Second Engineer STCW Reg. III/2 Written Examination Syllabus:

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Second Engineer STCW Reg. III/2
Engineering Knowledge

Candidates for a Steam Certificate will not be examined in items 10 (a), (b), (c), (d) and (h) and candidates for a Motor Certificate will not be examined in items 9 (a), (b), (c), (f) and (g).

Notes:

(i) The engineering knowledge to be shown by candidates is that which is required for operation and maintenance of the machinery, equipment and ship structure usually in charge of the engineering officer. A candidate will also be required to understand the legal and management responsibilities of a certificated officer.

(ii) Candidates should be well acquainted with machinery and boiler casualties which may occur at sea and be able to state how these can be prevented or remedied.

(iii) The oral examination syllabus is given in MGN 69

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(iv) Naturally there is a similarity between the Chief Engineer and Second Engineer Reg II/2 Engineering Knowledge syllabi, but as a general guide it is expected that the Chief Engineer candidate should be able to show a deeper knowledge of all aspects and a sounder understanding of the principles involved.

The candidate to have knowledge of the following:

1. Manufacturing methods for various machinery components and the physical properties of the materials commonly used.

2. Working principles and constructional details of:

(a) Boiler water gauges.

(b) Sensing and monitoring devices associated with marine equipment.

3. Bilge and ballast pumps, pumping and priming systems, including pollution prevention equipment and systems.

4.
   (a) Propulsion transmission systems, including thrust and shaft bearings, stern tubes and propellers.
   (b) Hull inspection and drydocking.

5. Steering and stabilising systems, including bow thrusters.

6. Refrigeration machinery and air conditioning systems.

7. Fresh water production and conditioning systems.

8. Deck machinery and cargo handling systems.

9.
   (a) Steam boilers, mountings and feed water systems. Assessment of plant efficiency.
   (b) Steam turbines, gearing and lubrication systems, steam distribution systems, and associated equipment
   (c) Astern running.

   (d) Auxiliary steam boilers and associated equipment.
   (e) Boiler water testing and conditioning.
   (f) Control and alarm system associated with automatic operation of steam plant.
   (g) Safe and efficient operation and maintenance of marine steam plant.

10.
   (a) Marine diesel engines, (trunk and crosshead types) gearing systems and clutches.
   (b) Starting and reversing systems.
   (c) Cooling and lubricating systems.
   (d) Fuel oil preparation systems.
   (e) Air compressors, receivers and association equipment.
   (f) Auxiliary diesel engines and association equipment.
   (g) Control and alarm system associated with automatic operation of a diesel plant.
   (h) Assessment of engine power, the running adjustments to maintain performance.
   (i) Safe and efficient operation and maintenance of marine diesel engines.

11. (a) Knowledge of Codes of Safe Working Practices as published and amended.

(b) Knowledge of the types of information issued by the MCA with regard to Safety at Sea.

12. (a) Knowledge of Codes of Safe Working Practices associated with the carriage of dangerous substances.

(b) Constructional details and maintenance of plant and equipment specifically used with dangerous substances.

13. (a) Precaution against fire or explosions, explosive mixtures, sources of ignition.

(b) Principles of fire prevention, detection and extinction in all parts of a ship.

(c) Testing and maintenance of fire detection and extinguishing systems.

(d) Testing of firemans outfits including BA sets.

(e) Operation, maintenance and testing of fire pumps and associated pumping systems.

(f) Control and organisation of fire and damage control parties.

14.

(a) Operation, testing and fault rectification of automatic control systems and alarm panels.

(b) Safe and efficient operation in the UMS mode.

15. Procedures to be adopted for operating main machinery under emergency conditions.

16.

(a) Constructional details of alternators, generators, motors, switchgear and batteries.

(b) Electrical Distribution Systems, AC and DC.

(c) Operational practice and fault finding associated with electrical systems.

17. Constructional details of ships.

SECOND ENGINEER REG. III/2
APPLIED MECHANICS

LIST OF TOPICS

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

A STATICS

1 Solves problems involving forces in static equilibrium

1.1 Defines vector and scalar quantities.
1.2 States examples of vector and scalar quantities.
1.3 Represents graphically the vector quantity force.
1.4 Determines the addition and difference of forces - graphically and analytically.
1.5 Explains the terms: Equilibrium; Resultant and Equilibrant.
1.6 Solves graphically problems involving Equilibrium Resultant and Equilibrant in concurrent coplanar force systems.
1.7 Defines the moment of a force.
1.8 Explains the principle of moments.
1.9 States the conditions of equilibrium for non-current coplanar force systems.
1.10 Solves problems graphically involving 1. 9 for a maximum of 4 forces.
1.11 Explains that 3 non parallel coplanar forces must be - concurrent for equilibrium.
1.12 Resolves forces into components at right angles, and in one or two planes.
1.13 Repeats 1.6 and 1.10 by analytical methods.
1.14 Describes stable, unstable and neutral equilibrium.

2 Discusses pin jointed frameworks and their solution.

2.1 Explains what is meant by a pin joint.
2.2 Explains Bows notations with reference to simple frameworks.
2.3 Determines the support reactions for simple frameworks subjected to a maximum of 3 vertically applied forces, by graphical and/or analytical methods.
2.4 Explains the terms Strut and Tie.
2.5 Determines the magnitude and nature of the force in the members of simple frameworks by graphical methods.

