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COOPERATIVE CADET TRAINING PROGRAMS NAVIGATION

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CONTENTS

INTRODUCTION

This document is intended for the guidance of colleges wishing to institute a post-secondary course in marine technology - Nautical Science, leading to examination pursuant to the Marine Certification Regulations.

Information is provided on the general scheduling of the course, together with the core curriculum of technical subjects to be taught. Entrance requirements will include the following:

(a) minimum age 16 years;
(b) Canadian citizenship or permanent resident status;
(c) be free of any physical or other disability which would render him unfit for sea service;
(d) passing of a sight test in visual acuity and colour perception to standards laid down by the Department of Transport; and
(e) educational standard required would be left to the management of the individual institution, however, it is recommended that completion of grade 12 or equivalent would be desirable.

PHILOSOPHY

This course is aimed at sustaining the vocational qualities of sea-going personnel and at the same time augment the technological values of the navigating officer.

The young seafarer who enters the nautical profession should not be deprived of the benefits of higher education that are available to young men of equivalent academic ability on shore. Such young seafarers, when educated to a sufficiently high level and experienced in the ways of the sea, will be able to contribute much to nautical improvement and development.

As the speed, dimensions and rate of port operation of the modern vessel increase, there is a clear need for officers of intellectual ability and knowledge of modern systems and scientific developments.

It is also recommended that not every young man who embarks on a seafaring career is inclined to continue for the remainder of his working life. The qualification envisaged here is such as will enable that seafarer to find satisfactory employment on shore within the marine field and not be lost to the industry.

The value of this higher education is recognized by the Department of Transport in that time attending college is accepted in full as qualifying service towards a certificate of competency. Additionally, satisfactory graduation from the course may attract exemption from certain examination papers for higher certificates of competency, subject to Department's approval of the course and subsequent monitoring.

IMPLEMENTATION

To achieve the preceding philosophy, cadet programs:

(a) should be expanded to the greatest degree possible, with the aim of making them
(b) the principal source of supply of ships' officers on vessels of significant size and trade;
(c) may, at the discretion of individual colleges, also contain non-technical courses providing that such courses do not take up an undue proportion of the time spent in college;
(d) will include as an integral part of the program, and to its termination, planned and monitored on-the-job training on board ship; and
(e) will, while fully covering the practical knowledge required for a certificate of competency, also include instruction in core subjects to a higher level than that required for certificate examinations.

PERSPECTIVE

Role of D.O.T.:

It is important to bear in mind that the role of DOT is principally that of ensuring that ships' officers are competent to perform their shipboard duties. DOT responsibility is to safety of navigation, life, property, and the protection of the marine environment. In some cases, other items have found their way into the examinations which concern the overall economic conduct of the ship, such as legal, business and cargo carriage matters. These items, while not bearing on safety, are justified on the grounds that they do provide some assurance of the competence of officers to operate a ship successfully in the economic sense and thus avoid placing Canadian ships in a disadvantageous position in relation to other flags. It is likely that these items may increase in time to include such items as management, human relations, supervisory practices, collective agreements, and the like. It is probable, however, that these matters could be handled more effectively, were they willing to undertake them, by the industry itself.

Academic Subjects:

There is little difficulty in designing the course in these subjects once the standard to be attained has been decided. The progression in these subjects is well defined, although some diversions may be needed to cover special areas of professional subjects.

Technical Subjects:

In this area, it is important to maintain a logical “flow” of instruction and experience. Not only must the subject be developed in a logical manner, but the application of that subject must be incorporated into the development, Nothing is more frustrating than to learn a subject without any reasonably immediate likelihood of putting it to use. This is the essence of a "co-operative" or "sandwich" training program.

The program in technical subjects must, then, be drawn up in concert with the training to be undertaken and jobs to be performed at sea, i.e., with the record of training manual. It is appreciated that this ideal may be difficult to achieve when dealing with the basics of technical subjects, and that these may have to be commenced **early in** the program, with some introduction of practical application to sustain interest earlier than warranted under the foregoing ideas. Nevertheless, every effort should be made to closely align college training and sea-going experience in professional subjects.

General:
There must, of course, be alignment between the technical and supporting academic subjects at all levels in the program.

SCHEDULING:

Factors governing the scheduling of the course are:

(a) the course should consist of a minimum of eighteen months of instructions interspersed with a minimum of eighteen months industrial service;
(b) the student may attempt the Watchkeeping mate, ship certificate after completion of two years of the course, providing he has completed at least twelve months industrial service;
(c) the student should receive instructions and be encouraged to gain credits for the higher level subjects either within or at completion of three years of the course; and
(d) the industrial service for the watchkeeping mate, ship certificate should be in three phases - during the first phase, the student should become familiar with shipboard routine and the duties and skills of a seaman, during the second phase, he should become familiar with the duties of the watchkeeper and during the third phase, he should actively assist the officer of the watch in watchkeeping duties on the bridge and deck.

The three year program described above will allow the student to graduate with either a First Mate, Intermediate voyage or a Watchkeeing Mate, ship with higher level credits and level one tanker endorsements.

It must be emphasized that the above arrangement is purely an example and is flexible. Individual colleges may opt for programs of longer duration with industrial and college training and education culminating at the First Mate, Intermediate voyage level .

The Department will assess each proposal individually.

The arrangement for completion of the industrial service should be mutually arranged between college and the industry ensuring that the full industrial service is spent on board ship. Individual colleges making adjustments to suit their peculiar situations.

It is recognized that there may be some difficulties regarding accumulation of industrial service resulting in occasional deficiencies. The Department will exercise limited flexibility in special cases while assessing such service so as not be unduly penalize students.

IDENTIFICATION OF SUBJECT AREAS

The course will naturally consist of both academic and technical subjects. To cope with modern-day transition to high technology, computer programming, auto controls and labour relations are also included. The academics to be covered are mathematics, physics, language arts, electricity, navigating instruments and engineering knowledge.

The main areas in the technical subjects are identified as Naval Architecture, Ship Operation, Navigation, Magnetism and Safety. These may be subdivided into specific subjects as indicated in Table I overleaf. However, it must be emphasized that this subdivision is purely to facilitate the preparation of the core curriculum and certain subjects may be combined for instructional purposes at the discretion of the individual college.

An example of the foregoing might be the combining of Navigation, Industrial and Environmental Safety to Constitute a teaching block entitled "Safety".

TABLE l (a)

IDENTIFICATION OF SUBJECT AREAS

ACADEMIC:

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Mathematics;
Physics;
Language Arts;
Electricity;
Navigating Aids; and
Engineering Knowledge.

