Such an arrangement would be difficult to administer and would be considered unfair by candidates, so the pass mark is fixed and published in the examination regulations. It is, therefore, essential when preparing papers to maintain as constant a standard as possible, such that the pass mark is an appropriate measure of competency.

The following instructions are typical of those produced for guidance of examiners on the marking of examinations:

In order to achieve uniformity in marking between the examiners in various centres and to facilitate the review of papers, the following guidelines are to be used at all centres:

.1 When several candidates write the same examination, papers, other than multiple choice, should be marked question by question, that is to say, question 1 of paper 1 should be marked for all applicants before proceeding to question 2, etc. This gives more uniform marking.

.2 All questions should be marked even if it becomes apparent that the candidate cannot achieve the pass mark.

.3 Neatness and Orderly Layout of Work:

Where work is not properly laid out or is not neat, marks should be deducted without regard to correctness of the answer. The number of marks deducted should vary according to the quality of the work up to a maximum of 10% where the correct answer is obtained.

.4 Important Engineering and Technical Terms:

Where, in general calculations or general questions, an incorrect term is used

and such a term is incidental to the work, the examiner should exercise his judgement as to whether or not marks should be deducted, but in any case, a deduction should not exceed 10% of the allotted marks. This does not apply to direct answers involving definitions or in answers involving the naming of parts.

.5 Types of Errors:

Errors can be divided into 3 types:

(a) P - error in principle; 50% of marks allotted for the whole or part of the question should be deducted.

(b) C - clerical error; 10% of the marks allotted should be deducted for each such error.

(c) M - major error; 30% of the marks allotted for the question or part of the question should be deducted.

Note: Large mark questions should be considered in their main sections and percentages of the sections deducted. Candidates should be given the benefit of any doubt which may exist.

.6 Drawings:

Too much importance should not be attached to elaborate drawings. Often a simple sketch with captions is very explanatory and indicative of a good understanding.

.7 Incomplete answers:

Where a problem or distinct section of a large problem is only partly worked and a step of principle remains to be made, marks allotted should not exceed 50% of the total marks or the split marks allotted as the case may be.

MARKING PAPERS:

.8 When marking papers, examiners should enter appropriate marginal notes in brief showing why marks have been deducted, using abbreviations in Paragraph 5. The actual error should be ringed and marked with a brief statement of the reason for the error, e.g. ‘wrong value. A paper should be so marked that any reviewing examiner can see at a glance just what happened, including a marginal note to indicate award of a ‘benefit of doubt’.

.9 In the case of marginal failure, the paper concerned should be carefully reviewed. This review is not to be regarded as having the purpose of passing the candidate, it is to ensure that the foregoing marking standards have been correctly applied and are consistent with those of other responses to the same examination. It may result in either an increase or a decrease in marks assigned. This review having been completed, the examiner should issue a fail result if it is still below the pass mark.

.10 Use of calculators:

When a pocket, non-programmable calculator is used by a candidate in an examination, all necessary formulae and transpositions must be shown for full marks to be allotted. In the case of a correctly set out answer, or partial answer, which has an incorrect final result, 30% of the whole or part should be deducted on the major error rule.

When the evaluation consists of oral and practical tests, which many topics as per the table A-III/1, column 2, Knowledge, understanding and proficiency, require, the following should be taken into consideration.

n Advantages and disadvantages of oral and practical tests

It is generally considered advisable that candidates for certificates of competency should be examined orally. Some aspects of competency can only be properly judged by having the candidate demonstrate his ability to perform specific tasks in a safe and efficient manner. The safety of the ship and the protection of the marine environment are heavily dependent on the human element. The ability of candidates to react in an organized, systematic and prudent way can be more easily and reliably judged through an oral/practical test incorporating the use of models or simulators than by any other form of test.

One disadvantage of oral/practical tests is that they can be time-consuming. Each test may take up about 1 to 2 hours if it is to comprehensively cover the topics concerned. Equipment must also be available in accordance with the abilities that are to be tested.

Some items of equipment can economically be dedicated solely for use in examinations.

APPENDICES

MARINE ENGINEERING AT THE OPERATIONAL LEVEL

■ Purpose

This syllabus covers the knowledge of basic engineering science which is deemed to provide the depth of knowledge required by the Standards of Competence in table A-III/1 of section A-III/1 of the STCW Code for a candidate for certification as officer in charge of an engineering watch.

It is recommended that the appended subjects area be considered as providing prerequisite level of knowledge required before attempting the main functional competences.

■ Training objectives

This function provides the background knowledge to support:

- An understanding of the physical principles underlying the behaviour of the ship and its environment and the functioning of equipment upon which to build professional studies. Trainees will also be better able to understand technical specifications and instructions regarding equipment with which they are not familiar.

■ Entry standards

Trainees should be proficient in calculations involving the basic arithmetical operations of addition, subtraction, multiplication and division, including the use of fractions and decimal fractions. They should also have some knowledge of elementary algebra and be capable of solving problems leading to simple equations, including transposition of equations, if necessary.

Some previous study of a science subject, involving experimental work and the making, recording and processing of measurements, would be an advantage. It is worth mentioning Maths, Physics and Chemistry at High School level.

■ Teaching facilities and equipment

In addition to ordinary classroom facilities, which may be used for the teaching of theory, a laboratory suitably equipped with work benches and apparatus for practical work and demonstrations will be required.

■ Guidance notes

These notes are included to provide additional information where appropriate.

Appendix 1 - Basic engineering science

The subject has been presented in this manner in an effort to introduce engineering principles for all training outcomes in order that trainees will, from the beginning, know the relationship between quantities when they are later taught separately about:

- thermodynamics
- mechanical science, and
- marine electrotechnology.

These basics should, as recommended, be a prerequisite to the main programme and should ideally be completed before the three engineering science subjects are commenced.

The guidance which follows refers to specific topics.

The term “specific gravity” is still in widespread use and attention should be drawn to this when covering training outcome 1.1, Mass and volume.

Measuring density and temperature is intended to give trainees an opportunity to recognize and use simple instruments.

It is very important that trainees learn the meaning of velocity and acceleration and the units.

The use of graphs in training outcome 1.2, Dynamics is introduced for the first time in this subject; they should be simple, showing constant speed, instant change of speed and uniform change of speed. Trainees must learn the difference between weight and mass and they must also be made aware of the misconceptions common in daily life.

The treatment of friction is intended to be simple but should include recognition of the fact that resistance occurs when bodies move on rough and on smooth surfaces, in air and in liquids.

When covering training outcome 1.3, Energy work and power, petroleum fuel oils should be used as examples of fuels and others could be mentioned.

The treatment of inertia should be simple and not include difficult calculations.

The area under a force-distance graph, representing work done, will often occur in later studies and should be treated with relevant importance.

Care should be taken to ensure that trainees understand the difference between work and power.

Trainees should be made aware that numerous ways are used to express pressure; however, they should use S.I. units.

Opportunity should be taken to show how very high forces occur when moderate pressures are applied to large surface areas.

A simple treatment of calorific values is required at this stage of training and realistic marine fuel values should be used.

Various marine examples of expansion and contraction should be used, such as expansion of pipes (including compensation bends etc.), shrinking metal by cooling or heating to obtain built-up construction such as crankshafts, rudder stocks, etc.

Appendix 2 - Mathematics

Trainees will probably enter the course already in possession of some mathematical ability. This being so, it would be advisable to give a simple test to establish their level of understanding.

There is a possibility that some revision will be necessary for trainees to meet the training outcomes, even if they have covered the work elsewhere.

Trainees need to be able to handle indices in their work on thermodynamics.

Although trainees may not require to use logarithms in their duties, it is considered that such knowledge is of fundamental importance. The evaluation of numbers raised to powers will be necessary in other subjects. Trainees are likely to encounter graphs with logarithmic scales later in their experience.

It is very important that the symbols for S.I. units are understood and used throughout. The prefixes for multiples of ten are in widespread use in marine work.

Trainees should be capable of evaluating expressions by using both a calculator and logarithms, as well as by basic arithmetic where applicable.

Trainees will have to perform algebraic processes in many applications. The examples used in training outcome 1.5 are typical.

It is quite adequate to be able to solve quadratic equations by one method.

Training outcomes in 1.6 are all used in the subject ‘electrotechnology’ in the chief and second engineer’s course (IMO model course 7.02).

A marine engineer frequently has to interpret graphs and occasionally has to plot them; hence training outcome 1.8.

