GENERAL ENGINEERING SCIENCE I & II

GENERAL ENGINEERING SCIENCE I

For:

Second Engineer <3000kW
Class 1 Fishing Engineer
Yacht 2 Chief Engineer (Y2)

LIST OF TOPICS

MATHEMATICS:

A Arithmetic
B Algebra
C Graphs
D Trigonometry
E Geometry
F Mensuration

APPLIED MECHANICS:

G Units
H Kinematics
I Dynamics
J Statics
K Friction
L Machines
M Strength of Materials
N Fluids at Rest0
O Transverse Stability

MATHEMATICS

A Arithmetic

1.

1.1 Defines numerator and denominator of a fraction.

1.2 Defines vulgar fractions, mixed number and improper fraction.

1.3 Uses common denominator in addition and subtraction of fractions.

1.4 Multiplies fractions.

1.5 Divides fractions.

1.6 Uses cancellation to reduce fractions.

1.7 Applies cancellation to manipulation of fractions.

1.8 Simplifies fractions involving the use of brackets.

1.9 Solves problems involving fractions.

1.10 Defines decimal fractions.

1.11 Converts vulgar fractions to decimal fractions.

1.12 Converts decimal fractions to vulgar fractions.

1.13 Add and subtracts decimal fractions.

1.14 Multiplies and divides decimal fractions.

1.15 Identifies a recurring decimal fraction.

1.16 Rounds off a decimal fraction to a specified number of places.

1.17 States a decimal number correct to a specified number of significant figures.

1.18 Converts vulgar fractions and decimal fractions to percentages.

1.19 Expresses "gain" as a percentage.

1.20 Expresses "decrease" as a percentage.

1.21 Expresses "error" as a percentage.

1.22 States that a ratio is a comparison of quantity magnitudes.

1.23 States that proportion is an equation of ratios.

1.24 Solves problems on ratio and proportion.

1.25 Defines logarithm.

1.26 Uses the log definition to put numbers in power form (ie 10^X if given $\log_{10}X$).

1.27 Defines the parts of a log viz; characteristic and mantissa, and their properties ie positive and/or negative.

1.28 Expresses numbers in standard form and so finds the characteristic.

1.29 obtains logarithm of a number from tables or calculator or slide rule.

1.30 Obtains antilogarithm from tables or calculator or slide rule indicating the position of the decimal point from the characteristic.

1.31 Applies logarithms to multiplication and to division of numbers.

1.32 Evaluates a number raised to a positive integral power using logarithms.

1.33 Evaluates square or cube root of a number using logarithms.

1.34 Evaluates a string of figures raised to different powers or roots.

B Algebra

2.

2.1 States that arithmetic operations can be carried out by generalising and employing letters to represent quantities.

2.2 Add algebraic quantities, both positive and negative.

2.3 Subtracts algebraic quantities, both positive and negative.

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

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

2.6 Defines the "power" and the "index" of a quantity.

2.7 States the laws of indices for multiplication and division of numbers.

2.8 Defines a fractional index of a quantity power.

2.9 Defines a negative index of a quantity power.

2.10 Defines the zero index of a quantity power.

2.11 States the "Law of Distribution".

2.12 Adds and subtracts algebraic fractions using common denominator.

2.13 Multiplies binomial factors.

2.14 Divides quadratic function by linear factor.

2.15 Identifies a statement of equality as an equation.

2.16 Solves simple algebraic equations.

2.17 States the axioms:

(a) If equal quantities be added to two quantities that are already equal, the result 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.

2.18 Solves problems involving transposition of formulae.

2.19 Identifies direct variation.

2.20 Identifies inverse variation.

2.21 Identifies the constant of variation.

2.22 Forms linear equations consistent with data provided in a question.

C Graphs

3.