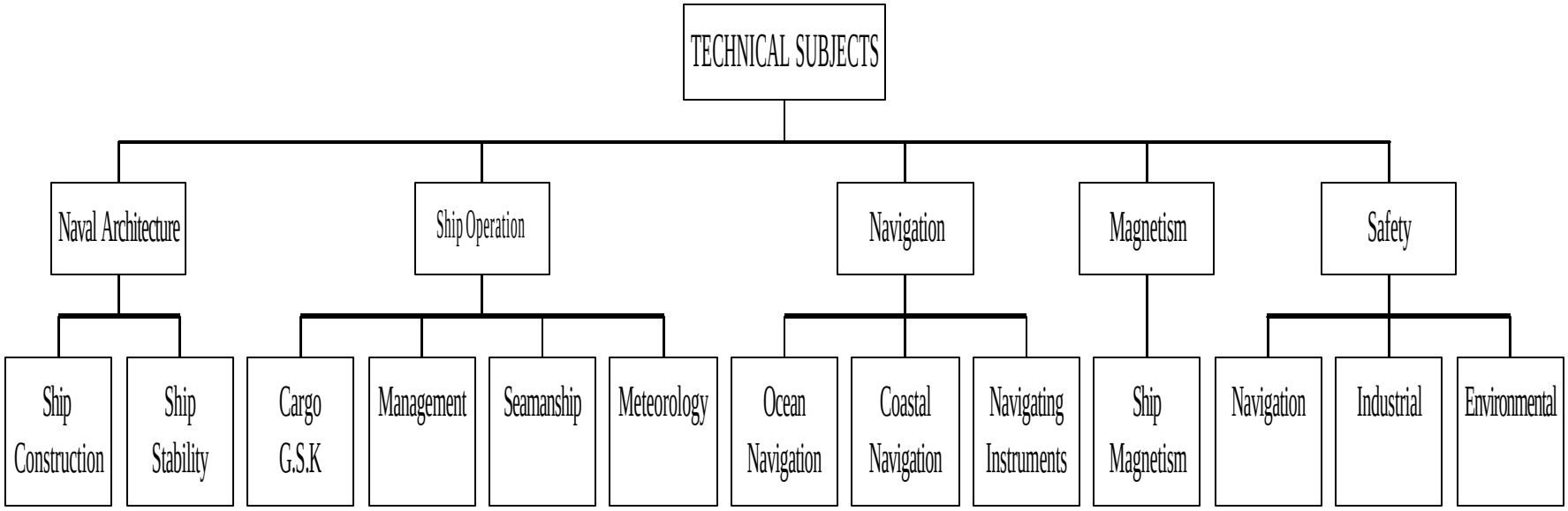
TECHNICAL:

Naval Architecture	:	Ship Construction & Ship Stability.
Ship Operation	:	Cargo & General Ship Knowledge;
	:	Management;
	:	Meteorology;
	:	Seamanship.
Navigation :		Ocean Navigation;
	:	Coastal Navigation;
	:	Navigating Instruments.
Magnetism	:	Ship Magnetism
Safety	:	Navigation;
	:	Industrial;.
	:	Environmental.

OTHERS:

Signals/Communications;
Labour Relations;
Strength of Materials;
Computer Programming;
Computer Technology;
Technical Report Writing.

TABLE 1 (b)


TECHNICAL SUBJECTS
Naval Architecture
Ship Operation
Navigation
Magnetism
Safety
Ship Construction
Ship Stability
Cargo G.S.K
Management
Seamanship
Meteorology
Ocean Navigation
Coastal Navigation
Navigating Instruments
Ship Magnetism
Navigation
Industrial
Environmental

ALLOCATION OF HOURS:

As each college will arrange instructional and industrial periods to suit their individual needs, taking into account vacation at Christmas and days lost during joining and leaving ship, a minimum of 2,400 hours at six and a half hours per day must be available for instruction in college periods. Based on this figure, it is suggested that the curriculum be arranged allotting the number of hours of instructions for each subject as indicated in Table 2.

The following factors should be taken into account while distributing number of hours of instruction to individual subjects between college periods:

(a) the student must undergo approved basic training in Marine Emergency Duties during the first college period;

(b) the student must undergo approved training in navigating instruments prior to attempting navigating instrument paper for the Watchkeeping Mate, ship certificate;

(c) mathematics and physics syllabus should be completed during the first two periods;

(d) due to its importance, Navigating Safety should form part of the curriculum during each period;

(e) coastal navigation should be completed prior to the end of second period to enable the student to attempt Chartwork paper for the Watchkeeping Mate, ship certificate;

(f) Ocean Navigation should be completed prior to the end of the third period; and

(g) Management, which is relevant to the higher shipboard positions, is deferred until the last period. It must be stressed that the total allocation of hours per subject and the distribution between college periods is purely tentative and is in no way binding. Colleges may adjust these items - bearing in mind the foregoing factors and the content of the core curriculum.

ADDITIONAL SUBJECTS:

It is suggested that colleges also give consideration to the inclusion of short, possibly non-credit, courses in various related subjects. Such courses might be included in the following list:

(1) Port Administration and Operation.
(2) Management and Labour Relations.
(3) Strength of Materials.
(4) Computer Programming.
(5) Computer Technology.
(6) Auto Controls.
(7) Technical Report Writing.
(8) Print Reading.
(9) Chemistry, with emphasis on the carriage of dangerous and hazardous chemicals in bulk.

TABLE 2

ALLOCATION OF HOURS

Subject Area	Subject	Total Hours of Instruction
Academic:	Mathematics	180
	Physics	120
	Language Arts	30
	Electricity	180
	Navigation Aids	180
	Engineering Knowledge	180
Technical:	Naval Architecture & Ship Stability	180
	General Ship Knowledge	90
	Management	90
	Seamanship	90
	Meteorology	90
	Ocean Navigation	180
	Coastal Navigation	120
	Navigation Instruments & SEN I	210
	MED A1,B1,B2 & C	103
	Magnetism	60
	Navigational Safety	90
Others:	Communications	30
	Labour Relations	20
	Technical Report Writing	30
	Strength of Materials	30
	Computer Programming	90
	Computer Technology	60
	Control Systems & Auto Controls	30
	TOTAL HOURS:	2,463

INSTRUCTIONAL STAFF:

It is not envisaged that the entire course will be taught by technical persons with a navigational background, but rather that college authorities will make use of the expertise available to them from amongst the academic staff and instructors in other technical fields. With this-in mind, guidelines with respect to the instructional staff for the various subjects are given as follows:

(1) Subjects which should be taught by members of the Academic Department:

- Mathematics;
- Physics;
- Language Arts;
- Electricity.

(2) Subjects which should be taught by Navigational staff:

- Cargo & General Ship Knowledge;
- Communications;
- Seamanship;
- Ocean Navigation;
- Coastal Navigation;
- Operational Ship Stability;
- Navigation Instruments - Operational;
- Navigation Safety;
- Industrial Safety;
- Environmental Safety;
- Technical Report Writing.

(3) Subjects which it is felt would be better taught by instructors in other technical fields:

- Mechanical Engineering;
- Electrical Engineering;
- Control Systems
- Auto Controls;
- Navigation Instruments
- Electronics Technology;
- Ship Construction & Theoretical Ship Stability;
- Strength of Materials;
- Computer Technology & Programming;
- Labour Relations.