Trainees do not have to carry out differentiation or integration; nevertheless, some insight into these concepts and their application would be of value.

Rates of change are of importance in control engineering; often the expression dy/dx occurs, particularly in technical journals, and trainees therefore need to be familiar with its meaning.

Appendix 3 - Thermodynamics

The terminology and concepts required in this subject are introduced in a simple manner in Appendix 1, Basic engineering science.

In some cases the book references develop the theory to a stage beyond that required for the watchkeeping certificate. Care must therefore be taken to ensure that trainees reach the level defined by the specific training outcome. Teaching beyond that level should only take place in rare instances, when it is absolutely necessary in order to give a clear understanding of the specific training outcome. The trainee should not be expected to achieve a level higher than that specified. For this reason the instructor is advised to prepare notes which give clear indication to the trainees of the work they need to do.

Training outcomes are intended to serve as reinforcement of earlier work. Pressure-measuring devices should already have been covered and should not have to be repeated.

Internal and intrinsic energy have reference to chapter 1.6 of the textbook (T3). It is questionable whether the descriptions of the early misconceptions should be used. Trainees may be in danger of becoming confused and remembering the wrong things.

Trainees will learn the difference between a non-flow system and a steady-flow system; the latter will be introduced when studying for more advanced certificates.

Energy change is included in order to provide a basis for **Vapours**.

The problems in training objectives referring to heat transfer should be simple, such as to find the final temperature of a mixture of liquids or of a solid placed in a liquid when all other required information is known. Heat losses can be mentioned but their inclusion in problems may cause confusion. Similarly, water equivalents can be introduced but should not be over-emphasized. Laboratory work can be introduced provided heat losses can be minimized.

Marine engineers are concerned with a number of vapours; however, steam and the refrigerants are the only vapours commonly used in cyclic processes. Although the references in the textbook are concerned mainly with steam, opportunity should be taken to introduce work involving the use of thermodynamic properties of refrigerants, using the appropriate tables.

A throttling calorimeter can be used to good effect providing the results obtained can be realistic.

In place of “perfect gas”, as for all practical purposes the behaviour of a gas deviates slightly, the term “ideal” is used. As far as practising marine engineers are concerned, the difference is of little importance. Problems should be concerned with practical compression and expansion in diesel engines and compressors.

Thermodynamic processes, the versatility of the equation $PV^n = C$ should be emphasized. Description should be given of processes which are nearly adiabatic and in practice are usually taken to be so. The second law of thermodynamics is introduced and should be related to practical applications. To handle problems concerned with polytrophic processes, trainees require to calculate values of, say, $5^{1.3}$. This is covered in **Mathematics**, but may

require some revision. Such evaluation could be by use of a suitable electronic calculator. It is important that the evaluation is not allowed to obscure the principles being learned.

It is recommended that any calculations used to ascertain values of *n* are kept simple and practical.

Appendix 4 - Mechanical science

The term “couple” is frequently used in technical papers, and trainees should therefore become familiar with its meaning.

Relative velocity should include that of two objects on converging and diverging paths. It

is intended that retardation, i.e. negative acceleration, should be included.

It is not intended to include friction on the inclined plane.

The principle of the pressure created by a head of liquid in a vertical pipe is very important to a marine engineer and should be illustrated by the use of realistic problems. This can also be demonstrated if the appropriate apparatus is available.

Energy changes in a moving liquid can be demonstrated if the equipment is available. It is also possible that the training outcome can be verified experimentally, using the same apparatus. It is not intended that the coefficient of discharge should be used in calculations at this stage.

Appendix 5 - Industrial chemistry

It is not intended that trainees should learn to handle chemical equations, and the objectives clearly indicate this. If, however, trainees enter the course already with a sound background in chemistry, the instructor may find it more acceptable to use equations and other more advanced processes to arrive at the same objectives. The important issue is to ensure that trainees achieve the standard laid down. Later, when studying for more advanced certificates, each topic is taken further, but even then the chemistry is not taken to any greater theoretical depth.

“Fundamentals” includes amongst its training outcomes a series of definitions; as these are not covered in the recommended textbook, suggested definitions are given in the guidance notes. If definitions are to be used from other sources, care should be taken to ensure that they are not so comprehensive as to obscure the purpose described above.

In many cases training outcomes may be best achieved by trainees performing experiments and tasks; the time suggested allows for this.

Simple definitions are adequate; examples are given below:

- An atom is the smallest particle of an element which can take part in a chemical reaction.
- A molecule is the smallest particle of a substance capable of independent existence while still retaining its chemical properties: it consists of more than one atom.
- Chemical element: a substance which cannot be decomposed by chemical means - there are 92 stable elements.
- Chemical compound: a substance composed of two or more elements in definite proportions by mass.
- Chemical reaction: a process in which a substance is changed into another - involves rearrangement of molecular structure.

  Trainees will see chemical symbols and equations in books, technical papers, or on instrument display faces, etc., and familiarity with them will therefore be an advantage. However, a seagoing marine engineer does not normally have to use symbols and equations except possibly as shorthand in reports.
- Solution: a mixture (of variable composition) of two or more substances, one of which is usually a liquid.
- Solubility: the ability of a substance to dissolve in a solvent.
- Saturated solution: a solution which can exist in equilibrium with excess of the dissolved substance.
- Suspension: a fluid in which denser particles cannot settle out and are distributed throughout. Opportunity should be taken to demonstrate these conditions by adding, say, sodium chloride to a beaker of fresh water and measuring its density at various stages until no more can be dissolved.

In later work, when preparing for a higher qualification, trainees will cover the determination of alkalinity of boiler feedwater by more accurate methods.

Samples of common metals with passive oxide films should be shown.

Seawater as an electrolyte can be easily demonstrated by setting up a cell, using seawater as the electrolyte, and a galvanometer.

If available, show pictures or samples of metals affected by graphitization and dezincification.

Opportunity can be taken to measure the density of salts in solution to demonstrate metallic salts.

It is sufficient for a marine engineer to consider the carbon content of each fuel stated to be reasonably constant. The increase in sulphur content is of particular importance as fuel becomes “heavier”. The same applies to the ash and water contents, which are zero or negligible for petrol and kerosene; both ash and water are usually present, sometimes in disturbing quantities, in “heavy” fuels.

Introduction to fuels and lubricants should include precautions with pipework, storage, venting, heating, protection against opening pressurized filters, sources of ignition, discharge from relief valves, operation of sludge valves, drip trays, cofferdams and pipe shrouding.

If laboratory equipment and time are available, trainees would benefit from at least witnessing the tests specified in training outcomes. In any case, trainees should be made familiar with the crude tests which can be performed on board ship.

n Teaching aids (A)

A classroom equipped with a black/white board and an overhead projector is required for the theory of the course.

A1 Instructor Manual.

n Textbooks (T)

There are many textbooks which cover mathematics at the level of this syllabus. The choice of textbook is left to the discretion of the instructor.

APPENDICES

SUPPORTING KNOWLEDGE OUTLINE

Knowledge, understanding and proficiency	Total hours for lectures and laboratory work	Total hours
Appendix 1		
1.1 BASIC ENGINEERING SCIENCE		
1.1.1 Mass and volume	3	
1.1.2 Dynamics	14	
1.1.3 Energy, work and power	12	
1.1.4 Fluids	12	
1.1.5 Heat	9	50
Appendix 2		
2.1 MATHEMATICS		
2.1.1 Calculations with positive and negative integers	18	
2.1.2 Simplifying expressions	12	
2.1.3 Indices	9	
2.1.4 Calculations	9	
2.1.5 Algebra	18	
2.1.6 Trigonometry	18	
2.1.7 Mensuration	10	
2.1.8 Graphs	6	100*
Appendix 3		
3.1 THERMODYNAMICS		
3.1.1 Thermodynamic properties	4	
3.1.2 Thermodynamic energy	8	
3.1.3 Thermodynamic systems	1	
3.1.4 Energy change	6	
3.1.5 Heat transfer	16	
3.1.6 Vapours	16	
3.1.7 Ideal gases	15	
3.1.8 Thermodynamic processes	12	
3.1.9 Work transfer	12	90

* These hours will need to be substantially increased if trainees commence the course without a reasonable mathematical background.

