

Form of examinations

4.—(1) An examination for a qualification leading to an engineer's grade of certificate of competency shall take the form of—

- (a) except in the case of an examination leading to an engine operator's licence—an examiner asking the examinee questions in writing and the examinee giving written answers either verbally or by the production of drawings; and
- (b) the examiner asking the examinee questions orally and the examinee giving either oral answers or a practical demonstration of his abilities.

(2) Subject to subregulation (3), an examination for a qualification leading to an engineer's grade of certificate of competency shall consist of 2 parts to be known as Part A and Part B.

(3) Subregulation (2) does not apply in respect of an examination leading to an engine operator's licence.

Written examinations

5.—(1) Subject to subregulation 7(1) and to subregulation 6(1) of the Marine (Certificates of Competency (Qualifications for Entry to Examinations) (Engineering Officers)) Regulations, 1989, the subjects to be covered in the written part of an examination leading to a qualification for an engineer's grade of certificate of competency are set out against that grade of certificate in column 3 of Part 1 of Schedule 1.

(2) Each subject referred to in subregulation (1) is to be the subject of a separate examination.

(3) An examinee shall be allowed the period specified in column 4 of Schedule 1 in which to undertake an examination specified in column 3.

(4) The syllabus for each examination referred to in subregulation (2) is specified under the name of that examination in Part 1 of Schedule 2.

Oral and practical examinations

6.—(1) The subjects to be covered in the oral and practical part of an examination leading to a qualification for an engineer's grade of certificate of competency are set out in Part 2 of Schedule 1.

(2) The syllabus for each examination referred to in subregulation (1) is specified under the name of that examination in Part 2 of Schedule 2.

Steamship and motor vessel endorsements

7.—(1) A person may omit from an examination leading to a qualification for a Grade 1 Engineer, Grade 2 Engineer or Grade 3 Engineer certificate of competency that part of the written examination entitled Engineering knowledge (steam) or Engineering knowledge (motor) and oral questions in respect of the items included in those examinations.

(2) Where a person has omitted part of an examination in accordance with subregulation (1) any certificate of competency issued to him shall be endorsed in accordance with subregulation 9(1) of the Marine (Certificates of Competency (Qualifications for Entry to Examinations) (Engineering Officers)) Regulations, 1989.

[LEGAL NOTICE NO. 13]

MARINE ACT
(ACT NO. 35 OF 1986)

MARINE (CERTIFICATES OF COMPETENCY (EXAMINATION SYLLABUSES) (ENGINEERING OFFICERS)) REGULATIONS, 1989

IN exercise of the powers conferred upon me by sections 98, 99, 143 and 212 of the Marine Act, 1986, I have made the following Regulations—

Short title

1. These Regulations may be cited as the Marine (Certificates of Competency (Examination Syllabuses) (Engineering Officers)) Regulations, 1989.

Object

2. These Regulations prescribed the subject matter of the various examinations a person must pass as part of the qualifications he must have before he can be issued with a certificate of competency as an engineering officer.

Regulations to be read as one

3.—(1) These Regulations are to be read as one with the Marine (Certificates of Competency and Manning of Vessels) (General) Regulations, 1989, and the other Regulations referred to in those Regulations.

(2) In particular words and phrases defined in the Marine (Certificates of Competency and Manning of Vessels) (General) Regulations, 1989 have the same meaning when used in these Regulations.

(3) For the purposes of obtaining either a motor vessel endorsement or a steamship endorsement on a certificate of competency endorsed in accordance with subregulation 9(1) of the Marine (Certificates of Competency (Qualifications for Entry of Examinations) (Engineering Officers) Regulations, 1989 the holder of the licence shall take those examinations omitted in accordance with subregulation (1).

Dated this third day of May 1989.

A. V. TORA
Minister for Communications, Works
and Transport

Regs. 5(1) and 5(3)

SCHEDULE I
PART I
WRITTEN EXAMINATION SUBJECTS

Column 1 Item	Column 2 Grade of Certificate of Competency	Column 3 Part	Column 3 Subjects	Column 4 Duration of Examination
1	Engineer Grade 1	A	Applied mechanics	3 hours
			Heat engines	3 hours
			Electrotechnology	3 hours
		B	Naval architecture and Ship construction	3 hours
			Engineering knowledge (general)	3 hours
			Engineering knowledge (motor) Engineering knowledge (steam)	3 hours 3 hours
2	Engineer Grade 2	A	Applied mechanics	3 hours
			Applied heat	3 hours
			Electrotechnology	3 hours
		B	Naval architecture and ship construction	3 hours
			Engineering knowledge (general)	3 hours
			Engineering knowledge (motor) Engineering knowledge (steam)	3 hours 3 hours
3	Engineering Grade 3	A	Applied mechanics	3 hours
			Heat and heat engines	3 hours
			Engineering drawings	4 hours

Column 1 Item	Column 2 Grade of Certificate of Competency	Column 3 Part	Column 3 Subjects	Column 4 Duration of Examination
4	Engineer Grade 4	B	Electrotechnology	3 hours
			Naval architecture and ship construction	3 hours
			Engineering knowledge (general)	3 hours
		A	Engineering knowledge (motor)	3 hours
			Engineering knowledge (steam)	3 hours
			Applied mechanics	3 hours
5	Engineer Grade 5	B	Heat and heat engines	3 hours
			Engineering drawings	4 hours
			Electrotechnology	2 hours
		A	Naval architecture	2 hours
			General engineering knowledge	2 hours
			Engineering knowledge (motor)	2 hours
B	Practical mathematics	2 hours		
	Engineering knowledge	3 hours		

Reg. 6(1)

PART 2
ORAL AND PRACTICAL
EXAMINATION SUBJECTS

Column 1 Item	Column 2 Grade of Certificate of Competency	Column 3 Subject
1	Grade 1 Engineer	Engineering knowledge
2	Grade 2 Engineer	Engineering knowledge
3	Grade 3 Engineer	Engineering knowledge
4	Grade 4 Engineer	Engineering knowledge
5	Grade 5 Engineer	Engineering knowledge
6	Engine Operator	Engineering knowledge Marine engineering knowledge Fire precautions

SCHEDULE 2

PART I

SYLLABUSES FOR WRITTEN EXAMINATIONS
(ENGINEERING OFFICERS)

Grade 1 Engineer—Part A—Applied Mechanics examination

1. Revision of basic mathematics required for the solution of problems in applied mechanics—Sine Rule—Cosine Rule—trig. formulae—resolution of triangles, sines, cosines, etc. of negative angles—solution of quadratic equations by completing the square—solution by quadratic formula—circular measurement and conversion from angular to linear.
2. Revision of statics—triangle of force—polygon of forces—introduction to Rapson Slide mechanism—Bow's Notation—roof trusses—Non-Coplanar force system.
3. Revision of basic principles of sliding—Rapson Slide with friction—conical clutch friction—centrifugal clutch—disc friction—thrust bearings—plate clutches.
4. Revision of kinematics—linear and angular motion formulae. Motion of a projectile—maximum height and range—projectile on incline. Relative velocity—instantaneous centres.
5. Revision of dynamics—Newton's Laws—impulse and momentum—conservation of energy—determine of radius of gyration—2nd moments of inertia of a mass—accelerating torque—conservation of momentum applied to friction clutch and fly wheels.
6. Application of centrifugal force principles—Balancing of rotation masses in one plane—Power Governor with friction—Hartnell Governor with droop setting application—effect of banked tracks.
7. Application of kinetic energy—kinetic energy of translation—kinetic energy of rotation. Application of kinetic energy and accelerating torque to fly wheels and lifting mechanisms. Derivation of radius of gyration experiment fluctuation of energy.
8. Simple harmonic motion—compound pendulum—free vibrations of a springslider crank mechanism considering simple harmonic motion—piston displacement formula.
9. Transverse vibration—with simple loading—beam deflection formulae for simple loading. Introduction to Nodal vibrations—longitudinal—torsional. Simple balancing of reciprocating masses. Simply supported beams with uniformly distributed load, including weight of beam. M.B. and S.F. diagrams with mixed loading.
10. Resilience—falling mass suddenly applied load—eccentric loading of short columns—loading of compound bars—temperature stresses.
11. Strut Formulae—Euler's Rankine and Gordon's formula for struts—Torsional strain energy—close coiled helical spring—Torsion composite shafts.

12. Combined bending and torsion of shafts—principal planes—Gyroscopic effect on shafting during ship's manoeuvres—Critical or whirling speed of shafts.
13. Hydrostatics—relative density—relation of pressure of depth—pressure on an immersed area—centre of pressure.
14. Hydraulics—introduction of Bernoulli's theorem. Flow through an orifice with a constant head—path of jet after issue—venturi meter—centrifugal pumps.

