GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify the following and rearrange to make x the subject of the expression:

(a) $y = \frac{x^3}{x^2} \times \frac{x^4}{4}$ (4)

(b) $y = \frac{x^2 \cdot z^3}{z^2} \div \frac{x^3 \cdot z}{x^2}$ (4)

2. The steel shell of a condenser can be considered cylindrical with flat, round ends. It has an overall length of 1.5 m, with a bore (diameter) of 700 mm, and a wall thickness of 10 mm.

Calculate EACH of the following:

(a) the mass of the steel condenser; (5)

(a) the mass of sea water that would completely fill the condenser ignoring all interior fittings; (3)

(c) the direct force in KN that would be exerted by the condenser when full of water. (2)

Note: Density of sea water = 1025 kg/m^3 Relative density of steel = 7.8

3. Determine the area of the shaded sector below in Fig Q3. (8)

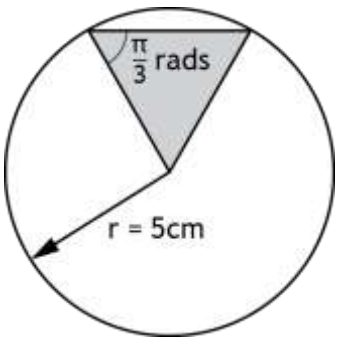

Fig Q3

4. A vessel of 6000 tonne displacement has a rectangular fuel tank 15 m long, 12 m wide and 4 m deep. The tank is full of fuel oil with a density of 900 kg/m^3 and the tank bottom is 1.2 m above the keel. The KG of the vessel is 6.2 m when the tank is full.

   Calculate the new KG after all of the oil has been used. (8)

5. A turbine rotor has a diameter of 0.6 m and rotates at 400 rad/s.

   Calculate EACH of the following:

   (a) the linear velocity of a point on the rim in m/s; (3)

   (b) the rotational speed of the rotor in rev/min; (3)

   (c) the number of radians turned when the rotor rotates through 325°. (2)

6. (a) Plot the graph of the equation $y = 2x^3 + 3$ between the limits of $x = -1$ and $x = 3$ indicating in the answer how the plotting points are obtained. (8)

   (b) Indicate on the graph plotted in Q6(a), the value of y when $x = 1.5$. (2)

7. Two ships leave a port at the same time. Ship A is on a bearing of 45 degrees travelling at 24 km/h, ship B is on a bearing of 70 degrees travelling at 15 km/h.

   (a) Draw a diagram indicating the movements of the ships (2)

   (b) How far apart are the ships after 4 hours? (8)

8. A fire pump discharges sea water through a 50 mm diameter pipe to a height of 16.5 m at a constant velocity of 3.5 m/s.

Calculate EACH of the following:

(a) the power of the pump; (5)

(b) the motor power to drive the pump if the combined electrical and mechanical efficiency is 82%. (3)

Note: Density of seawater 1025 kg/m^3

9. A lifeboat has a mass of 600 kg and is pulled alongside a distance of 90 m using a winch using a force of 150 N. It takes 1 minute and 20 seconds to complete this.

Ignoring friction, determine:

(a) the acceleration of the lifeboat; (2)

(b) the average speed; (2)

(c) the work done; (2)

(d) the power required. (2)

10. For the shape shown in Fig Q10, determine the position of the centroid in the x and y planes. (8)

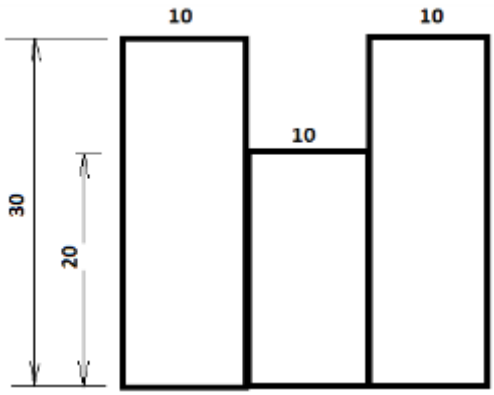

Fig Q10

11. Engineers have to consider the effects of friction in most situations.

(a) Briefly describe: (2)

(i) an example where friction is a problem and its effect;

(ii) an example where friction is useful and its effect.

(b) A wooden crate has a mass of 45 kg and requires a force of 90 N to slide it along the deck. Determine the dynamic coefficient of friction. (4)

12. Show that the shaded area in the diagram below, Fig Q12, is given by; (8)

$$Area = (4 - \pi)r^2$$

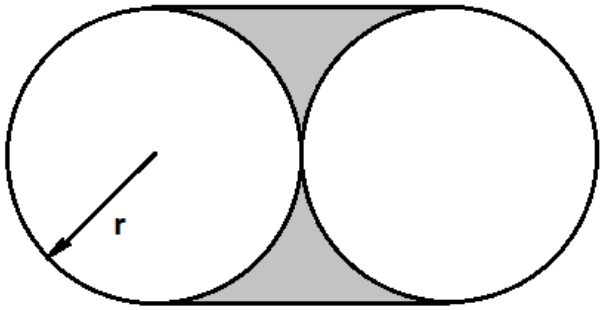

Fig Q12

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify EACH of the following expressions:

   (a) $\frac{12\,a\,b^3}{6\,b\,c} \div \frac{2\,a\,b^2}{c^2}$ (4)

   (b) $\frac{12\,a\,b^3}{6\,a\,b\,c} \times \frac{2\,a\,b^2}{12\,a\,b\,c^2}$ (4)

2. A triangle sail has a right angle between mast and boom at point A. The length of the sail is 10 m up the mast to point B and the length of the diagonal, BC, is 11 m.

   Calculate EACH of the following:

   (a) the length of the sail along the boom, AC using Pythagoras Theorem; (4)

   (b) the area of the sail in m^2. (4)

3. A jolly boat hoist has pulleys of radius R and r. When lifting a load of L the effort E can be found from the following formula:

$$E = \frac{L\,(R-r)}{2R}$$

   (a) transpose the formula to make R the subject. (6)

   (b) calculate the value of R when E = 83, L = 500 and r = 50. (2)

   Note: Ignore any units.

4. A right pyramid has an equilateral triangle base with sides of 200 mm and a perpendicular height of 300 mm.

   Calculate EACH of the following:

   (a) the volume of the pyramid in m^3; (5)

   (b) the area of any one of the triangular faces in mm^2.(Excluding base) (4)

5. (a) Sketch a complete load/extension diagram for a typical low carbon steel specimen. (2)

(b) Indicate EACH of the following on your diagram:

(i) limit of proportionality; (2)

(ii) yield point; (2)

(iii) maximum load. (2)

6. Fig Q6 shows a steel bar, of uniform cross section, 2.57 metres long having a mass of 11.05 kg.

Determine the value of W kg to give a balanced equilibrium condition about the fulcrum. (9)

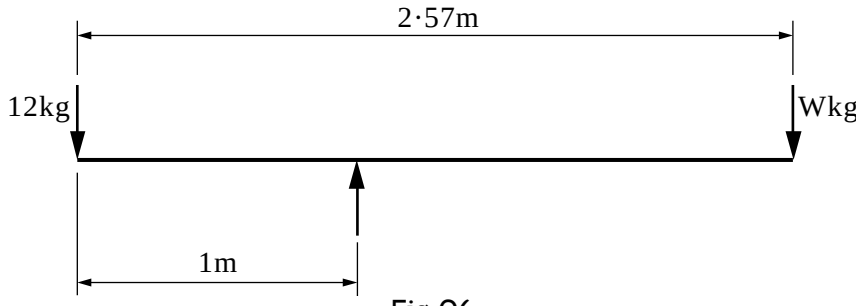

Fig Q6

7. An impulse turbine rotor is accelerated uniformly from 880 rpm to 1420 rpm in 16 seconds.

Determine EACH of the following:

(a) the angular acceleration in rad/s^2; (4)

(b) the final linear velocity, u, in m/s of a blade on the rotor rim if the effective rotor diameter is 0.4 m (4)

8. (a) Determine the thrust load in MN on a cofferdam (bulkhead) 25 m wide by 26 m deep when flooded with seawater of density 1025 kg/m^3 on one side only. (4)

(b) Determine the gauge pressure, in bar, at the lowest point on the bulkhead. (4)

9. A ship has a displacement of 35500 tonne.

Determine the distance a mass of 71 tonne, already on board, must be moved off the centreline to cause the ship to heel by exactly 1°. (8)

Given $m \times d = \Delta GM \tan\theta$ and that $KM = 6.2$ m, and $KG = 5.3$ m.

10. A power winch raises a mass of 580 kg through a distance of 14.6 m in 32 seconds.

The power input to the system in measured at 3.9 kW. Calculate the system efficiency. (8)

11. A stationary body of mass of 12.6 kg has a horizontal force of 44.5 N applied to it which causes acceleration in a horizontal plane, ignoring friction.

Calculate EACH of the following:

(a) the acceleration of the body; (3)

(b) the distance the body will travel from rest in 10 seconds. (5)

12. The equation for a straight line graph is given by the following expression:

$$y = mx + c$$

Where m is the slope of the graph and c is the intercept with the y axis.

(a) Plot points shown in Table Q12 using the given scales and draw the best fit line. (4)

(b) Determine the values of m and c from your graph. (3)

(c) State the law of the plotted straight line. (3)

Scales x axis 4 cm = 1 unit : y axis 4 cm = 2 unit

x	-1	1	3	5
y	-1	3	7	11

Table Q12

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) A large oil drum when filled contains 275 kg of heavy oil having a density of 927 kg/m^3.

   Calculate the mass of light oil of density 820 kg/m^3 that can be contained in an identical drum. (4)

   (b) The number 147 is divided in the ratio 2:3:5.

   Calculate the difference between the largest and smallest numbers. (4)

2. A right-angled triangle ABC has an hypotenuse AB of 17.4 cm which makes an angle of 1.27 radians to the base line BC.

   Calculate EACH of the following:

   (a) the length of BC in metre; (4)

   (b) the area of the triangle in m^2. (4)

3. An electric motor drive comes to rest from running speed in 1 minute 52 seconds and turns through 1627 revolutions whilst slowing down.

   Calculate EACH of the following:

   (a) the running speed in revolutions per minute; (4)

   (b) the retardation in rad/s^2. (4)

4. The following formula can be used to determine the minimum wall thickness in steel tubes:

   $$T = \frac{PD}{2f+P}$$

   Transpose the formula to make P the subject. (8)

5. (a) Plot the graph of the equation $Y = x^2 - 2.5$ between the limits of $x = -1$ and $x = +3$. (7)

(b) Indicate on the graph obtained in Q5(a) the value of y when $x = 2.5$. (3)

Note: Suggested Scale: *x axis 4 cm = 1 unit*
y axis 2 cm = 1 unit

6. A sphere has a surface area 1.6 times the curved surface area of a right cone.

Calculate the diameter of the sphere given that the cone has a base diameter of 10 cm and a perpendicular height of 12 cm. (10)

7. A double bottom tank is 5 m wide x 4.3 m long x 3.9 m deep and is flooded to 63% of its capacity with sea water of density 1025 kg/m^3.

Calculate EACH of the following:

(a) the pressure on the tank bottom due to flooding; (3)

(b) the load on the tank bottom if the tank is now filled so that sea water stands 1.85 m up the sounding pipe. (5)

8. A vessel has an underwater volume of 5512 m^3 in water of density 1.025 tonne/m^3. A cargo mass is now loaded on the centreline at a position 4.2 m above the keel causing G to rise by 0.13 m.

Calculate the final displacement of the vessel if KG is now 2.9 m. (8)

9. A vessel has a displacement of 2480 tonne and a KG of 4.3 m.

A mass of 5 tonne, already on board, when moved 4 m across the deck causes the vessel to heel by 0.95°.

Calculate the value of KM. (8)

Note: Given m x d = Δ GM tan Θ

10. A metal rod having a diameter of 2.2 cm is subjected to an axial load of 418 kg and extends by 0.06 mm. On removal of the load, the rod assumes its normal length of 90 cm.

Calculate EACH of the following:

(a) the stress in the loaded rod; (3)

(b) the strain in the loaded rod; (2)

(c) the value of the modulus of elasticity, E, for the material. (3)

11. A uniform simply supported beam AB has a mass of 280 kg and a length of 5 m. A uniformly distributed load (UDL) of 5 kN/m run is applied over a length of 2 m starting from the left hand end.

(a) Produce a simple sketch of the beam and forces in both magnitude and direction. (2)

(b) Calculate the value of the reactions R_A and R_B. (6)

12. A body starts from rest and reaches a speed of 36 km/h in 30 seconds with uniform acceleration. The body then continues at constant velocity for 40 seconds and then uniformly retards in 50 seconds coming to rest in a total time of 2 minutes.

(a) Construct the velocity time diagram for this motion. (3)

(b) Determine from the diagram in Q12(a) the total distance travelled. (5)

June 2015

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation: $\frac{3x}{5} - \left(\frac{x-9}{20}\right) = 3.75$ (8)

2. A rectangular lead block measures 0.25 m x 15 cm x 12 cm and is recast into a solid sphere with 2.5% material wastage.

   Determine the diameter of the sphere. (8)

3. (a) State the Theorem of Pythagoras. (2)

   (b) The diagonal of a rectangle exceeds the length by 3.25 cm, and the width is 11 cm.

   Calculate the length of the rectangle. (6)

4. The formula shown allows the stress in thick cylinders to be calculated.

   $$\frac{D}{d} = \left(\frac{f+P}{f-P}\right)^{1/2}$$

   Express f in terms of the other quantities. (8)

5. (a) Produce a simple diagrammatic sketch of a double purchase (double reduction) crab winch. (4)

   (b) Using the sketch in Q5(a) show that the movement ratio (V.R.) is equal to: (6)

   $$\text{MR} = \frac{L}{r} \times \frac{product\ of\ followers}{product\ of\ drivers}$$

   Note: L is the length of the effort handle
   r is the radius of the load drum

6. The velocity of a 36 kg mass is increased uniformly from 2.4 m/s to 3.2 m/s in 2.2 seconds.

The mass is then uniformly retarded at 0.3 m/s^2 until the mass just comes to rest.

Calculate EACH of the following:

(a) the accelerating force required; (3)

(b) the time taken for the mass to come to rest; (2)

(c) the distance travelled during the retardation period in Q6(b). (3)

7. (a) Define the radian. (2)

(b) Calculate the number of degrees in 2.62 radians. (2)

(c) Calculate the number of times a point on a flywheel passes an observer if the flywheel has an angular velocity of 2.73 rad/s and the count time is 45 seconds. (4)

8. An observation tank is 4 m long x 4 m wide x 5 m deep and contains liquid of density 1004 kg/m^3 to a depth of 4.7 m. A square glass viewing port, 0.22 m x 0.22 m, is fitted in the centre of one side.

Calculate EACH of the following:

(a) the hydrostatic pressure on the bottom edge of the glass viewing port; (4)

(b) the hydrostatic force on the glass. (4)

9. A vessel has a displacement of 4238 tonne and when a mass of 4 tonne, already on board, is moved 6.2 m across the deck, it causes the vessel to heel by 1.05°.

Calculate the distance from the keel to the metacentre M given that KG = 3.63 m and that $m \times d = \Delta GM \tan\theta$. (8)

10. A vessel has a displacement of 2463 tonne. An empty double bottom tank on the centreline is 1.8 m deep x 4.7 m wide and 5.76 m long and is now completely filled with water of density 1024 kg/m^3.

Calculate EACH of the following:

(a) the mass of water added to the double bottom tank; (3)

(b) the new position of the ship centre of gravity G when the tank is flooded, given that the original KG was 3.9 m. (5)

11. The coefficient of friction between a mass of 35 kg and a horizontal plane is 0.51.

Calculate EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the acceleration if a force of 285 N is now applied; (4)

(c) the time taken to travel 4.6 m from rest under the action of the accelerating force. (4)

12. A rectangular sheet of metal, x cm by y cm has squares of z cm cut from each corner. The sheet is then folded to form a shallow tray of depth z cm.

Write and simplify an expression to give the volume of the tray in terms of x, y and z. (8)

MARCH 2015

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. The illumination (I) of a lamp varies inversely as the square of the distance (d).

   If the illumination is 4 units at a distance of 3 m, determine the illumination at 1.9 m. (8)

2. A section of steel pipe is 1.8 m in length with an internal diameter of 153 mm and a wall thickness of 5 mm.

   Calculate EACH of the following:

   (a) the mass of the steel pipe; (5)

   (b) the mass of sea water that will completely fill the section of pipe when the system is working; (3)

   (c) the direct force in kN on a single pipe support when the system is operational. (2)

   Note: Relative density of steel 7.8, density of sea water is 1025 kg/m^3.

3. A triangle with a base BC and a right angle at C has an area of 2.21 m^2. The base is 1/5 of the perpendicular height.

   Calculate EACH of the following:

   (a) the length of the base BC; (4)

   (b) the value of the angle B. (4)

4. A bearing metal contains 17 parts tin, 1 part copper, 2 parts antimony and 1 part cadmium.

   Calculate EACH of the following:

   (a) the mass of tin in 3 kg of the bearing alloy; (5)

   (b) the percentage of cadmium in the bearing alloy. (3)

[OVER

5. Table Q5 shows the results from an experiment on a spiral spring.

Load kg	0	3	9	12
Extension mm	0	0.375	1.125	1.5

Table Q5

(a) Construct a load extension graph from the data in Table Q5. (4)

(b) Determine from the graph obtained in Q5(a), the possible law connecting load and extension. (4)

Suggested Scales: Load 1 kg = 2 cm
Ext 0.5 mm = 4 cm

6. A pumpset delivers 47 m^3 of sea water to a height of 17.8 m in 56 minutes.

Calculate EACH of the following:

(a) the output power of the pumpset in kW; (6)

(b) the input power to the motor if the efficiency of the pumpset is 73%. (2)

Note: Density of sea water 1023 kg/m^3

7. (a) Define the term Factor of Safety. (2)

(b) A wire rope having an effective diameter of 8 mm is subjected to a tensile test and fails at a load of 2312 kg.

Calculate EACH of the following:

(i) the breaking tensile stress in the rope; (3)

(ii) the safe working load if a factor of safety of 6 is given to ropes of this size. (3)

8. A box-shaped vessel is 28 m long x 8 m beam and floats at a draft of 4.8 m in water of density 1018 kg/m^3. When a mass of 5 tonne, already on board, is moved 2.8 m across the deck, the vessel heels by 0.94°.