3.1 Defines co-ordinate, axes and origin.

3.2 States on which axes the dependent and independent variable are plotted.

3.3 Plots ordered pairs on graph paper having been given or having calculated x and y values.

3.4 Joins the points with a straight line, or smooth curve, depending upon the graph or position of the plotting points.

3.5 States that the equation of a straight line is of the form $y = ax + b$.

3.6 States that, for a straight line graph, the constant b in the equation of the graph $y = ax + b$ is the intercept of the graph on the y axis ie where $x = 0$ and that the constant "a" is the slope (gradient) of the graph.

D Trigonometry

4.

4.1 Expresses acute angles in degrees and radians and states the relationship between degrees and radians.

4.2 Defines acute, right, obtuse and reflex angles.

4.3 Defines complementary angles and supplementary angles.

4.4 Defines sine, cosine, tangent, and the relationship between them.

4.5 Obtains numerical values of sine, cosine, tangent for any angle between 0 and 900 from tables, calculator or slide rule.

4.6 Obtains angle, given numerical value of its sine, cosine or tangent from tables, calculator or slide rule.

4.7 States Pythagoras's Theorem.

4.8 Solves problems using Pythagoras's Theorem.

4.9 Solves right-angled triangles given two facts about the triangle.

E Geometry

5.

5.1 States that a triangle has three sides and three angles and that the latter add up to 180*.

5.2 States that a right angle triangle has one angle of 90°.

5.3 States that an equilateral triangle has all angles equal and all sides equal.

5.4 States that an isosceles triangle has two sides equal and two angles equal.

5.5 States that a scalene triangle has no equal sides or angles.

5.6 Constructs a triangle to scale given:

(a) all sides;
(b) two sides and an included angle;
(c) one side and two angles.

5.7 Bisects a line and an angle, and erects a perpendicular to a line.

5.8 States that similar triangles have equal angles.

5.9 States that congruent triangles have equal angles and equal sides.

5.10 Defines radius, diameter, circumference, arc, sector, chord, segment of a circle.

5.11 States that a circle contains 3600.

5.12 States that a tangent to the circle at a given point is perpendicular to the radius at that point.

F Mensuration

6.

6.1 States the area of.a triangle and deduces the area given:

(a) the base and vertical height;
(b) two sides and the included angle.

6.2 Deduces the area of a parallelogram.

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

6.4 States the area of a circle in terms of radius/diameter and deduces the area of an annulus.

6.5 Defines the Mid-Ordinate Rule and determines the area of a figure using the Mid-Ordinate Rule.

6.6 Deduces the surface area of a cylinder, pyramid and cone.

6.7 States the surface area of a sphere.

6.8 Deduces the volume of a cylinder.

6.9 States the volume of a pyramid, cone and sphere.

6.10 Solves problems in mensuration relating to 6.7 and 6.9.

6.11 Determines the mass of a solid using volume and density.

6.12 Determines the ratios of masses and volumes of similar solids.

APPLIED MECHANICS

G Units

7. Know fundamental and derived metric units.

7.1 States the fundamental units of length, mass and time in S.I.

7.2 States the values of the prefixes: pico, nano, micro, milli, centi, kilo, mega, giga and tera.

7.3 Defines density and its units.

7.4 Defines relative density.

7.5 Solves simple problems relating to mass, volume and density of solids.

7.6 States that a litre is 1 X 10-3 M3.

H Kinematics

8. Solves problems involving distance, time, velocity and acceleration.

8.1 Defines speed.

8.2 Calculates average speed from given time and distance data.

8.3 States the difference between speed and velocity and between distance and displacement.

8.4 Plots straight line distance time graphs

8.5 Calculates the gradient of such graphs and interprets the slope as speed.

8.6 Defines acceleration.

8.7 Plots straight line velocity time graphs.

8.8 Calculates the gradient of such graphs and interprets the slope as acceleration.

8.9 Solves problems using the equation distance = average speed x time.

8.10 Calculates distance from the area under velocity/time graphs.

8.11 Defines the radian.

8.12 Converts revolutions and/or parts of a revolution to radians and vice versa.

8.13 Converts a given angular velocity in rev/min to rad/s and vice versa.

8.14 Solves simple problems involving distance, time, linear velocity, angle turned, uniform linear acceleration, using appropriate diagrams.