Grade 1 Engineer—Part A—Heat Engines examination

1. Revision of work on Gas Laws, Steam Tables, Internal Energy, Enthalpy, Adiabatic Process and Polytropic Processes, The First Law of Thermodynamics—Steady Flow and Non-Flow processes, Entropy as a property—its relation to other properties, Temperature Entropy diagrams for gas and steam, Entropy calculations, Thermo dynamic reversability—Carnot cycle for a gas—the ideal thermal efficiency.
2. Investigation of other ideal heat engine cycles—
 - (a) Otto—constant volume
 - (b) Diesel—modified constant pressure.
 - (c) Dual
 - (d) Gas Turbine—Constant pressure.
3. Air Standard Efficiency—temperature entropy diagrams.
4. Actual thermal efficiency of heat engines—relative efficiency—calculations of mean effective pressure. Modifications to the ideal gas turbine cycle— isothermic efficiency—regenerators and their use.
5. Reciprocating Air Compressors—ideal and actual cycles—single and multi-stage compression—conditions for minimum work, Intercooling and its uses—heat transfers to the cooling water.
6. Rotary Air Compressors—types and their application.
7. Carnot Cycle—vapour as the working fluid.
8. Rankine Cycles—pressure/volume, temperature/entropy diagrams—the enthalpy/entropy chart and its uses.
9. Basic Modifications to the Rankine Cycle—
 - (a) Superheat
 - (b) Re-heat
 - (c) Regenerative feed heating.
 Other considerations to modify the cycle—feed pump work—constant volume exhaust.
10. Carnot Reversed Cycle—vapour as the working fluid—the ideal heat pump—ideal coefficient of performance. The vapour compression refrigeration cycle—temperature/entropy diagrams—temperature/enthalpy diagrams actual coefficient of performance, power requirements and refrigeration effect.
Multi stage evaporation—the use of the vapour compression cycle for both heating and cooling.

11. Vapour flow through a nozzle—application of the first law of thermodynamics.
Types of nozzles—convergent, convergent/divergent—critical pressure ratio—isentropic efficiency and friction losses.
12. Steam Turbines—simple impulse turbines—compounding for pressure and velocity. Vector diagrams for simple impulse, and velocity compounding—friction losses—calculations for work, power and thrust, blade height and blade efficiency. Reaction turbines—vector diagrams—calculations on work, power and thrust, blade height and stage efficiency.
13. Daltons Laws for Partial Pressure—Mixing of non-reacting mixtures of gases and vapours. Condensers and their functions—surface and regenerative. Air pump and air ejector capacity—air leakage into condensers—vacuum efficiency.
14. Engine Trials—calculation of efficiency by testing—dynamometers—indicated power, brake power and friction power—mechanical efficiency—Morse test.
15. Heat Balance—for a steam engine, boiler and internal combustion engine. Graphs from engine testing.
16. Heat Transfer—types of heat transfer—conduction, radiation and convection. Heat conduction through composite walls—thin and thick wall cylinders. Radiation and the Stefan Boltzmann constant—grey and black bodies. Surface and overall heat transfer co-efficients. Revision of Stoichiometric air supply calculations.
17. Avagadro's Hypothesis—conversion from volumetric analysis to a mass analysis—the "Kg Mol". Description of the Orsat Apparatus Volumetric analysis of fuel gases, incompleted combustion—formation of carbon monoxide.
18. Higher and lower calorific values—the universal gas constant—average relative molecular mass.

Grade I Engineer—Part A—Electrotechnology examination

1. *Revision of the electric circuit*—Units—ampere, ohm and volt. Ohm's Laws. Series and parallel circuits of sources of e.m.f. and or resistances. Current distribution of simple circuits. Difference between e.m.f. and p.d. Power and energy. Relationships between heating, mechanical and electrical units. Conductor resistance, effect of length, area, material and temperature. Resistivity. Temperature coefficient of resistance. Types of insulation.

2. *Revision of bridge systems*—Wheatstone network bridge, slide wire bridge; application of steering gears, resistance pyrometers, strain gauges, and Kirchoff's Laws. Parallel operation of batteries with unequal e.m.f.'s and differing internal resistances. Distribution problems, volt-drop. Cells—primary and secondary (acid or alkaline) types. Construction and principles, mechanical formula. Maintenance, charging, Watt-hour and ampere-hour efficiencies.

3. *Revision of magnetism and electromagnetism*—Simple magnetic theory. Magnetic field. Line of force. Field strength. Field intensity. Magnetic fields due to current in straight conductors, loops coils and soleoids. Relative direction of current and field. Effect of iron. Flux density. Total flux. Permeability. Hysteresis. Typical B/

H curves. Magnetic circuit. Compare with electric circuit. Air gaps introduce high reluctance to a magnetic circuit. Simple numerical work—no elaborate circuit calculations. Self inductance, stored energy in an inductor.

4.—*Capacitance*—As a property—factors upon which it depends—charging and discharging a capacitor. Relationships $Q = CV$ Series and parallel coupling. Energy stored in a capacitor $\frac{1}{2}CV^2$.

5. *Revision of Instruments*—Principles and functions of switchboard indicating instruments. Moving-coil, moving-iron and dynamometer types. Uses of shunts and series resistances to increase the range. The current transformer potential transformer for instrument work (description and simple explanation).

6. *Electro-magnetic induction*—Faraday's and Lenz's Laws. Magnitude and direction induced e.m.f. Force produced on a current carrying conductor. Mutual induction (property only).

7. *Revision of D.C. generators*—Constructional details. Protection. E.m.f. and load voltage equation. Action of commutator. Simple properties of lap and wave windings. Methods of supplying the field—separate excitation, shunt, series and compounds windings. Brief treatment of theory for self-excitation. Reasons for failure to excite. Remedies.

8. *Revision of load characteristics*—Methods of voltage control. Parallel operation procedure for shunt and compound generators. The equalising bar. Load sharing treated qualitatively. D.C. motors—constructional details. Speed and torque equations. Load characteristics. Speed control. Motor calculations (no efficiency calculations). Applications to Ward Leonard systems. Steering Gear. Suitability of d.c. motors for the various types of work.

9. *Revision of starters*—Need for a starter. Types of manual starters. Drum controller. Types of Automatic Starters:

- (a) Counter e.m.f. starters
- (b) Current element starters
- (c) Time element starters.

10. *Revision of distribution circuits*—2 wire, and ring main systems for d.c. Use of fuses and circuit-breakers. Use of earth lamps.

11. *Revision of testing methods and measurements*—Resistance measured by ammeter-voltmeter, by bridge and by instrument. General insulation, continuity and millivolt-drop testing. Fault tracing. Temperature measurement by resistance.

12. *Revision of faults and maintenance of machines*—Overheating due to mechanical and electrical defects. Sparking at brushes. Loss of residual magnetism. Testing machines—use of the megger for insulation tests.

13. *Revision of wave form*—General A.C.—production of an alternating waveform. The sine law. Frequency; amplitude, instantaneous and maximum values. Relation between frequency, number of poles and speed of a machine. R.M.S. and average values. Form factors. Representation of an alternating quantity by means of a phasors to give instantaneous and R.M.S. values.

14. *Revision of A.C. circuits and the series circuit*—Resistance, inductance, capacitance and impedance. Current and voltage relationship. Use of vectors. Power, apparent power, reactive volt-amp and power factor. The impedance triangle. Reactive and active components of current.

15. *The parallel circuit*—Treatment by vectors only of fairly simple circuits. Capacitance and the application of capacitors of power factor improvement.

16. *Three-phase systems: Advantages of 3-phase over single-phase*—Star and delta (mesh) connections for supplies and loads. Phase and line relationships. Power. Three-phase 4-wire distributor. Alternators. Construction. Synchronising and reference to load sharing of alternators in parallel.

17. *Transformers*—Elementary principle of action and general description. Calculations on induced e.m.f. (losses of efficiency). Constructional layout of 3-phase transformers. Coiling methods (in general terms). Rating of both single and 3-phase transformers. Production of rotating magnetic field using a polyphase supply to a suitable stator.

18. *Induction motors*—Construction, slip, reference to rotor e.m.f. and frequency. Typical torque-speed curves. Clip-ring and cage types. Description of double cage type. Starting methods. Reversal of rotation direction.

19. *Synchronous motors*—Construction. Starting methods. Reference to use of power factor correction.

20. *Single-phase induction motors*—

- (a) Split phase
- (b) Capacitor start
- (c) Capacitor run.

Properties of these motors starting and running. Reasons for earthing apparatus. Reasons for earthing or not earthing one part of a system. 3-phase systems in ships. Comparison between solidly earthed, impedance earthed, and floating start point in a 3-phase system. Transducer as an energy converter, remote indication of speed, temperature, pressure, fluid-level torque.

21. *Electronics*—The function of a rectifier and thyristor. Single and 3-phase bridge circuits and the output wave-forms. The half-controlled and fully-controlled bridge uses of semi-conductor devices to drive d.c. motors. Need for protection of semi-conductors against over-voltage and over-currents. Methods of protection. Comparison of thyristor with Ward Leonard control.

22. *The transistor current gain B*—

- The transistor as a current amplifier.
- The transistor used as a switch.
- The transistor used as a small signal amplifier.