Knowledge, understanding and proficiency	Total hours for lectures and laboratory work	Total hours
Appendix 4		
4.1 MECHANICS		
4.1.1 Statics	24	
4.1.2 Dynamics	20	
4.1.3 Hydrostatics	10	
4.1.4 Hydraulics	6	60
Appendix 5		
5.1 INDUSTRIAL CHEMISTRY		
5.1.1 Chemical fundamentals	6	
5.1.2 Acidity/alkalinity	3	
5.1.3 Corrosion	12	
5.1.4 Water testing and treatment	12	
5.1.5 Introduction to fuels and lubricants	12	45
Total hours:		**345**

APPENDIX 1: BASIC ENGINEERING SCIENCE

APPENDIX 1	SUPPORTING KNOWLEDGE OUTLINE

Textbooks:

Teaching aids:

Demonstrates a knowledge and understanding of:

1.1 Mass and volume (3 hours)

- defines:
  - volume p
  - mass
  - centre of gravity
  - density as mass/volume - units are kg/m^3
  - relative density
- explains that for homogeneous masses the centre of gravity lies at the centre of volume
- solves simple problems involving the above objectives
- measures density of liquids, using a hydrometer

1.2 Dynamics (14 hours)

The relationship between speed, acceleration, mass, force and resistance

- defines speed as $\frac{\text{distance travelled;}}{\text{time}}$ units are m/s or km/h
- calculates mean speeds, given time and distance
- defines acceleration (for motion in a straight line) as change of $\frac{\text{speed}}{\text{time}}$
- plots speed-time graphs for straight-line motion
- defines free fall acceleration as 9.8 m/s^2
- solves problems using distance = speed × time
- uses the equation v = u + at to solve problems
- states that, in order to accelerate a mass, a force has to be applied
- states that the unit of force is the Newton (N)
- states that one Newton is the force which causes a mass of one kilogram to accelerate at the rate of 1 m/s^2
- states Newton's first law
- states Newton's second law
- defines weight as a force caused by gravitational attraction towards the centre of the earth
- uses the equation F = ma to solve simple problems
- identifies practical examples of the effect of friction
- defines friction
- states that force is required to overcome the effects of friction
- explains in general terms the factors which affect frictional resistance to motion

APPENDIX 1	SUPPORTING KNOWLEDGE OUTLINE

1.3 Energy, work and power (12 hours)

The relationship between forms of energy, work and power

- states that common fuels such as hydrocarbons are sources of energy
– defines work as force × distance travelled (newtons × metres); unit is the joule (J)
– defines the relationship between energy and work
– defines potential energy
- defines kinetic energy and derives the equation $\frac{mv^2}{2}$
– solves simple problems involving force, distance and work
– relates the work done to accelerate an object to its change of kinetic energy
– defines inertia
– using given data, draws graphs of force and distance moved and relates the area under the graphs to work done
- gives examples of the conversion of energy from one form to another
– defines efficiency in terms of input and output
– defines power as the rate of transferor energy or the rate of doing work, i.e. $\frac{\text{energy transfer (joules)}}{\text{time taken (seconds)}}$
- states that the unit of power is the watt (W)
– solves simple problems relating to the above objectives

1.4 Fluids (12 hours)

The effect of pressure, its relationship to depth of liquid and force

- defines a fluid
- defines pressure, i.e. $\frac{\text{force (newtons)}}{\text{area (metres}^2\text{)}}$
– states that the unit of pressure is the pascal (Pa)
– states that a practical unit of pressure is 10^5 newton/m^2 and is 1 bar
– states that atmospheric pressure is approximately 1 bar
– solves problems involving force, area and pressure
– states that the pressure at any level in a fluid is equal in all directions
– states that pressure acts in a direction normal to a surface
– states that the pressure at any level in a liquid depends upon the vertical height to the liquid surface (its head) and the density of the liquid
- explains in simple terms what is meant by:
  - atmospheric pressure
  - vacuum
  - partial vacuum
  - absolute zero pressure
  - gauge pressure
- draws a simple diagram of a:
  - piezometer
  - manometer
  - simple barometer
  - bourdon pressure gauge
- solves simple problems involving 9.8 × head × density

APPENDIX 1	SUPPORTING KNOWLEDGE OUTLINE

1.5 Heat (9 hours)

The relationship between temperature, heat energy and heat transfer

- explains what is meant by the temperature of a substance
– defines the Celsius scale and its fixed points
– defines the Kelvin
– measures temperature, using a mercury-in-glass thermometer
– defines the calorific value of a fuel
– solves simple problems, using the equation:
  heat transfer = mass of fuel × calorific value
- solves problems involving calorific value, mass of fuel, work done, energy transfer, fuel flow rates and efficiency
- defines specific heat capacity
– solves problems involving mass, specific heat capacity and temperature change
– explains in simple terms what is meant by:
  - conduction
  - convection
  - radiation
- gives examples of heat transfer by each of the processes described in the above objective
– explains the effect of raising their temperature on the physical dimensions of solids, liquids and gases
- gives examples where the above objective:
  - has to be allowed for
  - is used to advantage

APPENDIX 2: MATHEMATICS

The mathematics presented in this Appendix covers the teaching required to support marine engineering knowledge, understanding and proficiency for:

- Officer in charge of an engineering watch (model course 7.04), and Chief and second engineer officer (model course 7.02)

APPENDIX 2	SUPPORTING KNOWLEDGE OUTLINE

Textbooks:

Teaching aids:

Demonstrates a knowledge and understanding of:

1.1 Calculations with positive and negative integers (18 hours)

- performs calculations with positive and negative integers involving the following presses:
  - addition
  - subtraction
  - multiplication
  - division
- defines the parts of a fraction as the numerator and denominator
- simplifies fractions by cancellation
- adds, subtracts, multiplies and divides fractions and simplifies the results
- solves problems, using one or more of the operations in the above objective

1.2 Simplifying expressions (12 hours)

- solves problems, using ratios
- applies the four basic arithmetic operations to expressions involving decimals
- converts a decimal to a fraction and vice versa
- recognizes recurring decimals as non-terminating decimals
- reduces a decimal number to a specified number of decimal places
- reduces a decimal number to a specified number of significant figures
- adds and subtracts decimal numbers
- multiplies and divides decimal numbers, giving answers to a specified number of decimal places and significant figures
- solves problems involving more than one of the operations in the above objectives

1.3 Indices (9 hours)

- recognizes numbers involving indices, powers and roots
- applies the following rules, where *m* and *n* are integers:

  $a^m \times a^n = a^{m+n}$

  $\frac{a^m}{a^n} = a^{m-n}$

- deduces that $a^0 = 1$ and that $a^{-n} = \frac{1}{a^n}$

– expresses a binary number in the standard form of mantissa and exponent

- converts to normal decimal form a number given in standard form
- adds, subtracts, multiplies and divides two numbers given in standard form
- defines logarithms to the base of 10 and to the base of e (i.e. 2.718)

APPENDIX 2	SUPPORTING KNOWLEDGE OUTLINE

- uses logarithm tables to solve problems
- evaluates numbers raised to powers ranging from powers of 1.2 to 1.9
- states the meaning of and the symbol for prefixes for powers to ten, including: mega, kilo, hecto, deca, centi, milli, micro, nano and pico

1.4 Calculations (9 hours)

- defines percentage
- expresses one quantity as a percentage of another
- expresses increase and decrease as a percentage
- estimates the appropriate value of arithmetic problems and compares with given correct and false answers
- adds, subtracts, multiplies and divides numbers
- determines reciprocals, squares, square roots and fractional indices
- performs arithmetic operations on a calculator
- evaluates expressions, using realistic problems and the processes covered by the above objectives

1.5 Algebra (18 hours)

- states that an algebraic expression is a statement in which numerical quantities have been replaced by letters or other suitable symbols
- reduces an algebraic expression to its simplest form
- factorizes expressions by the extraction of a common factor
- applies any of the arithmetic expressions
- simplifies expressions when quantities are placed within brackets
- simplifies expressions when positive or negative signs are placed in front of a bracket
- solves linear equations with one unknown
- applies the rules which govern the transposition of quantities such as:

$V = IR;\ A = x^2,\ L_1 = (L\ 1) + t;\ v = u + \frac{mv^2}{2}$
at, $E =$

- expands the following:

  $(a + b)^2$

  $(a + b)^3$

  $(a + b)\ (a - b)$
- solves simultaneous equations with two unknowns
- solves problems by forming an equation, initially in algebraic, finally in numeric form
- solves quadratic equations by using the formula method