3 Solves problems involving centres of gravity and centroids.

3.1 Explains how a centre of gravity can be determined by taking moments of mass.
3.2 Explains how a centroid can be determined by taking moments of area.
3.3 Solves problems involving centres of gravity for bodies made up of combinations of: Cubes, rectangles, cylinders, square pyramids, cones and hemispheres. (N.B. C. of G. positions for pyramids, cones and hemispheres to be given).
3.4 Solves problems involving centroids for laminas made up of combinations of: Rectangles, Circles, Triangles, Semi circles. (N.B. Centroid position for semicircle- to be given).
3.5 Repeats 3.3 and 3.4 when negative quantities are involved.

B FRICTION

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

4.1 States the laws of dry friction.
4.2 Defines friction angle.
4.3 Distinguishes between static and dynamic friction.
4.4 Describes in simple terms the effects of lubrication.
4.5 States examples of both useful and detrimental effects of friction in engineering.
4.6 Solves simple problems involving: frictional force, normal reaction and coefficient of friction, for bodies on horizontal planes subjected to normal and inclined forces.
4.7 Describes the resolution into normal and parallel components of the gravitational forces of a body on an inclined plane.
4.8 Defines angle of repose.
4.9 Solves problems involving: frictional force, normal reaction and coefficient of friction for bodies both at rest and moving up or down an inclined place with uniform velocity.

C KINEMATICS

5 Solves problems involving linear, angular and relative motion.

5.1 Explains the terms displacement, velocity, speed and acceleration for linear motion.
5.2 Sketches distance/time graphs for constant velocity and identifies the slope as velocity.
5.3 Solves problems related to 5.2.
5.4 Sketches velocity/time graphs for uniform acceleration and identifies the slope as acceleration and the area as displacement.
5.5 Solves problems related to 5.4.
5.6 Derives the equations:

$$v = u + at$$

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

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

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

5.7 Solves the problems involved in 5.6.
5.8 Repeats 5.1 to 5.7 for angular motion.

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

6.1 Resolves the velocity of an inclined projectile into horizontal and vertical components.
6.2 States that the acceleration of the vertical motion is 'g' and the acceleration of the horizontal motion is zero.
6.3 Solves problems involving vertical and inclined projectiles (assuming no air resistance).

7 Understands and uses the concept of relative velocity.

7.1 Defines relative and absolute velocity.
7.2 Determines the relative velocity between two coplanar linear velocities.
7.3 Solves problems relating to 7.2 and to include elapsed time and closest approach.

D DYNAMICS

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

8.1 States Newtons 1st law of motion and explains the effect of force.
8.2 Defines linear momentum.
8.3 States Newtons 2nd law of motion.
8.4 Derives the expression: force = mass x acceleration.
8.5 Defines the newton.
8.6 States Newtons 3rd law of motion.
8.7 Explains the terms tractive effort and tractive resistance.
8.8 Solves problems involving force, mass and acceleration on vertical horizontal and inclined planes, and to include friction.
8.9 States the Law of conservation of linear momentum.
8.10 Solves problems relating to 8.9.
8.11 Defines work done and energy.
8.12 Derives the expressions for Potential Energy and Kinetic Energy of translation.
8.13 States the law of conservation of energy.
8.14 Defines power.
8.15 Derives the expression: Power = Force x Velocity.

8.16 Solves problems involving energy, work and power.
8.17 Sketches work diagrams for both constant forces and uniformly varying forces.
8.18 States that the areas under the diagrams at 8.17 above represents work done.
8.19 Determines the mean height of work diagrams from:

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

8.20 Discusses 8.17 with reference to springs and relates the slope of the diagram to spring rate (stiffness).
8.21 Solves problems relating to 8.17 to 8.20
8.22 Defines torque.
8.23 Derives the expressions:

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

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

9 Discusses centripetal and centrifugal effects and solves associated problems.

9.1 Derives the expression for centripetal acceleration.
9.2 Relates centripetal acceleration and centripetal force.
9.3 Explains the concept of centrifugal force.
9.4 Determines graphically whether a coplanar rotating mass system is in equilibrium. ,
9.5 Determines the unbalanced force and balancing mass required for coplanar rotating mass systems not in equilibrium.
9.6 Describes a conical pendulum.
9.7 Solves problems involving simple conical pendulum.

E MACHINES

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

10.1 Describes the concepts of a simple lifting machine.
10.2 Defines the terms: *Effort, Load, Mechanical advantage (MA) , Velocity or Movement ratio (VR) and Efficiency.*
10.3 Derives the expression: $Efficiency = \frac{MA}{VR}$
10.4 Derives the expressions for the Velocity Ratios of the following lifting machines: wheel and axle, differential wheel and axle, rope pulley blocks, differential rope pulley blocks, chain blocks, screw jack, Warwick screw, worm and wheel mechanisms, hydraulic jack.
10.5 Solves problems relating to 10.2, 10.3 and 10.4.
10.6 Describes the transmission of power and torque through simple and compound gear systems.
10.7 Explain briefly the term: Involute, Addendum Dedendum, Pitch circle and Pressure angle.
10.8 Discusses the characteristic of straight cut and helical gears.
10.9 Solves problems involving speed ratio, power and torque transmitted for geared system.
10.10 Derives expressions for the velocity ratios of single and double

purchase winches.