Calculate the height of the transverse metacentre M above the keel given that KG = 2 m and m x d = Δ GM tan Θ. (8)

9. A vessel has an underwater volume of 2737 m^3 in water of density 1023 kg/m^3.

Calculate the mass to be loaded on the centreline, with Kg of 4.9 m, such that it causes a shift of 0.15 m in ship G. (8)

Note: Original KG = 3.85 m

10. A worm and wheel lifting device has a single start worm which is operated by a chain driven pulley 180 mm in diameter. The wheel has 40 teeth and is directly connected to the load drum which is 150 mm in diameter.

Calculate EACH of the following:

(a) the movement ratio (VR) of the machine; (3)

(b) the effort in the chain if the machine efficiency is 36% at a load of 250 kg. (5)

11. A drydock gate has a width to depth ratio of 4.5:1. When flooded to the top on one side only with water of density 1019 kg/m^3, the hydrostatic load on the gate is 15.8 MN.

Calculate EACH of the following:

(a) the depth of the drydock gate; (6)

(b) the width of the drydock gate. (2)

12. (a) State the principle of Archimedes. (2)

(b) A piece of timber is 2.56 m long x 174 mm wide x 82 mm deep and floats horizontally in water of density 1012 kg/m^3.

Calculate the height of wood above the water surface (freeboard) if the density of wood is 813 kg/m^3. (8)

DEC 2014

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation:

   $2\,(x-2)+4\,(x-3)=x-6$ (8)

2. A right-angled triangle is standing on its base which is 3.8 cm long. The perpendicular height is 2.24 times the base length.

   Calculate EACH of the following:

   (a) the other base angle; (3)

   (b) the difference between the perpendicular height and the hypotenuse. (5)

3. A solid right cone has a base diameter of 15 cm and a perpendicular height of 20 cm.

   Calculate EACH of the following:

   (a) the surface area of the cone in m^2; (5)

   (b) the volume of the cone in m^3. (3)

4. The following formula is used when electric cells are connected in series.

   $$I=\frac{nV}{R+nr}$$

   Make n the subject of the formula. (8)

5. A screw jack has a turning lever 260 mm in length which operates a single start screw thread of 5 mm pitch.

   Calculate the efficiency of the machine when an effort of 230 N just lifts a mass of 3.4 tonne. (8)

6. A body is travelling at 1.3 m/s when it is uniformly accelerated to 6.1 m/s in 12 seconds.

   Calculate EACH of the following:

   (a) the acceleration; (3)

   (b) the distance travelled during the acceleration period. (5)

7. An electric drive comes to rest from running speed in 106 seconds and turns through 1236 complete revolutions.

   Calculate EACH of the following:

   (a) the running speed in rev/min; (4)

   (b) the retardation in rad/s^2. (4)

8. A uniform horizontal beam AB is 5 m long and simply supported at its ends. A mass of 220 kg is applied at a point 2.8 m from the left hand end A, while a uniformly distributed load (UDL) of 12 kg/m run is applied over a distance of 1.2 m from end B.

   (a) Make a simple sketch of the loaded beam. (2)

   (b) Using the sketch in Q8(a), determine the value of the reactions R_A and R_B. (8)

9. When a mass of 5.3 tonne is moved a distance of 3.7 m across the deck of an upright vessel, it generates a 0.8° angle of heel.

   Determine the underwater volume of the vessel given that GM = 0.62 m. (8)

   Note: Density of sea water is 1025 kg/m^3 and $m \times d = \Delta GM \tan\theta$.

10. A box shaped vessel is 32 m long x 12 m beam and floats at a draft of 3 m in fresh water. The vessel now moves into sea water and then loads 1624 tonne.

Determine the change in draft of the vessel that occurs when in sea water. (8)

Note: Density of fresh water is 1000 kg/m^3
Density of sea water is 1025 kg/m^3

11. A simple wall crane consists of a jib, 2.75 m long being of hollow tubular section, O.D. 150 mm, I.D. 136 mm and making an angle of 35° to the wall. The tie is 1.93 m long and makes a right angle with the jib. The wall crane is supporting a mass of 1.2 tonne at the jibhead.

(a) Produce a simple dimensional sketch of the crane. (2)

(b) Calculate EACH of the following:

(i) the load in the jib; (2)

(ii) the load in the tie; (2)

(iii) the direct stress in the jib. (4)

12. A bulkhead is 5.3 m deep and is flooded to the top on one side only with water of density 1014 kg/m^3.

Calculate EACH of the following:

(a) the hydrostatic pressure at the base of the bulkhead; (3)

(b) the width of the bulkhead if the hydrostatic force under these conditions is 1.16 MN. (5)

OCT 2014

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. A metal alloy consists of copper and zinc in the ratio, by volume, of 9:13.

   Calculate the mass of zinc in 1.09 m^3 of the alloy, given that 1 cm^3 of zinc has a mass of 7.3 grammes. (8)

2. Table Q2 shows data obtained from a test on a watertight door.

Time sec	0	5	10	15	20
Gap cm	80	71	62	53	44

Table Q2

   (a) Plot a graph of time against distance. (6)

   (b) Estimate the time in seconds for the door to completely close from the graph obtained in Q2(a). (2)

   (c) Determine the closing speed of the door in m/s. (2)

   Suggested scales: x 1 cm = 2 seconds
   y 1 cm = 5 cm gap

3. A solid lead cube has sides of 9 cm length and is recast into a solid sphere.

   Calculate EACH of the following if 7.5% of the lead is lost in the casting process:

   (a) the diameter of the sphere; (5)

   (b) the surface area of the sphere. (3)

4. A pump discharges sea water through a 75 mm diameter pipe to a height of 15.3 m at a constant velocity of 2 m/s.

Density of sea water 1025 kg/m^3.

Determine EACH of the following:

(a) the pump power in kW; (6)

(b) the power input to the pump if the system is operating at 62% efficiency. (2)

5. A flywheel has a diameter of 570 mm and rotates at 157 rad/s.

Determine EACH of the following:

(a) the rotary velocity in revolutions per minute; (2)

(b) the velocity of a point on the rim of the flywheel in km/hour. (6)

6. A base of a triangle is 93 cm long. An adjacent side is 42% longer and makes an angle of 1.08 radian to the base.

Calculate the area of the triangle in m^2. (8)

7. In a test on a simple lifting machine the following results were obtained:

Load 10.193 kg Effort 10 N
Load 20.38 kg Effort 15 N
The movement ratio is 40.

Calculate EACH of the following:

(a) the law of the machine in the form $E = aL + c$; (6)

(b) the force ratio and efficiency when the load is 91.75 kg. (4)

8. Simplify EACH of the following:

(a) $\dfrac{x^2 \times x^3 \times x^5}{x^3 \times x^4}$ (4)

(b) $\dfrac{x}{3} + \dfrac{3x}{2} - \dfrac{5x}{4}$ (4)

9. A centre tank on a ship measures 8 m x 12 m x 20 m deep and contains heavy oil having a density of 955 kg/m^3.

Calculate EACH of the following:

(a) the hydrostatic load on the tank bottom plating; (4)

(b) the draught of the ship, in sea water of density 1025 kg/m^3, so that the net force on the outer bottom plating is zero. (4)

10. A mass of 5 tonne is moved 10.3 m across the deck of a ship. This action causes the ship to heel by 1.2°.

Calculate the displacement of the ship, given that m x d = Δ GM tan θ and KM = 4.9 m and KG = 4.25 m. (8)

11. (a) Indicate on a simple transverse sketch of a box barge the position of EACH of the following:

(i) the centre of gravity; (1)

(ii) centre of buoyancy; (1)

(iii) metacentre. (1)

(b) Calculate the value of GM for a box barge floating at a draught of 4.7 m, given that KG = 3.63 m and BM = 2.69 m. (5)

12. Fig Q12 shows a circle with two tangents at right angles. Given that the radius of the circle is x, prove that the shaded area is equal to $x^2\left(1 - \frac{\pi}{4}\right)$. (8)

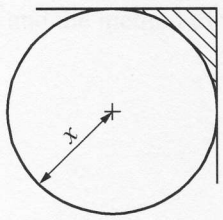

Fig Q12

July 2014

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Pump A can fill a tank in 12 hours.
   Pump B can fill the same tank in 8 hours.
   Pump C can fill the same tank in 9 hours.

   Calculate the time, in hours and minutes, to fill the tank if all pumps are working together. (8)

2. Given that $y = 14$ when $x = 2$, and that $y \propto x^2$, calculate the value of y when $x = 4.8$. (8)

3. A solid right cone having a base radius of 6 cm, and a perpendicular height of 10 cm, is lowered into a cylinder which contains sufficient water to completely submerge the cone without water spillage.

   Calculate the rise in water level if the cylinder has an internal diameter of 13 cm. (8)

4. The following formula can be used to determine the minimum wall thickness of tubes.

$$T = \frac{PD}{2f + P}$$

   Transpose the formula to make P the subject. (8)

5. One side of a triangle is 15.3 cm long. An adjacent side is 35% longer and the angle between these sides is 1.047 radian.

   Calculate the area of the triangle in cm^2. (8)

6. A simple wheel and axle lifting machine has an efficiency of 88%.

   Calculate the effort required to just lift a mass of 350 kg given that the diameters of the pulley wheel and axle are 480 mm and 80 mm respectively. (8)

[OVER

7. A shaft 1.86 m long has a diameter of 75 mm and when subjected to a tensile load of 330 kN extends by 0.93 mm.

Calculate EACH of the following:

(a) the direct stress in the shaft; (4)

(b) the direct strain in the shaft; (3)

(c) the Modulus of Elasticity, E, for the material. (3)

8. A bulkhead is 13.3 m high and is flooded with sea water on one side only.

Calculate EACH of the following:

(a) the depth of flooding if the hydrostatic pressure at the base of the bulkhead is 110.6 kN/m^2; (4)

(b) the hydrostatic force on a circular access door 513 mm diameter with its centre situated 11.8 m down from the top of the bulkhead. (6)

Note: Density of sea water 1025 kg/m^3.

9. A vessel has an underwater volume of 6829 m^3 when floating in water of density 1025 kg/m^3. A mass of 40 tonne is now loaded on the centreline and is then moved 5 m to port.

Calculate the angle of heel generated to the nearest degree, given that $m \times d = \Delta GM \tan \theta$ and KG = 6.5 m and KM = 7.3 m. (8)

10. A vessel has a displacement of 4900 tonne with a KG of 4.7 m. An empty double bottom tank, 6.3 m long x 5.7 m wide x 2.8 m deep is now filled with oil having a density of 970 kg/m^3.

Calculate EACH of the following:

(a) the mass of oil in the double bottom tank; (2)

(b) the new position of the centre of gravity KG if the double bottom tank is symmetrical about the centreline. (6)

11. A uniform beam AB simply supported at A and B is 4 m long and has a mass of 2 tonne. The beam has a vertical 16 kN load positioned at 1.5 m from end A, and a uniformly distributed load (U.D.L.) of 12 kN/m over a 1.5 m length from end B.

(a) Produce a simple sketch of the loads and reactions in both magnitude and direction. (2)

(b) Calculate the values of the reactions R_A and R_B. (6)

12. The velocity of a mass of 45 kg is increased from 1.9 m/s to 2.6 m/s in 3.5 seconds.

(a) Determine the accelerating force required. (3)

The mass is now retarded at 0.4 m/s^2 until the mass just comes to rest.

(b) Calculate the distance travelled in this retardation period. (5)

APRIL 14

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation:

$$\frac{3x}{5} - \left(\frac{x+12}{20}\right) = 3.25 \qquad (8)$$

2. A single start thread of a screw jack has a pitch of 8 mm and the machine is operated by a lever having an effective length of 380 mm.

   The screw jack lifts a mass of 485 kg with an applied effort of 53 N.

   (a) Define force ratio and calculate the value for this machine. (4)

   (b) Define movement ratio and calculate the value for this machine. (4)

3. A right angled triangle ABC has the hypotenuse AB = 17.55 cm long.

   Determine EACH of the following:

   (a) the length of side AC when the angle ABC = 22.62° ; (4)

   (b) the area of the triangle ABC in cm^2. (4)

4. The following formula relates to simple harmonic motion:

$$t = 2\pi \left(\frac{\text{displacement L}}{\text{acceleration g}}\right)^{\frac{1}{2}}$$

   (a) transpose the formula to make L the subject; (4)

   (b) calculate the displacement L when g = 9.81 m/s^2, t = 0.62 s and π = 3.142. (4)

5. Fig Q5 shows a cylindrical flask with a hemispherical top standing on its base and containing 56.7 litres of liquid.

Determine the liquid level when the flask is inverted. (10)

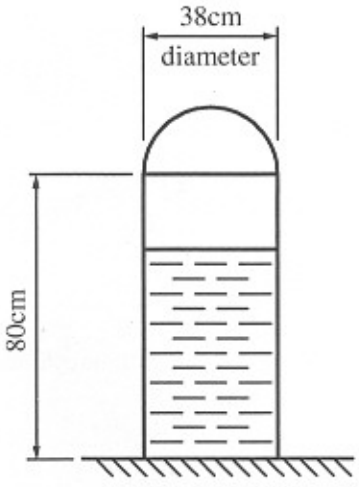

Fig Q5

6. A steel bar is 44 mm in diameter and 1.5 m long. The bar is placed in a centre lathe for turning down.

Determine the reduction in the mass of the bar when it has been machined down to a diameter of 35 mm. (10)

Note: relative density of steel = 7.7

7. A ship slows from 17 knots to 6 knots in 21 minutes.

(a) Sketch the velocity time diagram. (3)

(b) Determine the distance travelled in nautical miles. (5)

Suggested scale: 1 cm = 2.5 knots
4 cm = 30 minutes

8. A steel piston rod is 600 mm long. When subjected to a compressive stress of 12 N/mm^2 its length decreases by 0.034 mm.

Determine the Modulus of Elasticity E of the material in GN/m^2. (8)

9. When a mass of 6.75 tonne is moved a distance of 4 m across the deck of a vessel in the upright position it generates an angle of heel of 0.9°.

Determine the underwater volume of the vessel given the following: (8)

GM = 0.67 m, density of sea water 1025 kg/m^3 and $\tan \Theta = \frac{m \times d}{\Delta GM}$

10. Fig Q10 shows a bulkhead flooded with fresh water on one side only.

Determine the maximum head of water so that the thrust on the door does not exceed 46.63 kN. (8)

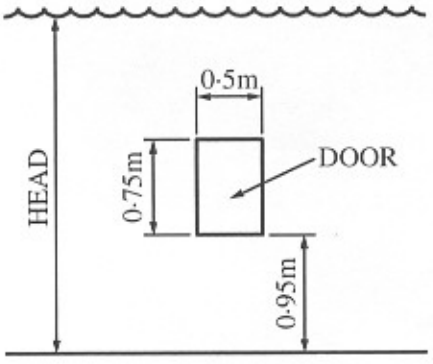

Fig Q10

11. (a) Indicate on a simple transverse sketch of a box shaped vessel the position of EACH of the following:

(i) the centre of gravity; (1)

(ii) the centre of buoyancy; (1)

(iii) metacentre. (1)

(b) Calculate the value of GM for a box barge floating at a draft of 4 m, given that KG = 3.23 m and BM = 2.8 m. (5)

12. A simple wall crane has a jib 2 m in length. The tie is 1.5 m long and makes an angle of 90° to the jib at the upper end (jib head).

A load of 2 tonne is suspended from this jib head.

Determine, by any suitable means, EACH of the following:

(a) the force in the jib; (4)

(b) the force in the tie. (4)

GENERAL ENGINEERING SCIENCE I DEC 13

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify EACH of the following expressions:

   (a) $\frac{3\,a\,b}{5\,c^2\,d^3} \times \frac{15\,c\,d^4}{9\,a^2\,b^2}$ (3)

   (b) $\frac{4\,L^2\,m}{5\,p} \div \frac{12\,L\,m^2}{20\,p^2}$ (5)

2. A triangle ABC has side AB = 5.3 cm, side AC 3.4 cm and angle BCA = a right angle.

   Calculate EACH of the following:

   (a) the length of the third side using Pythagoras Theorem; (4)

   (b) the area of the triangle in cm^2. (4)

3. A simple lifting machine has pulleys of radius R and r, and when lifting a load of L the effort E can be found from the following:

$$E = \frac{L(R-r)}{2R}$$

   (a) Transpose the formula to make R the subject. (6)

   (b) Calculate the value of R when E = 45, L = 480 and r = 48. (4)

   Note: Ignore any units.

4. A right square pyramid has sides of 115 mm and a perpendicular height of 150 mm.

   Calculate EACH of the following:

   (a) the volume of the pyramid in m^3; (3)

   (b) the area of any one of the triangular faces in mm^2. (5)

[OVER

5. (a) Sketch a complete load/extension diagram for a typical low carbon steel specimen. (2)

(b) Indicate EACH of the following on your diagram:

(i) limit of proportionality; (2)

(ii) yield point; (2)

(iii) maximum load. (2)

6. Fig Q6 shows a steel bar, of uniform cross section, 2.57 metres long having a mass of 11.05 kg.

Determine the value of W kg to give a balanced equilibrium condition about the fulcrum. (10)

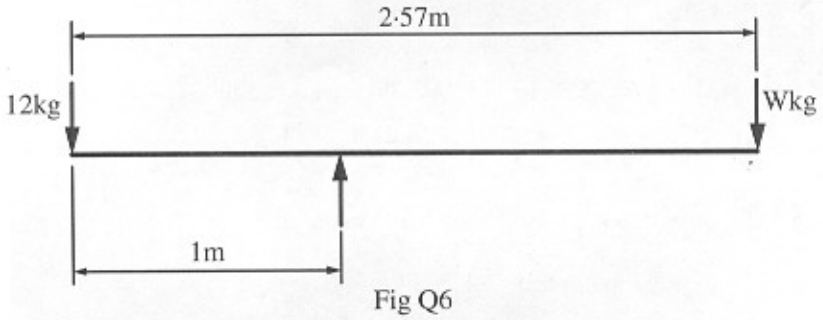

Fig Q6

7. A flywheel is accelerated from 880 rpm to 1420 rpm in 16 seconds.

Determine EACH of the following:

(a) the angular acceleration in rad/s^2; (4)

(b) the number of revolutions turned during the acceleration period. (4)

8. (a) Determine the thrust load in MN on a bulkhead 25 m wide by 26 m deep when flooded with seawater of density 1025 kg/m^3 on one side only. (4)

(b) Determine the gauge pressure, in bar, at the lowest point on the bulkhead. (4)

9. A ship has a displacement of 5500 tonne.

Determine the distance a mass of Δ /1000 tonne, already on board, must be moved off the centreline to cause the ship to heel by exactly 1°. (8)

Given $m \times d = \Delta GM \tan\theta$ *and that* $KM = 6.1$ *m, and* $KG = 5.3$ *m.*

10. A mass of 460 kg is raised through a distance of 11.3 m in 26 seconds by a power winch.

Calculate the power input to the system in kW if the system efficiency is 51%. (8)

11. A body has a mass of 17.8 kg and requires a force of 44.5 N to cause accelerated motion in a horizontal plane, ignoring friction.