I Dynamics

9. Solves problems involving mass, force, acceleration, area and pressure. Solves problems involving work, energy and power.

9.1 Defines force.

9.2 Defines momentum as the product of mass and velocity.

9.3 States that the formula F = ma is a mathematical representation of Newton's Law that force is proportional to the rate of change of momentum.

9.4 Uses the formula in 9.3 to define the newton as the unit of force.

9.5 Solves simple problems involving force, mass and acceleration.

9.6 States that gravitational force exists and leads to free fall acceleration.

9.7 States that the average acceleration due to gravity is approximately 9.81 m/s^2.

9.8 States that the weight is the effect of gravity on a mass, and that the weight of one kilogram mass is approximately 9.81 N.

9.9 Defines intensity of pressure as force per unit area.

9.10 States that the fundamental derived unit of pressure is the newton per square meter and is called the Pascal.

9.11 States that there is pressure due to the atmosphere.

9.12 Defines the bar as 10^5 pascals (10^5 N/m2).

9.13 States that absolute pressure equals guage pressure plus atmospheric pressure.

9.14 Solves simple problems involving force, area and pressure.

9.15 Defines work done in terms of force and distance moved.

9.16 Defines the joule.

9.17 Defines torque.

9.18 Defines work done in terms of torque and angle turned.

9.19 Draw graphs of force/distance and torque/angle turned and relate the area under the graph to work done.

9.20 Describes energy as a capacity to do work.

9.21 Gives examples of energy conservation devices.

9.22 States the law of conservation of energy.

9.23 Defines efficiency in terms of energy input and output.

9.24 States that power is the rate of doing work or the rate of transfer of energy.

9.25 States that the Watt is the unit of power.

9.26 Solves simple problems involving work, energy and power.

J Statics

10. Solves problems associated with the turning effect of a force.

10.1 Defines stable, unstable and neutral equilibrium.

10.2 Defines the moment of a force about a point.

10.3 States the principle of moments.

10.4 Defines centroid of a lamina and centre of area.

10.5 Sketches the position of the centroid of a symmetrical lamina such as a rectangle.

10.6 Defines centroid of a mass and refers to the centre of gravity of a mass.

10.7 Solves simple problems on levers, shafts, cantilevers and simply supported beams involving concentrated or uniformly distributed loads.

10.8 Defines a scalar quantity.

10.9 Defines a vector quantity.

10.10 States that a force is a vector quantity.

10.11 Resolves a force into horizontal and vertical components, deduces that V = F Sinθ and H = F Cosθ values of θ being restricted to the first quadrant.

10.12 Deduces the resultant of two forces meeting at a point.

10.13 States that the components of the resultant are theseparate sums of the components of the two forces.

10.14 States the theorem of the parallelogram of forces.

10.15 Solves simple problems involving two forces meeting at a point.

10.16 Defines static equilibrium.

10.17 States that three co-planar forces in equilibrium must meet at a point or act parallel to each other.

10.18 States the theorem of the triangle of forces.

10.19 Solves simple problems involving the triangle of forces with the aid of Bow's notation.

K Friction

11.

11.1 Defines a friction force.

11.2 States the laws of dry friction.

11.3 Distinguishes between "static" and "dynamic" friction.

11.4 Derives the Coefficient of Friction.

11.5 Applies the laws of friction to movement in a horizontal plane.

11.6 Describes the effect of lubricating two surfaces in contact.

L Machines

12.

12.1 Defines a machine as a device for changing the magnitude and line of action of a force.

12.2 Defines force ratio (Mechanical Advantage).

12.3 Defines a movement ratio (Velocity Ratio).

12.4 Determines efficiency in terms of MA and VR.

12.5 Derives the Linear Law applicable to a machine E = aW + c.

12.6 Explains why the machine efficiency cannot reach 100 per cent.

12.7 Describes with the aid of sketches the construction of:

(a) the differential wheel and axle;
(b) the Weston differential pulley block;
(c) the screwjack;
(d) the crabwinch;
(e) the worm and worm wheel;
(f) rope-pulley block system.