(4) Meteorology and Management are debatable subjects. Meteorology might just as easily be taught by a member of the academic staff as by a navigation instructor. However, while the former would probably have a finer appreciation of the principles involved, there **could** be a lack of knowledge in

certain practical areas, notably with respect to the marine aspects of weather observing, reporting and forecasting. Management could be divided into two areas, one being ship master's business and mainly related to the provisions of the Canada Shipping Act, and other being legal knowledge relating to the carriage of cargo and/or passengers, the hiring of ships and marine insurance. While the former would be taught by navigational staff, the latter might be better elucidated by a person having some legal expertise - such as a visiting lecturer practicing in marine law.

(5) It will be noted that Navigation Instruments consist of two distinct sectors, the operational use of the instruments and electronic theory, and how best to effect the merging of these sectors is a moot point. Such merging could probably best be effected by a member of the navigational staff having additional qualifications in electronics

TRAINING MANUAL:

An essential part of the students' industrial service is the "Navigating Cadet's Deck Training Manual" issued by the Department of Transport. The object of this book is to provide a comprehensive record of the progress and extent of the students' training, and to guide that training in areas which are felt by the Department to be of special importance.

The Training Manual is purely to ensure that the student undergoes training in areas which are felt to be essential to navigation safety and the efficient operation of the ship. There is no restriction on colleges setting additional assignments to be undertaken during the industrial service - particularly in areas of specialized operation such as the Great Lakes, Coast Guard operations or the offshore supply service. It is recognized that colleges might require the maintaining of a supplement. The administration of such additional assignments and supplement would fall to the individual college, but will also be included for the examiner's assessment.

A Training Manual must be maintained by each student and this will be inspected by an Examiner of Masters & Mates after each industrial period, and when the student makes application for examination for the Watchkeeping certificate. The purpose of such inspection is to ensure that the student has complied with its requirements and has made optimum use of his industrial service.

APPROVED TRAINING

Reference has been made to approved training, specifically in the areas of Marine Emergency Duties and Navigation Instruments.

The approved training in Marine Emergency Duties (MED) consists of a one-week course in marine fire fighting, a one-week course in survival craft and a three-day course in officer certification.

In Navigation Instruments, the course is termed Simulated Electronic Navigation (SEN I). SEN I will involve the operation of the instruments and simulated radar exercises.

It should also be mentioned, at this point, that students must undergo training in First Aid to the Marine Advanced Certificate level and, additionally, must obtain a Restricted Operator Certificate (ROC).

The MED training, SEN I, First Aid training and the obtaining of the Restricted Operator Certificate (ROC) must be completed prior to applying for examination for the Watchkeeping Mate, ship Certificate, as they are qualification requirements for that certificate.

CORE CURRICULUM

Here follows the core curriculum in academic subjects.

An attempt has been made to provide only an outline of the academic subjects. These suggested elements have been listed as a reference when colleges prepare their courses. Essentially, these subjects should reflect the current philosophy in the field, and should also include material relevant to the appreciation of the various technical subjects.

It is not unrealistic for the academic courses to be comparable with similar courses offered at university level, and it might even be possible for college administrations to obtain provincial university recognition of these courses.

MATHEMATICS:

Elements of:

- Plane & spherical trigonometry;
- Vectors, scalars and matrices;
- Series: arithmetic & geometrical progression:
  - Binomial theorem;
  - Exponential & logarithmic series;
  - Hyperbolic & inverse hyperbolic functions.
- Plane & solid coordinate geometry;
- Conics;
- Empirical laws & their determination;
- Differentiation;
- Maxima, minima and points of inflection;
- Partial differentiation;
- Integration;
- Polar coordinates;
- Complex quantities;
- Taylor's and Maclaurin's theorems;
- Calculus of finite differences;
- Harmonic analysis;

– Determinants .

PHYSICS

Elements of:

- Statics;
- Dynamics;
- Heat & thermodynamics;
- Light;
- Sound;
- Magnetism & electricity;
- Modern physics;
- Atomic & nuclear physics;

LANGUAGE ARTS

Elements of:

- Linguistic behaviour;
- Communication problems & remedies;
- Techniques of report writing;
- Development of linguistic skills:
  - receptivity;
  - selectivity;
  - reasoning;
  - argument;
  - exposition;
- Application of communication skills:
  - business correspondence;
  - technical correspondence;
  - public speaking;
  - discussion & debate;
  - committee work;
  - critical analysis of texts;
  - research, preparation & presentation of a technical paper or report;
  - second language skills.

ELECTRICITY:

Elements of:

- Electrostatic theory, electron charges, units of electricity (SI), coulomb's law;
- Electric potential: units, potential difference;
- The electric field, lines of electric force, intensity of the electric field, units;

- Capacitance, dielectric contstant & permittivity, dielectric strength, capacitors in series and parallel;
- The electrical circuit, resistance, resistivity, Ohm's law, resistors in series and parallel, potential difference batteries, generation of current, grouping of cells, care & maintenance;
- Power in an electrical circuit, Joule's law;
- Kirchhoff's point and closed path laws, and their application in series; parallel circuits and distribution cables.
- Magnetic theory, field, field strength, magnetic flux and flux density, magnetic induction. Magnetic properties of matter, magnetization of iron, relative and absolute permeability, B/H curves, hysteresis.
- Magnetic circuit, magneto-motive force and reluctance inductance.
- Magnetic field of a current carrying conductor, and hand rules, Lenz's law.
- Movement of a current carrying conductor in a magnetic field, force on the conductor.
- The D.C. generator: self and separate excitation types, principles of operation, load characteristics and uses of the types; open circuit, external and total characteristic curves, losses and efficiency, the electromotive force equations, voltage control.
- The D.C. motor: principles of operation; counter enf motor characteristics of the principal types, voltage, speed and torque; uses of the principal types.
- The A.C. generator principle.
- The alternator, general construction and principles of operation, single and polyphase.
- A.C. motors.
- Transformers: general construction and elementary principles.
- General arrangements of a ship's electrical generation and distribution system.
- The alternating current wave form, peak, RMS and average value, form factor.
- The AC circuit: resistance, inductance and capacitance in the circuit, impedance and the impedance triangle; current, voltage and power in the series circuit; parallel circuits, inductive impedances in parallel, inductive and capacitive impedances in parallel, resonance in series and parallel circuits.
- A general knowledge of the use of and principles employed by common measuring instruments found on board ship.

NAVIGATION AIDS:

- A descriptive understanding of the kinds of radio transmissions, reception and the practical aspects of the receiver tuning for SSB, CW, AM and FM, including the simple radio telephone.
- A general understanding of the different types of aerials used aboard-modern vessels,
- Radio distress signals, automatic alarm systems, fixed and portable radio room equipment.
- Directive and receiving properties of aerials, viz: fixed, rotating-loop and sense-aerials and their associated polar diagrams.
- The relative advantages and disadvantages of audio visual and automatic RDF systems.