1.6 Trigonometry (18 hours)

- describes the measurement of angles in degrees and radians
- sketches and names the following angles: obtuse, right, complementary, supplementary and reflex
- defines a degree as 1/360 of a revolution and a minute as 1/60 of a degree
- defines a radian
- converts angular measurement into radians and vice versa
- defines sine, cosine and tangent from trigonometric tables
- uses the theorem of Pythagoras to find the length of one side in a right-angled triangle
- states that the sum of angles inside a triangle is 180°
- applies numerical solutions in respect of the side and angles of a right-angled triangle

APPENDIX 2	SUPPORTING KNOWLEDGE OUTLINE

- solves problems, given the equations, using:
  - the sine rule
  - the cosine rule
- demonstrates that $\cos \omega t = \sin (\omega t \pm \frac{\omega}{2})$
- shows that $\sin^2 \omega t = \frac{1 - \cos 2\omega t}{2}$
- shows that $\sin\theta \cos\theta = \frac{\sin 2\theta}{2}$

– applies positive and negative values as appropriate to the sines, cosines and tangents of angles between 0° and 360°

1.7 Mensuration (10 hours)

- states and applies formulae to find the area of the following:
  - a circle
  - a sector of a circle
  - a triangle
  - parallelogram
  - a trapezium
- defines a centroid

– states the position of the centroid of common regular shapes

– deduces a formula for the areas of a segment of a circle

– defines volume, for shapes having a constant cross-sectional area, as the product of area and length

- applies formulae to find the volume of the following:
  - a cube
  - a cylinder
  - a sphere
  - a triangular prism
- defines centre of volume

– states the position of the centre of volume of common solids

– uses the mid-ordinate rule to find the area of irregular figures

– uses Simpson's 1st and 2nd rules to find the area of irregular figures

– uses Simpson's 1st and 2nd rules to find the volume of irregular objects

1.8 Graphs (6 hours)

- draws axes for positive values
- defines and labels axes
- from given data, determines suitable scales
- plots points accurately, given coordinates
- draws smooth graphs through plotted points
- plots sine waves
- plots cosine waves
- determines the coordinates of intersecting curves or lines
- draws graphs of values with positive, negative and mixed coordinates
- states that the average value of a sine wave and a cosine wave is zero

APPENDIX 2	SUPPORTING KNOWLEDGE OUTLINE

- indicates changing rates on graphs
- explains the concept of $\frac{dy}{dx}$
- defines an elemental area
- explains the concept of integration

APPENDIX 3: THERMODYNAMICS

APPENDIX 3	SUPPORTING KNOWLEDGE OUTLINE

Textbooks:

Teaching aids:

Demonstrates a knowledge and understanding of:

1.1 Thermodynamic properties (4 hours)

- describes the properties used to specify the state, or condition, of a substance, the units in which the property is measured and the usual symbol, e.g.
  - pressure
  - temperature
  - volume
  - energy
- explains what is meant by:
  - absolute quantities
  - specific quantities
  - intensive values
  - extensive values
- explains that a substance can exist in three states, or phases, which are:
  - solid
  - liquid
  - gaseous
- describes the energy required to change phase as:
  - enthalpy of fusion (solid-liquid)
  - enthalpy of evaporation (liquid-vapour)
- states that a change of phase is a constant-temperature process
- – explains that fluids can have a liquid or a gaseous form

1.2 Thermodynamic energy (8 hours)

- states that “internal” or “intrinsic” energy (*U*) is related to the motions of the molecules of a substance or a system
- states that internal energy is derived only from molecular motions and vibrations, is dependent only on thermodynamic temperature and is energy stored in the molecules
- states that the total energy stored in a body, or system, is termed enthalpy (*H*)
- – defines total stored energy the sum of internal energy and the product of pressure (*P*) and volume (V), *i.e.* $H = U + PV$
- defines potential energy as energy stored in the molecules by virtue of their vertical position above some datum level
- defines kinetic energy as energy stored in molecules by virtue of their velocity; kinetic energy has a value of $\frac{v^2}{2}$ (i.e. 0.5 of velocity squared) per unit mass of substance
- – states that energy in transition between bodies or systems can only be heat flow (or heat transfer) (*Q*) and work flow (or work transfer) (*W*)
- defines the first law of thermodynamics as “the energy stored in any given thermodynamic system can only be changed by the transition of energies *Q* and/or *W*”
- solves problems to demonstrate the above objectives

APPENDIX 3	SUPPORTING KNOWLEDGE OUTLINE

1.3 Thermodynamic systems (1 hour)

- states that systems are identified in terms of mass of substance (i.e. molecules) contained within a system and/or the mass entering and leaving
- states that this identification is of importance when evaluating property changes taking place during thermodynamic operations

1.4 Energy change (6 hours)

- explains that the "non-flow" equation derives directly from the first law of thermodynamics and is applicable only to "closed" systems (i.e. no molecules of substance are entering or leaving the system during the thermodynamic operation)
- defines the general form of the non-flow equation as $(U_2 - U_1) = \pm W \pm Q$
- explains that the mathematical sign associated with the transition energies of *Q* and *W* will be governed by "direction", i.e. whether the energy transfer is "into" or "out of" the closed system
- solves simple problems concerning energy changes in practice

1.5 Heat transfer (16 hours)

- states that heat transfer can take place by conduction, convection and radiation and that when substances at different temperatures are placed in contact they will, in time, reach a common temperature through transfer of heat
- defines specific heat capacity as the heat transfer, per unit mass, per unit of temperature change, for any given body or system
- uses laboratory equipment to determine:
  - specific heat capacity of substances
  - final temperature of mixtures, and verifies the observed value by calculation
- states that the Fourier law for the conduction of heat through a substance as given by

$$Q = \frac{\lambda A e t}{x}$$

– identifies the quantities in the Fourier law as

Q = heat flow, measured in joules

A = surface area, measured in square metres

e = temperature difference between the surface, measured in °C t =

time interval, measured in seconds

x = distance travelled between the surface by the heat, measured in metres λ =

the coefficient of thermal conductivity

- explains that the units for the coefficient of thermal conductivity are watts per metre per kelvin i.e.

$$\frac{\text{joules} \times \text{metres}}{\text{second} \times \text{metres}^2 \times \text{kelvin}}$$

- solves simple numerical problems involving heat transfer between substances when placed in contact with each other; to include mixtures of liquids and solids placed in liquids
- solves simple problems on the application of the Fourier law to solid homogeneous materials

– performs laboratory work to verify the above objective

1.6 Vapours (16 hours)

- defines the vapour phase as intermediate stage between the solid and the perfect gas state, and the property values, such as pressure, energy, volume
- states that the important fluids in this group are H_2O (i.e. steam) and the refrigerants

APPENDIX 3	SUPPORTING KNOWLEDGE OUTLINE

- defines the following conditions:
  - saturated vapour
  - dry vapour
  - wet vapour
  - dryness fraction
  - superheated vapour
- explains and uses the "corresponding" relationship that exists between pressure and temperature for a saturated liquid or saturated vapour
- demonstrates the above objective, using laboratory equipment
- uses tables of thermodynamic properties to determine values for enthalpy, internal energy and volume at any given condition of pressure and/or temperature defined in the above objective

1.7 Ideal gases (15 hours)

- states the "critical temperature" as being the limit of the liquid phase
- – defines an "ideal" gas as one which behaves almost as a perfect gas, whose temperature is above the critical one and whose molecules have a simple monatomic structure
- states that an "ideal" gas cannot be liquefied by alteration of pressure alone
- – states the laws of Boyle and Charles and identifies the following statements with them:

  $P \times V$ = a constant - Boyle

  $\frac{V}{T}$ = a constant - Charles
- sketches a *P-V* curve demonstrating Boyle's law
- – sketches a graph of *V* and *T*, demonstrating Charles' law
- – states that the result of combining the laws of Boyle and Charles is:

  $\frac{PV}{T}$ = a constant
- defines the specific ideal gas equation as:

  $\frac{PV}{T}$ = R, per unit mass of gas
- explains that R will have a different numerical value for each ideal gas or mixture of ideal gases
- – applies simple numerical calculations involving the elements of the above objectives

1.8 Thermodynamic processes (12 hours)

- defines a thermodynamic process as "an operation during which the properties of state, pressure, volume and temperature may change, with energy transfer in the form of work and/or heat flow taking place"
- states that the following processes are applicable to ideal gases and vapours:
  - heat transfer: heating and cooling
  - work transfer; compression and expansion
- explains in simple terms the second law of thermodynamics
- – explains with the aid of a sketched *P-V* diagram, where appropriate, the following "standard" processes:
  - pressure remaining constant
  - volume remaining constant
  - temperature remaining constant
  - zero heat transfer
  - polytrophic expansion and compression