12.8 Determines the Velocity Ratio for the machines specified in 12.7.

12.9 Solves problems related to simple lifting machines.

M Strength of Materials

13.

13.1 Recognises tensile, compressive and shear force.

13.2 Defines stress as the load carried by unit area.

13.3 Solves simple problems involving direct stress.

13.4 Defines strain as change in dimension per unit original dimension

13.5 Calculates simple problems involving direct strain.

13.6 Draws graphs of force/extension and stress/strain for an elastic material.

13.7 States Hooke's Law.

13.8 Defines Young's Modulus.

13.9 Sketches a complete load/extension diagram for a low carbon steel.

13.10 Describes the form of stress/strain graphs for brittle and ductile materials.

13.11 Defines the terms: ductility, brittleness, hardness, limit of proportionality, elastic limit, yield stress.

13.12 Defines Factor of Safety and relates it to the Ultimate Tensile Stress, Ultimate Compression Stress and working stress.

13.13 Solves problems involving stress, strain and Factor of Safety.

13.14 Defines shear stress.

13.15 Defines shear strain.

13.16 Defines ultimate shear strength.

13.17 Solves simple problems involving shear.

N Fluids at Rest

14.

14.1 Understands that the pressure at a point in a liquid is equal to ρgh and is independent of area.

14.2 Determines the thrust exerted on horizontally and vertically immersed surface.

14.3 Solves simple problems involving pressure and thrust due to liquid depth with liquid on one side only.

14.4 States the Principle of Archimedes and applies this principle to the equilibrium of floating bodies of simple geometrical form.

0 Transverse Stability (box shape only)

15.

15.1 Understands the term "centre of gravity", "centre of buoyancy" and metacentre as applied to a box shaped vessel.

15.2 States that it is usual to measure the vertical position of the centre of gravity of the ship above the keel and this is denoted by KG.

15.3 States that the height of the centre of gravity of an item on the ship above the keel is denoted by Kg.

15.4 Solves simple problems involving addition of mass to the ship.

15.5 Solves simple problems involving transverse movement of masses across the deck using the given formula

$$GM = \frac{m \times d}{\Delta ton \Theta}$$

GENERAL ENGINEERING SCIENCE II

For:

Second Engineer <3000kW
Class 1 Fishing Engineer
Yacht 2 Chief Engineer (Y2)

LIST OF TOPICS

HEATENGINES

1 Heat Energy
2 Gas Laws
3 Combustion
4 Refrigeration

ELECTROTECHNOLOGY

5 Nature of Electricity
6 Electric Currents
7 Electric Circuits
8 Resistance
9 Secondary Cells
10 Magnetic Field
11 Electromagnetic Induction
12 Measuring Instruments and Measurements

HEATENGINES

1 Heat Energy

Solves problems involving mass, specific heat capacity and temperature change.

1.1 Describes fuels as sources of energy.
1.2 States that heat being a form of energy, the unit for quantity of heat is the joule.

1.3 States that temperature differential decides the direction of transfer of heat energy.

1.4 Distinguishes between temperature and heat energy.

1.5 Defines the fixed points on the Celsius scale of temperature.

1.6 Defines a change in enthalpy without change of state (ie sensible heat).

1.7 Defines specific heat capacity.

1.8 States that a unit of specific heat capacity is the kJ/kg K..

1.9 Solves simple problems associated with mass, specific heat capacity and temperature change.

1.10 Defines conduction, convection and radiation.

1.11 Gives one example in each case of the transfer of heat energy by each of the processes given in 1.10

1.12 Discusses the use of insulation to conserve fuel in a heating installation.

1.13 Appreciates the effects of heat energy supplied to solids, liquids and gases.

1.14 Discusses expansion and contraction of solids and liquids and the practical application of thermal expansion and contraction.

1.14 Derives the relationship between temperature and the increase of linear dimensions of solids and volumetric dimensions of liquids.