10.11 Solves problems relating to 10.2, 10.3 and 10.10.

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

10.13 Explains the law of a machine.

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

10.15 Explains power transmission via flat belt drives.

10.16 Determines the torque transmitted in terms of belt tensions.

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

F STRENGTH OF MATERIALS

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

11.1 Defines stress as force per unit cross sectional area.

11.2 Defines direct stress and shear stress.

11.3 Defines direct strain.

11.4 Explains the term Elasticity and defines Modulus of Elasticity 'E'.

11.5 Solves simple problems relating to 11.1 to 11.4.

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

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

11.8 Defines UTS and breaking stress.

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

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

11.11 Explains the terms: Hardness, Malleability and Plasticity.

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

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

11.14 Solves problems related to 11.1 to 11.13.

12 Discusses the effect of temperature change on materials

12.1 Defines the term "Coefficient of Linear expansion".

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

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

12.4 Determines the thermal stresses associated with 12.3.

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

13.1 Explains the term 'thin cylinder'.
13.2 Derives the expression for Hoop Stress and Longitudinal stress in thin cylinders.
13.3 States the assumptions made when developing the expression in 13.2.
13.4 Solves problems related to 13.2.

14 Solves problems involving stress in thin rotating rims.

14.1 Derives the expression for the Hoop Stress in a thin - rotating rim.
14.2 Solves problems related to 14.1.

15 Solves problems involving cantilever and simply supported beams.

15.1 Explains the terms 'cantilever1 and simply supported' with reference to beams.
15.2 Describes point loading and uniformly distributed loading.
15.3 Determines support reactions for beams subjected to combinations of the loading at 15.2
15.4 Defines the terms Shear Force and Bending Moment.
15.5 Explains the need for sign convention when dealing with SF_s and BM_s
15.6 Determines the SF and BM at any section along a beam.
15.7 Sketches and draws to scale SF and BM diagram from results of 15.6.
15.8 Defines point of contraflexure
15.9 Determines maximum bending moment and point(s) of contraflexure from BM diagram.
15.10 States the expression-. $\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$ and defines each term.
15.11 Explains the term Neutral Axis.
15.12 States the I_{NA} values for the following sections: square, rectangle, circle, annulus.
15.13 Solves problems relating to 15.6, 15.10 and 15.12. 16

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16 Solves problems involving torsion on circular shafts.

16.1 States the expression: $\frac{T}{J} = \frac{\sigma}{y} = \frac{G\Theta}{l}$ and defines each
16.2 Explains the Polar Axis.
16.3 States the J values for solid and hollow circular sections.
16.4 Differentiates between maximum torque and mean torque.
16.5 Determines the shear force in shaft coupling bolts given the transmitted torque.
16.6 Solves problems relating to 16.1 to 16.5.

G HYDROSTATICS

17 Discusses the principle of Archimedes and solves associated problems.

17.1 States Archimedes principle.
17.2 Solves problems involving bodies totally and partially immersed in liquids.

18 Solves problems involving hydrostatic forces on immersed areas.

18.1 Derives the expression: Pressure pgh.
18.2 Describes the principle of: U-Tube manometers; inclined manometer; and mercury barometer.
18.3 Solves problems related to 18.1 and 18.2.
18.4 Sketches the pressure distribution diagram for an immersed vertical surface with one edge in the free surface.
18.5 Derives the expression for the resultant force on a vertical immersed surface.
18.6 Sketches the force diagram for a rectangular surface vertically immersed with one edge in the free surface.
18.7 Defines 'centre of pressure and identifies its position in 18.6 above.
18.8 Solves problems on rectangular and triangular surfaces vertically immersed in single liquids with one edge in the free surface and to include centre of pressure and wetted on each side.

H HYDRODYNAMICS

19 Solves problems related to liquids in motion.

19.1 Derives the continuity equation in terms of both volume and mass.
19.2 Applies 19.1 above to the flow of liquid through parallel pipes.
19.3 Explains the concepts of: C_v , C_c and C_d for a sharp edge orifice.
19.4 Discusses the motion of the jet in relation to the projectile theory.
19.5 Solves problems involving the flow of liquids through a sharp edged orifice under a constant liquid head.

SECOND ENGINEER REG III/2
ENGINEERING DRAWING

LIST OF TOPICS

A Engineering Communication
B Drawing Equipment
C Projection
D Assembly Drawings

The expected learning outcome is that the student:

General Note:

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

A Engineering Communication

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

    1.1 States the need for:

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

B Drawing Equipment

2. Discusses the use and care of drawing instruments.

    2.1 Demonstrates the use of the following:

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

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

c Projection

3. Discusses the use of orthographic projection in Engineering Drawing.

   3.1 States the need for orthographic projection.

   3.2 Explains the terms by reference to simple examples:

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

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

   3.4 Repeats 3.3 above to include sectional views.

D Assembly Drawings

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

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

SECOND ENGINEER REG III/2
MATHEMATICS

LIST OF TOPICS

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

A ARITHMETIC

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

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

1.2 States that proportion is an equation of ratios.

1.3 States that percentage is a ratio multiplied by 100.

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

1.5 Expresses an increase or gain as a percentage.

1.6 Expresses a decrease or contraction as a percentage.

1.7 Expresses an error as a percentage.

1.8 Solves problems related to 1.1 to 1.7.

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

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

1.11 Understands concepts such as "man hours", "kWh", etc.

1.12 Solves problems related to 1.9 to 1.11.

B ALGEBRA

2. Uses the rules of Algebra and solves associated problems.

2.1 Represents quantities by numbers, letters and symbols.

2.2 Adds algebraic quantities, both positive and negative.

2.3 Subtracts algebraic quantities, both positive and negative.

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

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

2.6 Defines the term index (power).

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

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

2.9 Solves problems related to 2.6, 2.7 and 2.8.

2.10 States the 'Law of Distribution'.

2.11 States the product of two binomial expressions.

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

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

2.14 Expands (a ± b)3 and factors of a3 ± b3.

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

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

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

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

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

2.19 Factorises trinomials which form a perfect square.

2.20 Factorises the difference of two squares.

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

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

2.23 Defines an equation as a statement of equality.

2.24 Simplifies and solves linear equations.

2.25 Understands the axioms

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

2.26 Solves problems on the transposition of algebraic expressions.

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

2.28 Solves linear simultaneous equations of two unknowns

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

2.29 Solves linear simultaneous equations of three unknowns.

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

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

2.32 Solves quadratic equations that factorise.

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

2.34 Solves quadratic equations using the general formula.

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

2.36 Describes direct and inverse variation.

2.37 Describes the use of the constant of variation.

2.38 Solves problems involving 2.35 and 2.36.

C LOGARITHMS

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

3.1 Define's logarithms.

3.2 States laws of logarithms.

3.3 Uses laws of logarithms to evaluate powers etc.

3.4 States base of natural logarithms.

3.5 Evaluates expressions involving natural logarithms.

D GRAPHS

4. Discusses the graphic representations of numerical quantities.

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

4.2 Defines the dependent and independent variables.

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

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

4.5 Determines suitable scales for plotting values calculated at 4.4.

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

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

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

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

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

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

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

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

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

4.15 Solves equations by graphical addition.

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

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

E TRIGONOMETRY

5. Discusses and uses the basic laws of trigonometry.

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

5.2 Defines acute, right, obtuse and reflex angles.

5.3 Defines complementary angles and supplementary angles.

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

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

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

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

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

5.9 States the theorem of Pythagoras.

5.10 Solves right angled triangles for any side or angle.

5.11 States the Sine Rule.

5.12 States the Cosine Rule.

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

F Mensuration

6. Solves problems related to plane figures and solids.

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

6.2 Determines the area of a triangle, given

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

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

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

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

6.6 Determines masses of solids at 6.5.

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

G CALCULUS - DIFFERENTIATION

7. Discusses differential calculus and solves associated problems.

7.1 Determines the gradient of a chord.

7.2 Discusses the concept of elemental lengths x and y.

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

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

7.5 Determines the derivatives of multinomial algebraic expressions.

7.6 States the derivative of a constant.

7.7 Discusses the concept of 2nd derivatives.

7.8 Repeats 7.5 for 2nd derivatives.

7.9 States the derivatives for sinx, cosx and lnx.

7.10 Determines the 1st derivatives of functions involving

7.11 Discusses the concept of rate of change.

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

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

7.14 Discusses the concept of maximum and minimum.

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

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

7.17 Writes derivatives in terms of functional notation.

H CALCULUS - INTEGRATION

8. Discusses integral calculus and solves associated problems.

8.1 States that integration is the reverse of differentiation.

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

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

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

8.5 Determines the constant of integration from given conditions.

8.6 Discusses the concept of limits.

8.7 Repeats 8.4 and includes limits.

8.8 States the integrals of sinx and cosx.

8.9 Determines the integrals of functions involving 8.8.

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

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

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

8.13 Solves problems relating to 8.12.

SECOND ENGINEER REG III/2
MARINE ELECTRO-TECHNOLOGY

LIST OF TOPICS

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

The expected learning outcome is that the student:

A Electric and Electronic Components

1. Understands the physical construction and characteristics of basic components.

1.1 Compares the characteristics of conductors, semi-conductors and insulators in terms of the Electron Theory.

1.2 Defines the basic quantities of electricity,eg charge, current, emf, potential difference, energy and power.

1.3 Describes resistance, inductance and capacitance in terms of physical dimensions and materials.

1.4 Solves numerical problems relating R, L and C to their physical parameters.

1.5 Appreciates how temperature affects conductors, semi-conductors and insulators.

1.6 Defines temperature coefficient of resistance at O˚C (α_0) and also at a stated temperature (α_t).

1.7 Calculates change in conductor resistance using the temperature coefficients in 1.6.

1.8 Draws and labels the principal parts of a lead acid cell.

1.9 Describes (without using chemical formulae) the action of charge and discharge on the components of the cell.

1.10 Explains how the state of charge of a lead acid cell may be measured using a hydrometer.

1.11 Draws and labels the principal parts of an alkaline cell, Nickel iron or nickel cadmium.

1.12 Explains how the state of charge may be assessed for alkaline cells.

1.13 Compares lead acid and alkaline cells on the basis of:

(a) voltage per cell;
(b) performance under poor conditions of charge/discharge;
(c) retention of charge;
(d) effect of temperature;
(e) mechanical strength;
(f) weight;
(g) cost.