Calculate EACH of the following:

(a) the acceleration of the body; (3)

(b) the distance the body will travel from rest in 15 seconds. (5)

12. The law of a straight line is given by the following expression:

$$Y = aX + b$$

(a) Plot and join the pairs of points shown in Table Q12 using the given scales. (4)

(b) Determine the values of *a* and *b* from your graph. (2)

(c) State the law of the plotted straight line. (2)

Scales X axis 4 cm = 1 unit

Y axis 4 cm = 1 unit

X	-1.5	0	2	3
Y	0	2	4.65	6

Table Q12

July 13

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. A bearing metal contains 21 parts tin, 2 parts copper and 3 parts antimony.

   Calculate the mass of EACH metal in 48 kg of bearing metal. (8)

2. Given that y varies directly as the square of x and $y = 12.8$ when $x = 4.7$, calculate the value of y when $x = 3.17$. (8)

3. An open top cylindrical tank, 1 m inside diameter and 2 m deep, is full of oil which is allowed to drain out leaving an oil film 0.87 mm thick on the internal surface of the drum.

   Calculate the mass of oil remaining in the tank if the density of the oil is 987 kg/m^3. (10)

4. A sphere has a curved surface area of 7.068 m^2.

   Determine the volume of the sphere in m^3. (8)

5. A screw jack has a single start thread of 4 mm pitch. An effort of 45 N is applied to the end of the operating handle which has an effective length of 57.3 cm.

   Determine EACH of the following when the jack is lifting a load of 485 kg:

   (a) the force ratio; (3)

   (b) the movement ratio; (3)

   (c) the efficiency. (2)

6. Fig Q6 shows a section of a vertical support column having a wall thickness of 9 mm. A vertical load of 3.6 tonne is applied at the top of the column.

Calculate EACH of the following:

(a) the stress in the column in N/mm^2; (6)

(b) the strain in the column given that the modulus of elasticity E for the material is 201 GN/m^2. (4)

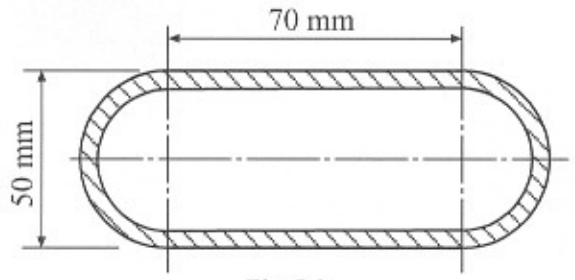

Fig Q6

7. A body has a mass of 17 kg. A force of 42.5 N is applied to cause accelerated motion on a smooth horizontal plane.

Determine EACH of the following:

(a) the acceleration of the body; (3)

(b) the distance the body will have travelled in 12 seconds from rest. (5)

8. A plank of wood is 2.1 m long x 20.3 cm wide x 102 mm deep and floats in water of density 1020 kg/m^3.

Calculate the height of wood above the water surface given that the wood has a density of 780 kg/m^3 and floats horizontally. (8)

9. A bulkhead is 27 m wide and 18 m deep and is flooded to the top on one side only with water of density 1023 kg/m^3.

Calculate EACH of the following:

(a) the pressure, in bar, at a point 16 m below the water surface; (3)

(b) the length of a rectangular plate, 1 m high, positioned with its lower edge 15.5 m below the water surface if the hydrostatic force on the plate is not to exceed 0.3 MN. (5)

10. Determine the distance a mass of 16 tonne, already on board, must be moved from port to starboard to cause a ship of 4720 tonne displacement to heel 1.75°. (8)

Given KM = 5.93 m, KG = 4.96 m and that $m \times d = \Delta GM tan\theta$

11. A ship has an underwater volume of 4390 m^3 when floating in water of density 1025 kg/m^3. 2000 tonne of cargo is now loaded with even distribution about the centreline, this cargo having an effective centre of gravity 3.3 m above the keel.

Calculate EACH of the following:

(a) the final displacement of the ship; (3)

(b) the shift in the centre of gravity of the ship that this loading will cause, given that the original KG = 4.1 m. (5)

12. Fig Q12 shows a mass of 150 kg suspended from points A and B by chains.

Determine the tensile force in chains AC and BC. (8)

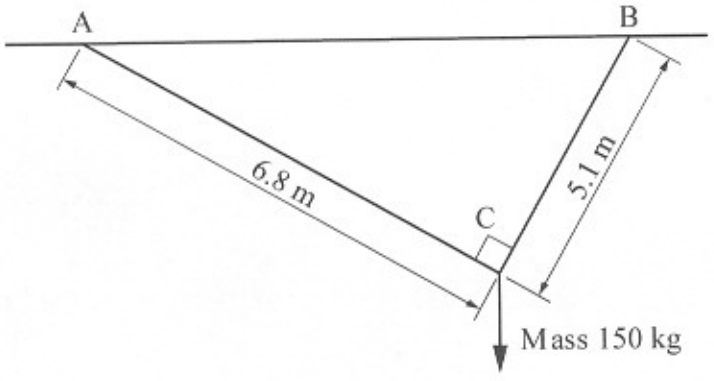

Fig Q12

GENERAL ENGINEERING SCIENCE I MARCH 13

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following expression:

$$2(x + 4) - 3(x - 5) = x + 9 \quad (8)$$

2. A cube of lead having sides of 15 cm is melted down and is recast, without loss, into three equal spheres.

   Calculate the diameter of the spheres. (8)

3. A hollow shaft has an inside diameter of 11 cm and has the same mass as a solid shaft of 16 cm diameter, both shafts being of the same length and material.

   Determine the outside diameter of the hollow shaft in mm. (8)

4. The following formula relates to electric cells in series.

$$I = \frac{nV}{R + nr}$$

   Transpose the formula to make n the subject. (8)

5. A vessel steams for 4 hours at y knots and then at $\frac{5}{8}$ y knots for a further 16 hours.

   Calculate the initial speed y knots of the vessel if the total distance travelled is 196 miles. (8)

6. A rope pulley system consists of 3 sheaves in one block and 2 sheaves in the other. The rope pulley system is applied horizontally to move a mass of 515 kg along a horizontal plane, with the 3 sheave block nearest the load. The coefficient of friction between the plane and the mass is 0.47, and the efficiency of the pulley system is 0.52.

Determine EACH of the following:

(a) the movement ratio of the pulley system; (4)

(b) the force ratio of the pulley system; (2)

(c) the effort required to just move the load. (4)

7. (a) Determine the height of a mast if the stay wires make an angle of 48° to the horizontal ground and are positioned exactly 12 m from the base of the mast. (3)

(b) Determine how far down the mast in Q7(a) the stays must be attached if they are shortened by 3.7 m and remain at the same ground anchor point. (5)

8. (a) Define EACH of the following terms as applied to a box shaped vessel:

(i) centre of gravity; (2)

(ii) centre of buoyancy; (2)

(iii) metacentre. (2)

(b) A barge has a displacement of 2736 tonne. When a mass of 3 tonne, already on board, is moved 6 m across the deck the barge heels by an angle of 1.4°.

Determine the value of GM given that $m \times d = \Delta GM tan\theta$ (4)

9. A tank with a base area of 3.5 m^2 is 3.7 m deep and is two thirds full of water of density 1019 kg/m^3.

Determine EACH of the following:

(a) the pressure on the bottom of the tank; (3)

(b) the thrust load on the bottom of the tank when the tank is completely filled and the water rises 1.8 m up the sounding pipe. (5)

10. A vessel has an underwater volume of 5383 m^3 in water of density 1018 kg/m^3 with KG = 3.9 m. An empty centreline double bottom tank 14 m wide x 8 m long x 2.3 m deep is now filled with fresh water.

Determine the new position of the vessel's centre of gravity G above the keel. (8)

11. Fig Q11 shows a uniform simply supported beam.

Determine EACH of the following:

(a) the value of W so that the reaction R_B does not exceed 250 kN; (5)

(b) the value of the reaction R_A. (3)

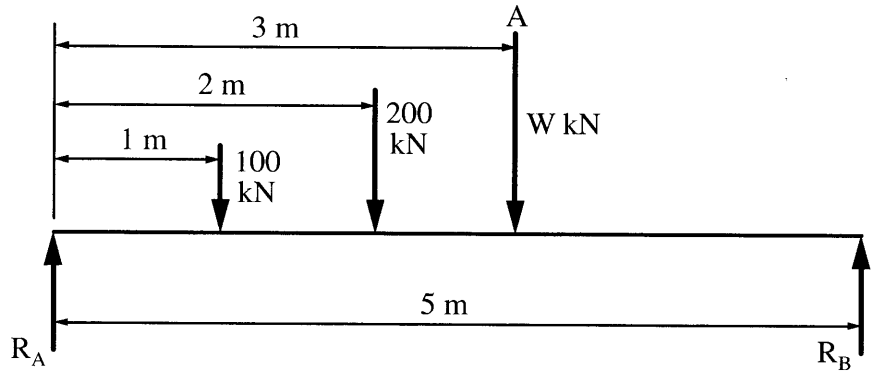

Fig Q11

12. A hole 18 mm in diameter is to be punched through a piece of plate 32 mm thick.

Calculate the load in the punch, given that the shear strength in the plate material is 400 N/mm^2. (8)

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

EXAMINATIONS ADMINISTERED BY THE
SCOTTISH QUALIFICATIONS AUTHORITY
ON BEHALF OF THE
MARITIME AND COASTGUARD AGENCY

STCW 95 SECOND ENGINEER REG. III/3 (< 3000 kW)
CLASS 1 FISHING ENGINEER
STCW 95 CHIEF ENGINEER REG. III/2 – "YACHT 2"

043-11 – GENERAL ENGINEERING SCIENCE I

THURSDAY, 13 DECEMBER 2012

1400 - 1600 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used.

2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook
Graph paper

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) Multiply $2x + 3$ by $4x - 2$ (3)

   (b) Simplify $\frac{4a}{3b} + \frac{5b}{2a}$ (5)

2. A solid lead sphere has a volume of 1.7 m^3. The sphere is recast into two solid shapes, a cube and a right circular cone.

   Determine EACH of the following:

   (a) the side dimensions of the cube if the volume of the cube is to be one quarter of the total volume; (4)

   (b) the base diameter of the cone if the perpendicular height is 0.93 m. (6)

3. A screw jack has a single start thread of 4 mm pitch. An effort of 65 N is applied to the end of the operating handle which travels 1.94 m for each complete turn.

   Determine EACH of the following when the jack is lifting a load of 596 kg:

   (a) the force ratio; (3)

   (b) the movement ratio; (3)

   (c) the efficiency. (2)

4. A ladder is 8 m long and reaches a point on a vertical wall 6.93 m from the ground.

   Calculate EACH of the following:

   (a) the distance from the wall to the foot of the ladder; (5)

   (b) the angle the ladder makes with the wall in radians. (3)

5. The following formula can be used to determine the displacement of a body when travelling in a straight line with constant velocity:

$$S = \frac{(u+v)}{2} \text{ x } t$$

(a) transpose the formula to make v the subject; (5)

(b) calculate the value of v, given that S = 276 m, u = 0 m/s and t = 8.625 seconds. (3)

6. Fig Q6 shows the section of a piece of metal 1.47 m long.

Determine the mass of metal to the nearest kilogram, given that 1 cm^3 has a mass of 8.7 grammes. (8)

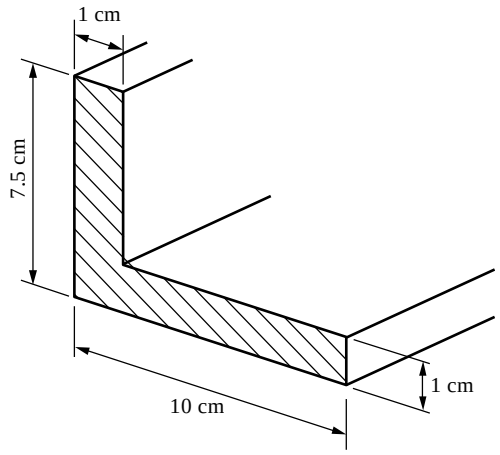

Fig Q6

7. (a) Plot the graph of the equation $y = x^2 + 1.75$ between the limits of $x = -1$ and $x = +2$. (6)

(b) Determine from the graph in Q7(a) the value of y when x = 1.5. (2)

8. Fig Q8 shows a vertical bulkhead fitted with an access door. These are flooded with seawater of density 1025 kg/m^3 on one side only.

Determine EACH of the following:

(a) the depth of flooding if the pressure at the bottom of the bulkhead is 90.5 kN/m^2; (4)

(b) the hydrostatic load on the access door. (6)

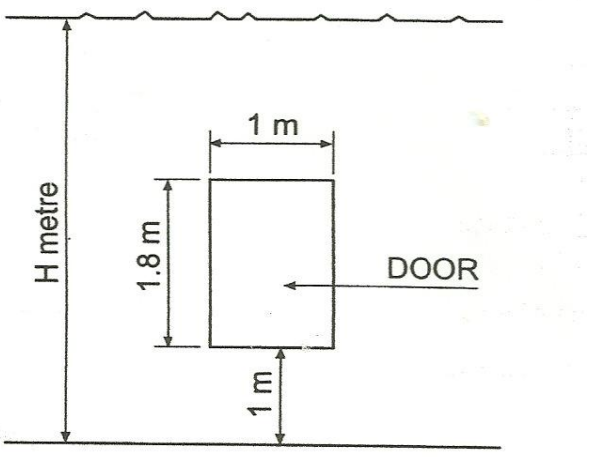

Fig Q8

9. A ship slows from 15 knots to 6 knots in 25 minutes.

(a) Sketch the velocity – time diagram. (4)

(b) Determine the distance travelled in nautical miles. (4)

10. A vessel has an underwater volume of 7760 m^3 when floating in water of density 1025 kg/m^3. A mass of 46 tonne is now loaded on the centreline and then moved 5 m to starboard.

Calculate the angle of heel adopted by the vessel. (8)

Given KM = 7.3 m, KG = 6.5 m and that $m \times d = \Delta GM tan\theta$

11. A ship of displacement 4930 tonne has its centre of gravity G positioned 5.0 m above the keel. Cargo mass of 862 tonne is now loaded on the centreline at 2.2 m above the keel.

Calculate the new position of the ship's centre of gravity G above the keel. (8)

12. A wire rope is subjected to a tensile test and fails at a load of 2325 kg. The effective cross sectional area is 53 mm^2.

(a) Determine EACH of the following:

(i) the breaking tensile stress; (3)

(ii) the safe working load if a Safety Coefficient (factor of Safety) is given for ropes of this size. (3)

(2)

(b) Define the term *linear strain*.

CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY – MARINE ENGINEER OFFICER

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EXAMINATIONS ADMINISTERED BY THE
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STCW 95 SECOND ENGINEER REG. III/3 (< 3000 kW)
CLASS 1 FISHING ENGINEER
STCW 95 CHIEF ENGINEER REG. III/2 – "YACHT 2"

043-11 – GENERAL ENGINEERING SCIENCE I

THURSDAY, 19 JULY 2012

1400 - 1600 hrs

Examination paper inserts:

Notes for the guidance of candidates:

1. Non-programmable calculators may be used. 2. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Materials to be supplied by examination centres:

Candidate's examination workbook Graph paper

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Given that y varies directly as the cube of x, and $y = 12.3$ when $x = 2.8$, calculate the value of y when $x = 1.1$. (8)

2. A section of steel pipe is 2 m in length, with a bore (diameter) of 150 mm, and a wall thickness of 6 mm.

   Calculate EACH of the following:

   (a) the mass of the steel pipe; (5)

   (b) the mass of sea water that will completely fill the section of pipe when the system is working; (3)

   (c) the direct force in kN that would be exerted by the section of pipe when the system was operational. (2)

   Note: Density of sea water = 1025 kg/m^3
   Relative density of steel = 7.8

3. The base of a triangle is 94 cm long. An adjacent side is 33% longer and makes an angle of 0.787 radians to the base.

   Calculate the area of the triangle in m^2. (8)

4. A simple wall crane consists of a jib, 2 m long, and a tie that is 1.5 m long with a right angle between them. The jib carries a load of 1.6 tonne at the jib head.

   Determine EACH of the following:

   (a) the force in the jib; (4)

   (b) the force in the tie. (4)

5. A flywheel has a diameter of 1.98 m and rotates at 2.13 rad/s.

Calculate EACH of the following:

(a) the linear velocity of a point on the rim; (2)

(b) the rotational speed of the flywheel in rev/min; (4)

(c) the number of radians turned when the flywheel rotates through 225°. (2)

6. (a) Plot the graph of the equation $y = x^2 + 2$ between the limits of $x = -1$ and $x = 3$ indicating in the answer how the plotting points are obtained. (8)

(b) Indicate on the graph plotted in Q6(a) the value of y when $x = 1.75$. (2)

7. A screwjack has a single start thread of 5 mm pitch and can lift a mass of 2.1 tonne with an effort of 85 N. The effort is applied at the end of a lever having an effective length of 0.6 m.

Determine EACH of the following:

(a) the movement ratio; (4)

(b) the force ratio; (2)

(c) the efficiency when lifting the 2.1 tonne mass. (2)

8. A pump discharges sea water through a 100 mm diameter pipe to a height of 14.4 m at a constant velocity of 2 m/s.

Calculate EACH of the following:

(a) the power of the pump; (6)

(b) the input power to the pump if the system is operating at 62% efficiency. (2)

Note: Density of seawater 1025 kg/m^3.

9. A rectangular dock gate is 24 m wide and is subjected to a hydrostatic thrust of 37 MN when flooded to the top, on one side only, with water of density 1021 kg/m^3.

Determine the height of the dock gate. (8)

10. A ship has an underwater volume of 3512 m^3 in sea water.

Calculate the mass to be loaded on the centre line at a Kg of 4.8 m to cause a change of 0.23 m in the position of the ship's centre of gravity. (8)

Note: KG = 3.75 m and density of sea water = 1025 kg/m^3

11. A ship with a GM of 0.31 m heels to an angle of 1.6° when a mass of 17 tonne, already on board, is moved 6.8 m across the deck.