1.16 Defines coefficient of linear expansion.

1.17 Derives coefficients of superficial and cubical expansions.

1.18 Distinguishes between real and apparent expansion of a liquid.

1.19 Solves problems relating change of temperature and change of dimensions of solids and liquids.

1.20 Defines specific heat capacity without reference to constant volume or constant pressure.

1.21 Solves problems involving heat and cooling of solids and liquids, relating heat energy and temperature.

1.22 Describes how changes of state occur without change in temperature.

1.23 Defines boiling and freezing points.

1.24 Defines specific enthalpy of fusion and specific enthalpy of evaporation.

1.25 Solves problems involving mixtures of solids and liquids, liquids and liquids, liquids and vapours.

1.26 Describes the following temperature measuring devices:

(a) a liquid in glass thermometer;
(b) thermocouple;
(c) pyrometer.

2 Gas Laws

2.1 Defines an ideal or perfect gas.

2.2 Defines Boyle's Law.

2.3 Defines Charles' Law.

2.4 Derives absolute zero temperature and relays Kelvin scale to the Celsius scale of temperature.

2.5 Derives the combination of $\frac{PV}{T} = C$

2.6 States that gas laws in the forms pV = mRT when R is the specific gas constant.

2.7 Defines the units of R.

2.8 States the meaning of standard temperature pressure (STP) and normal temperature pressure (NTP).

2.9 Solves problems involving pressure, volume, temperature and mass.

3 Combustion

3.1 Defines a fuel and the types of fuels available.

3.2 Defines combustion.

3.3 Gives the chemical symbols of the elements and compounds associated with combustion.

3.4 Gives meanings of suffix and prefix numbers applied to chemical symbols.

3.5 Develops combustion equations for hydrogen, carbon, sulphur.

3.6 Defines higher and lower calorific values of a fuel.

3.7 Determines combustion analysis by mass.

3.8 Determines theoretical or stoichiometric air requirements for complete combustion of a fuel by mass.

3.9 Defines excess air supply.

3.10 Discusses the effect of excess and inadequate air supply in relation to boilers and internal combustion engines.

Internal combustion engines.

3.11 Defines the following engine power:

(a) indicated power;
(b) brake power;

(c) friction power;

(d) cooling water power;
(e) exhaust power.

3.12 Determines mean effective pressure from an indicator card.

3.13 Derives formula for indicated power in relation to single acting engines operating on two and four stroke cycles.

3.14 Defines indicated and brake mean effective pressures.

3.15 Defines specific fuel consumption.

3.16 Defines the following engine efficiencies:

(a) mechanical efficiency;
(b) indicated thermal efficiency;
(c) brake thermal efficiency.

3.17 Solves problems involving two stroke and four stroke IC engines.

4 Refrigeration

4.1 States the properties of a refrigerant.

4.2 Describes the basic refrigerant circuit for a compression type domestic refrigeration plant.

4.3 States the condition of the refrigerant at the various points in the circuit.

ELECTROTECHNOLOGY

5 Nature of Electricity.

5.

5.1 Describes the structure of the atom and defines electron, proton and neutron.

5.2 Describes the shells of electrons in the atom and the detachment of a loosely held electron by some influence.

5.3 States that the free movement of electrons gives a current of electricity.

5.4 States that, for unidirectional continuous current, free electrons must be available in all parts of a circuit.

5.5 Defines the terms "conductor" and "insulator" and gives three examples of each.

5.6 States that all conductors offer some resistance to the flow of electric current.

5.7 Names secondary cells and generators, as sources of electricity.

5.8 Uses preferred symbols appropriate for the representation of sources, cells and resistors, and switches in an electric circuit.

6 Electric Current

Identifies the three main effects of an electric current.

6.1 States examples of an electric current being used for its magnetic effect.

6.2 States examples of an electric current being used for its chemical effect.

6.3 States examples of an electric current being used for its heating effect.

6.4 Identifies the effect being made use of in given specific cases. Example electromagnet, electroplating, electric fire, fuse.

7 Electric Circuits

Solves problems associated with simple electrical circuits.