- Factors affecting the accuracy of radio bearings, including methods of reducing and compensating errors.
- An understanding and graphical description of the general principles of position-fixing by measurement of distance from two or more fixed points: use of radio waves to obtain a position line by measurement of time difference and phase difference; generation of the hyperbolic curve by difference of distance from two fixed points; family of hyperbolic curves; the hyperbolic lattice on a navigational chart.
- An elementary knowledge of the Doppler phenomenon, and its use in position-fixing and distance and velocity measurements.
- Revisions of position-fixing radar systems and navigation aids studied in the SEN I and II courses; a fuller descriptive knowledge of Decca navigator, Loran, Omega and Satellite navigation systems, pertaining to the characteristics,, applications, radii of coverage areas, limitations and accuracy of each system.
- The errors that affect each radio position-fixing system, and their magnitudes; the sources and causes of such errors; corrections and allowances for variable and uncorrectable errors; fixing accuracy and ellipse of ambiguity.
- An understanding of and an ability to use the information supplied by modern anti-collision radar.
- The use of computers to -assess information from different types of electronic instruments when combined in integrated bridge systems as found on modern cargo ships.

NOTE:

The student should recognize the fallibility of all electronic aids, the importance of combining different methods, and a continuing ability and preparedness to fall back on basic, non-electronic navigation methods at any time.

ENGINEERING KNOWLEDGE:

Steam boilers, comprising:

- general principles of combustion;
- fuel-oil burning methods and arrangements;
- manual and automatic controls;
- steam generation up to the delivery of steam in the superheated state; the close-feed system;
- boiler construction, including mountings and associated auxiliaries, and an appreciation of maintenance; the use of superheaters and economizers; auxiliary and domestic boilers.

Marine steam engines, comprising:

- a general knowledge of the fundamental classes of turbines, impulse and reaction, their different principles and cycles of operation; requirements and precautions and procedures when warming through; block diagrams;
- gas turbines, their cycle and operation;
- an understanding of the steam engine other than as a main propulsion unit.

- Internal combustion engines, comprising:
- the principles of operation of common types of two and four-cycle and opposed-piston engines;
- the ignition of fuels in diesel engines; turbo-charging**;**
- cooling and lubricating systems associated with main engines;
- circulation systems for vessels operating in ice;
- control arrangements, including reversing;
- an appreciation of auxiliaries associated with main diesel units;
- special considerations of turbo-electric and diesel-electric propulsion.

The common types of reciprocating, rotary and screw pumps.

- Piping and pumping arrangements, including bilge ballast cargo, fuel and fire systems.

Drive systems, comprising:

- thrust and trailing blocks;
- reduction gearing;
- electro-magnetic coupling or hydraulic coupling for two or more engines on one shaft;
- flexible couplings.
- A general understanding of the principles of the transmission of heat and cold, refrigeration and insulation.

The general principles underlying the operation of remote control systems, including:

- type of control transmission: pneumatic, electric, hydraulic;
- data logging;
- alarm and fail-safe systems;
- an adequate knowledge of bridge control systems;
- basic computer concepts as found on modern cargo ships.
- A general understanding of the uses of hydraulic systems on board ship.
- shaft vibration, critical speed, effect of draft and trim.
- Venturi system: principle, use and limitations.
- Air receivers.
- Understanding of the measurement of engine power.
- Propeller pitch and power.

Here follows the core curriculum in technical subjects. An attempt has been made to provide only an outline of the technical subjects. Colleges preparing their cadet programmes for approval must follow the course syllabi as detailed in TP 2293.

NAVAL ARCHITECTURE:

Ship dimensions; terminology - general and structural; the general and structural arrangements of basic ship types - general trader, bulk carrier, ore carrier, Great Lakes carrier, oil tanker, package freighter, self-discharging vessel, roll-on/roll-off vessel, vehicle/passenger ferry, rail ferry, liquefied gas carrier, V.L.C.C., O.B.O. vessel, ice breaker and container vessel.

Framing, shell plating; decks, deck beams, hatchways; bulkheads; double bottoms and bilges.

Bow, stern and double bottom construction; watertight and centreline bulkheads. Structural details of machinery spaces, deep tanks, superstructures, deckhouses, hatchways and hatch covers. Deck fittings; bulwarks, rails; bilge keels.

Watertight and fire integrity of passenger vessels.

Oil tanker construction.

Load, stress and strain; modulus of elasticity; tensile and compressive stress, shearing stress, torsion, bending moment. Structural stresses experienced by ships; causes of failure of ship structures. Strength of materials; stress-strain diagrams; relative strengths, properties and characteristics of various construction materials; relative strengths, properties and characteristics of various construction materials; relative strengths of various rolled and built steel sections. Longitudinal bending moment; weight, buoyancy, load curves; shear curve, bending moment curve.

Principle of welding; types of welded joints and their imperfections; benefits and drawbacks of welded construction; distortion, residual stress, stress relieving. Riveted connections; rivet types; watertightness. Riveting and welding combinations. Inspection and testing of riveted and welded joints.

Various ship plans; shipboard piping systems, valves; damage reports and surveys, repair specifications; docking procedures; statutory surveys and inspections,

Shipyard practices; lofting; steel fabrication and erection; blocking and shoring.

Propeller terminology, theory and design; propulsive efficiency; factors affecting propeller performance - number of blades, number and location of propellers, material, pitch. Propeller shafting, Frictional resistance; wave, eddy and air resistance. Hull form, effect of variation on residual resistance; effect of shallow water, rolling pitching.

Manoeuvring; advance, transfer, drift angle, pivoting point« turning circle, tactical diameter, rate of turn; directional stability/instability. Rudder-principle and design; factors influencing steering; rudder terminology and types-unbalanced, balanced, semi-balanced, "spade"; steering gears-steam quadrant, hydraulic ram, rotary vane hydraulic, electric; hydraulic, electric and pneumatic methods of controlling steering gears. Transverse thrust units; Voith-Schneider propeller.

Ship trials - builder's, standardization, endurance and fuel economy; manoeuvring trials; steering gear tests; anchor gear tests.

Tonnage deck, length, breadth and depth. Gross tonnage; exemptions; deductions; propelling power allowance: net tonnage. Treatment of shelter deck spaces; "Dual Tonnage Method" of treatment of shelter deck spaces.

Loadlines, loadline certificate; general loadline rules, loadline rules for Lakes and Rivers; seasons and zones; loadline surveys; tanker loadlines.

Classification Societies - their organization and purpose; benefits of classification, classification Societies Rules.

Ice strengthening, details and extent; Ice Class.

SHIP STABILITY

Measurement of area and volume; determination of area of common plane figures; determination of volume of common solid figures. Determination of area and volume by Trapezoidal rule and Simpson's rules.

Block and prismatic coefficients of fineness. Determination of wetted surface of shipshapes by Taylor's formula. Determination of volume of shipshapes.

Centre of gravity of common plane and solid figures, centre of gravity of waterplane, centre of gravity of shipshapes.

Water pressure, variation with depth; thrust on plane surface, thrust on curved surfaces, centre of pressure. Archimedes principle, law of flotation, variation in draft with change of density of supporting liquid.

Displacement - light, loaded, intermediate; displacement curve and scale; deadweight, deadweight scale. Draft, draft scales, mean draft, variation in mean draft due to trim and list. Freeboard, mean freeboard when listed. Tons per inch immersion (T.P.I).