Calculate the displacement of the ship in tonne. (8)

---

12. Fig Q12 shows a circle with two tangents at right angles. Given that the radius of the circle is x, prove that the shaded area is equal to $x^2\left(1 - \frac{\pi}{4}\right)$ (8)

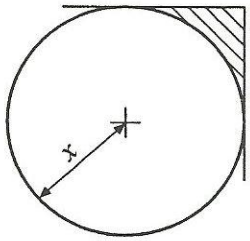

Fig Q12

GENERAL ENGINEERING SCIENCE I MARCH 2012

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify EACH of the following:

(a) $\dfrac{X^3 \times X^4 \times X^6}{X^3 \times X^5}$ (4)

(b) $\dfrac{X}{2} + \dfrac{2X}{3} - \dfrac{4X}{5}$ (4)

2. A lead sphere has a volume of 0.92 m^3. The sphere is recast into two solid shapes, a cube and a right cone.

Determine EACH of the following:

(a) the side dimensions of the cube if the volume of the cube is to be 20% of the total volume of the sphere; (3)

(b) the base diameter of the cone if the perpendicular height is to be 0.98 m. (5)

3. The following formula allows pipe diameters to be determined knowing the volumetric flow rate.

$$D = \sqrt{\frac{Q}{2.038V}}$$

Where D = diameter m, Q = volumetric flow rate m^3/s, V = velocity m/s

(a) Transpose the formula to make V the subject. (4)

(b) Calculate the value of D when Q = 1.37 m^3/s and V = 3.5 m/s. (4)

4. A turbine is uniformly accelerated from 1000 rev/min to 1420 rev/min in 12 seconds.

Determine EACH of the following:

(a) the angular acceleration in rad/s^2; (4)

(b) the number of revolutions turned during the acceleration period. (4)

[OVER

5. A simple wheel and axle lifting machine has the following dimensions:

Wheel diameter = 300 mm Axle diameter = 75 mm

(a) Produce a simple dimensioned sketch of the lifting machine. (2)

(b) Determine EACH of the following:

(i) the movement ratio of the machine; (2)

(ii) the efficiency of the machine if it requires an effort of 265 N to just lift a mass of 58 kg. (4)

6. The velocity of a 40 kg mass is uniformly increased from 1.6 m/s to 2.2 m/s in 4 seconds.

(a) Calculate the accelerating force required. (4)

(b) The mass is now uniformly retarded at 0.3 m/s^2 from 2.2 m/s until the mass just comes to rest.

Calculate for the retardation period EACH of the following:

(i) the time taken to come to rest; (2)

(ii) the distance travelled. (2)

7. A steel bar 1.48 m long has a diameter of 50.8 mm and when subjected to an axial pull of 195 kN extends by 1.02 mm.

Determine EACH of the following:

(a) the direct stress in the bar; (3)

(b) the direct strain in the bar; (2)

(c) the modulus of elasticity (E) for the steel. (3)

8. A uniform beam AB, 4 m long, is simply supported at points A and B. The beam has a mass of 2.5 tonne and carries a UDL of 5 kN/m over a length of 2 m starting from point C, 0.75 m from point A.

(a) Produce a simple sketch of the loaded beam. (2)

(b) Determine EACH of the following:

(i) normal reaction at point A; (4)

(ii) normal reaction at point B. (2)

9. A rectangular dock gate is 23 m wide and is flooded to its top edge, on one side only, with water of density 1023 kg/m^3.

Calculate EACH of the following:

(a) the height of the dock gate, given that the thrust under the flooded condition is 32 MN; (7)

(b) the gauge pressure at a point 7.5 m from the base of the gate. (3)

10. Determine the distance a mass of 28 tonne, already on board, must be moved across the deck of a vessel of 4160 tonne displacement to correct a heel of 1.6°. (8)

Note: $KM = 5.93\ m,\ KG = 4.96\ m,\ and\ m \times d = \Delta\ GM \tan\theta$

11. A ship has a displacement of 5463 m^3 in sea water of density 1025 kg/m^3.

Two double bottom tanks measuring 16.3 m long x 6.5 m wide x 2.2 m deep are positioned equally either side of the centre line. These tanks are now completely filled with fuel oil of density 968 kg/m^3.

Calculate the change in position of G, in both magnitude and direction, given that the initial KG=3.8 m. (8)

12. A plank of wood is 2.88 m long x 15.8 cm wide x 75 mm deep and floats in water of density 1010 kg/m^3.

Calculate the height of wood above the water surface (freeboard) given that the wood has a density of 730 kg/m^3 and floats horizontally. (10)

DEC 2011

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify EACH of the following:

   (a) – – – (3)

   (b) – - 3– x – + 3— (5)

2. Determine the perpendicular height of a solid right cone having a total surface area of 245 cm^2 given that the radius of the base is 5 cm. (8)

3. A solid metal sphere having a diameter of 11 cm is totally submerged in a tank of water.

   Calculate by how much the water level will rise given that the tank is 12 cm wide by 13 cm long. (8)

4. The three sides of a triangular area are in the ratio of 5:8:13.

   Determine the lengths of the sides given that the perimeter of the area is 470 m. (8)

5. A hole 26 mm diameter is to be punched through a piece of steel plate 18 mm thick.

   Determine the force to be exerted by the punch given that the shear strength of the steel is 380 MN/m^2. (8)

6. Table Q6 shows a set of results from a simple lifting machine.

Load kg	5	10	15	20
Effort N	20	32	44	56

TableQ6

(a) Construct a graph from the tabulated results. (4)

(b) Determine the law of the machine from Q6(a). (4)

(c) Determine the probable effort required when the load is 18.5 kg. (2)

Suggested scales: *Load axis 4 cm = 5 kg*
Effort axis 4 cm = 10 N

7. A uniform beam of mass 2.5 tonne and length 5 m is simply supported at each end at points A and B.

A point load of 250 kg is applied at point C, positioned 2.1 m from A, whilst a uniformly distributed load (UDL) of 15 kg/m is positioned for a length of 2.3 m from B.

(a) Produce a simple sketch of the loaded beam indicating forces and reactions. (2)

(b) Calculate EACH of the following:

(i) the reaction force at A; (4)

(ii) the reaction force at B. (2)

8. The coefficient of friction between a body of mass 34 kg and a horizontal plane is 0.43.

Determine EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the acceleration if a total force of 300 N is now applied to the body; (4)

(c) the distance moved in 7 seconds from rest under the action of the accelerating force. (4)

9. A centre tank measures 8 m wide x 16 m long x 18 m deep and is full of oil having a density of 770 kg/m^3.

Calculate EACH of the following:

(a) the hydrostatic thrust on the tank bottom plating; (3)

(b) the draught of the ship in sea water of density 1025 kg/m^3 so that the external sea water pressure on the outer bottom plating is just equal to the internal oil pressure. (5)

10. A mass of 68 tonne is loaded on the centre line of a vessel having an original displacement of 9600 tonne in seawater of density 1025 kg/m^3.

Determine how far the mass must be moved transversely to correct an angle of heel of 1.2°. (8)

Note: KM=5.3 m, KG= 4.2 m, and ——

11. A vessel has a displacement of 950 tonne, KG of 4.9 m, and is floating on an even keel in sea water of density 1025 kg/m^3.

A double bottom tank 3.82 m wide x 4 m long x 1.6 m deep is now completely filled with sea water.

Calculate the new position of the vessel's centre of gravity G. (8)

12. A simple wall crane consists of a solid jib 4 m long and a tie 2.8 m long, which makes a right angle with the jib.

Determine the direct stress in the jib when the crane is lifting 1.5 tonne given that the jib diameter is 65 mm. (8)

OCT 2011

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. If y varies directly as the cube of x, and $y = 12.7$ when $x = 1.3$, calculate the value of y when $x = 0.5$. (8)

2. A piece of steel piling is driven into a river bed such that one quarter of its total length is in the river bed, ⅓ of its total length is in the water, and 2.5 m remains above the water.

   Calculate the length of the steel pile. (8)

3. A solid body is formed from a cone and a hemisphere, the flat faces of which exactly coincide. The maximum circumference of the body is 44 cm, while the total height is 17 cm.

   Calculate EACH of the following:

   (a) the maximum radius of the solid body; (1)

   (b) the volume of the cone; (4)

   (c) the volume of the hemisphere; (4)

   (d) the total volume of the solid body in m^3. (1)

4. A Weston Differential Pulley Block has a large pulley of 250 mm diameter and a small pulley of 225 mm diameter. An effort of 250 N can just lift a mass of 260 kg.

   (a) Make a simple sketch of this machine. (2)

   (b) Calculate EACH of the following:

   (i) the movement ratio of the machine, showing ALL workings; (4)

   (ii) the efficiency of the machine. (2)

5. The following formula relates to coupling bolts and shaft diameters:

$$D = \left[\frac{d^3}{3.5 \times n \times r} \right]^{\frac{1}{2}}$$

(a) transpose the formula to make n the subject; (4)

(b) calculate the number of bolts (n) when D = 100, d = 600 and r = 450. (4)

6. A mass of 240 kg is suspended by chains, as shown, in Fig Q6.

Determine the tensile force in chains AC and BC. (8)

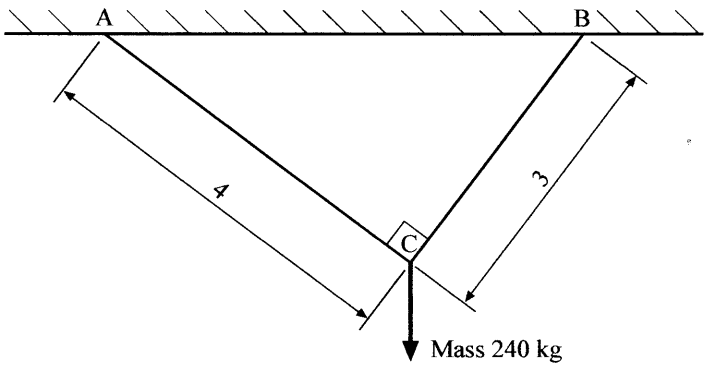

Fig Q6

7. (a) Define the radian and express its value in degrees. (3)

(b) Calculate the number of radians in 168°. (2)

(c) A flywheel is rotating at 1400 revolutions/minute.

Express this angular velocity in radians/seconds. (3)

8. A uniform horizontal beam AB is 5 m long and is simply supported at its ends. A mass of 300 kg is applied at a point C, 3 m from the right hand end B.
A uniformly distributed load (U.D.L.) of 18 kg/m is applied over a distance of 1.5 m from end A.

(a) Make a simple sketch of the loaded beam. (2)

(b) Determine the values of the vertical reactions R_A and R_B. (6)

9. A solid steel bar has a diameter of 50 mm and a length of 2 m. The bar is now compressed and shortened by 0.01 mm.

Determine the load in the bar if the modulus of elasticity E for the material is 200 GN/m^2. (8)

10. A box barge is 27 m long x 16 m beam and is floating in water of density 1017 kg/m^3.

Calculate EACH of the following:

(a) the draught of the barge if the displacement is 1318 tonne; (4)

(b) the pressure on the outer bottom plating when the barge is floating at the draught determined in Q10 (a). (4)

11. (a) Define EACH of the following terms as applied to a box shaped vessel:

(i) centre of buoyancy; (2)

(ii) metacentre. (2)

(b) A vessel has a displacement of 1328 tonne. When a mass of 4 tonne, already onboard, is moved 3 m across the deck, it causes the vessel to heel by 1.8^0.

Determine the value of GM given $\tan\theta = \dfrac{m \times d}{\Delta\, GM}$ (4)

12. A box shaped vessel has a beam of 8 m and floats at a draught of 4.5 m.

Determine the height of the transverse metacentre M above the keel. (10)

Given $BM = \dfrac{I}{V}$ and $I = \dfrac{L\, b^3}{12}$ where L = length (m)

b = beam (m)

V = underwater volume (m^3)

MARCH 2011

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) Multiply $3x + 2y - z$ by $x - 3y$ (3)

   (b) Determine the value of x in the following equation: (5)

$$\frac{2x}{3} + \frac{x}{5} - \frac{2}{3} = \frac{2x}{5} + \frac{7}{8}$$

2. Table Q2 shows data obtained from a test on a watertight door.

Time sec	0	5	10	15	20
Gap cm	80	71	62	53	44

Table Q2

   (a) Plot a graph of time against distance. (6)

   (b) Estimate the time in seconds for the door to completely close from the graph obtained in Q2 (a). (2)

   (c) Determine the closing speed of the door in m/s. (2)

   Suggested scales: *x 1 cm = 2 seconds*
   y 1 cm = 5 cm gap

3. A solid lead sphere 10 cm in diameter is to be melted down and be recast into a right cone with a base diameter of 6 cm.

   Calculate EACH of the following:

   (a) the perpendicular height of the cone assuming no metal loss in the process; (7)

   (b) the mass of lead if the relative density is given as 11.3 times that of an equal volume of fresh water. (3)

4. Rearrange the following motion formula so as to express a in terms of the other quantities. (8)

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

5. A simple wheel and axle lifting machine has a wheel of 27 cm diameter and an axle of 45 mm diameter.

Determine EACH of the following:

(a) the motion ratio of the machine; (3)

(b) the efficiency of the machine if it requires an effort of 160 N to just lift a mass of 58 kg. (5)

6. A simple wall crane consists of a jib, 6.3 m long, attached at its lower end to a vertical wall.

A tie, 3.3 m long, is attached to the head of the jib, and is fixed at right angles to the vertical wall. The crane is carrying a load of 1 tonne at the jib head.

Calculate EACH of the following:

(a) the compressive force in the jib; (4)

(b) the force in the tie indicating its nature. (4)

7. A body has a mass of 8 kg and is moving at a constant velocity of 24 m/s when it is uniformly retarded to 10 m/s in 3.5 seconds.

Calculate EACH of the following:

(a) the retardation in m/s^2; (2)

(b) the value of the retarding force; (3)

(c) the distance travelled in the 3.5 second retardation period. (3)

8. A pump rod is 350 mm long and has a modulus of elasticity E = 205 GN/m^2.

Determine its new length when subjected to a compressive stress of 15 N/mm^2. (8)

9. (a) State the Principle of Archimedes. (2)

(b) A plank of wood is 1.37 m long x 25 cm wide x 90 mm deep and floats horizontally in water of density 1019 kg/m^3.

Calculate the height of wood above the water surface if the wood has a density of 740 kg/m^3 . (6)

10. A rectangular drydock gate is 19 m wide and is designed to withstand a maximum hydrostatic thrust of 20.3 MN when flooded on one side only.

Determine the greatest height of river water on one side only so that the maximum hydrostatic thrust is not exceeded. (8)

Note: Density of river water 1010 kg/m^3.

11. A vessel has an underwater volume of 3850 m^3 and floats in sea water of density 1025 kg/m^3. A mass of 4 tonne is then loaded on the centreline and is moved 5.5 m across the deck causing the vessel to heel by 1.8°.

Calculate EACH of the following:

(a) the final displacement, Δ ; (4)

(b) the value of GM given GM = $\dfrac{m \times d}{\Delta \tan \theta}$ (4)

12. A vessel has a displacement of 1380 tonne with a KG of 3.7 m. A double bottom tank, on the centreline, is 7 m wide x 7 m long x 1.2 m deep and is now completely flooded with sea water of density 1025 kg/m^3.

Determine EACH of the following:

(a) the mass of sea water in the double bottom tank; (3)

(b) the new position of the ship's centre of gravity G. (5)

DEC 2010

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Fig Q1 shows three right angled triangles.

   Calculate EACH of the following:

   (a) the remaining other FOUR internal angles; (4)

   (b) the area of the triangle ABC when AB = 8.96 cm and CA = 7 cm. (4)

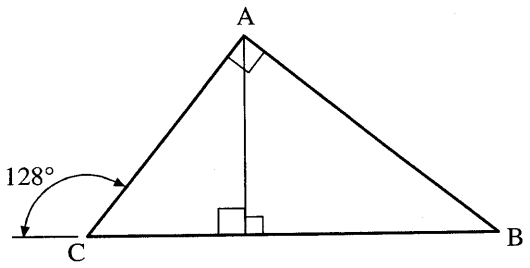

Fig Q1

2. (a) Plot a straight line graph from the data in Table Q2. (5)

x	0	1	3	4
y	-10	0	20	30

Table Q2

   (b) Obtain from the graph plotted in Q2(a) EACH of the following:

   (i) the value of x when $y = -5$; (1)

   (ii) the value of y when $x = 2.25$. (1)

   (c) Determine the law of the plotted straight line obtained from the graph in Q2(a). (3)

   Suggested scales *x axis: 4 cm = 1*
   y axis: 2 cm = 5

3. An observer's eyes are 1.75 m above the ground, and at a horizontal distance of 18 m from a vertical mast.

The angle of elevation to the top of the mast is 42°.

Determine the height of the mast to TWO significant figures. (8)

4. (a) Transpose the following stress equation to make d the subject. (4)

$$T = \frac{\pi d^3 \tau}{16}$$

(b) Calculate the value of d given that T = 662 kNm, $\pi = 3.142$ and $\tau = 72.25$ MN/m^2. (4)

5. A screw jack has a turning bar that is effectively 570 mm long and a screw thread of 6 mm pitch.

Calculate the efficiency of the machine when an effort of 302 N just lifts a mass of 4 tonne. (8)

6. A wire rope having an effective cross sectional area of 51 mm^2 is subjected to a tensile test and fails at a load of 2540 kg.

(a) Calculate EACH of the following:

(i) the breaking tensile stress; (3)

(ii) the safe working load if a factor of safety of 5 is given to ropes of this size. (3)

(b) Define the term *linear strain*. (2)

7. A pump delivers 28 tonne of fresh water to an average height of 15 m in 32 minutes.

Calculate the output power of the pump, in kW. (8)

8. A rectangular dry dock gate is 27 m wide and has river water of density 1017 kg/m^3 to a depth of 10.7 m on one side only.

Calculate EACH of the following:

(a) the hydrostatic thrust on the dry dock gate; (5)

(b) the hydrostatic pressure at a point 6.1 m up from the bottom of the dry dock gate. (5)

9. A vessel has an underwater volume of 7805 m^3 in sea water.

A mass of 45 tonne, already on board, is moved 5 m to starboard from the centreline.

Calculate the angle of heel Θ to the nearest whole degree. (8)

Given: KG = 6.3 m and KM = 7.1 m, density of sea water 1025 kg/m^3.

$$GM = \frac{m \times d}{\Delta \tan \theta}$$

10. A vessel has a displacement of 5000 tonne, with a KG at 4.8 m.

A double bottom tank, 7 m wide x 5.5 m long x 1.4 m deep is now filled with oil having a specific gravity of 950 kg/m^3.

