SECOND ENGINEER REG III/2
NAVAL ARCHITECTURE

LIST OF TOPICS

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' 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 ecLually spaced stations above the keel.
(b) TPC values at ecLually 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 ExpIains 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 keeI 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

15.3 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.