APPENDIX 3	SUPPORTING KNOWLEDGE OUTLINE

- describes a process of constant temperature as “isothermal”
- describes a process in which there is no heat transfer as “adiabatic”
- describes practical applications of the process described in the above objectives
- solves simple numerical problems relating to the elements in the above objectives

1.9 Work transfer (12 hours)

- explains that “work” is calculated by force × distance moved by that force
– sketches a *P-V* diagram relating the area of the diagram to the work done when a fluid exerts constant pressure on a piston in a cylinder
- explains the work transfer for a vapour or an ideal gas terms of pressures and volumes
– sketches a *P-V* diagram, relating the area of the diagram to work done on or by a piston in a cylinder during polytrophic expansion and compression
- states the equation for work transfer, i.e.

$$W = \frac{P_1 V_1 - P_2 V_2}{n - 1}$$

where: *W* is the work done, in joules

P is the pressure at specific points in the process, in newtons/m^2 *V*

is the volume at the same points as for pressure, in m^3

n is a numerical index

- states that the numerical index *n* is derived by experiment, using the equation

$$(P_1 V_1)^n = (P_2 V_2)^n$$

- states that, for most practical operations, *n* has numerical values between 1.2 and 1.5
– applies simple numerical calculations related to the elements in the above objectives

APPENDIX 4: MECHANICAL SCIENCE

APPENDIX 4	SUPPORTING KNOWLEDGE OUTLINE

Demonstrates a knowledge and understanding of:

1.1 Statics (24 hours)

- defines scalar and vector quantities, giving examples, e.g. mass and weight
- defines force
- shows force as a graphic representation
- uses the parallelogram of forces to obtain the resultant of two forces acting as a Common point
- states the principle of equilibrium
- defines the equilibrant
- states the necessary conditions for three forces to be in equilibrium
- defines the triangle of forces
- describes the polygon of forces
- defines the condition for equilibrium in the polygon of forces
- defines the net effect of a number of forces acting at a common point as the resultant
- defines the moment of a force about a point
- determines the moment produced by a couple
- describes the conditions required for equilibrium when a number of forces and moments act on a body
- balances moments
- resolves a force into a force and a couple
- defines the factors which govern the stability and overturning of a box
- states that the centre of gravity of a mass suspended from a single point lies vertically below the point of suspension
- states that the centre of gravity of a mass supported by a single point lies vertically above the point of support
- solves simple numerical and graphical problems related to the elements in the above objectives

1.2 Dynamics (20 hours)

Velocity and the effect of change of direction

- defines velocity as a vector quantity
- plots graphs of velocity against time
- defines relative velocity
- determines average velocity from initial and final values of velocity
- states that the area enclosed by a velocity-time curve is distance
- defines acceleration in terms of initial and final values of velocity
- solves simple problems, using the equations

  $v = u \pm at$

  $v^2 = u^2 \pm 2as$

  $s = ut \pm \frac{at^2}{2}$
- defines velocity as a graphic representation
- uses the parallelogram and the triangle of velocities to obtain resultant velocity

APPENDIX 4	SUPPORTING KNOWLEDGE OUTLINE

Friction

- defines friction in the horizontal plane
- defines the force required to overcome friction in the horizontal plane as
  $F = \mu N$
  where: F = force in newtons
  N = normal (i.e. 90°) reaction force between contact surfaces
  μ = coefficient of friction
- solves simple numerical problems related to the elements in the above objectives

1.3 Hydrostatics (10 hours)

- states the formulae for the pressure exerted by a liquid at any given vertical depth
- deduces the equation F = 9.81 × head × density × area, to give the force on the surfaces of a rectangular tank when filled with liquid
- defines the effect of ‘sounding pipes’, ‘air release pipes’ or other ‘standpipes’ when containing liquid
- defines, with the aid of sketches, a hydraulic lifting machine
- applies simple numerical calculations related to the elements in the above objectives

1.4 Hydraulics (6 hours)

- describes the different energies stored in a liquid when in motion as potential energy, pressure energy and kinetic energy
- defines the “head of a liquid”
- states the energy components in a moving liquid in terms of its head
- states the expression to give the volumetric flow of liquid as its
  velocity × cross-sectional area, measured in m^3/second
- states the expression to give the mass flow of liquid as its
  velocity × cross-sectional area × density, measured in kilogram/second
- solves simple problems concerning the above objectives

APPENDIX 5: INDUSTRIAL CHEMISTRY

APPENDIX 5	SUPPORTING KNOWLEDGE OUTLINE

Textbooks:

Teaching aids:

Demonstrates a knowledge and understanding of:

1.1 Fundamentals (6 hours)

- defines an atom
- describes a molecule
- defines:
  - chemical elements
  - chemical compounds
- explains the difference between compounds and mixtures and names of:
  - elements
  - compounds
  - mixtures
- defines a chemical reaction
- defines an oxide
- uses as necessary the convention denoting elements, compounds and mixtures by letters and numbers; for example, carbon dioxide represented by CO_2
- explains what is meant by:
  - solution
  - solubility
  - saturated solution
  - suspension
  - precipitation

1.2 Acidity/alkalinity (3 hours)

- defines the composition of an atom
- explains the result of an atom gaining or losing electrons
- defines a hydrogen ion
- defines a hydroxyl ion
- given pH values, demonstrates whether a solution is alkaline, neutral or acidic, indicating its strength or weakness
- uses an indicator such as litmus paper to determine whether a solution is acid or alkaline

1.3 Corrosion (12 hours)

- defines how metallic hydroxide is formed when an iron is immersed in an acidic solution
- defines the effect of dissolved oxygen and high acidity on polarization
- states that boiler water should be alkaline and contain little or no dissolved oxygen
- explains the fundamental process of corrosion
- names common engineering materials which produce passive oxide films
- states the main cause of corrosion
- names the components of a galvanic cell and applies these to the corrosion of a metal
- defines that seawater is an electrolyte
- defines an anode

APPENDIX 5	SUPPORTING KNOWLEDGE OUTLINE

- from a list of common metals, selects relative anodes
– defines metals as being noble or base relative to each other
– defines the use of sacrificial anodes
– recognizes the problems if graphite grease is used when seawater is present
– defines practical means of reducing galvanic action in the choice of metal and exposed surface area
- defines pitting corrosion
– recognizes the process of graphitization of cast iron
– defines the reasons why corrosion increases when seawater velocity increases
– defines the terms and what is meant by stress corrosion and names the metals in which It commonly occurs
- explains what is meant by dezincification and dealuminification
– defines how the process in the above objective can be prevented
– explains what is meant by fretting corrosion
– defines the factors which increase the rate of fretting
– defines what is meant by corrosion fatigue
– identifies the major factors affecting the corrosion process as:
  - differential temperatures
  - stresses within the metal structure
  - variation in crystal structure of the metal
  - distribution/concentration of impurities in the metal crystals
  - flow of oxygen to the cathode
  - flow of carbon dioxide to the anode and cathode
  - hydroxyl ion concentration of the aqueous solution
- recognizes that some films and coatings on metal surfaces can provide protection so long as they remain intact
- recognizes that surface preparation prior to the application of protective coatings is very important
- identifies the important methods of surface protection as:
  - paints
  - chemical films
  - metallic coatings
  - anodizing

1.4 Water testing and treatment (12 hours)

- recognizes the importance of controlling the pH value of aqueous solutions within the minimum corrosive range
- identifies the chemical additives that can be used to obtain the condition required in the above objective
- knows the importance of maintaining a gas-free condition in the water used to “feed” a steam boiler or to circulate in an engine cooling system
- identifies the methods in common use for conditioning the water content of marine power plant, e.g. trisodium phosphate, hydrazine
- explains that natural water supplies contain metallic salts in solution
- demonstrates the standard method of measuring metallic salt content, i.e. state the actual quantity of metallic salt present in a specified quality of water

APPENDIX 5	SUPPORTING KNOWLEDGE OUTLINE

- knows the standard measurement given in the above objective as in units of “parts per million” (ppm) or less accurately in ‘32’s’ (seawater density measurement)
- lists the main metallic salts found in:
  - fresh water
  - average seawater
- defines:
  - permanent hardness
  - temporary hardness
- defines briefly how scale and sludge are produced in a steam boiler
- explains the different effects of using seawater, fresh water and distilled water as boiler feedwater
- defines the principal objects of treatment of boiler feedwater