Calculate EACH of the following:

(a) the mass of oil loaded into the double bottom tank; (3)

(b) the new position of KG if the double bottom tank is symmetrical about the centreline. (5)

11. A uniform simply supported beam AB, having a mass of 1.07 tonne, is shown in Fig Q11.

Calculate EACH of the following:

(a) the value of the reaction R_A; (5)

(b) the value of the reaction R_B. (3)

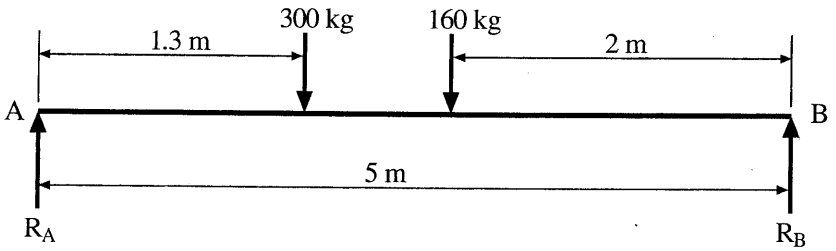

Fig Q11

12. Simplify EACH of following expressions:

(a) $\dfrac{3\,a\,b}{5\,c^2\,d^3} \times \dfrac{15\,c\,d^4}{9\,a^2\,b^2}$ (3)

(b) $\dfrac{4\,L^2\,m}{5\,p} \div \dfrac{12\,L\,m^2}{20\,p^2}$ (5)

JULY 2010

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. A circle has an area 1.94m^2.

   Calculate the volume of a sphere having the same radius as the circle. (8)

2. A right angled triangle is standing on its base which is 4.7cm long. The vertical height is 2.4 times the length of the base.

   Calculate EACH of the following:

   (a) the other base angle; (3)

   (b) the difference in length between the vertical height and the hypotenuse. (5)

3. A piece of steel has a mass of 25kg and rests on an air lubricated surface.

   Calculate EACH of the following:

   (a) the value of μ, the coefficient of friction, if it takes 4.72N applied horizontally to just cause motion; (3)

   (b) the acceleration caused if the applied force is now increased to 35N. (5)

4. (a) Plot the graph of the equation $y = x^2 + 2$ between the limits of $x = -1$ and $x = +3$, indicating in a table how the plotting points are obtained. (8)

   (b) Indicate on the graph obtained in Q4(a) the value of y when $x = 1.8$. (2)

   Suggested scales: Unit x = 4cm Unit y = 2cm

5. An electric drive comes to rest uniformly from running speed in 1 minute 23 seconds and in doing so turns through 1106 revolutions.

   Calculate EACH of the following:

   (a) the running speed of the drive in rev/min; (4)

   (b) the retardation in rad/s^2. (4)

6. Solve for x in the following equation:

$2(x-3)-3(x-4)=x-6$ (8)

7. A hole 25mm in diameter is to be punched through a plate 32mm thick. The shear strength (stress) is not to exceed $350N/mm^2$ in the punch.

Calculate the load in the punch. (8)

8. Fig Q8 shows a uniform simply supported beam AB.

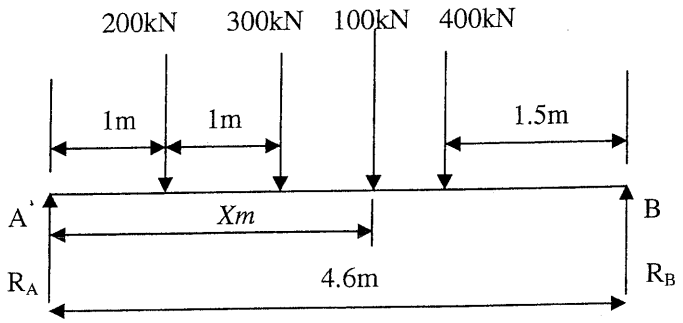

Fig Q8

Calculate the position of the 100kN force from the beam end A so that reaction R_A = reaction R_B. (8)

9. A bulkhead is 6.8m high and 5m wide and is flooded with sea water to a height of 5.9m on one side only.

Calculate EACH of the following:

(a) the hydrostatic pressure at a point 4.2m from the top of the bulkhead; (3)

(b) the hydrostatic force on a circular access door 720mm in diameter with the door centre situated at 1.9m up from the bottom of the bulkhead. (7)

Note: Density of sea water = 1025kg/m^3.

10. A centreline cargo hold measures 18m wide x 20m long x 6m deep and is filled with cargo having a density of 1169kg/m^3.

The original displacement of the vessel is 4475 tonnes and the Kg of the cargo is noted at 4m above the keel.

Calculate the movement of the ships G when loaded in both magnitude and direction if the original KG is 4.9m. (8)

11. When a mass of 8.5 tonne is moved a distance of 3.3m across the deck of an upright vessel it generates a 0.7° angle of heel.

Determine the underwater volume of the vessel given that GM is 0.67m. (8)

Note: Density of sea water 1025kg/m^3 and $\tan\theta = \dfrac{m \times d}{\Delta \times GM}$

12. Calculate the thread core (minimum) diameter of an eyebolt to lift a maximum mass of 2000kg if the U.T.S. of the material is 464MN/m^2 and Factor of Safety (FOS) = 8. (8)

GENERAL ENGINEERING SCIENCE I MARCH 2010

Attempt ALL questions

Marks for each question are shown in brackets.

1. A bearing metal contains 19 parts tin, 1.3 parts antimony, 1 part copper and 0.9 part cadmium.

   Calculate the masses of the above metals to produce 27kg of the bearing metal. (8)

2. (a) Multiply $2x + 3$ by $2x - 5$ (3)

   (b) Simplify $\frac{4a}{3b} + \frac{5b}{2a}$ (5)

3. A triangle ABC has a base BC of 25cm with a right angle at point C. AC has a length of 20cm.

   Calculate EACH of the following:

   (a) the angle of elevation to the top of the triangle from point B, giving your answer in degrees and minutes; (3)

   (b) the length of side AB. (5)

4. The following formula relates to a simple lifting machine having pulleys of radius R & r and with load and effort of L & E respectively.

$$E = \frac{L(R-r)}{2R}$$

   (a) Make R the subject of the given formula. (6)

   (b) Determine the value of R when a mass of 50.968kg is lifted given that E = 70N and r = 60mm. (4)

5. A cast metal fitting is in the shape of a hexagon, 16mm across the corners with a hole of 6mm diameter at its centre.

   Calculate the number of complete fittings that can be cast from a block of metal 6cm x 2.8cm x 1.32cm if the fittings are 10mm thick. (10)

[OVER

6. A body has a mass of 14.3kg.

(a) Calculate the least force to be applied in the horizontal plane to just cause motion if the coefficient of friction is 0.58. (3)

(b) Express the reduction in effort needed to just move the body as a percentage of the original value obtained in Q6(a), if the coefficient of friction is now reduced by 0.17 due to the addition of a suitable lubricant. (5)

7. Table Q7 shows the results from an experiment on a spiral spring.

Load kg	0	4	8	12
Ext mm	0	0.5	0.93	1.5

Table Q7

(a) Construct a load/extension graph from the data in Table Q7. (4)

(b) Determine from the graph obtained in Q7(a) the probable law connecting load and extension. (4)

Suggested scales: load 1kg = 2cm Ext 0.5mm = 4 cm

8. Fig Q8 shows a uniform simply supported beam AB which has a mass of 2 tonne.

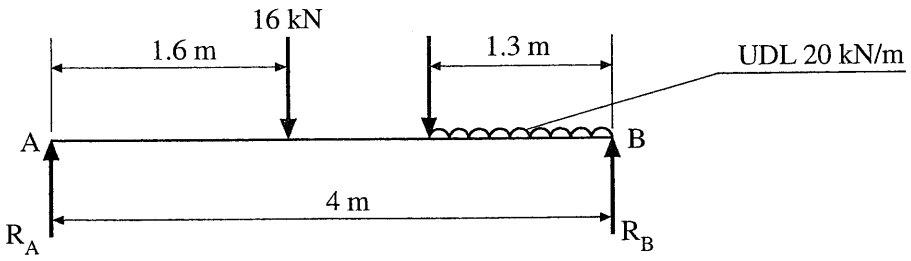

Fig Q8

Calculate EACH of the following:

(a) value of reaction R_A; (5)

(b) value of reaction R_B. (3)

9. A bulkhead is 5.8m deep and is flooded to the top, on one side only, with water of density 1016kg/m^3.

Calculate EACH of the following:

(a) the hydrostatic pressure at the base of the bulkhead; (3)

(b) the width of the bulkhead if the hydrostatic force under these conditions is 1.844MN. (5)

10. A mass of 28 tonne, already on board, is moved 3.9m across the deck of a vessel having an underwater volume of 3914m^3 in water of density 1022kg/m^3.

Calculate the angle of heel produced given that KG = 5.4m, KM = 6.3m, and $GM = \dfrac{m \times d}{\Delta \tan \theta}$ (8)

11. A vessel has a displacement of 5300 tonne with a KG of 4.6m. Cargo is now loaded on the centreline with the centre of gravity Kg 3.05m above the keel.

Calculate the mass of the loaded cargo if the KG of the system is now 4.53m. (8)

12. A mass M tonne is to be lifted using two chains and a ring as shown in Fig Q12.

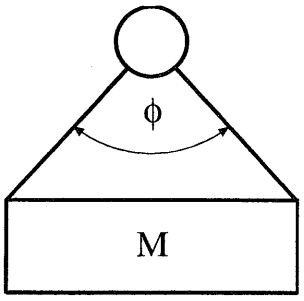

Fig Q12

Determine, by any suitable method, the value of the mass M in tonne if the tension in each lower chain is to be a maximum 11200N when the angle ϕ is 120°. (8)

DEC 09.

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in EACH of the following:

   (a) $2(x+4)-3(x-4)=2x-7$ (4)

   (b) $\frac{3x}{5}-\frac{(2x+8)}{20}=5$ (4)

2. A right angled triangle ABC has a hypotenuse AB of 14.25cm which makes an angle of 1.08 radians to the base BC.

   Calculate EACH of the following:

   (a) the length of the base BC; (4)

   (b) the area of the triangle ABC. (4)

3. Table Q3 gives the load carrying capacity of roller bearing journals running at constant speed.

   (a) Plot and draw the graph from the tabular values. (6)

   (b) Estimate from the graph obtained in Q3(a) the safe load in kg for a roller bearing having a bore of 40mm. (2)

Bore mm	27.5	38	45	55
Load kg	700	1150	1650	2200

Table Q3

Suggested scales: *1cm = 2.5mm bore*
1cm = 250kg load

4. The formula stated relates to a simple machine.

$$E = \frac{L(R-r)}{2R}$$

(a) Transpose the formula to make R the subject. (5)

(b) Calculate the value of R given E = 70N, L = 500N and r = 60mm. (3)

5. Calculate the curved surface area of a hollow cone having a perpendicular height of 26cm and a volume of $0.09m^3$. (10)

6. A tank measuring 7.5m long x 5.8m wide x 3.7m deep is completely filled with oil having a relative density of 0.86.

Calculate EACH of the following:

(a) the hydrostatic pressure on the bottom of the tank; (3)

(b) the mass of oil to be discharged to reduce the hydrostatic pressure determined in Q6(a) to $20kN/m^2$. (5)

7. A flywheel is uniformly retarded from 1420rpm to 980rpm in 16 seconds.

Calculate EACH of the following:

(a) the angular retardation in rad/s^2; (5)

(b) the number of revolutions turned during the retardation period. (3)

8. Calculate the safe working load of a collared eyebolt having a safety coefficient (factor of safety) of 14 and the specifications shown in Table Q8. (8)

Size	Major Diameter	Minor Diameter
M24	24mm	20.75mm

Table Q8

Note: Material UTS = $850N/mm^2$

9. A simple wall crane, supporting a load of 1 tonne at the jib head, consists of a jib 2.25m long being of hollow tubular section, OD 150mm, ID 138mm, and making an angle of 35° to the wall. The tie is 1.4m long and makes a right angle with the jib.

(a) Produce a simple dimensioned sketch of the crane. (1)

(b) Calculate EACH of the following:

(i) the load in the jib; (3)

(ii) the load in the tie; (3)

(iii) the stress in the jib. (3)

10. A vessel has an underwater volume of $3902m^3$ in water of density $1025kg/m^3$, and has the following particulars KB = 2.9m, BM = 3m and KG = 5.1m.

Calculate the angle of heel generated when a mass of 5.5 tonne, already on board, is moved 7.38m across the deck. (8)

Given $GM = \dfrac{m \times d}{\Delta \tan \theta}$

11. A worm and wheel lifting device has a single start worm which is operated by a belt driven pulley 220mm in diameter. The wheel has 50 teeth and is directly connected to the load drum which is 160mm in diameter.

Calculate EACH of the following:

(a) the movement ratio of the machine; (3)

(b) the effective pull in the belt if the efficiency of the machine is 31% at a load of 289kg. (5)

12. A ship has an underwater volume of $2927m^3$ in seawater of density $1025kg/m^3$.

Calculate the load to be landed on the centreline to cause a change of 0.15m in the position of ship G. (8)

Given KG = 3.85m and the load is to be positioned 4.9m above the keel.

GENERAL ENGINEERING SCIENCE I July 2009.

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify the following:

   (a) $\dfrac{a \times a^2 \times a^5}{a^3 \times a^7}$ (4)

   (b) $\dfrac{x}{2} + \dfrac{2x}{3} - \dfrac{2x}{5}$ (4)

2. The abrasive tank in a pressure cleaning machine is in the shape of an inverted cone having a diameter of 1.4m and an apex angle of 60°.

   Determine the volume of the abrasive tank. (8)

3. Two sides of a triangle measure 5.3cm and 7.3cm respectively, and the included angle between them is 44° 27'.

   Calculate the area of the triangle in square metres. (8)

4. (a) Given that $n^2r + 1 =$ NR, rearrange the terms to make n the subject. (4)

   (b) Calculate the value of R when $r = 0.725$, N = 16 and $n = 7.192$. (4)

5. (a) Plot the graph of $y = \dfrac{x^2}{2} - 3x$ between the limits of $x = 0$ and $x = 6$. (8)

   (b) Using the graph obtained in Q5(a) state the value of x when $y = -3$. (2)

6. The thread of a screwjack has a pitch of 12mm and the machine is operated by a lever having an effective length of 350mm. When an effort of 80N is applied a load of 455kg can just be lifted.

Calculate EACH of the following:

(a) the force ratio of the machine; (3)

(b) the movement ratio of the machine; (3)

(c) the efficiency of the machine under these load conditions. (2)

7. A body is travelling at 2.27m/s when it uniformly accelerates to 5m/s in 6.3 seconds.

(a) Define EACH of the following:

(i) acceleration, stating units; (1)

(ii) distance travelled, in terms of velocity and time. (1)

(b) Calculate EACH of the following:

(i) the acceleration of the body; (3)

(ii) the distance the body travelled in 6.3 seconds. (3)

8. Determine the value of the uniformly distributed load (UDL) in kN/m for the loaded beam shown in Fig Q8, given that the value of R_B is to be 85kN. (10)

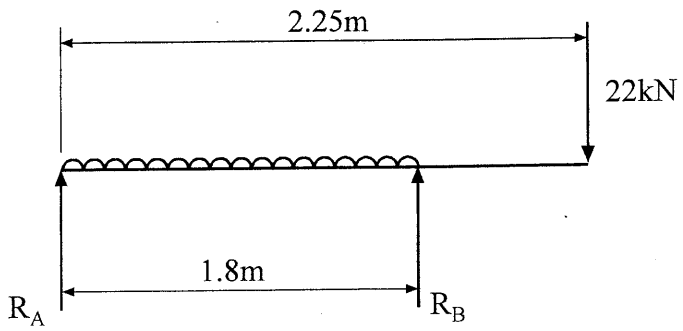

Fig Q8

9. Determine the factor of safety for a rod 101.6mm in diameter if the maximum static tensile load is 327kN and the ultimate tensile stress of the material is 460MN/m^2. (8)

10. (a) A ship has a displacement of 6495 tonne and when a mass of 28 tonne, already on board, is moved transversely across the upper deck by a distance of 8.3m, an angle of heel of 2° is generated.

Determine the position of the centre of gravity KG above the keel given that $m \times d = \Delta\ GM\ tan\theta$ and KM = 4.02m. (6)

(b) State the effect the removal of the 28 tonne mass will have on the position of *G* and the stability of the vessel. (2)

11. A rectangular bulkhead, 18m wide, is flooded on one side only with water of density 1020kg/m^3.

Calculate EACH of the following:

(a) the depth of flooding if the hydrostatic pressure at the bottom of the bulkhead is 63kN/m^2; (3)

(b) the hydrostatic load on the bulkhead at the depth of flooding determined in Q11(a). (5)

12. A vessel has an underwater volume of 3415m^3 when in water of density 1025kg/m^3.

A double bottom tank 15m long x 12m wide x 2.3m deep, on the centreline, is now completely filled with oil having a relative density of 0.86.

Determine the position of the centre of gravity above the keel, KG, given that the original KG was 6.1m. (8)

GENERAL ENGINEERING SCIENCE I APRIL 2009.

Attempt ALL questions

Marks for each question are shown in brackets.

1. Given that y varies directly as x, inversely as z, and $y = 2$ when $x = 3$ and $z = 5$.

   Determine the value of y when $x = 4$ and $z = 6$. (8)

2. A triangular field has a perimeter of 649m. The sides are in the ratio 9:13:15.

   Calculate the length of EACH side. (8)

3. A wooden pattern is in the shape of a sphere with a diameter of 15cm and is oversize by 1.67% on the linear dimension, to allow for manufacture.

   Calculate the mass of a metal sphere cast in material having a density 8.7 times that of fresh water. (8)

4. Solve for x in the following equation:

   $$\frac{3x}{5} - \left(\frac{x+12}{20}\right) = 3.25$$ (8)

5. A solid right cone has a volume of 1231.5cm^3 and stands on a base of radius 7cm.

   Calculate EACH of the following:

   (a) the perpendicular height of the cone; (4)

   (b) the total surface area. (6)

6. The periodic time of a pendulum is given by the formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

(a) Transpose the formula to make L the subject. (4)

(b) Calculate the value of g to 2 decimal places given that L = 50cm, π = 3.142 and T = 1.418 seconds. (4)

7. A body accelerates from rest for 8 seconds and attains a speed of 10m/s. The body continues at this steady speed for 8 seconds and then accelerates to 20m/s in 4 seconds. The body continues at uniform velocity for 10 seconds and then retards to rest in a further 30 seconds.

(a) Sketch the velocity time diagram. (3)

(b) Calculate EACH of the following:

(i) the second stage acceleration in m/s^2; (2)

(ii) the distance travelled in metres. (5)

8. Fig Q8 shows a simple wall crane.

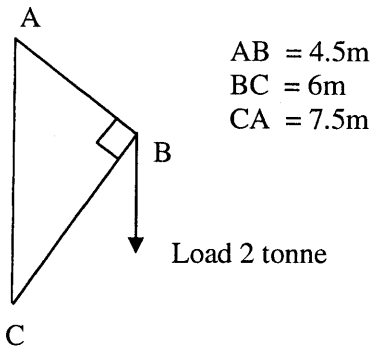

Fig Q8

Calculate EACH of the following:

(a) the direct force in the tie; (4)

(b) the direct force in the jib. (4)

9. A wire rope having an effective cross sectional area of 47.3mm² is subjected to a tensile test and fails at a load of 2475kg.