1.14 States that the capacity of a battery is measured in ampere hours at a given rate.

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

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

1.17 Draws a simple charging circuit from a dc supply.

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

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

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

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

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

1.23 States the need for rectification of alternating voltages.

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

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

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

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

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

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

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

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

1.31 State some marine applications of 1.28 and 1.30.

B Electric Circuit Principles

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

2.1 States Ohms Law.

2.2 Solves problems on 2.1.

2.3 States Kirchhoffs Current Law.

2.4 States Kirchhoffs Voltage Law.

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

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

2.7 Solves problems on series/parallel circuits.

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

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

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

2.11 Solves problems related to 2.10.

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

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

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

2.15 Solves problems related to 2.13 and 2.14.

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

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

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

2.19 Explains the term phasor quantity.

2.20 Explains how phasors may be used to represent sinusoidal quantities.

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

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

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

when connected to a sinusoidal supply.

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

2.24 Defines and calculates inductive reactance and capacitive reactance.

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

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

2.27 Defines phase angle and active and reactive components.

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

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

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

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

2.32 Solves problems related to 2.30 and 2.31.

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

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

C Electromagnetism

3. Understands the principles of magnetism and electromagnetic induction.

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

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

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

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

3.5 Explains the terms magnetomotive force and magnetic field strength.

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

3.7 States the units of flux and flux density.

3.8 Explains the use of magnetic screening.

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

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

3.11 Explains the terms

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

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

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

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

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

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

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

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

3.19 Determines the direction of the force in 3.18.

3.20 States that the magnitude of the force is given by

$F = BIl$ newton and **Error! Bookmark not defined.** newton.

3.21 Solves problems related to 3.20.

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

3.23 States Faraday's law of electromagnetic induction.

3.24 States Lenz's Law.

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

(a) the number of turns;
(b) the rate of change of flux cutting the coil and

$$e = \frac{N\Delta\Phi}{\Delta t} \text{ volts.}$$

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

3.27 Solves problems related to 3.25.

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

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

3.30 Defines the unit of self inductance.

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

3.32 Solves problems related to 3.29, 3.31.

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

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

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

3.36 Defines the unit of mutual inductance.

3.37 States that the emf of mutual inductance is given by $e = M\frac{\Delta_i}{\Delta_t}$ and $M = k\sqrt{L_1}L_2$

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

3.39 Solves problems related to 3.37.

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

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

3.42 Solves problems related to 3.41.

D Electrical Machines

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

4.1 States that:

(a) motors convert electrical energy into mechanical energy;

(b) generators convert mechanical energy into electrical energy.

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

4.3 Describes the function of a commutator.

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

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

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

4.7 Solves problems related to 4.6.

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

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

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

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

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

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

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

4.15 Solves problems using

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

4.16 Recognises the power losses which occur in dc machines.

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

4.18 Explains the basic operation of an ac generator.

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

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

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

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

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

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

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

SECOND ENGINEER REG III/2
NAVAL ARCHITECTURE

LIST OF TOPICS

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

The expected learning outcome is that the student:

A Hydrostatics

Calculations - Displacement and Buoyancy

1. Understands the principles of flotation.

    1.1 Applies the principle of floating bodies to ships.

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

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

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

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

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

    1.7 Defines buoyancy and centre of buoyancy.

    1.8 Explains the relation between buoyancy and displacement.

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

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

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

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

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

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

Tonne Per Centimetre Immersion TPC

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

2.1 Defines TPC.

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

2.3 Sketches the curve of TPC against draught.

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

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

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

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

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

Change in Draught due to Density

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

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

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

3.3 Applies the formula to derive the fresh water allowance.

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

Coefficients of Form

4. Describes coefficients of form and their uses.

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

4.2 Solves problems, involving coefficients of form.

Wetted Surface Area

5. Describes the wetted surface area and calculates its value.

5.1 Defines wetted surface area.

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

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

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

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

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

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

B Simpson's Rule

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

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

(a) waterplane area at a particular draught using half ordinates at equally spaced stations along the vessel.

(b) volume of Displacement at a particular draught using:-

(i) Immersed cross-sectional areas at equally spaced stations along the vessel.

(ii) Waterplane areas at equally spaced stations above the keel.

(c) displacement at a particular draught using the TPC values at equally spaced stations above the keel.

