

# **UK MCA General Engineering Science I Syllabus**

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## **General Engineering Science I Exam**

**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 Rest
- O Transverse Stability

# MATHEMATICS

## A Arithmetic

- 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**

- 2.1 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**

- 3.1 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**

- 4.1 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**

- 5.1 States that a triangle has three sides and three angles and that the latter add up to  $180^\circ$ .
- 5.2 States that a right angle triangle has one angle of  $90^\circ$ .
- 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**

- 6.1 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  $1 \times 10^{-3} \text{ m}^3$ .

### **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  $9.81 \text{ m/s}^2$ .
- 9.8 States that the weight is the effect of gravity on a mass, and that the weight of one kilogram mass is approximately  $9.81 \text{ N}$ .
- 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 105 pascals ( $105 \text{ N/m}^2$ ).
- 9.13 States that absolute pressure equals gauge 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  $V = F \sin\theta$  and  $H = F \cos\theta$  values of  $\theta$  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 the separate 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**

- 11.1 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**

- 12.1 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**

- 13.1 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**

- 14.1 Understands that the pressure at a point in a liquid is equal to  $\rho gh$  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)**

- 15.1 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

$$GM = \frac{mxd}{\Delta \tan \Theta}$$

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