1.5 Introduction to fuels and lubricants (12 hours)

- identifies the average carbon, hydrogen, sulphur and ash content of the following fuels:
  - petrol
  - kerosene
  - marine diesel fuel
  - boiler fuel oil
- defines flashpoint and explains its importance for marine fuels and lubricants
- knows flashpoint temperature for the following hydrocarbons:
  - petrol
  - kerosene
  - marine diesel fuel
  - boiler fuel oil
  - lubricating oil
- identifies the minimum closed flashpoint of marline fuels
- states the maximum temperature to which fuel oil may be raised
- describes precautions taken on board ship to prevent accidental ignition of the oils listed in the above objective
- defines viscosity in terms of resistance to flow
- demonstrates why it is necessary to raise the temperature of some fuel oils
- carries out tests on fuels and lubricants for:
  - flashpoint
  - viscosity
- explains the reason why values of flashpoint or of viscosity need to be known for the following:
  - fuels and lubricants in storage
  - transfer of fuels and lubricants
- carries out tests on fuels and lubricants for water content

Guidance on the Implementation of IMO Model Courses

Contents

Part 1: Preparation

1. Introduction

1.1 The success of any enterprise depends heavily on sound and effective preparations.

1.2 Although the IMO model course "package" has been made as comprehensive as possible, it is nonetheless vital that sufficient time and resources are devoted to preparation. Preparation not only involves matters concerning administration or organization, but also includes the preparation of any course notes, drawings, sketches, overhead transparencies, etc., which may be necessary.

2. General considerations

2.1 The course "package" should be studied carefully; in particular, the course syllabus and associated material must be attentively and thoroughly studied. This is vital if a clear understanding is to be obtained of what is required, in terms of resources necessary to successfully implement the course.

2.2 A "checklist", such as that set out in annex A1, should be used throughout all stages of preparation to ensure that all necessary actions and activities are being carried out in good time and in an effective manner. The checklist allows the status of the preparation procedures to be monitored, and helps in identifying the remedial actions necessary to meet deadlines. It will be necessary to hold meetings of all those concerned in presenting the course from time to time in order to assess the status of the preparation and "troubleshoot" any difficulties.

2.3 The course syllabus should be discussed with the teaching staff who are to present the course, and their views received on the particular parts they are to present. A study of the syllabus will determine whether the incoming trainees need preparatory work to meet the entry standard. The detailed teaching syllabus is constructed in "training outcome" format. Each specific outcome states precisely what the trainee must do to show that the outcome has been achieved. An example of a model course syllabus is given in annex A2. Part 3 deals with curriculum development and explains how a syllabus is constructed and used.

2.4 The teaching staff who are to present the course should construct notes or lesson plans to achieve these outcomes. A sample lesson plan for one of the areas of the sample syllabus is provided in annex A3.

2.5 It is important that the staff who present the course convey, to the person in charge of the course, their assessment of the course as it progresses.

3. Specific considerations

3.1 Scope of course

In reviewing the scope of the course, the instructor should determine whether it needs any adjustment in order to meet additional local or national requirements (see Part 3).

3.2 Course objective

.1 The course objective, as stated in the course material, should be very carefully considered so that its meaning is fully understood. Does the course objective require expansion to encompass any additional task that national or local requirements will impose upon those who successfully complete the course? Conversely, are there elements included which are not validated by national industry requirements?

.2 It is important that any subsequent assessment made of the course should include a review of the course objectives.

3.3 Entry standards

.1 If the entry standard will not be met by your intended trainee intake, those entering the course should ·rst be required to complete an upgrading course to raise them to the stated entry level. Alternatively, those parts of the course affected could be augmented by inserting course material which will cover the knowledge required.

.2 If the entry standard will be exceeded by your planned trainee intake, you may wish to abridge or omit those parts of the course the teaching of which would be unnecessary, or which could be dealt with as revision.

.3 Study the course material with the above questions in mind and with a view to assessing whether or not it will be necessary for the trainees to carry out preparatory work prior to joining the course. Preparatory material for the trainees can range from refresher notes, selected topics from textbooks and reading of selected technical papers, through to formal courses of instruction. It may be necessary to use a combination of preparatory work and the model course material in modified form. It must be emphasized that where the model course material involves an international requirement, such as a regulation of the International Convention on Standards of Training, Certification and Watchkeeping (STCW) 1978, as amended, the standard must not be relaxed; in many instances, the intention of the Convention is to require review, revision or increased depth of knowledge by candidates undergoing training for higher certificates.

3.4 Course certificate, diploma or document

Where a certificate, diploma or document is to be issued to trainees who successfully complete the course, ensure that this is available and properly worded and that the industry and all authorities concerned are fully aware of its purpose and intent.

3.5 Course intake limitations

.1 The course designers have recommended limitations regarding the numbers of trainees who may participate in the course. As far as possible, these limitations should not be exceeded; otherwise, the quality of the course will be diluted.

.2 It may be necessary to make arrangements for accommodating the trainees and providing facilities for food and transportation. These aspects must be considered at an early stage of the preparations.

3.6 Staff requirements

.1 It is important that an experienced person, preferably someone with experience in course and curriculum development, is given the responsibility of implementing the course.

.2 Such a person is often termed a “course coordinator” or “course director”. Other staff, such as lecturers, instructors, laboratory technicians, workshop instructors, etc., will be needed to implement the course effectively. Staff involved in presenting the course will need to be properly briefed about the course work they will be dealing with, and a system must be set up for checking the material they may be required to prepare. To do this, it will be essential to make a thorough study of the syllabus and apportion the parts of the course work according to the abilities of the staff called upon to present the work.

.3 The person responsible for implementing the course should consider monitoring the quality of teaching in such areas as variety and form of approach, relationship with trainees, and communicative and interactive skills; where necessary, this person should also provide appropriate counselling and support.

3.7 Teaching facilities and equipment

.1 Rooms and other services

It is important to make reservations as soon as is practicable for the use of lecture rooms, laboratories, workshops and other spaces.

.2 *Equipment*

Arrangements must be made at an early stage for the use of equipment needed in the spaces mentioned in 3.7.1 to support and carry through the work of the course. For example:

- blackboards and writing materials
- apparatus in laboratories for any associated demonstrations and experiments ● machinery and related equipment in workshops
- equipment and materials in other spaces (e.g. for demonstrating firefighting, personal survival, etc.)

3.8 Teaching aids

Any training aids specified as being essential to the course should be constructed, or checked for availability and working order.

3.9 Audiovisual aids

Audiovisual aids (AVA) may be recommended in order to reinforce the learning process in some parts of the course. Such recommendations will be identified in Part A of the model course. The following points should be borne in mind:

.1 Overhead projectors

Check through any illustrations provided in the course for producing overhead projector (OHP) transparencies, and arrange them in order of presentation. To produce transparencies, a supply of transparency sheets is required; the illustrations can be

transferred to these via photocopying. Alternatively, transparencies can be produced by writing or drawing on the sheet. Coloured pens are useful for emphasizing salient points. Ensure that spare projector lamps (bulbs) are available.

.2 Slide projectors

If you order slides indicated in the course framework, check through them and arrange them in order of presentation. Slides are usually produced from photographic negatives. If further slides are considered necessary and cannot be produced locally, OHP transparencies should be resorted to.

.3 Cine projector

If films are to be used, check their compatibility with the projector (i.e. 16 mm, 35 mm, sound, etc.). The films must be test-run to ensure there are no breakages.

.4 Video equipment

It is essential to check the type of video tape to be used. The two types commonly used are VHS and Betamax. Although special machines exist which can play either format, the majority of machines play only one or the other type. Note that VHS and Betamax are not compatible; the correct machine type is required to match the tape. Check also that the TV raster format used in the tapes (i.e. number of lines, frames/second, scanning order, etc.) is appropriate to the TV equipment available. (Specialist advice may have to be sought on this aspect.) All video tapes should be test-run prior to their use on the course.

.5 Computer equipment

If computer-based aids are used, check their compatibility with the projector and the available software.

.6 General note

The electricity supply must be checked for correct voltage, and every precaution must be taken to ensure that the equipment operates properly and safely. It is important to use a proper screen which is correctly positioned; it may be necessary to exclude daylight in some cases. A check must be made to ensure that appropriate screens or blinds are available. All material to be presented should be test-run to eliminate any possible troubles, arranged in the correct sequence in which it is to be shown, and properly identified and cross-referenced in the course timetable and lesson plans.