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

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

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

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

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

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

C Ship Stability

Centres of Gravity

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

7.1 Explains that a ship is a system of masses.

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

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

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

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

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

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

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

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

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

7.11 Solves problems involving suspended masses.

Stability at Small Angles

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

8.1 Explains the meaning of the term stability.

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

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

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

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

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

8.7 Defines transverse metacentre.

8.8 Defines transverse metacentric height.

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

8.10 Discusses stable, unstable and neutral equilibrium.

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

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

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

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

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

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

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

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

8.19 States the object of the inclining experiment.

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

8.21 Solves problems relating to the inclining experiment

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

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

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

8.25 Discusses the procedure of the experiment.

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

8.27 Calculates the final lightship displacement and KG inclining experiment.

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

Change in Draughts due to Bilging

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

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

9.2 Explains the term permeability.

9.3 Defines bilging.

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

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

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

9.7 Discusses the conditions under which 9.6 may be applied.

9.8 Calculates the change in mean draught due to bilging

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

9.10 Calculates the change in metacentric height due to bilging

D Ship Resistance

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

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

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

    10.3 Discusses the components of frictional resistance.

    10.4 Discusses the components of residuary resistance.

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

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

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

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

Propellers

11. Understands basic propeller terminology.

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

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

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

    11.4 Defines speed of advance and real slip.

    11.5 Solves problems involving apparent and real slip.

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

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

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

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

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

E Admiralty Coefficients

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

12.1 Derives the Admiralty Coefficient formula.

12.2 Explains the assumptions and limitations of the Admiralty Coefficient.

12.3 Sketches the form of the Admiralty Coefficient curve

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

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

12.6 Solves problems related to Admiralty Coefficient.

F Fuel Consumption

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

13.1 Defines specific fuel consumption.

13.2 Sketches a typical curve of specific fuel consumption

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

13.4 Derives an expression for fuel coefficient.

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

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

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

13.8 Solves problems related to fuel consumption.

G Ship Terminology

14. Knows ship terminology.

14.1 Defines the following terms:

(a) forward perpendicular;
(b) after perpendicular;
(c) length between perpendiculars;
(d) length overall;
(e) amidships;
(f) station or section;
(g) moulded and extreme breadth;
(h) moulded and extreme depth;
(i) moulded and extreme draught;
(j) sheer;
(k) freeboard;
(1) camber;
(m) rise of floor;
(n) bilge radius;
(o) tumble home;
(p) flare;
(q) parallel middle body;
(r) lightweight;
(s) deadweight.

H Ship Construction

Framing Systems

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

15.1 Illustrates the following framing systems:

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

15.2 Describes the systems illustrated in 15.1

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

Ship Types

16. Recognises the design features of various types of ships.

    16.1 Illustrates the profiles of the following ship types:

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

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

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

Construction of Structural Components

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

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

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

Rudders and Sternframes

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

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

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

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

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

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

18.6 Describes with the aid of a sketch a sternframe suitable for the rudder in 16.3
Anchor and Cable Arrangement

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

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

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

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

I Ship Stresses

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

20.1 Explains the meaning of the following terms:

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

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

20.3 Identifies the structural items resisting the stress in 18.2.

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

J Ventilation

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

21.1 Explains why spaces must be ventilated.

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

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

Drainage of Compartments

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

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

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

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

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

SECOND ENGINEER REG. III/2
APPLIED HEAT

LIST OF TOPICS

A Pressure, Temperature, Energy
B Heat Transfer
C Internal Energy, Thermodynamic systems. First Law of Thermodynamics
D Gas Laws, Displacement Work
E Ideal Cycles and IC Engines
F Air Compressors
G Working Fluids
H Nozzles and Steam Turbines
I Refrigeration
J Combustion
K Boiler Feed Densities

The expected learning outcome is that the student:

A PRESSURE, TEMPERATURE, ENERGY

1. Recognises and measures the effect of pressure in fluid.
   - 1.1 Defines pressure as force per unit area.
   - 1.2 Recognises the effect of atmospheric pressure.
   - 1.3 States that standard atmospheric pressure is 1.01325 bar = 1.01325 x $10^5 N/m^2$.
   - 1.4 Measures atmospheric pressure using a mercury barometer.
   - 1.5 Converts pressure units using water lead, mercury lead with bar units.
   - 1.6 Defines:

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

   - 1.7 Solves simple problems relating to 1.1 to 1.6.

2. Defines and measures temperature.
   - 2.1 Defines temperature.
   - 2.2 Defines the absolute scale of temperature.
   - 2.3 Differentiates between Celsius and Kelvin Scales.
   - 2.4 Defines Standard Temperature and Pressure (S.T.P.) and Normal Temperature and Pressure (N.P.T.).

3. Discusses heat as a form of energy, specific heat capacity, sensible heat, latent heat and solves associated problems.
   - 3.1 Defines heat energy.
   - 3.2 Defines specific heat capacity of a solid and of a liquid.
   - 3.3 Defines sensible heat.
   - 3.4 Explains phase change and defines the latent heat of fusion.
   - 3.5 Sketches the change of phase (solid/liquid) diagram for water.

3.6 Determines the resultant temperature when a solid is placed in a liquid at a different temperature.
3.7 Determines the resultant temperature when up to three liquids at different temperatures are mixed.
3.8 Defines water equivalent.
3.9 Solves simple problems relating to 3.1 to 3.8.

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

B HEAT TRANSFER

5. Describes the way in which heat may be transferred and the factors which may influence heat transfer. Solves simple problems involving conduction, convection and radiation.
   5.1 Describes heat transfer by conduction.
   5.2 Gives practical examples of heat transfer by conduction.
   5.3 Defines the term coefficient of thermal conductivity.
   5.4 States an expression for the rate of heat transfer through a single plane wall.
   5.5 States that for a composite wall the rate of heat transfer is constant.
   5.6 States an expression for the transfer of heat through a composite wall made up of not more than three flat layers in contact.
   5.7 Solves simple problems relating to 5.1 to 5.6.
   5.8 Describes heat transfer by convection.
   5.9 Lists practical examples of forced and natural convection.
   5.10 Defines the term 'coefficient of conductance'.
   5.11 States an expression for the rate of heat transfer from a flat surface to its surroundings.
   5.12 Solves simple problems relating to 5.8 to 5.11.
   5.13 Describes heat transfer by radiation.
   5.14 Gives practical examples of heat transfer by radiation.