Comparison of:

- (i) valve circuits
- (ii) transistor circuits using discrete components
- (iii) integrated circuit.

Limitations, reliability and economics.

Grade I Engineer—Part B—Naval Architecture and Ship Construction examination

1. *Revision of Simpson's 1st Rule*— in determining the areas, and volumes of ship forms.

- Trapezoidal rule for areas and volumes.
- Transverse 2nd moments of area of water plane.
- Longitudinal 2nd moments of area of water plane.

Simpson's 2nd rule and its use—Simpson's 3rd rule.
Improving accuracy of Simpson's 1st rule with intermediate ordinates.

2. *Revision of shift of C.G.*—problem requiring greater depth of understanding.

Stability problems—requiring the determination of 2nd moments of area by the "Parallel Axes Theorem"—large angles of heel. *Free surface-effect*—effect on free surface by—

- (a) sub-dividing tanks longitudinally;
- (b) sub-dividing transversely.

3. *Longitudinal trim*—centre of flotation—longitudinal B.M.—change of trim due to moving masses—change of trim due to adding or removing masses.

4. *Flooding*—change of trim of a box barge due to flooding end compartments.

5. *Relationship between powers*—effective power, delivered power, thrust power, shaft power—propulsive propeller co-efficient—hull efficiency thrust reduction factor.

6. *Rudders*—types—rudder forces—centre of pressure—torque—diameter of rudder stock—bending and twisting.

7. *Strength of ships*—bending moment curve—load diagrams—load distribution—sheer force diagram and modulus calculations.

8. *Ship types and classifications*— Ship construction definitions. Tonnage measurements.

9. *Ship structural stresses* and structure fitted to accommodate these stresses including strengthening of bottom forward and panting area. Typical midship section showing double bottom framed:

- (i) transversely;
- (ii) longitudinally;
- (iii) double bottomed floors.

10. *Watertight bulkheads*—

- (i) construction;
- (ii) attachment to deck ship's and tank top or bottom;
- (iii) method of carrying services through bulkheads.

Watertight doors.

11. *Structural fire protection.*

12. *Survey in dry dock.*— Dry docking. Damage stability—levelling arrangements for damaged side compartments.

GRADE I ENGINEER—PART B—ENGINEERING KNOWLEDGE (GENERAL) examination

GRADE I ENGINEER—PART B—ENGINEERING KNOWLEDGE (MOTOR) examination

GRADE I ENGINEER—PART B—ENGINEERING KNOWLEDGE (STEAM) examination

Candidates for a combined steam and motor Grade I Engineer Certificate of competency must be prepared to be examined in all items (1) to (26), but those for a steam certificate of

competency or the steam endorsement of a motor certificate of competency shall not be examined in items (19) to (23) and those for a motor certificate of competency or the motor endorsement of a steam certificate of competency shall not be examined in items (12) to (18).

A. *The Engineering knowledge to be shown by candidates is that which is required for the use, operation, and maintenance of the machinery, equipment, and ship structure usually in the charge of the engineer.*

B. *Candidates may be required to illustrate their answers by means of freehand sketches.*

1. A knowledge of the methods of manufacture of the various components, the general effects of various treatments on the physical properties of materials commonly used in the construction of marine engines and boilers and the mechanical tests to which these materials are normally subjected.
2. The natural and desirable properties of steam, fuel, lubricants and other liquids, gases and vapours used in machinery on board ship.
3. The use, constructional details, and principles involved in the action of the pressure gauge, thermometer, pyrometer, barometer, salinometer, hydrometer and other meters commonly used by engineers on board ship.
4. Dissolved solids, scale formation and feedwater treatment. Corrosion inhibition.
5. The methods of dealing with wear and tear of machinery and boilers. The alignment of machinery parts. The correction of defects due to flaws in material or accident. Temporary or permanent repairs in the event of derangement or total breakdown.
6. Constructional details and principles of action of pumps and oily water separators fitted in ships. The general requirement concerning feed, fuel, bilge, ballast and fire pumping systems.
7. The constructional arrangement, details and working of steering machinery, refrigerating machinery, hydraulic and other auxiliary machinery and such steam and internal combustion engines as are used for emergency and auxiliary machinery on board ship.
8. (a) Application of the indicator. Fluctuation of pressure in the cylinder as shown by indicator diagrams. Interpretation of normal conditions. Candidates for Class I licence, motor only limiting endorsement, will be expected to illustrate, by means of sketches, the changes produced in the diagram due to an alteration in the setting or working of the valves or any other factors.
(b) Methods of determining engine shaft power. The principles of working and methods of calibration of dynamometers and torsion meters.
9. Safe working practices, overhauling machinery, mechanical safety in workshops, protective equipment, lifting tackle.

10. Knowledge of the appropriate statutes that concern marine engineers (e.g. those dealing with oil pollution and clean air) is required.
 - (a) Precautions against fire or explosion. Flash point. Explosive mixtures of air and gas of vapour given off by fuel or lubricating oils. The danger of leakage from oil tanks, pipes, gas producers and vaporisers, particularly in bilges and other unventilated spaces; sources or ignition. The action of wire gauze diaphragms and the places in which such devices should be fitted.
 - (b) Toxic and other dangerous properties of substances used in marine practice. Maintenance of plant associated with the carriage of dangerous cargoes.
 - (c) Fire detection. Methods of dealing with fire. Action and maintenance of mechanical and chemical fire extinguishers and other fire-fighting appliances, respirators and safety lamps.
11. Control systems, automation and instrumentation. Periodically unmanned machinery spaces. Bridge control arrangements, alarm systems, operational techniques and work practices.
12. The methods of constructing marine steam turbines, gearing and boilers, the process to which the several parts are submitted or which are incidental to their manufacture, and the methods employed in fitting the machinery on board ship.
13. The various types of propelling and auxiliary machinery now in use, the functions of each important part and the attention required by the different parts of the machinery on board ship.
14. The methods of testing and altering the setting of the steam admission and exhaust valves of auxiliary machinery and the effect produced in the working of the engine by definite alterations in the settings of the valves.
15. The constructional details and working of evaporators, feed water heaters and feed water filters.
16. Marine boilers of various modern designs, their construction and manner of attachment of ship.
17. The use and management of boiler fittings and mountings with special reference to water gauges and safety valves. Precautions necessary when raising steam and operating stop valves with particular reference to the danger arising from water-hammer action.
18. Constructional details, operational and maintenance of installations generally employed for assisting draught, superheating steam and burning fuel.
19. The principles underlying the working of internal combustion engines. The differences between various types of engines. Constructional details of internal combustion engines, gearing and clutches in general use. The processes to which the several parts are submitted or which are incidental to their manufacture and the methods in fitting the machinery on board ship.
20. The nature and properties of the fuel and lubricating oils generally used in internal combustion engines. The supply of air and fuels to

- cylinders of engines of different types. The means of cooling the cylinders and pistons. Constructional details and working of air compressors.
21. Starting and reversing arrangements and the various operations connected therewith.
 22. The attention required for the operation and maintenance of the various parts of machinery. The use and management of valves, pipes, connections and safety devices employed.
 23. Constructional details and management of auxiliary steam boilers, their fittings and mounting, with special reference to water gauges and safety valves. Constructional details and management of auxiliary machinery. Draught combustion equipment, oil fuel equipment.
 24. The administrative duties of a Chief Engineer, organisation of his staff for emergency duties and the use of safety equipment; organisation of repairs and surveys; reports to owners; training marine engineer cadets; personnel/management.
 25. The recognition of irregularity in the performance of machinery. Analysis and interpretation of monitoring equipment and instrument readings to determine machine condition and future availability. Diagnostic techniques to forestall breakdown.
 26. International maritime law embodied in international agreements and conventions as they affect the specific obligations and responsibilities of the engine department.

Grade 2 Engineer—Part A—Applied mechanics examination

1. *Statics*—Force as a vector. Triangle and polygon of forces. Resultant and equilibrant of a system of co-concurrent, coplanar forces. Equilibrium of 3 coplanar forces. Moment of force. Couples. Moments of areas and volumes. Centroids and centres of gravity (limited to geometrical shapes). Conditions of equilibrium of solids. Necessary force applied parallel to an inclined plane to pull body up or down the plane, or to hold it stationary (including effect of friction). Work done at uniform speed up the plane.
2. *Friction*—Laws of friction for dry surfaces. Co-efficient of friction. Friction angle. Energy and power lost due to friction in simple bearings.
3. *Kinematics*—Linear motion: Graphs and equations for displacement, speed, velocity, and uniform acceleration. Simple cases of vector change of velocity and the acceleration produced. Relative velocities in one plane only. Angular motion: Equations for displacement, velocity, and uniform acceleration.
4. *Dynamics*—Work and power. Problems with constant force or force with linear variation. Energy. Conservation of energy, potential energy. Kinetic energy of translation. Newton's Laws of motion. Momentum and rate of change of momentum. Centrifugal force and its application to conical pendulum, unloaded governor, curved tracks, and machine parts. Stress in thin rim due to centrifugal action.
5. *Machines*—Simple lifting machine. Graphs of load-efficiency; linear law. Velocity ratio, mechanical advantage, and efficiency of the following machines: Wheel and axle, differential wheel and axle, rope pulley blocks, differential pulley

blocks screwjacks, warwick screw, hydraulic jack, wormdriven chain blocks, and single and double purchase crab winches. Reduction gearing.