7.1 States that the SI unit for current is the ampere.

7.2 States that one ampere is one coulomb per second, that a coulomb is the unit for quantity of electricity and that a coulomb is composed of a specific and very large number of electrons.

7.3 Explains how a current flows due to the existence of a potential difference between two points in an electrical conductor.

7.4 Defines potential difference and states that the unit is the volt.

7.5 Defines electromotive force and states that the unit is the volt.

7.6 States that watts equals volts multiplied by amperes.

7.7 States ohms Law in terms of the proportionality of current to potential difference.

7.8 States that this constant of proportionality for a particular resistor is called the resistance and that the unit of resistance is the ohm.

7.9 Solves simple problems using Ohm's Law.

7.10 Describes a series circuit as one which provides only one path for the flow of current through the circuit.

7.11 Describes a parallel circuit as one which provides alternative paths for the flow of current through the circuit.

7.12 States that the current is the same in all parts of a series circuit.

7.13 States that the sum of the voltages in an external series circuit is equal to the total applied voltage.

7.14 Shows that for resistors connected in series the equivalent resistance is given by $R = R_1 + R_2 + R_3\ldots$

7.15 Solves simple problems involving up to three resistors connected in series, including the use of Ohm's Law.

7.16 States that the sum of the current in resistors connected in parallel is equal to the current flowing into the parallel network.

7.17 States that the potential difference (voltage) is the same across resistors in parallel.

7.18 Shows that for resistors connected in parallel the equivalent resistance is given by:

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\ldots..$$

7.19 Solves simple problems involving up to three resistors connected in parallel by use of Ohm's Law.

7.20 States that power dissipated in a given conductor is the product of a potential difference difference and the current.

7.21 Uses Ohm's Law to show that $P = I^2R$ or $\frac{V^2}{R}$

7.22 Calculates the power dissipated in simple circuits.

8 Resistance

Solves problems involving resistance variation with temperature and resistivity.

8.1 States the effect of temperature increase on the resistance of metals, carbon, electrolytes and insulation.

8.2 Defines the temperature coefficient of resistance.

8.3 Solves simple problems involving the temperature coefficient of resistance.

8.4 Defines resistivity.

8.5 Solves simple problems involving resistivity.

Is aware of the concepts of e.m.f. and internal resistance.

8.6 Describes the potential difference (voltage) of a source on no load as the e.m.f.

8.7 Defines internal resistance.

8.8 Explains the effect of load current on terminal p.d. and hence determines internal resistance.

9 Secondary Cells

9.1 Explains difference between primary and secondary cells.

9.2 Describes the chemical changes during the charging and discharging of a simple lead-cell.

9.3 Describes how, using a high resistance voltmeter, the e.m.f. of charged lead-acid cells is measured:

(a) singly;
(b) in series;
(c) in parallel.

9.4 Explains the effects of load current on terminal p.d. and hence determines internal resistance of cells.

9.5 Labels, given diagram, the mains parts of:

(a) lead-acid cells;
(b) alkaline cells.

9.6 States that the capacity of a cell is measured in ampere hours.

10 The Magnetic Field

10.1 Defines the terms flux, flux density, m.m.f., and magnetizing force.

10.2 Recognises the effects of ferromagnetic materials on flux density.

10.3 States the units of B, H, m.m.f.

11 Electromagnetic Induction

11.1 States Lenz's Law.

11.2 States Faraday's Laws of electromagnetic induction.

11.3 Explains the motor principle in terms of the interaction between two magnetic fields.

11.4 Explains the function of the commutator.

11.5 Recognises from the formula F = BIL, the linear relationship between F and the other terms.

11.6 Explains the generator principle in terms of Faraday's Laws and Lenz's Law.

11.7 Recognises the linear relationship between E and the other terms from the formulae E - BLv.

11.8 Describes production of an induced e.m.f. due to a change in magnetic field.

12 Measuring Instruments and Measurements

12.1 Describes with the aid of given diagrams, the principles of operation of:

(a) moving iron;
(b) moving coil instruments.

12.2 Explains the needs for shunts and multipliers to extend the range of a basic electrical indicating instrument.