C INTERNAL ENERGY, THERMO-DYNAMIC SYSTEMS, FIRST LAW

6. Defines and describes Thermo-dynamic Systems and solves problems involving the First Law of Thermodynamics.
   6.1 Defines Internal Energy.
   6.2 States Joules Law for the internal energy of a gas.
   6.3 Defines a Thermodynamic system.
   6.4 Differentiates between an open and a closed system.
   6.5 Give examples of:
      a) closed system with fixed boundary (constant volume);
      b) closed system with elastic boundary (constant pressure);

c) open system with fixed boundary.

6.6 Defines work with reference to a thermodynamic system.
6.7 States the First Law of Thermodynamics in terms of heat energy, work energy and internal energy.
6.8 States that Q = W + U and that this is the non-flow energy equation.
6.9 States that power is the rate of transfer of energy.
6.10 States that H + Q = H + W and that this is the flow energy equation.
6.11 Solves simple problems relating to 6.1 to 6.10.

D GAS LAWS, DISPLACEMENT WORK

7. Solves simple problems involving the basic gas laws.
   7.1 Defines a perfect gas.
   7.2 States Boyles Law.
   7.3 States Charles Law.
   7.4 Shows Boyles Law and Charles Law on a pV diagram.
   7.5 Combines Boyles Law and Charles Law and states that for a perfect gas pV/T = a constant.
   7.6 Derives the Characteristic Gas Equation pV = mRT.
   7.7 Derives the units of the Characteristic Gas Constant R from the units of pressure, volume, temperature and mass.
   7.8 Solves simple problems relating to 7.1 to 7.7.

8. Describes processes which will produce a change of state in a non-flow system and solves problems concerned with non-flow processes.
   8.1 Differentiates between constant pressure and constant volume operations.
   8.2 Defines specific heat capacities of a gas at constant pressure and at constant volume.
   8.3 States that the ratio of the specific heat capacities of a gas Cp/Cv = γ (gamma) the adiabatic index.
   8.4 Defines:

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

   8.5 Shows the Isothermal, Adiabatic and Polytropic Operations on a pV diagram
   8.6 Shows that the area of the pV diagram represents W.D. during the operation.
   8.7 States expressions for the work done during isothermal, adiabatic and polytropic non-flow processes.

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

   8.8 States the temperature - pressure and temperature -volume relations for an operation to the law pV = a constant.
   8.9 States that change in internal energy is given by $mC_v\ (T_2 - T_l)$.

   8.10 States that the relationship between the Characteristic Gas Constant and the specific heat capacities of a gas is

$R = (C_p - C_v)$.

8.11 Solves simple problems relating to 8.1 to 8.10.

E IDEAL CYCLES AND I.C. ENGINES

9. Sketches p - V diagram and describes the operation for the ideal constant volume (Otto) cycle, the Diesel cycle and the Dual Combustion cycle.
   - 9.1 Sketches the pV diagram for the ideal Otto, Diesel and Dual Combustion cycles and names the processes making up these cycles.
   - 9.2 Names the practical engines that operate on these cycles.
   - 9.3 Compares the ideal cycle with the practical four stroke cycle.
   - 9.4 Gives reasons for the differences between the ideal and the practical cycle.
   - 9.5 Answers simple descriptive questions only on the Otto, Diesel and Dual Combustion cycles.
   - 9.6 Defines air standard efficiency and solves problems involving engine cycles.

10. Determines indicated power, brake power and mechanical efficiency of an I.e. engine and solves problems involving power, efficiency, fuel consumption and heat balance.
    - 10.1 Defines mean effective pressure (m.e.p.).
    - 10.2 Determines the area of an indicator card using the mid-ordinate rule.
    - 10.3 States the terms, spring rate, spring stiffness and spring constant when referred to indicators.
    - 10.4 Determines the indicated m.e.p. from an actual indicator diagram.
    - 10.5 Defines indicated power.
    - 10.6 Derives an expression for calculating indicated power.
    - 10.7 Defines brake power.
    - 10.8 Defines brake mean effective pressure (b.m.e.p.) and uses this term in the determination of brake power.
    - 10.9 Derives an expression for brake power in terms of torque and angular velocity.
    - 10.10 Determines mechanical efficiency.
    - 10.11 Calculates indicated power, brake power and mechanical efficiency from engine test data.
    - 10.12 Defines thermal efficiency for an actual engine.
    - 10.13 Differentiates between brake and indicated thermal efficiencies.
    - 10.14 Calculates thermal efficiency from engine data.
    - 10.15 Defines specific fuel consumption based on indicated power and brake power.
    - 10.16 Relates specific fuel consumption to thermal efficiency.
    - 10.17 Calculates specific fuel consumption from engine data.
    - 10.18 Draws up a heat energy balance for an I.e. engine.
    - 10.19 Solves simple problems relating to 10.1 to 10.18.
    - 10.20 Solves problems involving thermal, mechanical and overall efficiency.