6. *Stress and Strain*—Direct stress and strain. Shear stress. Hooke's Law. Modulus of elasticity. Ultimate tensile stress. Yield stress. Limit of proportionality. Percentage of elongation and reduction of area. Working stress. Factor of safety. Stress due to restricted expansion or contraction of single members.

7. *Beams*—Cantilevers and simply supported beams with concentrated or uniformly distributed loads. Shearing force and bending moment diagrams. Stress due to bending.

8. *Torsion*—Twisting moment due to engine crank mechanism. Strength and stiffness of solid or hollow shafts of circular cross-section. Stress due to torsion. Power transmitted by shafts. Coupling bolts.

9. *Thin Shells*—Circumferential and longitudinal stress in thin cylindrical and spherical shells subject to internal pressure.

10. *Hydrostatics*—Equilibrium of floating bodies. Variation of fluid pressure with depth. Level control. Total force due to liquid pressure on immersed plane surfaces horizontal or vertical. Centre of pressure on a rectangular vertical plane surface or triangle plane surface, both with one edge parallel to the surface of the liquid.

11. *Hydraulics*—Full bore flow of liquid through pipes under constant head. Flow through orifice. Coefficients of velocity, contraction of area, and discharge.

Grade 2 Engineer—Part A—Applied Heat examination

1. *Basic Thermodynamic Principles*—Properties, energy, the first law of thermodynamics, flow and non-flow processes.
2. *Elements*—Temperature and its measurement. Linear, superficial, and volumetric expansion due to temperature changes. Coefficients and the relationship between them. Specific heat.
3. *Heat Transfer*—Qualitative treatment of heat transfer by conduction and thermal conductance and applications to problems.
4. *Mixtures*—Heat and temperature problems involving change of phase and not more than 3 substances.
5. *Gases*—Boyle's and Charles's Laws for perfect gases. Absolute temperature. Characteristic equation. Constant R and its use in simple problems. Isothermal and a diabatic expansion and compression. Relation between P, V and T when $PV^n = \text{Constant}$. Specific heats C_p and C_v and the relationship between them.
6. *Air Compressors*—Elementary principles and cycles of operation. Calculation of work done. Indicator diagrams.
7. *Internal Combustion Engine*—Elementary principles and cycles of operation. Actual indicator diagrams. Work done and power developed. Fuel consumption.
8. *Properties of Steam*—Changes of enthalpy with and without change of phase. Specific volume of steam under various conditions. Throttling. Separating and throttling calorimeters. Boiler efficiency. Use of steam tables. Effect of air leakage into condensers.

9. *Reciprocating Steam Auxiliary Machinery*—Mean effective pressure and work done. Advantages of using steam expansively. Steam consumption per hour and per power—hour. Thermal, mechanical, and overall efficiencies of engines.

10. *Boilers and Engines*—Boiler efficiency. Heat balance for engine and boiler trials.

11. *Steam Turbines*—Elementary principles. Simple velocity diagrams. Thermal, mechanical, and overall efficiency. Steam consumption per hour and output.

12. *Combustion*—Solid and liquid fuels, higher calorific value. Chemical equation for complete combustion. Theoretical minimum air required. Excess air.

13. *Refrigeration*—Vapour compression cycle. Refrigerating effect. Cooling load. Use of tables of properties of refrigerants.

14. *Boilers and Evaporators*—Change in dissolved solids due to contaminated feed. Blowing down.

Grade 2 Engineer—Part A—Electrotechnology examination

1. *The Electric Circuit*—Units—ampere, ohm and volt. Ohm's Law. Series and parallel circuits of sources of e.m.f. and/or resistance. Current distribution of simple circuits. Difference between e.m.f. and p.d. Power and energy. Relationship between heating, mechanical and electrical units.

Conductor resistance, effect of length, area, material and temperature. Temperature co-efficient of resistance. Types of insulation. Resistivity.

2. *Bridge Systems*—Wheatstone network bridge, slide wire bridge; applications to steering gears, resistance pyrometers, strain gauges. Kirchhoff's Law. Parallel operation of batteries with unequal e.m.f.s. and differing internal resistances. Distribution problems, voltage drop.

3. *Cells*—primary and secondary (acid and alkaline) types.

Construction and principles, no chemical formula. Maintenance, charging. Watt-hour and ampere-hour efficiencies.

4. *Magnetism and Electromagnetism*—Simple magnetic theory, magnetic field, Lines of force, Field strength, Field intensity, Magnetic fields due to current in straight conductors, Loops, coils and solenoids. Relative directions of current and field. Effect of iron, Flux density, Total flux, Permeability, Hysteresis, Typical B/H curves, Magnetic circuit, Compare with electrical circuit.

5. *Electromagnetic induction*—Flux-Linkages, Faraday's and Lenz's laws of electromagnetic induction, static induction—e.m.f. of self and mutual induction, dynamic induction—magnitude of e.m.f. direction of induced e.m.f.—the right hand rule. Use of electromagnetic induction principles in electric machines.

6. *Instruments*—Principles and function of switchboard indicating instruments, Moving-coil, moving-iron and dynamometer types. Uses of shunts and series resistances to increase the range. The current transformer and potential transformer for instrument work (description and simple explanation). Electromagnetic induction—Faraday's and Lenz's Laws, Magnitude and direction of induced e.m.f. Force produced on a current-carrying conductor.

7. *D.C. Generators*—Constructional details, Protection, E.M.F. and load voltage equation, Action of commutator, Simple properties of lap and wave windings.

Methods of supplying the field separate excitation, shunt, series and compound windings. Brief treatment of theory of self-excitation. Reasons for failure to excite. Remedies.

8. *Load Characteristics*—Methods of voltage control, Parallel operation procedure for shunt and compound generators. The equalising bar, Load sharing treated qualitatively, D.C. motors: constructional details, Speed and torque equations, Load characteristics, Speed control Motor calculations (no efficiency calculation), Application to Ward Leonard systems, Steering gear, Suitability of d.c. motors for the various types of work.

9. *Starters*—Need for a starter, Types of manual starters, Drum controller, Types of automatic starters, Distribution circuits, Two wire and ring main system for d.c. (emergency generator and circuit), Use of fuses and circuit-breakers, Use of earth lamps.

10. *Testing Methods and Measurements*—Resistance measured by ammeter-voltmeter by bridge and by instrument, General insulation, continuity and milli-volt-drop testing, Fault tracing, Temperature measurement by resistance.

11. *Faults and maintenance of machines*—Overheating due to mechanical and electrical defects, Sparking at brushes, Loss of residual magnetism, Testing machines—use of the megger for insulation tests.

12. *Alternating Wave Form*—General a.c.—production of an alternating wave form, The sine law, Frequency, Amplitude: instantaneous and maximum values, Relation between frequency, number of poles and speed of a machine, R.M.S. and average values, Form factor, Representation of an alternating quantity by means of phasor to give instantaneous and R.M.S. values.

13. *A.C. Circuits, The Series circuit*—Inductance, capacitance and impedance, Current, resistance, voltage relationship, Use of vector, power, apparent power, reactive volt-amp and power factor, The impedance triangle, Reactive and active components of current, Simple explanation of an alternator as a generating unit, Construction, synchronising and reference to load sharing of alternators in parallel.

Grade 2—Engineer—Part B—Naval Architecture and Ship Construction examination

1. *Ship dimensions*, L.B.P., L.O.A, B(MLD), depth (MLD) freeboard, displacement, dead weight, tonnage measurement, gross, net, deductions and exemptions.

2. *Areas and volumes*, Simpson's 1st Rule applied to areas and volumes, Centroids of areas by Simpson's Rule.

3. *Tonnes per cm immersion*, *Ship form co-efficients*—Block co-efficient, midship co-efficient, water-plane area prismatic co-efficient.

4. *Centre of gravity calculations*—Adding weights—removing weights—moving weights horizontally, vertically-suspended weights.

5. *Buoyancy*—Freeboard—reserve buoyancy—centre of buoyancy determined by Simpson's 1st Rule, Change in mean draught due to change in density.

6. *Transverse stability*—Stable—neutral—unstable condition—metacentre—metacentric height—stiff and tender ship GZ as a righting arm; moment of statical stability—effect on stability by moving the C.G. of the ship, Inclining experiment—conditions for experiment.

7. *Hydrostatic curves* Use of the development of graphical exercises on hydrostatic curves: GZ curves; angle of maximum stability; range of stability; point of disappearing stability; point of contraflexure. Cross—curves of stability and its uses—effect on GZ curve by GM adjustment.