Buoyancy, volume of buoyancy, centre of buoyancy (B), reserve buoyancy; KBT, KBL, determination of KB for box shaped vessels. Centre of flotation tf), movement of vessel about centre of flotation, movement of centre of flotation with change in draft, movement of B when vessel heeled or listed.

Centre of gravity of ship(G), KG_T and Kgt, movement of G_T due to adding, removing or shifting weights; real and virtual centres of gravity; effect of free surface of liquids on G_T.

Metacentre (M), metacentric height, metacentric radius; equilibrium: stable, unstable and neutral; righting lever, capsizing lever; righting moment (moment of statical stability); stiff and tender ships; angle of loll.

Inclining experiment; initial stability and range of stability; factors affecting statical stability. List resulting from unequal distribution of weights about transverse centerline; effect of positioning of weights - including "winging-outZ - on vessels transverse statical stability. Determination of statical stability at any angle of heel by Attwood's formula.

Dynamical stability: determination from curve of statical stability, determination by Moseley's formula.

KG_L; movement of G_L due to adding, removing or shifting weights. KB_L; movement of B_L due to change of trim. GM_L; moment to change trim one inch (M.C.T.I."); Trim, change of trim due to loading or discharging weights away from centre of flotation, change of trim due to shifting weights already on board.

Loading, discharging and/or shifting weights to achieve desired transverse metacentric height, and trim.

Bilging; volume of intact buoyancy, area of intact waterplane; velocity of inflow of water; effect of bilging midships compartment, effect of bilging end compartment, effect of bilging compartment off transverse centreline. Permeability.

Damage stability; bulkhead deck, margin line, floodable length. Permissible length; subdivision length, breadth and depth; curve of floodable lengths; freeboard ratio (f/d); sheer ratio. Effect of longitudinal bulkheads on damage stability. Pressure exerted on bulkheads and centre of pressure.

Drydocking; critical period, advantage of trim by stern; necessity for upright condition with positive GM. Grounding; effect on stability; grounding upright, with list, overall or at one point.

Stability information available to ships; use of this information to produce curves of statical stability for various conditions of loading. Curves of statical stability; point of origin, point of inflexion, range of stability, angle of maximum stability.

Formation of waves, period of waves; period of ship; synchronism; unresisted rolling, bilge keels, other factors resisting rolling. Stabilizers, active and passive.

Launching. Standing way, camber and slope, sliding ways; poppets. Pressure on fore poppets and way ends. Effect of varying camber, declivity; influence of height of tide.

CARGO & GENERAL SHIP KNOWLEDGE:

Cargo handling arrangements on general traders, dry bulk carriers, self-unloaders, oil tankers, Great Lakes carriers, ro-ro vessels, vehicle and rail-car ferries, package freighters, container vessels, ore carriers, O.B.O. vessels and liquefied gas carriers.

Shipboard cargo handling equipment - cargo booms, deck cranes both level-luffing and gantry.

Preparing compartments for dry cargo; cleaning, ventilating and deodorizing; testing of bilges and drains; inspection for damage, survey of readiness to load.

Preparing compartments for liquid cargo; washing, gas freeing, cleaning; testing of pumps, lines, valves, heating coils and ventilation system; survey of readiness or gas-free.

Preparing compartments for refrigerated cargo; cleaning, drying, disinfecting/deodorizing; testing of bilges and drains; inspection of insulation; testing of cooling system; pre-cooling; survey of readiness.

Rigging cargo gear; swinging boom - including "deadman", union purchase (yard and stay), house fall, split topping lift rig, conventional heavy lift boom, Stulcken heavy left boom. Doubling-up union purchase and swinging booms.

Ancillary equipment; snotter, strop, bridle, tray, pallet,- timber dogs, plate clamps, case clamps, can hooks, bale hooks; cargo net, save all net; bull rope.

Stowage planning and cargo computations. Stowage principles for dry, liquid and refrigerated cargoes; handling of dry, liquid and refrigerated cargoes. Handling heavy lifts. Dunnaging and securing of cargo; attention during voyage. Palletization and containerization of cargo.

Objectives of ventilation, effects of inadequate ventilation; atmosphere control by natural ventilation; atmosphere control by mechanical ventilation- Drihold and Cargocaire systems. Ventilation of cargo oil tanks, pressure-vacuum valves.

Duties and responsibilities of master, cargo officer and other shipboard personnel with respect to the loading, carriage and discharge of cargo.

Preparation and interpretation of cargo plans, distribution of completed cargo plans.

Shore facilities at general cargo wharf, container terminal, bulk cargo wharf, oil terminal, ro-ro terminal including - wharf space, cargo sheds, cargo handling and loading/discharging equipment, road and rail access to dock area, container and vehicle park requirements, cargo storage facilities.

Regulations and codes; Grain Cargo Regulations, Canadian Bulk Cargoes Code, Timber Deck Cargo Regulations, Deck Cargo Safety Code, Dangerous Goods Shipping Regulations; duties and responsibilities of Port Wardens.

Canada Ports Corporation; composition, responsibilities; port operation and control.

MANAGEMENT:

International law of the sea, the high seas, territorial waters, bays and gulfs, straits and canals; contraband, neutrality, blockade, right of search. The Canada Shipping Act.

The ship, ownership, registration, national character and flag, transfer of registry, sale to foreign interests.

Master and crew: master's authority, liabilities and duties; qualifications of officers, rights and privileges of holders of certificates of competency; crew accommodation, provisions and water; provision of medical treatment, provisions for complaint; registry of seamen.

Engagement of seamen; shipping masters and shipping offices; classification of voyages; class of agreements - foreign, home trade and inland waters; types of agreement - voyage, time; opening agreement; engagement of seamen in Canada and abroad - in the presence and in the absence of the proper officer; reporting changes in crew. Advance and allotment of wages,- payment of wages; disrating; discharge; termination of agreement; discharge of seamen in Canada and aboard, proper return port; distressed seamen; births and deaths, property of deceased seamen. Discipline and offences, application of fines and forfeitures. Stowaways.

Customs procedure: arrival and departure foreign; quarantine requirements; Coasting trade of Canada: coasting licenses, coasting bond, reporting to Customs.

Collision; casualties to ships or persons; wreck; reporting of casualties or wreck. Distress and rescue at sea; dangers to navigation; unseaworthy and unsafe ships; SOLAS convention.

Water carriage of goods Act, compliance with regulations governing the carriage of cargo; shipment, stowage and delivery of goods. Contracts of affreightment: common law warranties, common carriers; charter parties, subletting; bills of lading, Hague rules; Harter Act; freight; cargo documentation.

Marine losses: particular average; general average; York/Antwerp rules; Protection and Indemnity clubs; self-insurance; war risks insurance.

Wreck, receiver of wrecks; salvage, salvage agreement, salvage award.

Pilotage: pilotage authorities; compulsory pilotage, exceptions; licensing of pilots, privileges and duties of pilots, offences by pilots.

Cargo damage: cause and prevention; surveys, claims; pilferage and security; general average considerations; protest and extending protest; limitation of liability.