F AIR COMPRESSORS

11. Describes the factors which influence the performance of a reciprocating air compressor and solves simple problems involving single stage single acting compressors.S
    - 11.1 Sketches the ideal p - V diagram for a compressor without clearance volume.
    - 11.2 Sketches the ideal p - V diagram for a compressor with clearance volume.
    - 11.3 Defines clearance volume.
    - 11.4 Defines induced volume.
    - 11.5 Defines 'free air' delivery for an air compressor.
    - 11.6 Defines volumetric efficiency based on 'free air1 and actual air conditions.

$$V = \frac{ActualVolu\,meInduced}{SweptVolume}$$

    - 11.7 Solves simple problems relating to 11.1 to 11.6.
    - 11.8 Solves problems involving work input and mechanic efficiency.

G WORKING FLUIDS

12. Recognises the differences in the properties of vapours, gases and the perfect gas and uses the steam tables to solve simple problems related to water and steam in the wet, saturated and superheated states.
    - 12.1 Differentiate between a gas and a perfect gas.
    - 12.2 Differentiate between a gas and a vapour.
    - 12.3 Defines the term ENTHALPY (h).
    - 12.4 States that h = u + pV.
    - 12.5 Defines the term pV as flow energy.
    - 12.6 Shows that pV is the work transfer in pumping a fluid under constant pressure conditions.
    - 12.7 Defines the term 'saturated' when applied to a vapour.
    - 12.8 Defines saturation temperature.
    - 12.9 Differentiates between wet, dry-saturated and superheated vapours.
    - 12.10 Defines the term dryness fraction.
    - 12.11 Defines the terms 'quality' and 'degree of superheat' as applied to a vapour.
    - 12.12 Demonstrates how to obtain values of specific enthalpy, specific volume and internal energy for water and for wet dry saturated and superheated vapours from the Thermodynamic Properties tables by direct reading or interpolation.
    - 12.13 Sketches a pressure-enthalpy diagram.
    - 12.14 States that the specific enthalpy of a wet vapour is given by hf + x hfg.
    - 12.15 States that the specific internal energy of a wet vapour is given by uf + x ufg.
    - 12.16 States that the specific volume of wet vapour is given by x Vg + (1 - x) Vf.
    - 12.17 Determines from information given in the tables the pressure-temperature relationship for a saturated vapour.

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

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

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

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

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

12.23 Solves problem relating to 12.1 to 12.22.

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

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

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

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

12.28 Solves simple problems relating to 12.1 to 12.27.

H NOZZLES AND STEAM TURBINES

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

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

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

13.3 Solves simple problems relating to 13.1 to 13.2.

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

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

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

13.7 Shows velocity of whirl on a combined diagram.

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

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

13.10 Solves problems relating to 13.1 to 13.5.

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

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

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

13.14 Solves simple problems relating to 13.12 to 13.13.

13.15 Solves problems involving axial force on blades.

I REFRIGERATION

14. Understands the concepts of the reversed heat engine cycle and its applications to vapour compression refrigeration plant and solves simple problems.
    - 14.1 Sketches the circuit diagram for the basic vapour compression refrigeration cycle.
    - 14.2 Identifies the principal components of a vapour compression refrigerator and describes its operation.
    - 14.3 Sketches a vapour compression cycle on a p - h diagram showing:

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

    - 14.4 Defines 'refrigerating effect' in kJ/kg, mass flow rate in kg/s and 'cooling load' in kW.
    - 14.5 Shows that work transfer from the compressor during an adiabatic operation is equal to the enthalpy change of the vapour.
    - 14.6 Defines 'coefficient of performance' of a refrigeration plant.
    - 14.7 Defines 'capacity' of a refrigeration plant.
    - 14.8 Uses property tables to determine the specific enthalpy and specific volume of wet, dry and superheated refrigerants.
    - 14.9 Solves simple problems relating to 14.1 to 14.8.

J COMBUSTION

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

    - 15.1 Defines the chemical definitions of atom, molecule, atomic mass, molecular mass, element, compound and a mixture.
    - 15.2 States the combustion equations for the complete combustion of Carbon to Carbon Dioxide, Hydrogen to Water, and Sulphur to Sulphur Dioxide.
    - 15.3 States the equation for the partial combustion of Carbon to Carbon Monoxide.
    - 15.4 Derives the equations for the combustion of simple hydro-carbon fuels.
    - 15.5 States that air contains approximately 23% oxygen and 77% nitrogen by mass.
    - 15.6 Determines the stoichimetric mass of air required for the complete combustion of a hydro-carbon fuel.
    - 15.7 Determines the percentage excess air required for complete combustion of a hydro-carbon fuel.
    - 15.8 Defines the Higher Calorific Value and the Lower Calorific Value of a fuel.
    - 15.9 Determines the Higher and Lower Calorific Values of a fuel given the calorific value of its constituents.
    - 15.10 Lists on a percentage basis the products of combustion of a fuel, burned in excess air, by mass.
    - 15.11 Solves problems relating to 15.1 to 15.10.

K BOILER FEED DENSITIES

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

    16.1 Defines parts per million (ppm).

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

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

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

    16.4 Determines the heat lost to blowdown.

    16.5 Defines boiler efficiency.

    16.6 Solves simple problems relating to 16.1 to 16.5.