Calculate EACH of the following:

(a) the tensile stress at the moment of failure; (4)

(b) the safe working load if a Factor of Safety of 5 is given to wire ropes of this size. (4)

10. A tank measuring 8.3m long x 6.3m wide x 4.3m deep is full of oil having a relative density of 0.86.

Calculate EACH of the following:

(a) the hydrostatic pressure at the bottom of the tank; (3)

(b) the mass of oil to be discharged to reduce the hydrostatic pressure calculated in Q10(a) to 25kN/m². (5)

11. When a mass of 5 tonne is moved 4m across the deck of a vessel it causes a heel of 0.9° to be generated.

Calculate the displacement of the vessel given that KM = 4.6m, KG = 3.8m and

$$GM = \frac{m \times d}{\Delta \tan \theta}$$ (8)

12. A vessel has an underwater volume of 2938m³ in water of density 1021kg/m³.

Calculate the mass to be loaded on the centreline to cause a change of 0.18m in the position of G given that KG is 3.63m and the load is to be positioned on deck 4.77m above the keel. (8)

GENERAL ENGINEERING SCIENCE I

DEC 2008

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) State the Theorem of Pythagoras. (3)

   (b) A ladder is 8.66m long and is positioned against a vertical wall such that the foot of the ladder is 4.065m from the wall.

   Calculate the perpendicular height to the top of the ladder. (5)

2. (a) Draw the graph of $y = x^2$ for values of x between $x = -1$ and $x = +2$. (4)

   (b) Using the same axes draw the graph of:

   $y = x + 1.5$ for values of x between $x = -1$ and $x = +2$. (4)

   (c) Determine the co-ordinates of the points of intersection of the graphs. (2)

   Note: suggested scales 1 unit x = 4cm
   1 unit y = 4cm

3. A right angled triangle has an area of 2.8m². The sides are in the ratio of 5:12:13 and the triangle stands on the shortest side.

   Calculate EACH of the following:

   (a) the perpendicular height; (5)

   (b) the hypotenuse. (3)

4. A solid hemisphere has a diameter of 21cm.

   Calculate the <u>total</u> surface area in m². (8)

5. The following formula may be used to determine torque in shaft transmission systems.

$$T = \frac{\pi D^3 \tau}{16}$$

(a) Transpose the formula to make D the subject. (5)

(b) Calculate the shear stress τ when $T = 6350\text{Nm}$ and $D = 0.0974\text{m}$. (3)

6. (a) Multiply $2x + 4$ by $3x - 5$ (3)

(b) Simplify $\frac{4a}{3b} + \frac{5b}{2a}$ (5)

7. An electric motor comes to rest from running speed in 1 minute 7 seconds and turns through 1018 revolutions before coming to rest.

Calculate EACH of the following:

(a) the running speed in rev/min; (4)

(b) the retardation in rad/s^2. (4)

8. Calculate EACH of the following:

(a) the coefficient of friction between a machine having a mass of 462kg and a horizontal surface if it takes 2.7kN applied parallel to the horizontal surface to just cause motion; (4)

(b) the force applied parallel to the horizontal surface to just cause motion if rollers are introduced under the load reducing the coefficient of friction by 73%. (4)

9. (a) Produce a simple diagrammatic sketch of a double purchase (double reduction) crab winch. (4)

(b) Using the sketch in Q9(a) prove that the movement ratio is equal to

$$\frac{L}{r} \times \frac{product\ of\ followers}{product\ of\ drivers}$$ (6)

where L = effort arm length and r = load shaft radius.

10. (a) Indicate on a simple transverse sketch of a box barge the position of EACH of the following:

(i) centre of gravity G; (1)

(ii) centre of buoyancy B; (1)

(iii) metacentre M. (1)

(b) Calculate the value of GM for a box barge floating at a draught of 4.7m given that KG = 3.95m and BM = 2.83m. (5)

11. A vessel has an underwater volume of 2927m³ in water of density 1025kg/m³. A mass of 40 tonne is loaded on the centreline, then moved 2.48m to port, and in this condition KG = 4.95m and KM = 5.88m.

Calculate EACH of the following:

(a) the displacement in tonnes; (3)

(b) the angle of heel generated to the nearest whole degree, given that

$$GM = \frac{m \times d}{\Delta \tan \theta}$$ (5)

12. A drydock gate is 42m wide and has water of density 1018kg/m³ on one side only to a depth of 14.8m.

Calculate EACH of the following:

(a) the hydrostatic gauge pressure, in bar, at a point 2m up from the bottom of the gate; (3)

(b) the hydrostatic load on the gate. (5)

July 2008

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation:

   $2(x+4)-3(x-5)=x-7$ (8)

2. Pump A can fill a tank in 12 hours.
   Pump B can fill the same tank in 6 hours.
   Pump C can fill an identical tank in 3.5 hours.

   Calculate the time, in hours and minutes, to fill the tank if all the pumps are working together. (8)

3. The area of an annulus is given by the following formula:

   $A=\frac{\pi D^2}{4}-\frac{\pi d^2}{4}$ where D = major diameter, d = minor diameter.

   (a) Transpose the formula to make d the subject; (6)

   (b) Find the area of an annulus having a major diameter of 7cm and a minor diameter of 5cm. (4)

4. Calculate EACH of the following:

   (a) the perpendicular height of a right angled triangle having a base length of 7.34cm and a hypotenuse of 11.31cm using Pythagoras Theorem; (5)

   (b) the area of the triangle in Q4(a) in m^2. (3)

5. An open ended cylinder, diameter 10cm and height 23cm, is half filled with liquid. A heavy metal sphere of 9.6cm diameter is now submerged in this liquid.

   Calculate the distance from the rim of the cylinder to the liquid level. (8)

6. Calculate the diameter of pipe that will pass six times as great a volume of water as a pipe 1.25m in diameter.

Note: Assume the water velocity remains constant. (8)

7. A body starts from rest and reaches a speed of 54km/h in 32 seconds, continues at this speed for 1.5 minutes and then retards to come to rest in 45 seconds. Assume acceleration and retardation to be uniform.

(a) Draw the speed-time graph representing this movement. (3)

(b) Calculate EACH of the following:

(i) the total distance travelled in km; (3)

(ii) the retardation in m/s^2. (2)

8. A pump delivers $65m^3$ of sea water to a height of 28m in 6 minutes.

Calculate EACH of the following:

(a) the output power of the pump in kW; (5)

(b) the input power of the pump if the efficiency is 0.65. (3)

Note: Density of sea water 1025kg/m³

9. A screwjack has a single start thread with a pitch of 5mm and is operated by a lever having an effective length of 285mm.

Calculate the efficiency of the machine when lifting a load of 290kg with an effort of 29.94N. (8)

10. A bulkhead is 7m high and is flooded to a height of 6.1m with sea water on one side only.

Calculate EACH of the following:

(a) the hydrostatic pressure at the base of the bulkhead; (4)

(b) the hydrostatic force on a circular access door 740mm in diameter having its centre situated 5.9m down from the top of the bulkhead. (6)

Note: Density of sea water 1025kg/m³

11. A vessel has an underwater volume of 3918m³ in water of density 1021kg/m³ and when a mass of 5.5 tonne, already on board, is moved 9.7m across the deck it causes the vessel to heel by 1.8°.

Calculate the distance from the keel to the transverse metacentre given KG = 3.75m and

$$GM = \frac{m \times d}{\Delta \tan \theta}$$

(8)

12. A vessel has a displacement of 1060 tonne. A double bottom tank on the centre line is 1.3m deep x 4.4m wide x 5.76m long and is completely flooded with water of density 1018kg/m³.

Calculate EACH of the following:

(a) the mass of water added to the double bottom tank; (3)

(b) the new position of the ship's centre of gravity G when the tank is flooded, given that the original KG is 3.9m. (5)

APRIL 2008

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify EACH of the following:

(a) $\dfrac{x^2 \times x^3 \times x^5}{x^3 \times x^4}$ (4)

(b) $\dfrac{x}{3} + \dfrac{3x}{2} - \dfrac{5x}{4}$ (4)

2. Table Q2 gives the mass W (kg) and the corresponding effort E newton for a simple lifting machine.

W (kg)	3	8.8	15.2	18
E (N)	45	72	105	118

Table Q2

(a) Plot the graph from the tabular values. (6)

(b) Determine, from the graph produced in Q2(a), the effort needed to just lift a mass of 12kg. (2)

(c) The significance of the origin of the graph in Q2(a). (2)

Note: *suggested scales* *W axis* *1cm = 2kg*
E axis *1cm = 5N*

3. Calculate the area of an equilateral triangle having sides of length 13cm. (8)

4. A right pyramid is 78cm high and stands on a hexagonal base having sides of 21cm.

Calculate the volume of the pyramid in m^3. (8)

5. The total surface area of a solid cylinder is given by the formula:

$$S = 2\pi r^2 + 2\pi rh$$

(a) Transpose the formula to make h the subject. (5)

(b) Calculate the total surface area of a solid cylinder having the following dimensions: diameter 18cm; height 15cm. (3)

6. Calculate the mass of a piece of steel tube 2.85m long having an inside diameter of 25mm and a tube wall thickness of 6mm. (8)

Note: Steel is 7.6 times heavier than an equal volume of fresh water.

7. A body of mass 25kg is moving at a uniform velocity of 29m/s when it is retarded to 11m/s in 5 seconds.

Calculate EACH of the following:

(a) the retardation in m/s²; (3)

(b) the retarding force necessary; (2)

(c) the distance travelled during the 5 second retardation period. (3)

8. A uniform simply supported beam AB is 5m long and has a mass of 1.8 tonne. Point loads of 0.9 tonne and 1.3 tonne are applied at 1.3m and 4.1m from the left hand end A.

(a) Sketch the beam AB, showing ALL relevant loads and dimensions. (2)

(b) Calculate EACH of the following:

(i) the vertical reaction R_A at the left hand end A; (3)

(ii) the vertical reaction R_B at the right hand end B. (3)

9. A steel rod of diameter 2.5cm is subjected to an axial tensile load of 517kg and extends by 0.08mm. On removal of the load the rod assumes its normal length of 95cm.

Calculate EACH of the following:

(a) the direct stress in the rod when loaded; (4)

(b) the direct strain in the rod when loaded; (3)

(c) the value of the Modulus of Elasticity, E, for the material. (3)

10. A rectangular bulkhead is 15m wide and is flooded on one side only with water of density 1019kg/m^3.

Calculate EACH of the following:

(a) the depth of flooding if the pressure at the bottom of the bulkhead is 120kN/m^2; (4)

(b) the hydrostatic load on the bulkhead when flooded to the depth determined in Q10(a). (4)

11. A vessel has an underwater volume of 1039m^3 in water of density 1023kg/m^3.

Calculate EACH of the following:

(a) the displacement of the vessel; (3)

(b) the distance a mass of 1.06 tonne, already on board, must be moved athwartships to correct a list of 0.4° . (5)

Given $GM = \dfrac{m \times d}{\Delta \tan \theta}$ KM = 4.23m KG = 3.97m.

12. A vessel has a displacement of 5750 tonne. A cargo mass of m tonne is now loaded on the centreline at a position 4.1m above the keel causing ship's G to rise by 0.13m.

Calculate the final displacement of the vessel given that the original KG is 2.8m. (8)

Dec 2007

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) A large drum when filled contains 273kg of heavy oil having a density of 920kg/m^3.

Calculate the mass of light oil of density 810kg/m^3 that can be contained in an identical drum. (4)

(b) The number 152 is divided in the ratio 2:3:5.

Calculate the difference between the largest number and the smallest number. (4)

2. The formula shown allows the stress in thick cylinders to be calculated:

$$\frac{D}{d} = \sqrt{\frac{f+P}{f-P}}$$

Express f in terms of the other quantities. (8)

3. A right angled triangle ABC has a hypotenuse AB of 18.2cm which makes an angle of 1.176 radians to the base line BC.

Calculate EACH of the following:

(a) the length of side BC to the nearest whole centimetre; (4)

(b) the area of the triangle ABC. (4)

4. A solid lead sphere has a diameter of 112.8mm. The sphere is melted down and recast into a cube with 3% material wastage.

Calculate the length of the largest diagonal in the cube. (8)

5. A solid right cone has a perpendicular height of 24cm and a base diameter of 12cm.

Calculate the total surface area to the nearest cm^2. (8)

6. A body accelerates uniformly from rest at $1.5m/s^2$ for 12 seconds, then travels at constant velocity for 34 seconds and finally decelerates uniformly for a further 24 seconds before coming to rest.

(a) Sketch the velocity – time diagram. (3)

(b) Determine the total distance travelled. (3)

(c) Determine the average velocity for the whole journey. (2)

7. A metal component 337mm long has a diameter of 50mm and when subjected to an axial tensile load of 285kN extends by 0.61mm.

Calculate EACH of the following:

(a) the direct stress in the component; (3)

(b) the direct strain in the component; (3)

(c) the modulus of elasticity E for the material. (2)

8. A rope pulley tackle has three pulleys in the upper block and two pulleys in the lower load carrying block. An effort of 265N is required to just lift a mass of 108kg.

Calculate EACH of the following:

(a) the force ratio of the system; (3)

(b) the movement ratio of the system; (3)

(c) the efficiency of the system. (2)

9. A plank of wood 2.44m long x 144mm x 85mm deep floats in water of density $1006kg/m^3$.

Calculate the height of wood above the water surface given that the wood has a density of $730kg/m^3$ and floats horizontally. (10)

10. An empty container has a mass of 2.1 tonne and is on the centreline of a vessel of 6030 tonne displacement.

Calculate the mass that can be loaded in the container to cause the vessel to heel by 0.9° when the container and cargo are moved across the vessel by 4.6m. (10)

Note: $m \times d = \Delta\ GM \tan\theta$ *with* $KG = 4.7m$ *and* $KM = 5.1m$

11. A vessel having a displacement of 5120 tonne has its centre of gravity G located at 4.7m above the keel. A load of 780 tonne is now positioned on the centreline at 2.9m above the keel.

Calculate the new position of the ship's centre of gravity KG. (8)

12. (a) Plot the graph using the co-ordinates in Table Q12. (4)

(b) Using the graph obtained in Q12(a), determine the equation of the line. (4)

X	1	2	2.75	3.5
Y	2.25	5.11	7.02	8.87

Table Q12

Suggested scales: *x axis 4cm = 1 unit*

y axis 2cm = 1 unit

July 2007

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Convert EACH of the following decimal fractions to the lowest vulgar fraction showing ALL workings:

   (a) 0.375 (3)

   (b) 0.44736 (5)

2. The following formula can be used to determine the wall thickness of tubes:

$$T = \frac{PD}{2f + P}$$

   Transpose the formula to make f the subject. (6)

3. (a) Plot the graph of the equation $y = x^2 - 1.5$ between the limits of $x = -1$ and $x = +2$. (7)

   (b) Indicate on the graph in Q3(a) the value of y when $x = 1.8$ (3)

   Suggested scales: *x axis 4cm = 1 unit*
   y axis 4cm = 1 unit

4. (a) State the Theorem of Pythagoras. (2)

   (b) The diagonal of a rectangle exceeds the length by 2.5cm.

   Calculate the length of the rectangle given that the width is 12cm. (6)

5. An isosceles triangle has sides of 45cm standing on a base of 35cm. The angle between a side and the base is 67.1°

   Calculate the area of the triangle in square metres. (8)

6. A rectangular lead block measuring 25cm x 18cm x 12cm is recast into a solid sphere with 2% material wastage.

Calculate the diameter of the sphere. (8)

7. A flywheel is accelerated from 980rpm to 1420rpm in 16 seconds.

Calculate EACH of the following:

(a) the angular acceleration in rad/s^2; (5)

(b) the number of revolutions turned during the acceleration period. (3)

8. The coefficient of friction between a body of mass 46kg and a horizontal plane is 0.72.

Calculate EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the force applied given that the resulting acceleration is 2.1m/s^2; (4)

(c) the distance moved in 7 seconds from rest under the action of the accelerating force. (4)

9. A horizontal uniform beam AB is simply supported at each end. The beam is 4m long and has a mass of 1250kg. A uniformly distributed load of 5kN/m is 2m long and is situated to begin at 0.75m from the left hand end, A.

(a) Sketch the beam, indicating ALL relevant information and forces acting. (3)

(b) Determine the values of the reactions at the supports. (7)

10. The gauge pressure at the bottom of a lock gate is 1.78 bar when flooded to the top with seawater of density 1025kg/m^3 on one side only. The gate is 18m wide.

Calculate EACH of the following:

(a) the depth of the gate; (3)

(b) the hydrostatic thrust on the gate. (5)

11. A ship has an underwater volume of $2927m^3$ when floating in seawater of density $1025kg/m^3$.

Calculate the mass to be loaded on the centreline to cause a change of 0.15m to the position of the ships G, given that KG is 3.85m and the load is to be positioned on the deck 4.9m above the keel. (8)

12. A vessel has a displacement of 4380 tonne and is listing to port by 1.1°.

Calculate the distance a container, already on board, must be moved from the centreline to cause the vessel to become upright. The container is 6m long x 1.98m wide x 2.13m high and is filled with cargo having a mass of 0.71 tonne/m^3. The empty container has a mass of 2 tonne. (8)

Given $m \times d = \Delta \times GM \times \tan\theta$ *and* $GM = 0.7m$

MARCH 2007

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Simplify EACH of the following, showing ALL working:

   (a) $\dfrac{\left(8\frac{1}{3} \times 1\frac{1}{4}\right)}{\left(4\frac{1}{4} + 4\frac{1}{2}\right)}$ (4)

   (b) $\dfrac{\left(3 + 1\frac{3}{4} - 2\frac{1}{3}\right)}{\left(\frac{2}{3} \times 1\frac{3}{4}\right)}$ (4)

2. Solve EACH of the following:

   (a) the sum of three consecutive whole numbers is 39, state the numbers; (4)

   (b) two numbers are in the ratio 1:9 and their sum is 23, state the numbers. (4)

3. A pump rod is 520mm long and has a modulus of elasticity of 200GN/m^2.

   Calculate the axial compressive stress that will cause the rod to shorten by 0.08mm when under load conditions. (8)

4. Calculate the area of a regular hexagon that measures 5cm across the corners. (8)

5. A pipe 1.85m long has an outside diameter of 75mm and an inside diameter which is 84% of the outside diameter.

   Calculate the mass of the pipe given that the relative density of the pipe material is 7.7 times that of fresh water. (10)

   Note: Density of fresh water is 1000kg/m^3

6. Calculate the height of a right cone having a volume of 2.7 litres and standing on a base of 8cm radius. (8)

7. A screwjack has a single start thread of 6mm pitch and can lift a load of 1.7 tonne with an effort of 92N. The effort is applied to a lever having an effective length of 40cm.