Passengers: master's duties and responsibilities; passenger's contract; limitation of liability; baggage and effects.

Governmental and other agencies: Ministry of Transport, marine safety, maintenance of aids to navigation, pollution prevention; Canadian Coast Guard; Canada Customs; Lloyds. Canadian Labour Code and labour relations, employers groups, maritime unions, union contracts.

Computation of optimum load capacities involving seasonal and bunkering considerations. Completion of time sheets involving laydays, demurrage and despatch, freight payable.

SEAMANSHIP:

Arrangement and responsibilities of shipboard departments.

Duties and responsibilities of master and officers with respect to: joining and leaving the ship; executive and organizational duties; issuance and observation of general, standing, night and special orders; manning and conduct of watches; organization and direction of crew with respect to working cargo, fuelling, storing, cleaning and maintaining the ship and equipment; official logbook, deck log, owner's and charterer's records; bridge discipline, organization and routine.

Rigging of ships - standing and running; use of cordage - natural and synthetic fibre, wire rope; knots, bends and hitches in common use; splicing wire and fibre ropes; use, care and rigging of purchases and determination of the power gained; slinging a stage, rigging a bosun's chair and pilot ladder.

Inspection and maintenance of ship and equipment - hull, holds, double bottoms, deep and peak tanks, bilges, strums, pipelines, rudder, accommodation, anchors and cables, davits, derricks, deck machinery and all items of cargo working gear.

Properties and uses of paints and other protective coverings; methods of corrosion control in steelwork and between dissimilar metals; treatment of woodwork and composition decks; maintenance of cement work.

Ship handling: general manoeuvring characteristics of merchant ships of all types; turning circle, advance, transfer, pivoting point, drift angle, tactical diameter; use of tables of stopping distances and turning circle diagrams. Effect of transverse thrust ahead and astern; pivoting point ahead and astern; head and stern reach; effect of cavitation and wake current; immediate steering effect; rudder force; sail effect of superstructures; use of the “water wedge" in berthing and unberthing; bank suction and cushion effects in narrow channels; effect of shallow water resistance on ship's behaviour; influence of trim, draft, list and squat, interaction in narrow channels.

Handling and manoeuvring single or twin screw ships with fixed or controllable pitch propellers, in open and narrow waters, with or without wind, tide or current, with or without the aid of tugs: turning short round mooring to buoy/s, locking and unlocking, passing close to other vessels, coming alongside and leaving a berth, embarking and disembarking a pilot.

Anchor work: construction of anchors and cables, marking cables, stowage of anchors and cables; anchoring to single bower anchor, anchoring to stern anchor, *anchoring* in emergency, mooring to two anchors, use of anchor in manoeuvring or to bring vessel up short; influence of depth of water, type of bottom, degree of shelter, and swinging room on scope of cable used.

Action and manoeuvres in emergencies: man overboard, dragging anchor, running aground, collision, discovery of fire, sighting or receiving distress signals, breakdowns and power failures, loss or

damage to rudder, beaching, taking or being taken in tow, heaving to, running before a sea, keeping head to sea, use of oil in emergency situations.

Procedures in ice, alone or in convoy.

Port operations with respect to: tending lines and gangways, routine and exceptional fire patrols and inspections, action on discovery of fire aboard or ashore, protection of crew members or shore personnel, parting moorings, burst oil lines, tank overflows, being struck by another vessel, accident to any person on board, ship taking bottom.

Damage control in circumstances of: collision, grounding, fire, explosion, heavy weather.

Preparations for: getting underway, making port, heavy weather.

METEOROLOGY

The sun; wind in space, solar wind, magnetic field; Radiation Kirchoff's, Wien's and Stefan's laws, blackbody and blackbody radiation from the sun.

The atmosphere; composition, vertical structure; thermal structure, solar constant, heat budget, gains and losses, temperature variation with latitude, equation of balance; conduction process, convection process, temperature variation with height; influence of land and sea, horizontal exchange; annual variation, diurnal variation, local changes.

Atmospheric pressure; units; pressure distribution; isobars, pressure gradients; diurnal variation in pressure, pressure tendency; variation with height and hydrostatic law.

Atmospheric stability; equation of state, first law of thermodynamics; adiabatic processes; adiabatic lapse rates; stable and unstable conditions; potential temperature; mixing, subsidence and inversions.

Water vapour; relative humidity, diurnal variation; evaporation and condensation; hygroscopic nuclei; dew point and frost point; formation and growth of water droplets, fall velocity of drops; precipitation mechanisms; ice-crystal process, capture process.

Cloud; forms, height, classification; general ascent of warm air, convective clouds, clouds and lapse rates; turbulence cloud, orographic cloud, clouds in large scale ascent; mixing and cooling, mixing and evaporation.

Precipitation; hydrometeors; formation of drizzle, rain, snow, hail. Patterns of thunderstorms, thunderstorm development, thunderstorm cells and clusters, squall lines.

Atmospheric obscurity; classification of haze, mist and fog; fog producing processes; radiation fog, diurnal and seasonal variation, local effects; advection fog; smoke pollution (smog); mist, haze and dust; mixing fog; evaporation fog (sea smoke); regions with frequent fog.

Wind; forces and motion, Newton's second law; Pressure force, Coriolis force, cyclostrophic force, Geostrophic wind; modifying influence of friction, surface wind in relation to isobars; wind circulation around pressure systems, Buys Ballot's law; wind structure at the lowest level, vertical structure, the thermal wind; circulation - vorticity and divergence; divergence and vertical motion, Dine's compensation; baroptric and baroclinic structures, sources and sinks of heat.

Planetary system of pressure and winds; actual pressure distribution, Tropical regime, extra-tropical regime; wind systems; Intertropical Convergence Zone; the index cycle, the jet stream: influence of continents and oceans; trade winds; monsoon systems; winds of the temperate zones; polar winds. Land and sea breezes; anabatic and katabatic winds; drainage winds; foehn winds; local winds,

Air masses: source regions, classification; air mass properties; life history of air masses; air mass boundaries (fronts); formation of fronts, principal frontal zones, fronts and waves-aloft; warm and cold fronts.

Frontal surface as a surface of equilibrium; convergence and divergence, the formation of frontal depressions; life cycle of a frontal depression, occlusion, dissolution of depressions; movement of fronts in relation to isobars and winds. Families of depressions, secondary depressions, non-frontal depressions; thermal depressions, depressions due to vertical instability; topographical depressions

Anticyclones: cold and warm; troughs of low pressure; ridges of high pressure; the Col.

Geographical distribution of depressions and anticyclones, seasonal variation.

Tropical disturbances: easterly wave, tropical depression, tropical revolving storm; formation and life cycle of tropical revolving storm; shape, isobaric distribution, size, weather, wind and waves; origins and track; movement; areas of occurrence, seasons and warnings; swell, storm tides. Avoidance of tropical revolving storms, including the use of the "safety sector" system.

Ocean currents; generation, direct effect of wind; current variability; warm and cold currents; gradient currents; general circulation of the oceans and seasonal variations; influence of ocean currents on temperature regimes and climate; subsurface circulation; upwelling.