3.10 IMO references

The content of the course, and therefore its standard, reflects the requirements of all the relevant IMO international conventions and the provisions of other instruments as indicated in the model course. The relevant publications can be obtained from the Publication Service of IMO, and should be available, at least to those involved in presenting the course, if the indicated extracts are not included in a compendium supplied with the course.

3.11 Textbooks

The detailed syllabus may refer to a particular textbook or textbooks. It is essential that these books are available to each student taking the course. If supplies of

textbooks are limited, a copy should be loaned to each student, who will return it at the end of the course. Again, some courses are provided with a compendium which includes all or part of the training material required to support the course.

3.12 Bibliography

Any useful supplementary source material is identified by the course designers and listed in the model course. This list should be supplied to the participants so that they are aware where additional information can be obtained, and at least two copies of each book or publication should be available for reference in the training institute library.

3.13 Timetable

If a timetable is provided in a model course, it is for guidance only. It may only take one or two presentations of the course to achieve an optimal timetable. However, even then it must be borne in mind that any timetable is subject to variation, depending on the general needs of the trainees in any one class and the availability of instructors and equipment.

Part 2: Notes on teaching technique

1. Preparation

1.1 Identify the section of the syllabus which is to be dealt with.

1.2 Read and study thoroughly all the syllabus elements.

1.3 Obtain the necessary textbooks or reference papers which cover the training area to be presented.

1.4 Identify the equipment which will be needed, together with support staff necessary for its operation.

1.5 It is essential to use a “lesson plan”, which can provide a simplified format for coordinating lecture notes and supporting activities. The lesson plan breaks the material down into identifiable steps, making use of brief statements, possibly with keywords added, and indicating suitable allocations of time for each step. The use of audiovisual material should be indexed at the correct point in the lecture with an appropriate allowance of time. The audiovisual material should be test-run prior to its being used in the lecture. An example of a lesson plan is shown in annex A3.

1.6 The syllabus is structured in training outcome format and it is thereby relatively straight forward to assess each trainee’s grasp of the subject matter presented during the lecture. Such assessment may take the form of further discussion, oral questions, written tests or selection-type tests, such as multiple-choice questions, based on the objectives used in the syllabus. Selection-type tests and short-answer tests can provide an objective assessment independent of any bias on the part of the assessor. For certification purposes, assessors should be appropriately qualified for the particular type of training or assessment.

REMEMBER - POOR PREPARATION IS A SURE WAY TO LOSE THE INTEREST OF A GROUP

1.7 Check the rooms to be used before the lecture is delivered. Make sure that all the equipment and apparatus are ready for use and that any support staff are also prepared and ready. In particular, check that all blackboards are clean and that a supply of writing and cleaning materials is readily available.

2. Delivery

2.1 Always face the people you are talking to; never talk with your back to the group.

2.2 Talk clearly and sufficiently loudly to reach everyone.

2.3 Maintain eye contact with the whole group as a way of securing their interest and maintaining it (i.e. do not look continuously at one particular person, nor at a point in space).

2.4 People are all different, and they behave and react in different ways. An important function of an instructor is to maintain interest and interaction between members of a group.

2.5 Some points or statements are more important than others and should therefore be emphasized. To ensure that such points or statements are remembered, they must be restated a number of times, preferably in different words.

2.6 If a blackboard is to be used, any writing on it must be clear and large enough for everyone to see. Use colour to emphasize important points, particularly in sketches.

2.7 It is only possible to maintain a high level of interest for a relatively short period of time; therefore, break the lecture up into different periods of activity to keep interest at its highest level. Speaking, writing, sketching, use of audiovisual material, questions, and discussions can all be used to accomplish this. When a group is writing or sketching, walk amongst the group, looking at their work, and provide comment or advice to individual members of the group when necessary.

2.8 When holding a discussion, do not allow individual members of the group to monopolize the activity, but ensure that all members have a chance to express opinions or ideas.

2.9 If addressing questions to a group, do not ask them collectively; otherwise, the same person may reply each time. Instead, address the questions to individuals in turn, so that everyone is invited to participate.

2.10 It is important to be guided by the syllabus content and not to be tempted to introduce material which may be too advanced, or may contribute little to the course objective. There is often competition between instructors to achieve a level which is too advanced. Also, instructors often strongly resist attempts to reduce the level to that required by a syllabus.

2.11 Finally, effective preparation makes a major contribution to the success of a lecture. Things often go wrong; preparedness and good planning will contribute to putting things right. Poor teaching cannot be improved by good accommodation or advanced equipment, but good teaching can overcome any disadvantages that poor accommodation and lack of equipment can present.

Part 3: Curriculum development

1. Curriculum

The dictionary defines *curriculum* as a “regular course of study”, while *syllabus* is defined as “a concise statement of the subjects forming a course of study”. Thus, in general terms, a curriculum is simply a course, while a syllabus can be thought of as a list (traditionally, a “list of things to be taught”).

2. Course content

The subjects which are needed to form a training course, and the precise skills and depth of knowledge required in the various subjects, can only be determined through an in-depth assessment of the job functions which the course participants are to be trained to perform (job analysis). This analysis determines the training needs, hence the purpose of the course (course objective). After ascertaining this, it is possible to define the scope of the course.

(**Note**: Determination of whether or not the course objective has been achieved may quite possibly entail assessment, over a period of time, of the “on-the-job performance” of those completing the course. However, the detailed learning objectives are quite specific and immediately assessable.)

3. Job analysis

A job analysis can only be properly carried out by a group whose members are representative of the organizations and bodies involved in the area of work to be covered by the course. The validation of results, via review with persons currently employed in the job concerned, is essential if undertraining and overtraining are to be avoided.

4. Course plan

Following definition of the course objective and scope, a course plan or outline can be drawn up. The potential students for the course (the trainee target group) must then be identified, the entry standard to the course decided and the prerequisites defined.

5. Syllabus

The final step in the process is the preparation of the detailed syllabus with associated timescales; the identification of those parts of textbooks and technical papers which cover the training areas to a sufficient degree to meet, but not exceed, each learning objective; and the drawing up of a bibliography of additional material for supplementary reading.

6. Syllabus content

The material contained in a syllabus is not static; technology is continuously undergoing change and there must therefore be a means for reviewing course material in order to eliminate what is redundant and introduce new material reflecting current practice. As defined above, a syllabus can be thought of as a list and, traditionally, there have always been an “examination syllabus” and a “teaching

syllabus"; these indicate, respectively, the subject matter contained in an examination paper, and the subject matter a teacher is to use in preparing lessons or lectures.

7. Training outcomes

7.1 The prime communication difficulty presented by any syllabus is how to convey the "depth" of knowledge required. A syllabus is usually constructed as a series of "training outcomes" to help resolve this difficulty.

7.2 Thus, curriculum development makes use of training outcomes to ensure that a common minimum level and breadth of attainment is achieved by all the trainees following the same course, irrespective of the training institution (i.e. teaching/ lecturing staff).

7.3 Training outcomes are trainee-oriented, in that they describe an end result which is to be achieved by the trainee as a result of a learning process.

7.4 In many cases, the learning process is linked to a skill or work activity and, to demonstrate properly the attainment of the objective, the trainee response may have to be based on practical application or use, or on work experience.

7.5 The training outcome, although aimed principally at the trainee to ensure achievement of a specific learning step, also provides a framework for the teacher or instructor upon which lessons or lectures can be constructed.

7.6 A training outcome is specific and describes precisely what a trainee must do to demonstrate his knowledge, understanding or skill as an end product of a learning process.

7.7 The learning process is the "knowledge acquisition" or "skill development" that takes place during a course. The outcome of the process is an acquired "knowledge", "understanding", "skill"; but these terms alone are not sufficiently precise for describing a training outcome.

7.8 Verbs, such as "calculates", "defines", "explains", "lists", "solves" and "states", must be used when constructing a specific training outcome, so as to define precisely what the trainee will be enabled to do.

7.9 In the IMO model course project, the aim is to provide a series of model courses to assist instructors in developing countries to enhance or update the maritime training they provide, and to allow a common minimum standard to be achieved throughout the world. The use of training outcomes is a tangible way of achieving this desired aim.

7.10 As an example, a syllabus in training-outcome format for the subject of ship construction appears in annex A2. This is a standard way of structuring this kind of syllabus. Although, in this case, an outcome for each area has been identified - and could be used in an assessment procedure - this stage is often dropped to obtain a more compact syllabus structure.