   Calculate EACH of the following:

   (a) the movement ratio of the machine; (3)

   (b) the force ratio of the machine; (2)

   (c) the efficiency of the machine when lifting a load of 2 tonne with an effort of 97N. (3)

8. A power hoist is used to raise a mass of 312kg through a vertical height of 11m in 8.6 seconds.

   Calculate the efficiency of the system given that the power input is 9.1kW. (8)

9. A horizontal uniform beam AB is simply supported at each end. The beam is 4.7m long and carries a uniformly distributed load of 14.7kN/m over its entire length. A mass of 235kg is applied vertically downwards at a point 1.8m from end B.

   (a) Sketch the beam, indicating ALL relevant information and the forces acting. (3)

   (b) Calculate the value of the reactions at the supports. (7)

10. The centre of a glass viewing port that is 0.406m in diameter is situated in a vertical plane 2m above the tank bottom.

    Calculate the maximum height of water in the tank if the glass can withstand a hydrostatic load no greater than 6.5kN. (8)

    Note: Density of water 1025kg/m^3

11. A vessel has an underwater volume 2817m^3 when floating in water of density 1013kg/m^3.

    Calculate the angle of heel generated when a load of 4.8 tonne, already on board, is moved 3.8m athwartships. (8)

    Given: $m \times d = \Delta GM \tan\theta$ *with* $KM = 4.9m$ *and* $KG = 4.05m$

12. A vessel has a displacement of 8460 tonne with KG = 5.3m. Four double bottom tanks, on the centreline, of 15m length x 4m beam x 2.08m depth are now filled with seawater.

Calculate the change in the position of G in the vessel in both magnitude and direction. (8)

Note: Density of seawater 1025kg/m^3.

DEC 2006

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. (a) Multiply $2x-4$ by $2x+3$ (3)

   (b) Simplify $2\frac{1}{3} + 3\frac{1}{3} \times 2\frac{1}{5}$ (5)

2. Calculate EACH of the following:

   (a) the length of the vertical side of a right angled triangle having a base of 7.8cm and a hypotenuse of 12.48cm, using Pythagoras Theorem; (5)

   (b) the area of the triangle to the nearest cm^2. (3)

3. A cylindrical vessel has an internal diameter of 1.85m and a maximum internal length of 4.96m measured from inside the outwardly dished hemispherical ends.

   Calculate the volume of the vessel. (10)

4. A screwjack has a screw thread of 4mm pitch operated by a lever 280mm in length.

   Calculate the efficiency of the screwjack when a horizontal effort of 270N applied at the end of the lever just lifts a mass of 1.885 tonne. (8)

5. A pump delivers $68m^3$ of sea water to a height of 24m in one hour and eight minutes.

   Calculate EACH of the following:

   (a) the output power of the pump in kW; (5)

   (b) the input power of the pump if its efficiency is 60%. (3)

   Note: Density of sea water is 1025kg/m³

6. (a) Define the radian. (2)

(b) State the number of degrees in 2.09 radians. (2)

(c) Calculate the number of revolutions made by a flywheel in 25 seconds if the flywheel has an angular velocity of 4.02 rad/s. (4)

7. A pump rod is 0.46m long and has a modulus of elasticity E = 200GN/m².

Calculate EACH of the following:

(a) the strain in the rod when subjected to an axial compressive stress of 16N/mm²; (5)

(b) the new length of the rod when loaded as in Q7(a). (3)

8. A tank has the following dimensions 12m long x 8m wide x 8m deep and is filled to the top with liquid of density 1038kg/m³.

Calculate EACH of the following:

(a) the hydrostatic pressure at a point 1m from the bottom of the tank; (3)

(b) the hydrostatic force on the largest tank side. (5)

9. A vessel of displacement 4460 tonne is heeled to port by 1.8° and is required to heel to starboard by exactly 1°.

Calculate the distance a mass of 19 tonne, already on board and on the centre line, must be moved to complete the change. (8)

Note: $m \times d = \Delta GM \tan \theta$ with KG = 5.1m and KM =5.7m

10. A simple crane consists of a jib that is 4.5m long attached at its lower end to a wall and a tie rod 6.5m long connecting the jib head to the wall.
The angle between the jib and tie is 90° and the crane supports a load of 1.5 tonne at the jib head.

Determine EACH of the following:

(a) the force in the jib; (4)

(b) the force in the tie rod; (4)

(c) the direct stress in the tie rod which is 55mm in diameter. (2)

11. A vessel has a displacement of 4780 tonne with a KG of 4.7m.
An empty double bottom tank, 6m long x 5.8m wide x 2.8m deep is now filled with oil having a density of 960kg/m^3.

Calculate the new position of the centre of gravity KG given that the tank is symmetrical about the centre line of the vessel. (8)

12. The law of a straight line is given by the following expression:

$$Y = aX + b$$

(a) Plot and join the pairs of points shown in Table Q12 using the given scales. (4)

(b) Determine the values of *a* and *b* from your graph. (2)

(c) State the law of the plotted straight line. (2)

Scales: X axis 4cm = 1 unit
Y axis 4cm = 1 unit

X	-1.5	0	2	3
Y	0	2	4.65	6

Table Q12

GENERAL ENGINEERING SCIENCE I SEPT 2006

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation: (8)

$$2(x+4)-2(x+5)=x-7$$

2. A sphere has a surface area 1.6 times the curved surface area of a right cone.

Calculate the diameter of the sphere given that the cone has a base diameter of 10cm and a perpendicular height of 12cm. (10)

3. The periodic time of a pendulum is given by the formula:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

(a) Transpose the formula to make g the subject. (5)

(b) Calculate the value of g to one decimal place given that $L = 50\text{cm}$, $\pi = 3.142$ and $T = 1.418$ seconds. (3)

4. A body is at rest and is then uniformly accelerated for 75 seconds during which it covers a distance of 1406m.

Calculate EACH of the following:

(a) the value of the uniform acceleration in m/s^2; (4)

(b) the velocity of the body after 75 seconds. (4)

5. If y varies inversely as the square of x, and $y = 12$ when $x = 3.1$, calculate the value of y when $x = 0.93$. (8)

6. (a) Define the moment of a force about a point. (3)

(b) Determine the value of P, the force necessary to maintain equilibrium of the moments of force about point O shown in Fig Q6. (5)

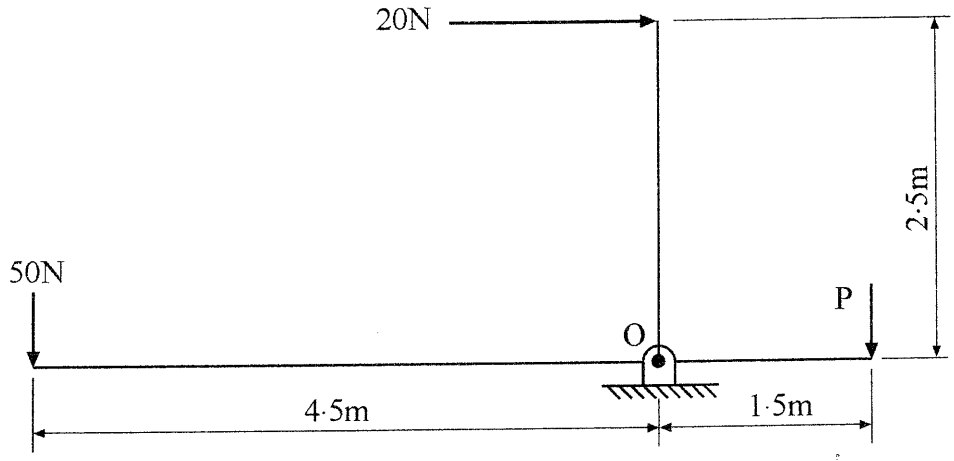

Fig Q6

7. A simple wheel and axle lifting machine has an efficiency of 68%.

Calculate the effort required to just lift a mass of 330kg given that the diameters of the pulley wheel and axle are 450mm and 75mm respectively. (8)

8. A box barge is 42m long and 18m beam and floats in water of density 1021kg/m^3.

Calculate EACH of the following:

(a) the draught of the barge if the displacement is1540 tonne; (4)

(b) the pressure on the outer bottom plating when the barge is floating at the draught calculated in Q8(a). (4)

9. A vessel has an underwater volume of 7805m^3 when floating in water density 1025kg/m^3. A mass of 45 tonne is now loaded on the centre line and is then moved 5m to starboard. KG = 6.5m and KM = 7.3m.

Calculate the angle of heel generated to the nearest degree. (8)

Note: $m \times d = \Delta GM \tan\theta$

10. A ship has a displacement of 7000 tonne when floating in water of density 1023kg/m^3, with KG = 3.8m.

Two double bottom tanks measuring 15m long x 3.5m wide x 2.3m deep are equally spaced either side of the centre line. These tanks are now completely filled with slurry having a density of 1800kg/m^3.

Calculate the change in the position of G in the ship in millimetres. (10)

11. A rectangular bulkhead is 16.5m wide and when flooded to the top on one side only with water of density 1020kg/m^3 supports a hydrostatic load of 32MN.

Calculate the height of the bulkhead to the nearest metre. (8)

12. A uniform beam simply supported at each end is 4.6m long and has a mass of 2 tonne. Point loads of 30kN are applied at 1.5m and 2.5m from the left hand end.

(a) Sketch a labelled diagram of the loaded beam. (2)

(b) Calculate the values of the reactions at the supports. (6)

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

June 2006

Marks for each question are shown in brackets.

1. A bearing metal contains 19 parts tin, 1.2 parts antimony, 1 part copper and 1 part cadmium.

   Calculate the masses of tin, antimony, copper and cadmium to produce 35kg of the bearing metal. (8)

2. Calculate the sum of:

$$\left(1\frac{1}{4}+2\frac{1}{5}\right)\times 3\frac{1}{3}-1\frac{1}{4}+2\frac{1}{5}\times 3\frac{1}{3}$$ (8)

3. A weather balloon is released vertically from a position on a deck, point D.
   After some time interval the angle of elevation from a point P on the same deck is 24^0 and the distance between D and P is measured at 150m.

   Calculate EACH of the following:

   (a) the height of the balloon; (4)

   (b) the angle of elevation when the balloon is three times as high. (4)

4. The following formula relates to a simple machine having pulleys of radii R and r and with Load and Effort L and E respectively.

$$E=\frac{L(R-r)}{2R}$$

   (a) Transpose the formula to make R the subject. (6)

   (b) Using the equation from Q4(a), calculate the value of R when $E = 70$, $L = 500$, and $r = 60$. (4)

5. A hexagonal nut is 16mm across the corners and has a plain hole 6mm diameter at its centre.

Calculate the number of nuts that can be cast from a block of metal 6cm x 2.5cm x 1.2cm if the nuts are 8mm thick. Assume that 1.86% of the metal is lost in the casting process. (10)

6. A body has a mass of 16.4kg and lies on a horizontal plane.

(a) Calculate the least force applied parallel to the plane to just cause motion if the coefficient of friction between the body and the plane is 0.49. (3)

(b) The coefficient is now reduced by 0.13 by the addition of a suitable lubricant. Express the reduction in effort needed to just move the body as a percentage of the original value obtained in Q6(a). (5)

7. Table Q7 shows the results from an experiment on a spiral spring.

Load (kg)	0	4	7	12
Ext. (mm)	0	0.5	0.875	1.5

Table Q7

(a) Construct a load/extension graph. (4)

(b) Determine from the graph in Q7(a) the probable law connecting load and extension. (4)

Suggested scales: *Load* *1kg* = *2cm*
Ext *0.5mm* = *5cm*

8. Fig Q8 shows a uniform simply supported beam AB, which has a mass of 2.2 tonne.

Calculate the values of reactions R_A and R_B. (8)

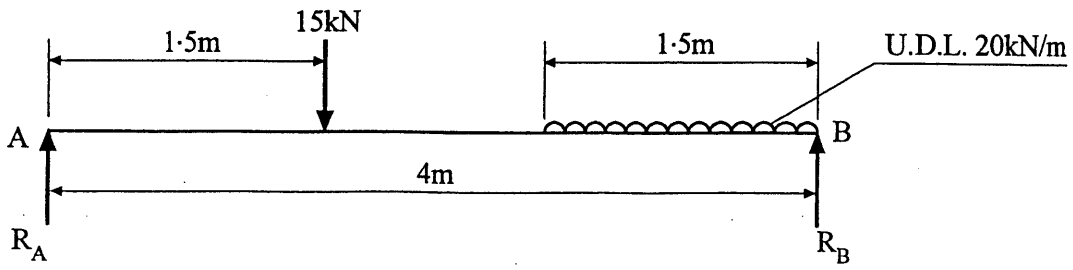

Fig Q8

9. A vertical rectangular bulkhead is 5.6m deep, and is flooded to the top on one side only with water of density 1016kg/m^3.

Calculate EACH of the following:

(a) the hydrostatic pressure at the bottom of the bulkhead; (4)

(b) the width of the bulkhead, given that the hydrostatic force on the bulkhead is 2.188MN. (4)

10. A vessel has a displacement of 5440 tonne with KG at 4.7m.
Cargo is now loaded on the centreline with its centre of gravity 2.83m above the keel.

Calculate the mass of the loaded cargo if the KG of the system is now 4.55m. (8)

11. A mass of 13 tonne already on board is moved 6.8m across the deck of a vessel having a displacement of 4327 tonne.

Calculate the angle of heel produced. (8)

Given $m \times d = \Delta GM \tan\theta$ and KG = 5.4m and KM = 6.3m

12. A uniform beam of mass M tonne is to be lifted using three chains and a ring as shown in Fig Q12.

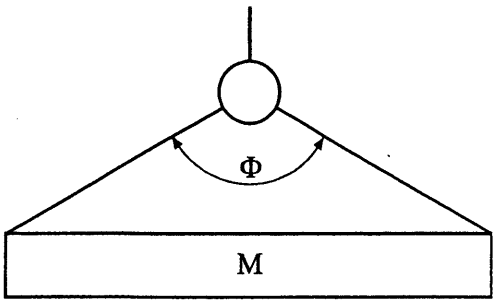

Fig Q12

Determine by any suitable means the value of M in tonne, given that the tension in the lower chains is 11200N when the angle Φ is 120^0. (8)

DEC 05

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. The perimeter of a rectangle is 800mm. When the length is halved and the breadth is doubled the perimeter is increased by 300mm.

   Calculate the dimensions for the original rectangle. (8)

2. The time of swing of a pendulum is given by the following formula:

$$t = 2\pi\sqrt{\frac{L}{g}}$$

   Transpose the formula to make g the subject. (8)

3. A plate is in the form of an equilateral triangle. The area of the plate is $1.93m^2$.

   Calculate the length of side of the triangle. (8)

4. A flywheel has a diameter of 660mm and rotates at 154 rad/s.

   Calculate EACH of the following:

   (a) the rotational speed of the flywheel in rev/min; (4)

   (b) the linear velocity of a point on the flywheel rim; (3)

   (c) the angular retardation if the flywheel slows uniformly from running speed to rest in 25 seconds. (3)

5. Table Q5 give the load carrying capacity of roller bearing journals running at speed.

Bore (mm)	25	35	55	65
Safe load (kg)	626	1031	2182	3143

Table Q5

(a) Plot the graph from the tabular values. (6)

(b) Estimate, using the graph in Q5(a), the safe load in kg for a roller bearing having a bore of 45mm. (2)

Suggested scale: *1cm = 2.5mm bore*
1cm = 250kg load

6. Fig Q6 shows a section of a vertical support column having a wall thickness of 9mm. A vertical load of 3.6 tonne is applied at the top of the column.

Calculate EACH of the following:

(a) the stress in the column in N/mm^2 (6)

(b) the strain in the column given that the modulus of elasticity E for the material is $201GN/m^2$. (4)

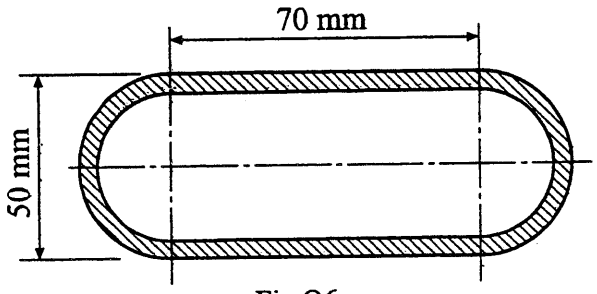

Fig Q6

7. A bulkhead is 27m wide and 18m deep and is flooded to the top on one side only with water of density $1023kg/m^3$.

Calculate EACH of the following:

(a) the pressure at a point 16m below the water surface; (3)

(b) the length of a rectangular plate, 1m high, positioned with its lower edge 15.5m below the surface if the hydrostatic force is not to exceed 0.3MN. (5)

8. Calculate the distance a mass of cast iron, 1.25m long x 0.88m x 0.8m, already on board, must be moved across the deck to cause a vessel of 844 tonne to heel by 0.7^0. (8)

Note: $KG = 4.7m$ $KM = 5.9m$ *density of CI* $= 7.2 \times 10^3 kg/m^3$

9. A box barge 18m long and 6m beam has a displacement of 550 tonnes and floats in water of density $1018 kg/m^3$.

Calculate the height of the transverse metacentre above the keel. (8)

Given $BM = \frac{I}{V}$ and $I = \frac{LB^3}{12}$

L = length (m)

B = beam (m)

V = underwater volume (m^3)

10. The coefficient of friction between a mass of 25kg and a horizontal plane is 0.18.

Calculate EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the acceleration if the force is now increased to 320N; (3)

(c) the time taken to travel 8.5m from rest under the action of the accelerating force. (3)

11. Fig Q11 shows a simply supported beam AB.

Calculate the distance *x* metres such that the reaction R_B is 10kN less than reaction R_A. (8)

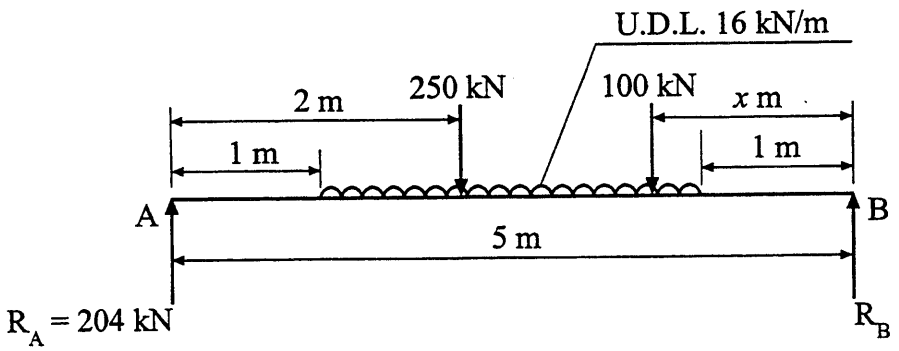

Fig Q11

12. Fig Q12 shows two forces acting at a point *P*.

Calculate the resultant force in both magnitude and direction. (8)

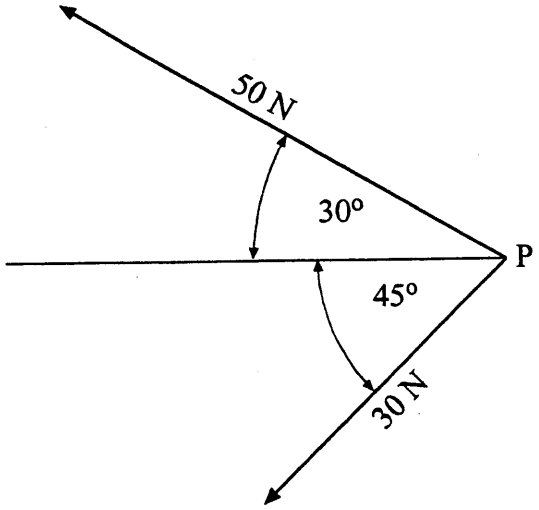

Fig Q12

GENERAL ENGINEERING SCIENCE I SEPT 2005

Attempt ALL questions

Marks for each question are shown in brackets.