Ice classification, nomenclature; formation, development and decay of sea ice; pack-ice, shelf ice; icebergs; the distribution and movement of ice.

Optical phenomena: aurora, halos, coronae; sky colouring, green flash, rainbows, crepuscular rays, iridenscence; mirage; waterspouts; lightning, corposants.

Meteorological instruments: barometers, various types, reduction of readings to standard datum; thermometers, various types, Stevenson screen; psychrometer, hygrometer, determination of relative humidity and dew point temperature; Anemometers, various types; Barograph, thermograph.

World Meteorological Organization; Canadian Atmospheric Environment Service; collection and reporting of meteorological information, distribution of weather information, use of codes in the reporting and distribution of weather information; compilation of synoptic charts; use of synoptic charts and facsimile weather maps in weather forecasting.

OCEAN NAVIGATION:

The earth: shape, dimensions; rotation, eulerian motion, nutation; great circle, geodesic, small circle; spherical angle, spherical triangle, spherical excess; direction, distance.

Latitude, parallel of latitude, difference in latitude; longitude, meridian of longitude, prime meridian, difference in longitude; mean latitude, middle latitude.

Chart projections: equatorial, polar, oblique; cylindrical, conic, azimuthal; principle of gnomonic, Lambert conformal, mercator, orthographic, polyconic and stereographic projections; properties of mercator, polyconic and gnomonic charts; Polar charts.

Moon: size, orbit, common centre of mass; perigee and apogee; rotation, revolution, revolution, libration, phases, age.

Artificial satellites: uncontrolled in steady orbits, controlled in variable orbits; satellite orbits: polar, equatorial, oblique (inclined).

Solar system; lnferior and superior planets; size of planets; inner and outer planets; navigational planets; major planets; asteroid belt.

Planetary orbits; perihelion and aphelion; conjuction-superior ana inferior; Kepler's first, second and third laws; Newton's first, second and third laws of motion, universal law of gravitation; synodic rotation, sidereal revolution.

Ecliptic, equinoxes, solstlces; first points of Aries and Libra; precession of the equinoxes; variable length of day and night, the seasons, length of seasons.

Stars; double, multiple and globular stars; the Milky Way; nebulae, novae; scintillation and colour; magnitude, magnitude units, negative magnitude, variable magnitude; name, Bayer's name, Flamsteed's number, catalogue number.

Celestial sphere; poles, meridians, hour circles, rational horizon, equinoctial; zenith, nadir, vertical circles, prime vertical; altitude, zenith distance, altitude circle; celestial triangles, navigational

triangle: azimuth angle, amplitude. Figure drawing- stereographic, equidistant; plane of observer's rational horizon, plane of observer's celestial meridian.

Motion; apparent motion due to rotation of the earth, revolution of the earth; apparent motion of sun, moon, inferior and superior plants, stars; aberration.
Hour angles: Greenwich, local and sidereal; meridian angle; right ascension; polar diagram.
Geographical position; sub-solar, sub-lunar and sub-stellar points; declination, polar distance.

Time, units of time; Greenwich and local times; apparent, mean, sidereal and lunar time; zone and standard times; relationship between longitude and time; equation of time; Nautical Almanac.

Sunrise and sunset, theoretical and visible; civil, nautical and astronomical twilight.
Marine sextant: Principle, operation and errors: care of sextant. Construction and care of chronometer; rating.

Horizons: visible, sensible, geoidal and rational; dip, refraction, abnormal refraction; semi-diameter and its augmentation: parallax; correction of sextant altitudes.

Latitude by meridian altitude of heavenly body; latitude by Polaris; use of ex-meridian tables; position by two or more simultaneous observations of heavenly bodies; position by two observations of heavenly body or bodies separated in time; use of short method tables H.O. 229.

Inertial D.R. calculators (S.I.N.S.); Doppler D.R. calculators; Satellite navigation system.

Voyage planning; selection of courses; preparations. Courses and distances - great circle, composite great circle, rhumb line. Emergency planning, critical point of passage, point of no return.

High latitude navigation; projection and adequacy of charts; polar grid; meteorological effects; celestial compasses.

Errors, systematic and random; faults; mistakes; two dimensional errors, Most Probable Position; errors in position lines; precision, accuracy.

Tides and tidal streams; gravitational and tide-raising forces of sun and moon; effects of earth's rotation, moon's declination and changes in the distance of sun and moon; tide wave; response of water in tidal basin, harmonic constituents of the tide. Equinoctial, solsticial and equatorial tides; seiches, bores, seismic waves.

COASTAL NAVIGATION:

Charts; scales of latitude and longitude, natural scale, measuring distance; distortion associated with mercator, polyconic and gnomonic charts; Canadian Hydrographic Office; U.S. Hydrographic Office;

availability of charts, chart catalogues; chart symbols and abbreviations; use and care of charts, correction of charts; accuracy and reliability of charts.

Lights, beacons, buoys and fog signals used as aids to navigation.

Use of sailing directions ("pilots"), light lists, tide and current tables and tidal current atlases. Navigational Warnings; Notices to Mariners and their use in correcting charts and publications.

Code of Navigating Practices and Procedures so far as it concerns the keeping of a navigational watch.

Use of various chartwork instruments - parallel rules, station pointers, patent protractors.

Tides; tidal datum; tidal and non-tidal currents.

Position fixing: by simultaneous observations, by observations separated by a run; selecting marks for fixing; indicating position; fixing position of uncharted objects; use of position lines/circles obtained by visual bearings, radar range/bearing, Decca readings, Loran readings, transits, echo-sounding.

The earth and its magnetic field; magnetic poles; variation, change in variation, local magnetic anomalies; isogonic charts; conversion of true courses to -magnetic and vice versa.

Determination of true courses; determination of courses, distances and speeds made good; dead reckoning position; effect of wind and current; estimated position; counteracting the effect of wind and current; selection of safe courses.

Symbols used to indicate: position lines, transferred position lines; dead reckoning, estimated and observed positions; tidal vector; course steered, course made good.

Accuracy of position fixing; errors in taking and layingoff bearings; the "cocked hat"; the diamond of error in hyperbolic position line fixing; common failures in coastal navigation.

Navigation in restricted visibility; importance of soundings; increased effect of current at reduced speeds; point-to-point navigation; parallel-index technique; homing.

Navigation in ice; publications available: information on ice conditions; recommended routes; use of radar; indications of ice; unreliability of winter buoys in ice.

Record keeping; deck log book; bridge movement book; night order book.

Landfall considerations; importance of radar, echo-sounder and radio direction-finder; influence of meteorological conditions including refraction and haze; compliance with traffic separation schemes.

Pilotage; ranges transits, clearing lines and danger bearings; harbour and pilotage regulations; tidal considerations; allowing for advance and transfer; compliance with routing and/or vessel traffic management systems. Shallow water effects and bank suction. Blind pilotage. Common errors in piloting.