8. *Development of EM Standard* 2nd moments of area of geometrical figures. Determination of BM given 2nd moments of area of waterplane.

9. *Bilging*—or flooding central compartments of box-shaped vessels—permeability—lost buoyancy method; added mass method.

10. *Propellers*. Pitch—face pitch—measurement of pitch—apparent slip—true slip—wake fraction—negative slip.

11. *Resistance to propulsion*. Skin friction R_f — f_{svn} . Froude's Laws of comparison—equivalent speeds for model. Development of e.p. (effective power)—propulsive co-efficient.

12. *Admiralty co-efficient*. Development—limitations fuel co-efficient. Relation between power and specific fuel consumption—relationship between speed and fuel consumption over a voyage, economical speed.

13. *Centre of pressure* of simple geometrical forms of immersed vertical planes.

14. *Ship Types and Classifications*. Ship construction definitions. Tonnage measurements. Ship structural stresses and structure fitted to accommodate these stresses including strengthening of bottom forward and panting area.

15. *Watertight bulkheads*:

- (i) construction
- (ii) attachment to deck, ship's side and tank top or bottom
- (iii) method of carrying services through bulk-heads.

16. *Watertight hatch covers*:

- (i) types
- (ii) construction
- (iii) operation

17. *Watertight doors*:

- (i) regulation and notes
- (ii) types
- (iii) operation

18. *Lifeboat davits and winches*

19. *Ventilation of holds* including those of colliers for carriage of coal bunkers and pump rooms in tankers. Structural fire protection.

20. *Stabilisers*:

- (i) fin
- (ii) tank—active and passive.

21. *Cathodic protection*—Survey in dry dock. Dry docking. Damage stability—levelling arrangements for damage side compartments.

Grade 2 Engineer—Part B—Engineering knowledge (General) examination
Grade 2 Engineer—Part B—Engineering knowledge (Motor) examination
Grade 2 Engineer—Part B—Engineering Knowledge (Steam) examination

Candidates for a combined steam and motor Grade 2 Engineer certificate of competency must be prepared to be examined in all items (1) to (25), but those for a steam certificate of competency or the steam endorsement of a motor certificate of competency shall not be examined in items (19) to (23), and those for a motor certificate of competency or the motor endorsement of a steam certificate of competency shall not be examined in items (12) to (18).

Note:

A. *The Engineering knowledge to be shown by candidates is that which is required for the use, operation, and maintenance of the machinery, equipment, and ship structure usually in the charge of the Engineer.*

B. *Candidates may be required to illustrate their answers by means of freehand sketches.*

1. A knowledge of the methods of manufacturers of the various components, the general effects of various treatments on the physical properties of materials commonly used in the construction of marine engines and boilers and the mechanical tests to which these materials are normally subjected.

2. The natural and desirable properties of steam, fuel, lubricants and other liquids, gases and vapours used in machinery on board ship.

3. The use, constructional details and principles involved in the action of the pressures gauge, thermometer, pyrometer, salinometer, hydrometer and other meters commonly used by engineers on board ship.

4. Dissolved solids, scale formation and feedwater treatment. Corrosion inhibition.

5. The methods of dealing with wear and tear of machinery and boilers. The alignment of machinery parts. The correction of defects due to flaws in material or accident. Temporary or permanent repairs in the event of derangement or total breakdown.

6. Constructional details and principles of action of pumps and oily water separators fitted in ships. The general requirement concerning feed, fuel, bilge, ballast and fire pumping systems.

7. The constructional arrangement, details and working of steering machinery, refrigerating machinery, hydraulic and other auxiliary machinery and such steam and internal combustion engines as are used for emergency and auxiliary machinery on board ship.

8. (a) Application of the indicator. Fluctuation of pressure in the cylinder as shown by indicator diagrams. Interpretation of normal conditions. Candidates for Class I licence, motor only limiting endorsement, will be expected to illustrate, by means of sketches, the changes produced in the diagram due to an alteration in the setting or working of the valves or any other factors.

(b) Methods of determining engine shaft power. The principles of working and methods of calibration of dynamometers and torsion meters.

9. Safe working practices, overhauling machinery, mechanical safety in workshops, protective equipment, lifting tackle.
10. (a) Precautions against fire or explosion. Flash point. Explosive mixture of air and gas or vapour given off by fuel or lubricating oils. The dangers of leakage from oil tanks, pipes, gas producers and vaporisers, particularly in bilges and other unventilated spaces; sources of ignition. The action of wire gauze diaphragms and the places in which such devices should be fitted.
- (b) Toxic and other dangerous properties of substances used in marine practice. Maintenance of plant associated with the carriage of dangerous cargoes.
- (c) Fire detection. Methods of dealing with fire. Action and maintenance of mechanical and chemical fire extinguishers, respirators and safety lamps.
11. Control systems, automation and instrumentation. Periodically unmanned machinery spaces. Bridge control arrangements, alarm systems, operational techniques and work practices.
12. The methods of constructing marine steam turbines, gearing and boilers, the process to which the several parts are submitted or which are incidental to their manufacture, and the methods employed in fitting the machinery on board ship.
13. The various types of propelling and auxiliary machinery now in use, the functions of each important part and the attention required by the different parts of the machinery on board ship.
14. The methods of testing and altering the setting of the steam admission and exhaust valves of auxiliary machinery and the effect produced in the working of the engine by definite alterations in the settings of the valves.
15. The constructional details and working of evaporators, feed water heaters and feed water filters.
16. Marine boilers of various modern designs, their construction and manner of attachment of ship.
17. The use and management of boiler fittings and mountings with special reference to water gauges and safety valves. Precautions necessary when raising steam and operating stop valves with particular reference to the danger arising from water-hammer action.
18. Constructional details, operation and maintenance of installations generally employed for assisting draught, superheating steam and burning fuel.
19. The principles underlying the working of internal combustion engines. The differences between various types of engines. Constructional details of internal combustion engines, gearing and clutches in general use. The processes to which the several parts are submitted or which are incidental to their manufacture and the methods employed in fitting the machinery on board ship.
20. The nature and properties of the fuel and lubricating oils generally used in internal combustion engines. The means of cooling the cylinders and pistons. Constructional details and working of air compressors.
21. Starting and reversing arrangements and the various operations connected therewith.

22. The attention required for the operation and maintenance of the various parts of machinery. The use and management of valves, pipes, connections and safety devices employed.

23. Constructional details and management of auxiliary steam boilers, their fittings and mounting, with special reference to water gauges and safety valves. Constructional details and management of auxiliary machinery. Draught combustion equipment, oil fuel equipment.

24. The administrative duties of an engineer, organisation of staff for emergency duties and the use of safety equipment, organisation of repairs and surveys; personnel management, organisation and training aboard ships.

25. International maritime law embodied in the international agreements and conventions as they affect the specific obligations and responsibilities of the engine department.

Grade 3—Part A—Applied Mechanics examination

1. Force, gravitational units, force as a vector. Triangle and polygon of forces, moment of force. Couples. Moments of areas and volumes. Centroids and centres of gravity (limited to geometrical shapes). Conditions of equilibrium of solids. Work done over an inclined plane.

2. Laws of friction for dry surfaces. Friction angle. Co-efficient of friction. Energy and power expended due to friction in simple applications.

3. Linear motion. Graphs and equations for displacement, speed, velocity and uniform acceleration. Relative velocities in one plane only. Angular motion. Equations for displacement, velocity and uniform acceleration.

4. Work done. Problems with constant force and force with linear variations. Conservation of energy. Newton's Law of motion. Momentum and rate of change of momentum. Centrifugal force and its application to conical pendulum, unloaded governor, curved tracks and machine parts. Stress in thin rims due to centrifugal force.

5. Direct stress and strain and modulus of elasticity. U.T.S.; Yield stress. Limit of proportionality. Percentage elongation and reduction of area. Working stress. Factor of safety. Stress due to restricted expansion or contraction of single members.

6. Cantilevers and simply supported beams with concentrated or uniformly distributed loads. Shearing force and bending moment diagrams. Stress due to bending, given fundamental bending equation and the second moment of area of the section.

7. Torsion—Torque and stress relationships in circular shafts, given the fundamental formulae. Twisting moment due to crank engine mechanism.

8. Archimedes' principle. Equilibrium of floating bodies. Specific gravity. Total pressure on an immersed surface (plane), horizontal or vertical. Centre of pressure on a rectangular vertical plane surface or triangular plane surface, both with one edge parallel to the surface of the liquid.

9. Full bore flow of liquids through pipes under constant head. Flow through orifice. Co-efficient of velocity, contraction of area and discharge.