8. Assessment

Training outcomes describe an outcome which is to be achieved by the trainee. Of equal importance is the fact that such an achievement can be measured OBJECTIVELY through an evaluation which will not be influenced by the personal opinions and judgements of the examiner. Objective testing or evaluation provides a sound base on which to make reliable judgements concerning the levels of understanding and knowledge achieved, thus allowing an effective evaluation to be made of the progress of trainees in a course.

Annex A1 - Preparation checklist

Ref	Component	Identified	Reserved	Electricity supply	Purchases	Tested	Accepted	Started	Finished	Status OK
1	Course plan									
2	Timetable									
3	Syllabus									
4	Scope									
5	Objective									
6	Entry standard									
7	Preparatory course									
8	Course certificate									
9	Participant numbers									
10	Staffing									

Coordinator _____

Lecturers _____

Instructors _____

Technicians _____

Other _____

Annex A1 - Preparation checklist *(continued)*

Ref	Component	Identified	Reserved	Electricity supply	Purchases	Tested	Accepted	Started
11	Facilities							
	a) Rooms							
	Lab							
	Workshop							
	Other							
	Class							
	b) Equipment							
	Lab							
	Workshop							
	Other							
12	AVA Equipment and Materials							
	OHP							
	Slide							
	Cine							
	Video							
13	IMO Reference							
14	Textbooks							
15	Bibliography							

Annex A2 - Example of a model course syllabus in a subject area

Subject area : Ship construction

Prerequisite : Have a broad understanding of shipyard practice

General aims : Have knowledge of materials used in shipbuilding, specification of shipbuilding steel and process of approval

Textbooks : No specific textbook has been used to construct the syllabus, but the instructor would be assisted in preparation of lecture notes by referring to suitable books on ship construction, such as *Ship Construction* by Eyres (T12) and *Merchant Ship Construction* by Taylor (T58)

Course outline

Knowledge, understanding and proficiency	Total hours for each topic	Total hours for each subject area of Required performance
Competence :		
3.1 CONTROL TRIM, STABILITY and STRESS		
3.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY		
.1 Shipbuilding materials	3	
.2 Welding	3	
.3 Bulkheads	4	
.4 Watertight and weathertight doors	3	
.5 Corrosion and its prevention	4	
.6 Surveys and dry-docking	2	
.7 Stability	83	102

Part C3: Detailed Teaching Syllabus

Introduction

The detailed teaching syllabus is presented as a series of learning objectives. The objective, therefore, describes what the trainee must do to demonstrate that the specified knowledge or skill has been transferred.

Thus each training outcome is supported by a number of related performance elements in which the trainee is required to be proficient. The teaching syllabus shows the Required performance expected of the trainee in the tables that follow.

In order to assist the instructor, references are shown to indicate IMO references and publications, textbooks and teaching aids that instructors may wish to use in preparing and presenting their lessons.

The material listed in the course framework has been used to structure the detailed training syllabus; in particular:

- Teaching aids (indicated by A)
- IMO references (indicated by R), and ●

Textbooks (indicated by T)

will provide valuable information to instructors.

Explanation of information contained in the syllabus tables

The information on each table is systematically organized in the following way. The line at the head of the table describes the FUNCTION with which the training is concerned. A function means a group of tasks, duties and responsibilities as specified in the STCW Code. It describes related activities which make up a professional discipline or traditional departmental responsibility on board.

The header of the first column denotes the **COMPETENCE** concerned. Each function comprises a number of COMPETENCES. Each competence is uniquely and consistently numbered on this model course.

In this function the competence is **Control Trim, Stability and Stress**. It is numbered 3.1, that is the first competence in Function 3. The term “competence” should be understood as the application of knowledge, understanding, proficiency, skills, experience for an individual to perform a task, duty or responsibility on board in a safe, efficient and timely manner.

Shown next is the required TRAINING OUTCOME. The training outcomes are the areas of knowledge, understanding and proficiency in which the trainee must be able to demonstrate knowledge and understanding. Each COMPETENCE comprises a number of training outcomes. For example, the above competence comprises three training outcomes. The first is concerned with FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY. Each training outcome is uniquely and consistently numbered in this model course. That concerned with fundamental principles of ship construction, trim and stability is uniquely numbered 3.1.1. For clarity, training outcomes are printed in black type on grey, for example TRAINING OUTCOME.

Finally, each training outcome embodies a variable number of Required performances - as evidence of competence. The instruction, training and learning should lead to the trainee meeting the specified Required performance. For the training outcome concerned with the fundamental principles of ship construction, trim and stability there are three areas of performance. These are:

3.1.1.1 Shipbuilding materials
3.1.1.2 Welding
3.1.1.3 Bulkheads

Following each numbered area of Required performance there is a list of activities that the trainee should complete and which collectively specify the standard of competence that the trainee must meet. These are for the guidance of teachers and instructors in designing lessons, lectures, tests and exercises for use in the teaching process. For example, under the topic 3.1.1.1, to meet the Required performance, the trainee should be able to:

- state that steels are alloys of iron, with properties dependent upon the type and amount of alloying materials used
- state that the speci · cation of shipbuilding steels are laid down by classi · cation societies
- state that shipbuilding steel is tested and graded by classi · cation society surveyors who stamp it with approved marks

and so on.

IMO references (Rx) are listed in the column to the right-hand side. Teaching aids (Ax), videos (Vx) and textbooks (Tx) relevant to the training outcome and Required performances are placed immediately following the TRAINING OUTCOME title.

It is not intended that lessons are organized to follow the sequence of Required performances listed in the Tables. The Syllabus Tables are organized to match with the competence in the STCW Code, table A-II/2. Lessons and teaching should follow college practices. It is not necessary, for example, for shipbuilding materials to be studied before stability. What is necessary is that *all* of the material is covered and that teaching is effective to allow trainees to meet the standard of the Required performance.

FUNCTION 3: CONTROLLING THE OPERATION OF THE SHIP AND CARE FOR PERSONS ON BOARD AT THE MANAGEMENT LEVEL

COMPETENCE 3.1	**Control trim, stability and stress**	**IMO reference**

3.1.1 FUNDAMENTAL PRINCIPLES OF SHIP CONSTRUCTION, TRIM AND STABILITY

Textbooks: T11, T12, T35, T58, T69

Teaching aids: A1, A4, V5, V6, V7

Required performance:

1.1 Shipbuilding materials (3 hours) R1

- states that steels are alloys of iron, with properties dependent upon the type and amounts of alloying materials used
- states that the specifications of shipbuilding steels are laid down by classification societies
- states that shipbuilding steel is tested and graded by classification surveyors, who stamp it with approved marks
- explains that mild steel, graded A - E, is used for most parts of the ship
- states why higher tensile steel may be used in areas of high stress, such as the sheer strake
- explains that the use of higher tensile steel in place of mild steel results in saving of weight for the same strength
- explains what is meant by:
  - tensile strength
  - ductility
  - hardness
  - toughness
- defines strain as extension divided by original length
- sketches a stress-strain curve for mild steel
- explains
  - yield point
  - ultimate tensile stress
  - modulus of elasticity
- explains that toughness is related to the tendency to brittle fracture
- explains that stress fracture may be initiated by a small crack or notch in a plate
- states that cold conditions increase the chances of brittle fracture
- states why mild steel is unsuitable for the very low temperatures involved in the containment of liquefied gases
- lists examples where castings or forgings are used in ship construction
- explains the advantages of the use of aluminium alloys in the construction of superstructures
- states that aluminium alloys are tested and graded by classification society surveyors
- explains how strength is preserved in aluminium superstructures in the event of fire
- describes the special precautions against corrosion that are needed where aluminium alloy is connected to steelwork

Annex A3 - Example of a lesson plan for annex A2

Subject area : 3.1 Control trim, stability and stress **Lesson Number: 1** **Duration : 3 hours**

Training Area : 3.1.1 Fundamental principles of ship construction, trim and stability

Main element Specific training outcome in teaching sequence, with memory keys	Teaching method	Textbook	IMO reference	A/V aid	Instructor guidelines
1.1 Shipbuilding materials (3 hours)					
States that steels are alloys of iron, with properties dependent upon the type and amounts of alloying materials used	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	
States that the specifications of shipbuilding steels are laid down by classification societies	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	
Explains that mild steel, graded A to E, is used for most parts of the ship	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	
States why higher tensile steel may be used in areas of high stress, such as the sheer strake	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	
Explains that use of higher tensile steel in place of mild steel results in a saving of weight for the same strength	Lecture	T12, T58	STCW II/2, A-II/2	V5 to V7	