Selection of anchorages; quality of bottom, depth of water, shelter, tidal conditions, swinging room; selection of marks and determination of bearings to indicate selected position. Anchor watches, determination of vessel position - visual bearings, radar ranges horizontal angles, Decca readings.

NAVIGATING INSTRUMENTS:

- Knowledge of the radar display unit, the various controls and the different presentations.
- The practical interpretation of the radar display, including the limitations of the equipment.
- The practical effects of weather and ice on radar performance and display.
- The use of radar in position fixing.
- The use of radar as a collision warning device, and its limitations.
- Periodic operational checks to be performed by the radar operator.
- The purpose and contents of the radar log.
- Radar observational errors and the allowances to be made for them.
- The practical use of RDF equipment, including the limitations of the equipment, errors and their correction.
- The practical operation of the Decca receiver, including errors and their correction, variation in accuracy and routine operational checks.
- The practical operation of the Loran receiver, including errors and their correction, variation in accuracy.
- The practical operation of the Omega receiver, including errors and their correction and limitation as to accuracy.
- The application of navigational satellites to marine navigation. The use and care of modern logs.
- The practical operation of echo sounding machines including: operator checks and adjustments, action and use of controls, adjustments for draft, limitations of the equipment, errors and their correction, and interpretation of recordings.
- The use and care of magnetic compasses.
- Magnetic and non-magnetic materials and their possible effect on the compass.
- Use of azimuth mirror and circle.
- Use of pelorus.
- The use and care of marine gyro compasses comprising procedure for starting and stopping, setting-up repeaters and course recorders and operational checks emphasizing use of manuals.
- Instrument errors and their corrections.
- Auto pilots, changeover procedures.

- Determination of gyro and magnetic compass errors by the various means at the disposal of the Officer of the Watch (O.O.W.), including amplitude or azimuth by any recognized method of the sun and the pole star.
- Conversion of magnetic to compass courses, true to gyro courses, and vice versa, including determination of deviation from cards.
- Care and use of the marine sextant for the measurement of terrestrial angles only.
- Proper bridge-to-bridge voice communication as an aid to navigation.

NAVIGATION SAFETY & COMMUNICATIONS:

- Collision Regulations 1983 (with Canadian modifications):
- Code of Navigating Procedures & Practices; Navigating Appliances Regulations; Charts & Nautical Publications Regulations; Crewing Regulations; VHF Radio/Telephone Practices & Procedures Regulations; Ship Station Radio Regulations; Ship Station Technical Regulations; Steering Appliances & Equipment Regulations; Standard Marine Navigation Vocabulary.
- International Code flags and their individual meanings; transmission and reception of messages by morse flashing light or sound, morse signalling by hand flags or arms, and radio/telephone.
- Use of International Code of Signals in the transmission and reception of messages by code flags, morse, morse signalling by hand flags or arms, and radio/telephone. Use of the Radio Aids to Marine Navigation publication to ascertain facilities and services. Lifesaving signals depicted in the International Code of Signals.
- Vessel traffic management systems; St. Lawrence Seaway Regulations and Handbook.

INDUSTRIAL SAFETY:

Tackle Regulations; marking of gear fencing and gangways, lighting; inspection and testing of gear and machinery; Machinery Register; tackle inspectors.

Safe Working Practices and Regulations; recognition and correction of unsafe practices. Accident prevention; operation of safety programmes; investigation accidents.

Measurement and strength of wire rope, synthetic and fibre ropes, chains; safe working loads and their importance; stresses in the various parts of a single boom and a union purchase rig when working cargo.

First Aid Training to Marine Advanced Certificate level.

Marine Emergency Duties: approved training in Marine Firefighting, Survival Craft, and Officer Certification. Fire prevention, patrols and surveillance systems; safety precautions to be taken during the loading and discharging of bulk oil, chemicals and other inflammable commodities. Care maintenance and use of all lifesaving and firefighting appliances, lifeboat and liferaft equipment, light and sound signals, organization and direction of firefighting and life boat and liferaft preparation parties. Boat and

Fire Drill regulations, Fire Detection and Extinguishing Equipment regulations, Life Saving Equipment regulations.

Steps to be taken when vessel disabled and in distress; preservation of passengers and crew in the event of wreck; abandoning ship, survival procedure; management of boats in heavy weather, recovering boats at sea; abandoning a wrecked ship, communications Wit the shore, use of rockets and rocket apparatus.

Assisting a ship or aircraft in distress, rescuing crew of a disabled ship or ditched aircraft.

Organization, frequency and routing of fire patrols; recognition and assessment of fire hazards; organization of realistic fire drills and training of crew; inspection and testing of fire fighting equipment. Organization of realistic boat drills and the training of crew

ENVIRONMENTAL SAFETY:

Oil Pollution Prevention Regulations; Garbage Pollution Prevention Regulations; Arctic Waters Pollution Prevention Regulations: Shipping Safety Control Zones Order.

Measures to be taken to prevent the spillage of oil during cargo work, bunkering or oil transfer. The keeping of records and the pollution prevention regulations.

Methods of pest control; fumigation of holds and living spaces; safeguards in applying the various methods.

Routine inspections of living quarters, store rooms and provisions.

CONTROL SYSTEMS & AUTO CONTROLS:

Transfer function.

Representation of Control Components: Operational rotation. Translational and rotational mechanical components. Electrical components. Series and parallel combination of elements. Analogies. Comparators. Integrators. Non-linear devices. Linear approximation of a non-linear function.

Block Diagram Representation of Control Systems: Hydraulic syervomotor. Temperature control system. Block diagram algebra. Speed control system.

Steady-State operation: Steady-state analysis of a control system. Proportional, Integral, Proportional-Integral controllers.

The Characteristic Function: Definition of characteristic equation. Poles, Zeroes, Complex conjugate zeroes. Damping ratio and natural frequency. Transient response to step and impulse functions. Routh-hurwitz stability criterion.

The Root-Locus Method: Significance of Root-Loci. Construction of Loci.

Analogue Computers: Introduction. Computer operations. Computer diagrams. Amplitude and time scaling. Simulation.

Frequency-Response Methods: Polar representation, Logarithmic representation. Polar plots of type 0,1,2,3 systems. Closed loop response from open loop response. Correlation between transient and frequency response. Design by variation of gain. Nyquist stability criterion. Gain and Phase margin. Series compensation. Internal feedback. Inverse plots.

Data Transduction: Measurement of displacement, velocity, acceleration, force, torque, pressure, flow-rate, level, temperature, weight, density, radiation.

Data Processing and Computation: Monitors and date-logging equipment. Process control computers. Analogue computers, linear operation and simulation. Digital computers, organization, input-output devices.

Pneumatic Systems: Power supplies. Flapper amplifier. Two stage amplifier. Proportional, derivative and integral controllers. Force type pneumatic controller. Pneumatic actuators.

Electrical Systems: D.C. Motors. Field and armature control. Ward-Leonard system. D.C. tachometer. Rototrol Generator, Amplidyne. Position servome chanism. A.C. Two-phase motor. Synchro error detectors. Vacuum tube amplifiers. Push-pull amplifier. Modulators and Demodulators. Transistor amplifiers.