Grade 3 Engineer—Part A—Heat and heat engines examination

1. Linear, volumetric and superficial expansion. Application to marine problems.
2. Heat transfer through a composite body. Conduction, radiation (excluding log mean temperature difference).
3. Boyle's and Charles' Laws for perfect gases. Isothermal and adiabatic expansion and compression. Relation between P, V and T when $PV = C$. Specific heat C_p and C_v and the relationship between them.
4. IC Engines and Compressors—Calculation of work done from a given formulae. Otto, Diesel and dual combustion cycle and simple problems. Specific fuel consumption.
5. Steam Turbines—Simple velocity diagrams, nozzles, use of steam tables to determine nozzle velocity.
6. Combustion equations. Basic analysis of exhaust gases. Determination exhaust gases by fuel analysis. Relation between volumetric and gravimetric analysis of a gas mixture.
7. Refrigeration—Vapour compression cycle. Use of refrigeration tables to solve simple problems. Types and characteristics of refrigerants in common use.
8. Properties of Steam—Sensible heat, latent heat, enthalpy. Throttling and separating calorimeter. Simple problem involving feed water.

Grade 3 Engineer—Part A—Engineering drawing examination

The drawing will consist of a test of ability to apply the principles of projection and candidates will be asked to draw a plan, elevation, or section, or a combination of these views, or a piece of marine machinery from information supplied. All required information for the completion of the drawing will be given in the question paper. Candidates may be asked to include simple calculations on the drawing and draw up a list of materials used in the example.

Grade 3 Engineer—Part B—Electrotechnology examination

1. Electrical Units—SI system.
2. Ohm's Law, series and parallel circuits and e.m.f. of resistance. Power and energy. Relationships between heating, mechanical and electrical units. Conductors, resistance, temperature co-efficient of resistance. Wheatstone bridge, slide-wire bridge.
3. Cells—Primary and secondary; maintenance; charging. Watt's law and ampere law efficiencies.
4. Magnetic theory, magnetic field, lines of force. Field strength; field intensity. Magnetic fields due to a current in straight conductors, coils and solenoids. Effects of iron; flux density. Total flux. Reluctance. Permeability.
5. A.C. Theory—The sinusoidal wave, frequency maximum, rms and average values phase difference. The a.c. circuit. The inductor. The general series circuits. Simple treatment of power factor.

6. Star and delta (mesh) connections for supplies; load; phase and line relationships; power. Three phase 4-wire distributor, preferential tripping.

Grade 3 Engineer—Part B—Naval Architecture and Ship construction examination

1. Displacement, wetted surface, block, mid-section, prismatic and waterplane area co-efficients.
2. Buoyancy and reserve buoyancy. Effects of bilging amidship compartments.
3. Stability at small angles of heel (given second moment of area of the water plane or formulae). The inclining experiment. Effects of free liquid surface and subdivision of tanks. Dangers due to accumulation of water during fire fighting. Management of water and fuel tanks. Filling and emptying tanks at sea.
4. Resistance and Propulsion—Law of corresponding speeds. Simple problems in propellers, Pitch ratio, wake, true slip, apparent slip. Thrust and power. Cavitation. Admiralty and fuel co-efficients.
5. Longitudinal B.M. and G.M. and statical stability. Centre of flotation. Moment to change trim 1 cm.
6. Forces on ship under various conditions including effects of panting and pounding. Structural fire protection arrangements, dry docking.
7. Sketches of ship structural members in ordinary types of steel ships, machinery seating arrangements, watertight doors, hatches, Rudders, Propellers, Stern tubes, Watertight bulkhead, Double bottoms, Preservation in good conditions of the ship's structure, in particular the bilges, bunkers, tanks under boilers and watertight doors. Common terms used in tonnage measurements e.g. gross tonnage, nett tonnage, propelling power allowance, tonnage hatch.

Grade 3 Engineer—Part B—Engineering knowledge (General) examination

Grade 3 Engineer—Part B—Engineering knowledge (Motor) examination

Grade 3 Engineer—Part B—Engineering knowledge (Steam) examination

Candidates for a combined steam and motor Grade 1 Engineer certificate of competency must be prepared to be examined in all items (1) to (19), but those for a steam certificate of competency or the steam endorsement of a motor certificate of competency shall not be examined in items (9) to (13) and those for a motor certificate of competency or the motor endorsement of a steam certificate of competency shall not be examined in items (14) to (19).

1. Safety equipment, portable tools, power tools, care, use, testing and survey of lifting gear. Staging, precautions before entering tanks, duct keels and other void spaces. Protective clothing.
2. Constituents and properties of more common materials used in marine engineering. Basic welding; heat treatment processes. Manufacture of the principal components of boiler and marine engines.
3. Heat and combustion. The properties of steam, fuel, lubricants and other liquids, gases and vapours used in machinery on board ship.
4. Working principals and constructional details of pumps and oily water separators fitted aboard ship. General requirements concerning feed, fuel, bilge, ballast and fire pumping systems.

5. The constructional arrangement, details and working of steering gears, refrigerating machinery, hydraulic and other auxiliary machinery, and such steam and internal combustion engines as are used for emergency and auxiliary machinery on board ship.

6. Precautions against fire and explosions due to oil or gas. Flash point. Explosive properties of gas or vapour given off by fuel or lubricating oils when mixed with a quantity of air. The danger of leakage from oil tanks and pipes particularly in bilges and other unventilated spaces. The action of wire gauze diaphragms and the places in which such devices should be fitted. Spontaneous combustion. Fire detection. Methods of dealing with fire. Action and maintenance mechanical and chemical fire extinguishers and other fire fighting appliances, respirators and safety lamps.

7. The duties of a Chief Engineer, organisation of his staff for emergency duties. Organisation of repairs and surveys. Knowledge of classification societies rules. Reports to owners.

8. The principles underlying the working of internal combustion engines. The difference between various types of engines. Constructional details of various types of engines in general use.

9. The properties of fuels and lubricating oils generally used in internal combustion engines. The supply of air and fuels to cylinders of engines of different types. The constructional details of apparatus for carburetting and atomising the fuel.

10. Methods of lubricating and cooling IC engine parts.

11. Methods of determining the power of engines. Use of the engine indicator for the detection of faults.

12. Constructional details and operation of air compressors and air receivers with a knowledge of the safety devices incorporated.

13. Methods employed for the starting and reversing of IC engines.

14. The principles underlying the working of steam reciprocating engines, turbines and boilers. The constructional details of various types of engines in general use.

15. Knowledge of slide and piston valves on a steam reciprocating engine. Methods of testing and altering the settings.

16. Constructional details of boiler in general use; tank and water tube types.

17. Construction and testing of boiler water level gauges and safety valves. Precautions necessary when raising steam and operating stop valves with particular reference to the dangers arising from water hammer.

18. Constructional details, operation and maintenance of installations generally employed for assisting draught, super heating steam and burning fuel.

19. Boiler feed water conditioning and treatment. The effects of scale and dissolved solids in boilers and evaporators.

Grade 4 Engineer—Part A—Applied Mechanics examination

1. *Statics* Relationship between pressure, area and force applied on a plane surface. Force as a vector. Triangle and polygon of forces. Resultant and equilibrant of a system of concurrent co-planar forces. Equilibrium of three forces in the same plane. Moment of force. Qualitative treatment of friction.

2. *Kinematics*—Linear motion. Graphs and equations for displacement, velocity and uniform acceleration. Relative velocity in one plane only.

3. *Dynamics*—Work and power. Problems with constant force. Qualitative treatment of energy. Conservation of energy. Potential energy. Kinetic energy. Newton's Laws of Motion.

4. *Machines*—Graphs of load/effort and load/efficiency. Mechanical advantage, velocity ratio and efficiency of:

(a) Wheel and axle;

(b) Rope and pulley blocks;

(c) Screw jack;

(d) Hydraulic jack;

(e) Single and reduction gear;

(f) "V" belt and pulleys.

5. *Stress and Strain*—Direct stress and strain. Shear stress and strain. Hooke's Law. Modulus of elasticity. Ultimate tensile strength. Yield stress. Proof stress. Working stress Factor of safety. Stress/strain diagrams for ductile and brittle materials.

7. *Properties of Materials*—The types of materials used in the construction of the ship's hull and machinery with reasons for their use. The joining of metals by welding and brazing. The repair of iron castings. Appearance of ductile and brittle fracture caused by direct and shear stress.

Grade 4 Engineer—Part A—Heat and Heat Engines examination

1. *Temperature*—Measurement of temperature. Linear—superficial and volumetric expansion. Qualitative treatment of heat transfer by conduction, convection and radiation.

2. *Mixtures*—Specific heat. Problems on latent heat involving one change of phase. Problems on specific heat not involving more than three substances.

3. *Gases*—Measurement of pressure. Absolute pressure. Boyle's Law. Charles's Law. Absolute temperature. Relationship between P, V and T.

4. *Air Compressors*—Elementary principles and cycle of operation.

5. *I.C. Engines*—Elementary principles and cycles of operation. 4 Stroke and 2 Stroke Cycles. Compression and Spark Ignition. B.P. and its measurement. I.P. and its measurement. Fuel consumption. Losses. Thermal efficiency. Mechanical efficiency. Conversion H.P. to Watts.

6. *Combustion*—Constituents of liquid fuels. Constituents of air. Combustion of liquid fuel in air. Products of combustion if insufficient air is available. Flash point of fuel and how it is obtained (closed cup test).

7. *Refrigeration*—Elementary principles and cycle of operation.

Grade 4 Engineer—Part A—Engineering Drawing examination

1. 50% of total marks

(a) Construction of simple scales and dimensioning exercises. Practical Tangency.

(b) Simple pictorial, isometric, or oblique freehand sketch from a drawing of 3 views.

(c) Types of common engineering fastenings—nuts and bolts studs, pivets, keys, collers, couplings splined shafts.

2. 50% of total marks

An appreciation of one or two dimensioned views (one may be in section) of a part or piece of marine machinery.

Grade 4—Engineer Part B—Electrotechnology examination

1. *General Principles*—Chemical, magnetic and thermal effects of electric current. Electric shock, prevention and treatment. Production of E.M.F. by chemical and magnetic means.

2. *Electric Circuits*—Units: ampere, ohm, volt, Ohm's Law, Power, Difference between P.D. and E.M.F. Conductor resistance: effect of length, area and material. Electrolytic dissociation: application to cells and hulls corrosion. Distribution systems for a.c. and d.c. installations. Fuses, circuit breakers and earth lamps.

3. *Cells*—Primary and secondary cells: construction and principles: maintenance and charging. Watt-hour and ampere-hour efficiency.

4. *Magnetism and Electric Magnetism*—Simple magnetic theory. Magnetic field due to current in straight conductors, loops and coils. Lines of force. Relative directions of current and field produced by a current in a conductor. Faraday's Law for a conductor moving in a magnetic field. Generation of direct current.

5. *Electrical Machines*—Maintenance and protection of a.c. and d.c. generators and motors. Parallel running of a.c. and d.c. generators. Motor Starters.

6. *Electrical Instruments*—Principle and function of a.c. and d.c. switch board indicating instruments (moving coil, moving iron, dynamometer type). Testing methods and measurement. Resistance measured by ammeter/voltmeter. Simple ohm meter and insulation testing. Drop test and fault tracing.

7. *Alternating Current Theory*—Generation of alternating current. The sinusoidal wave. Frequency. Maximum, R.M.S. and average values of current and voltage.

8. *Operation and Repairs*—Questions may be asked on operating procedures, common faults, breakdowns, and repairs of the components dealt with in this paper.

Grade 4 Engineer—Part B—Naval Architecture

1. *General*—Terminology: registered length, length between perpendiculars, length overall, moulded and extreme breadth, moulded depth, draught, block coefficient, displacement, tonnes/centremetre immersion, etc.

2. *Stability*—Simple treatment. Centre of buoyancy, Centre of gravity, Stable, neutral and unstable equilibrium.

The candidate should be aware of:

- (a) the effects of large surface areas of liquids, e.g. slack tanks, flooded decks, etc.;
- (b) the possibility that a list may be due to unstable equilibrium of the vessel in the upright position and methods of dealing with the situation;
- (c) the effect of lifting heavy weights by means of a derrick or crane (located on board the vessel).

3. *Consumption*—Calculation of fuel consumption. Variation of fuel consumption with speed: Consumption/hour or day, consumption/voyage.

4. *Ship Construction*—Construction and method of attachment of ship's side valves and fittings to the vessel's hull and material used. Stern tube construction. Maintenance and repair of the hull structure.

5. *Rudders and Steering Gear*—Hydraulic ram steering gear. Chain or cable steering. Tillers. Rudder stocks. Rudders. Rudder bearings and their lubrication.

Grade 4 Engineer—Part B—General Engineering knowledge examination

1. *Pumps*—The construction and principles of operation of:

- (a) Centrifugal pumps
- (b) Gear pumps
- (c) Screw pumps
- (d) Reciprocating pumps
- (e) Priming pumps

Alignment of pumps will drive motors.

2. *Piping Systems*—Oil fuel, bilge, ballast, cooling water, lubricating oil and compressed air pipe systems. Typical layouts with types of valves used, materials, types of joints, etc. Candidates should be aware of the reason for using non-return valves in bilge systems, and the precautions required with regard to the installation of oil fuel systems and the siting of pipes adjacent to electrical installations.

3. *Air compressors*—Construction—Interstage coolers and their purpose. Safety devices.

4. *Bearings and Shafting*—Types of line-shaft bearing and their lubrication. Thrust bearings. Stern tube bearing: lubrication, clearance, wear, oil glands, stern glands. Alignment of shafting. Fitting of propellers.

5. *Instrument and Gauges*—Construction, operation and purpose of:

- (a) Pressure gauges
- (b) Manometers
- (c) Level gauges
- (d) Pneumercator gauges
- (e) Micrometers
- (f) Explosion meters

6. *Refrigerating Plant*—Refrigerating cycle of operations. Condensers. Evaporators. Separators. Expansion valves. Gases used in refrigerating plant.

7. *Heat Exchangers*—Construction of straight and "U" tube, and plate heat exchangers; single and multi-pass.

8. *Gears and Clutches*—Construction of single and double reduction spur and helical gears. Construction of multiplate clutches.

9. *Operation and Repairs*—Questions may be asked on operating procedures, common faults, breakdowns and repair of the machinery dealt with in this paper.

Grade 4 Engineer—Part B—Motor Engineering knowledge examination

1. *I.C. Engines*—Construction and principles of operation of:
 - (a) 4 stroke and 2 stroke engines
 - (b) Compression ignition and spark ignition engines
 - (c) Trunk piston and cross head engines

Supercharging. Bearings. Lubrication. Cooling. Valves and valve gear. Fuel pumps. Injectors. Timing. Governors. Flywheels and overspeed trips. Cylinder heads and liners. Jackets. Bed plates. Crankcases and crank safety devices. Camshafts and camshaft drives. Balance weights. Holding down bolts.

2. *Pressure Vessels*—Construction and principles of operation. Safety valves. Fusible plugs. Shell mountings. Manholes and other openings in the shell. Drainage of water and oil.

3. *Operation and Repairs*—Questions may be asked on operating procedures common faults, breakdowns, and repairs of the machinery dealt with in this paper.

Grade 5 Engineer—Part A—Practical Mathematics examination

1. Simple problems involving addition, subtraction, multiplication and division.
2. Simple fraction: addition, subtraction, multiplication and division.
3. Simple decimals, involving addition, subtraction, multiplication and division.
4. Transposition of simple formulae.
5. Areas, volumes of regular figures.
6. Simple calculations involving tank contents and weights.
7. Fuel consumption calculation. Estimate of requirements of a voyage in fuel, water and lubricating oil.

Grade 5 Engineer—Part B—Engineering knowledge examination

General

1. Elementary knowledge of shafting, bearings, stern bearings, rudders and propellers.
2. Elementary knowledge of steering gears in common use (chain and hydraulic types).
3. Fires and fire fighting. Types of portable fire extinguishers and fixed fire fighting installations and their uses. A working knowledge of the fire fighting appliances required to be carried on smaller class of vessel.
4. Basic ship construction. Names of main parts of ship including stem, keel, transom, rudder post, deck, coaming, bulwark, forecastle, bulkhead, tank tops, tiller, quadrant frame, beam. Understanding of hog, sag, pounding, collision bulkhead, water tight bulkheads, cavitation, electrolytic action. Effect of free surfaces and high centre of gravity. (no calculation or formula is required, only an awareness of the effects). Tanks; sounding and venting. Basic pumping system for bilge, ballast, water, oil and fire fighting.
5. Thorough knowledge of the duties and responsibilities of an engineer in charge on a motorship, including maintenance, instruction, supervision, discipline, interpretation of a Log Book, reporting defects.

6. Electrical understanding of:

- (a) the practical connection of batteries in series and parallel;
- (b) the relation between load and sizes of cables, switches and fuses;
- (c) the ability to use and read a Hydrometer, Voltmeter and Prong tester. Fault finding. Detecting a defective cell in a battery by using a short length of cable and shorting it out so that it will be temporary usable;
- (d) the identification of battery terminals. The importance of making correct connections and the possible effects of making wrong ones;
- (e) battery storage and ventilation, gassing and fire or explosion risks;
- (f) the practical care and maintenance of electrical motors, starters, brushes and brush gear; commutators (AC and DC);
- (g) basic understanding of AC and DC systems and circuits.

7. Basic knowledge of slipping and dry docking procedures with respect to the responsibility of engineers for underwater fittings.

8. Accident prevention and safe practice in the engine room. Protective clothing, use and care of hand tools and portable power tools. Precaution to be taken before entering tanks and other confined spaces.

Motor

9. Basic constructional details of internal combustion engines. The operation and routine maintenance.
10. Principles of two and four stroke cycles.
11. Elementary knowledge of lubricating systems, lubricating pumps and filters and the importance of maintenance.
12. Engine cooling system. Open and closed systems, advantages and disadvantages. Air cool system.
13. Need for governors on engines, both constant and variable speeds. Awareness of different starting systems.
14. Engine fuel system, fuel tanks, service tanks, fuel transfer pumps, injectors, fuel pumps and filters.
15. Methods of reversing I.C. engines. Basic knowledge of reversing gear box.
16. Basic knowledge of local control and bridge control system. Testing of such systems. An awareness of the possible failure of such systems. Understanding methods of changing between manual and automatic.

PART 2

SYLLABUSES FOR ORAL AND PRACTICAL EXAMINATIONS

Grade 1 Engineer—Part B—Engineering knowledge examination

The oral examination will be based upon the subjects included in the syllabuses for the Grade 1 Engineer—Part B—Engineering knowledge (General), the Grade 1 Engineer—Part B—Engineering knowledge (Motor), and the Grade 1 Engineer—Part B—Engineering knowledge (Steam) examinations and will include questions on the management of engines and boilers, electrical machinery, prevention of fire and methods of fighting fires at sea, the duties of the supervising engineer, the work to be done to

engines, boilers and auxiliary machinery in port and the periodical examination of the working parts.
Candidates should also be well acquainted with machinery and boiler casualties which may occur at sea and be able to state how these may be prevented and remedied.

Grade 2 Engineer—Part B—Engineering knowledge examination

The oral examination will be based upon the subjects included in the syllabuses for the Grade 2 Engineer—Part B—Engineering knowledge (General), the Grade 2 Engineer—Part B—Engineering knowledge (Motor), and the Grade 2 Engineer—Part B—Engineering knowledge (Steam) examinations and will include questions on the management of engines and boilers, electrical machinery, prevention of fire and methods of fighting fires at sea, the duties of the supervising engineer, the work to be done to engines, boilers and auxiliary machinery in port and the periodical examination of the working parts.

Candidates should also be well acquainted with machinery and boiler casualties which may occur at sea and be able to state how these may be prevented and remedied.

Grade 3 Engineer—Part B—Engineering knowledge examination

The oral examination will be based upon the subjects included in the syllabuses for the Grade 3 Engineer—Part B—Engineering knowledge (General), the Grade 3 Engineer—Part B—Engineering knowledge (Motor), and the Grade 3 Engineer—Part B—Engineering knowledge (Steam) examination and will include questions on the management of engines and boilers, electrical machinery, prevention of fire and methods of fighting fires at sea, the duties of the supervising engineer, the work to be done to engines, boilers and auxiliary machinery in port and the periodical examination of the working parts.

Candidates should also be well acquainted with machinery and boiler casualties which may occur at sea and be able to state how these may be prevented and remedied.

Grade 4 Engineer—Part B—Engineering knowledge examination

The oral examination will be based upon the subjects included in the syllabus for the Grade 4 Engineer—Part B—General Engineering knowledge and the Grade 4 Engineer—Part B—Motor Engineering knowledge examination and the following topics. The candidates may also be asked to expand on the answers given to the written papers of Grade 4 Engineer Part B.

1. Care, maintenance and repairs of the main and ancillary engines, pressure vessels, electrical equipment pumps and piping equipment.
2. Fire Fighting—Three necessary constituents to support combustion. Methods of fighting and prevent fires by—
 - (a) Removal of combustible material;
 - (b) Exclusion of oxygen;
 - (c) Lowering temperature.

(Candidates must be aware of the importance of prevention of fires and of fighting a fires in its early stages).

Construction, operation and maintenance of the following hand operated fire extinguishers and the types of fire they are suitable for:

- (a) Soda/acid;
- (b) CO²/Water;
- (c) Foam;
- (d) Liquid CO²;
- (e) Dry Powder;
- (f) B.C.F.

Means of recognition of different types of hand operated fire extinguishers. Construction, maintenance and testing of fixed CO² gas smothering systems.

Use and maintenance of smoke helmet and hose and self contained breathing apparatus. Signals used by fire fight team using safety line. Causes of fires and prevention of fires. Machinery space cleanliness. Methods of fighting fires in holds, machinery spaces and accommodation. Oil tank remote shut off valves. Oil pump remote stops. Oil tank gauges. Ventilation flaps or covers. Remote stops for ventilation fans. Air pipe and ventilator gauges.

(Candidates must be aware that lubricating oil will burn as readily as oil fuel).

3. Machinery—Guards and protection rails. Crankcase explosions. Air start system explosions. Scavenge fires.

(The candidate will be required to complete fire-fighting course approved by the National Administration.)

4. Pressure Vessels—Safety valves. High lift safety valves. Repairs.

5. General Safety—Insulation of high temperatures surfaces. Ventilation and gas freeing of tanks. Use of explosion meter. Hazardous properties of gas used on board ship, e.g. CO², ammonia, freon, acetylene, etc.

6. The maintenance and repair of the hull structure.

7. Dry docking and work to be carried out during the docking.

8. Pressure vessel and machinery breakdowns which may occur, their preservation and temporary or permanent repair.

9. Calculation of fuel consumption. Variation of fuel consumption with speed. Consumption per hour or per day and consumption per voyage.

Grade 5 Engineer—Part B—Engineering knowledge examination

The examination shall be conducted in such a manner as the examiner deems fit to satisfy himself that the candidate possesses sufficient working knowledge to operate and maintain (routine maintenance and simple emergency repairs only) the class of engine or engines he will be in charge of. He may ask the candidate to go through a pre-start routine, checking oil, cooling water and fuel availability and quantity and ask simple questions to satisfy himself that the candidate knows what he is checking for. The examiner may also ask simple questions relating to the care and routine maintenance of the stern gear, batteries, switchboard and fuses.

The candidate may then be asked to start the engine and go through post start checks on oil pressure, temperatures, cooling water flow, revolution, exhaust, etc; he will once again be asked simple questions designed to find out if he knows the purpose of the checks and what simple and immediate remedial actions he would take

in the event of any proving unsatisfactory. Some questions may be asked on simple fault finding such as how to identify and clear the following—

- (a) fuel blockages;
- (b) air locks in fuel;
- (c) dirty injectors;
- (d) leaking or sticking valves;
- (e) overheating;
- (f) faulty ignition;
- (g) faulty fuel and spill timing;
- (h) faulty battery connection, if fitted.

The candidate may be expected to give answers to satisfy the examiner that he would be able to deal adequately with any of the simple faults listed, given time, tools and, if necessary, spare parts.

The examiner will ask the candidate questions designed to test his knowledge on safety, which may include questions on the following—

- (a) keeping bilges free from oil or petrol;
- (b) the dangers of using naked lights, especially with respect to internal combustion engine;
- (c) the use of small portable fire extinguishers on board ships, and the smothering of oil fires with sand and/or wet clothing;
- (d) testing of steering gear before entering and leaving port and inspections during voyage;
- (e) safe practice when fuelling.

Engine Operator—Engineering knowledge examination

1. The working on internal combustion and compression ignition engines.
2. Engine maintenance.
3. Starting and reversing arrangements.
4. Two stroke and four stroke cycles.
5. Circulation systems.
6. Lubrication systems.
7. Care and changing of injectors.
8. Care and charging of batteries, fuses.

Engine Operator—Marine Engineering Knowledge examination

1. Shaft couplings and bearings.
2. Stern glands and bushes.
3. Circulating systems.
4. Propellers.
5. Water Strainers.

Engine Operator—Fire Precautions examination

1. Precautions to be taken against outbreak of petrol, oil or electrical fires.
2. Use and recharging of fire extinguishers.

[LEGAL NOTICE No. 14]

MARINE ACT, 1986
(ACT No. 35 OF 1986)

MARINE (CERTIFICATES OF COMPETENCY (SUPPLEMENTARY COURSES)) REGULATIONS, 1989

In exercise of the powers conferred upon me by sections 98, 99, 143 and 212 of the Marine Act, 1986, I have made the following Regulations—

Short title

1. These regulations may be cited as the Marine (Certificates of Competency (Supplementary Courses)) Regulations, 1989.

Objects

2. These Regulations prescribe the various courses which—
 - (a) a person must successfully attend as part of the qualification he must have before he can be issued with a certificate of competency; and
 - (b) the aims and scope of those courses.

Regulations to be read as one

3.—(1) These Regulations are to be read as one with the Marine (Certificates of Competency and Manning of Vessels) (General) Regulations, 1989, and the other Regulations referred to in those Regulations.

(2) In particular words and phrases defined in the Marine (Certificates of Competency and Manning of Vessels) (General) Regulations, 1989 have the same meaning when used in these Regulations.

Supplementary Subjects

4.—(1) Before a person can be issued with a grade of certificate of competency he must have successfully completed the supplementary courses listed under that grade of certificate of competency in Part I of the Schedule.

(2) The Marine Board shall not accept that a person has successfully completed a supplementary course which he is required to complete under subregulation (1) unless he has been issued with a certificate, in a form acceptable to the Marine Board, indicating that he has successfully completed that course.

(3) The syllabus for each supplementary course referred to in subregulation (1) is specified under the name of that supplementary course in Part 2 of the Schedule.