1. A flywheel has a diameter of 0.68m and turns at 1400 rev/min.

   Calculate EACH of the following:

   (a) the angular velocity in rad/s; (4)

   (b) the linear velocity in m/s of a point on the flywheel rim. (4)

2. Fig Q2 shows the tapered end of a pump rod.

   Calculate the angle of the taper.

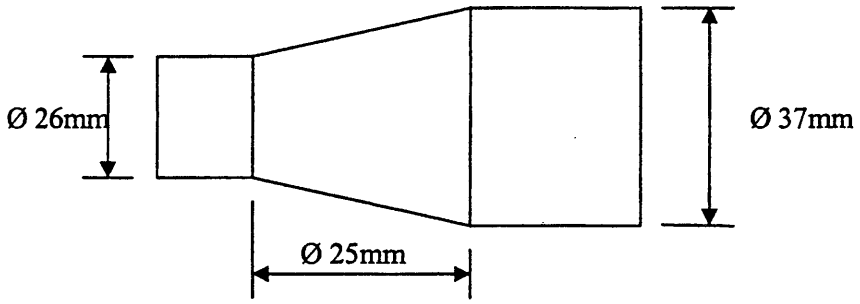

Fig Q2

(8)

3. A solid sphere has a diameter of 186mm.

   Calculate EACH of the following:

   (a) the surface area in m^2; (4)

   (b) the volume in m^3. (4)

4. A rope pulley system consists of three sheaves in one block and two sheaves in the other. The rope pulley system is applied horizontally to move a mass of 650kg along a horizontal plane. The coefficient of friction equals 0.52 between the mass and the plane.

   Calculate the effort required when the three sheave pulley is nearest the load, given that the efficiency of the system is 0.55. (10)

5. One side of a triangle is 46.8mm long.
One adjacent side is 38% longer and the angle between these sides is 59°.

Calculate the area of the triangle. (8)

6. A pump rod is 590mm long and has a modulus of elasticity E = 202GN/m^2.

Calculate the final loaded length when subjected to a direct compressive stress of 18N/mm^2. (10)

7. A ship has a displacement of 1060 tonne. A double bottom tank on the centreline is 1.3m deep by 4.2m wide by 5.76m long and is completely filled with water of density 1018kg/m^3.

Calculate EACH of the following:

(a) the mass of water added to the double bottom tank; (3)

(b) the new position of the ship's centre of gravity G when the tank is filled, given that the original KG is 3.9m. (5)

8. (a) Define EACH of the following terms as applied to a box shaped vessel:

(i) centre of buoyancy; (2)

(ii) metacentre. (2)

(b) A vessel has a displacement of 1313 tonne. When a mass of 4 tonne, already on board, is moved 5m across the deck it causes the vessel to heel by 1.3°.

Calculate the value of GM given $m \times d = \Delta \ GM \tan \theta$. (4)

9. The following formula allows torque to be determined in a shaft.

$$T = \frac{\pi d^3 \tau}{16}$$

Where T = Torque, τ = shear stress, d = shaft diameter.

(a) Transpose the formula to make d the subject. (3)

(b) Calculate the value of d when T = 575kNm, π = 3.14 and τ = 78MN/m^2. (5)

10. A bulkhead is 17m high and 13m wide and is flooded on one side only with water of density 1023kg/m^3.

Calculate EACH of the following:

(a) the pressure, in bar, at the base of the bulkhead; (3)

(b) the hydrostatic force on an access door, 1.5m x 1.5m, the lower edge of which is situated 2m above the bottom of the bulkhead. (5)

11. Fig Q11 shows a simply supported beam AB.

Calculate the value of reactions R_A and R_B (8)

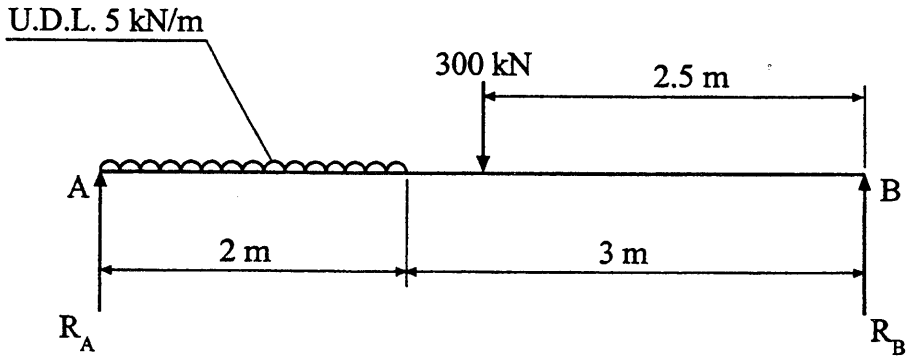

Fig Q11

12. A pump delivers 50m^3 of sea water, having a density of 1025kg/m^3, to a height of 23m in 25 minutes.

Calculate EACH of the following:

(a) the output power of the pump in kW; (5)

(b) the input power of the pump if the efficiency of the pump is 0.73. (3)

GENERAL ENGINEERING SCIENCE I July 2005

Attempt ALL questions

Marks for each question are shown in brackets.

1. An equilateral triangle has an area of $2.68m^2$.

   Calculate the length of the sides of the triangle. (8)

2. A rectangular sheet of metal, *x*cm by *y*cm, has squares of *z*cm cut from EACH corner. The sheet is then bent to form a tray of depth *z*cm.

   (a) Derive an expression for the contained volume of this tray. (4)

   (b) Calculate the volume of the tray using the expression derived from Q2(a) and the following values, $x = 6cm$, $y = 8cm$ and $z = 1cm$. (4)

3. The following formula relates to acceleration, time and distance.

$$a = 2\frac{(s - ut)}{t^2}$$

   (a) Transpose the formula to make *u* the subject. (4)

   (b) Find the value of *u* in km/h when $s = 90m$, $a = 9.81m/s^2$ and $t = 2.75s$. (4)

4. Calculate the mass of a piece of steel tube 1.85m long having an outside diameter of 38mm and a tube wall thickness of 5.5mm. (10)

   Note: Steel is 7.7 times heavier than an equal volume of fresh water.

5. A uniform beam AB supported at each end is 7m long and has a mass of 2.15 tonne. A uniformly distributed load of 4kN/m run is applied from the A or left hand end over a length of 3m.

   Calculate the value of the reaction forces at points A and B. (8)

6. A box barge is 18m long x 6m beam and floats at a draught of 5m in water of density 1024kg/m^3. When a mass of 3 tonne, already on board, is moved 4m across the deck the barge heels by 1.3°.

Calculate the height of the transverse metacentre M above the keel given that KG = 2m. (8)

Note: $m \times d = \Delta GM \tan\theta$

7. An observation tank is 4m long x 4m wide x 5m deep and contains liquid of density 1006kg/m^3 to a depth of 4.3m.

A square glass viewing port, 0.5m x 0.5m, is fitted in the centre of one side.

Calculate EACH of the following:

(a) the hydrostatic pressure on the bottom edge of the glass viewing port; (4)

(b) the hydrostatic force on the glass. (4)

8. A vessel has an underwater volume of 2439m^3 in water of density 1025kg/m^3 with KG = 3.95m.

Two cylindrical tanks 5m diameter and 12m long are located symmetrically about the centre line and are now filled with liquid having a density of 1018kg/m^3.
KG of tanks = 2.7m.

Calculate the shift in the centre of gravity G in the vessel in BOTH magnitude and direction. (8)

9. A flywheel has a diameter of 120mm and rotates at 98 rad/s.

Calculate EACH of the following:

(a) the angular velocity of the flywheel in revolutions per minute; (2)

(b) the linear velocity of a point on the rim in km/h. (6)

10. A worm and wheel lifting device has a single start worm which is operated by a belt driven pulley 150mm in diameter. The wheel has 50 teeth and the load drum diameter is 100mm.

Calculate EACH of the following:

(a) the movement ratio; (3)

(b) the effective pull in the belt if the efficiency is 35% and the load is 265kg. (5)

11. The coefficient of friction between a body of mass 40kg and a horizontal plane is 0.4.

Calculate EACH of the following:

(a) the least horizontal force to just cause motion; (2)

(b) the acceleration of the body if the force is increased to 300N; (4)

(c) the distance the body moves in 5 seconds from rest under the action of the accelerating force. (4)

12. A hole 22mm in diameter is to be punched through a piece of plate 25.4mm thick.

Calculate the load in the punch given that the shear strength of the plate material is $400N/mm^2$. (8)

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions APRIL 2005

Marks for each question are shown in brackets.

1. A pump discharges $95m^3$ of sea water to an upper deck situated 14.8m vertically above the pump in 1 hour 7 minutes.

   Calculate the power supplied to the pump motor if the system efficiency is 71%.

   Note: Sea water density is 1025kg/m³. (8)

2. The area of a circle is $1.06m^2$.

   Calculate the volume of a sphere having the same radius as the circle. (8)

3. A right angled triangle is standing on its base which is 6cm long.
   The vertical height is 2.3 times the length of the base.

   Calculate EACH of the following:

   (a) the other base angle; (3)

   (b) the difference in length between the vertical height and the hypotenuse. (5)

4. A piece of steel has a mass of 23.7kg and sits on an air lubricated horizontal surface.

   Calculate EACH of the following:

   (a) the value of the coefficient of friction if it takes a force of 4.65N applied parallel to the surface to just cause motion; (3)

   (b) the acceleration of the mass, if the applied force is now increased to 34N. (5)

5. An electric motor comes to rest from running speed in 1 minute 47 seconds and turns through 1193 revolutions.

   Calculate EACH of the following:

   (a) the running speed in rev/min; (4)

   (b) the retardation in rad/s^2. (4)

[OVER

6. (a) Plot the graph of the equation $y = x^2 + 2$ between the limits of $x = -1$ and $x = 3$. (6)

(b) Indicate on the graph in Q6(a) the value of y when $x = 1.5$. (2)

Suggested scale: x axis: 4cm = 1 unit
y axis: 2cm = 1 unit

7. Calculate EACH of the following:

(a) the movement ratio of the crab winch shown in Fig Q7. (6)

(b) the effort required to lift a mass of 480kg, given that the efficiency of the crab winch in Q7(a) is 0.392. (4)

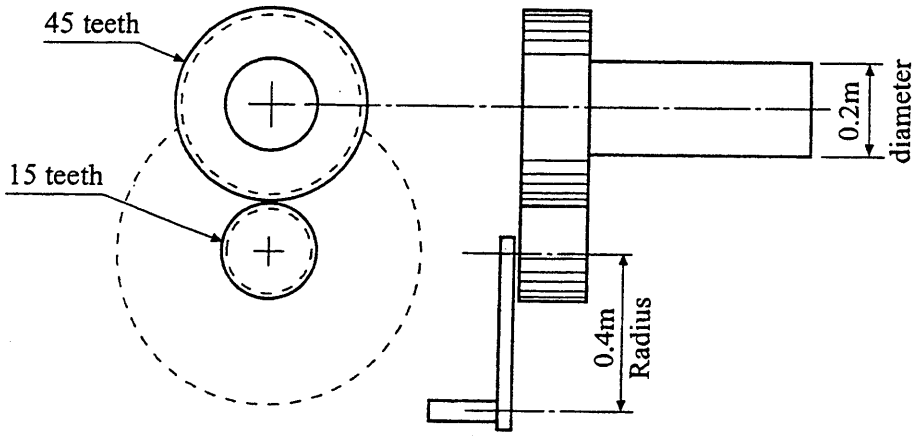

Fig Q7

8. Fig Q8 shows a simply supported beam AB.

An additional 100kN force acting vertically downwards is to be applied to the beam.

Calculate the position of the additional 100kN force, so that reaction R_A = reaction R_B. (8)

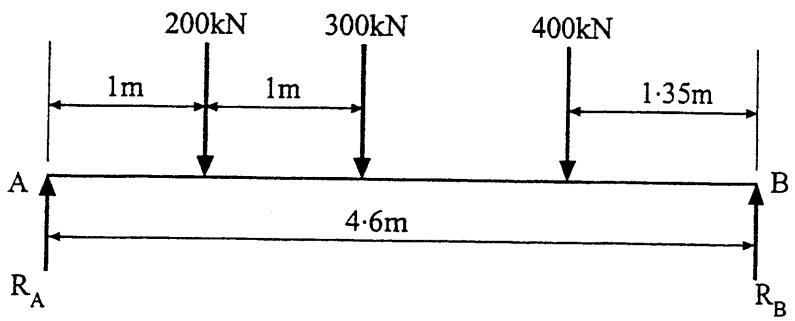

Fig Q8

9. A vessel has an underwater volume of $3918m^3$ in water of density $1021kg/m^3$, and when a mass of 5.5 tonne already on board is moved 9.7m across the deck it causes the vessel to heel by 1.8^0.

Calculate the distance from the keel to the metacentre given that KG = 3.75m and that $m \times d = \Delta GM \tan \theta$. (8)

10. A vertical bulkhead is 7m high and 5m wide and is flooded with sea water to a height of 6.3m on one side only.

Calculate EACH of the following:

(a) the hydrostatic pressure at the base of the bulkhead; (4)

(b) the hydrostatic force on a circular access door 760mm diameter with its centre situated 5.7m down from the top of the bulkhead. (6)

Note: Density of sea water = 1025kg/m³

11. A vessel has a displacement of 6200 tonne and a KG of 5m.
Cargo of average density $1140kg/m^3$ is now loaded to fill a centreline hold 20m wide x 20m long x 8m deep and the centre of gravity of this cargo is 4.7m above the keel.

Calculate the movement of the ship's G when loaded, in both magnitude and direction. (8)

12. Calculate the thread core diameter of an eyebolt to lift a maximum load of 2000kg if the U.T.S. of the material is $490MN/m^2$ and the Safety Coefficient (Factor of Safety) is 8. (8)

GENERAL ENGINEERING SCIENCE I

SEPT 2004

Attempt ALL questions

Marks for each question are shown in brackets.

1. Solve for x in the following equation: (8)

$$\frac{3x}{5} - \frac{(x+12)}{20} = 3.25$$

2. Calculate the perpendicular height of a triangle whose base is 60mm in length and whose area is $3 \times 10^{-3} m^2$. (8)

3. A solid lead cone having a base diameter of 144mm and perpendicular height of 232mm is melted down and recast into FIVE identical spheres.

   Calculate the diameter of these spheres assuming 7% of the cone volume is lost in the process. (8)

4. The thread of a screw jack has a pitch of 10mm and the machine is operated by a lever having an effective length of 318mm. The screw jack lifts a mass of 530kg with an applied effort of 58N.

   (a) Define force ratio (mechanical advantage), stating the value for this machine. (4)

   (b) Define movement ratio (velocity ratio), stating the value for this machine. (4)

5. (a) Draw the graph of $y = x^2$ for even values of x between 0 and 10. (7)

   (b) Determine from the graph drawn in Q5(a) the value of the square root of 75. (3)

   Suggested scales: *X axis* *1 cm = 0.5*
   Y axis *1 cm = 5*

[OVER

6. The area of a trapezium is given by the formula $A = \frac{(a+b)h}{2}$

(a) Transpose the formula to make b the subject. (4)

(b) Calculate the value of b given that $A = 48\text{m}^2$, $a = 5\text{m}$ and $h = 4\text{m}$. (4)

7. A box barge has a length to beam ratio of 2.8:1 and an underwater volume of 484m^3 when floating in water of density 1018kg/m^3. The beam of the barge is 6m.

Calculate EACH of the following:

(a) the hydrostatic pressure on the bottom plating; (4)

(b) the hydrostatic force on the bottom plating. (4)

8. A vessel has a centre of gravity of 4.93m while the position of the metacentre is 5.95m above the keel. A mass of 6.5 tonne already loaded on the vessel is now moved 3.25m across the deck causing the vessel to heel by 0.8°.

Calculate the displacement of this vessel given that $m \times d = \Delta GM \tan\theta$. (8)

9. A vessel has a displacement of 4324 tonne with a KG = 4.7m.
A centreline double bottom tank 18.2m long x 9.8m beam x 1.9m deep is now filled with fuel oil, relative density(specific gravity) 0.878.

Calculate the new position of the centre of gravity above the keel. (8)

10. The velocity of a 45kg mass is increased from 1.75m/s to 2.15m/s in 2 seconds.

(a) Calculate the accelerating force required. (5)

(b) The mass is now retarded with uniform retardation of 0.3m/s^2 until the mass just comes to rest.

Calculate EACH of the following for the retardation period:

(i) the time taken to come to rest; (2)

(ii) the distance travelled. (3)

11. A steel pipe in a fresh water system has an external diameter of 38mm, an internal diameter of 32mm and is 10.3m long. Relative density of steel is 7.8.

Calculate EACH of the following:

(a) the mass of the pipe; (5)

(b) the volume of fresh water in the pipe. (3)

12. Fig Q12 shows a simple wall crane.

Calculate EACH of the following:

(a) the force in the jib; (3)

(b) the direct stress in the jib given that the jib is of hollow section 190mm x 190mm with 7.5mm wall thickness. (5)

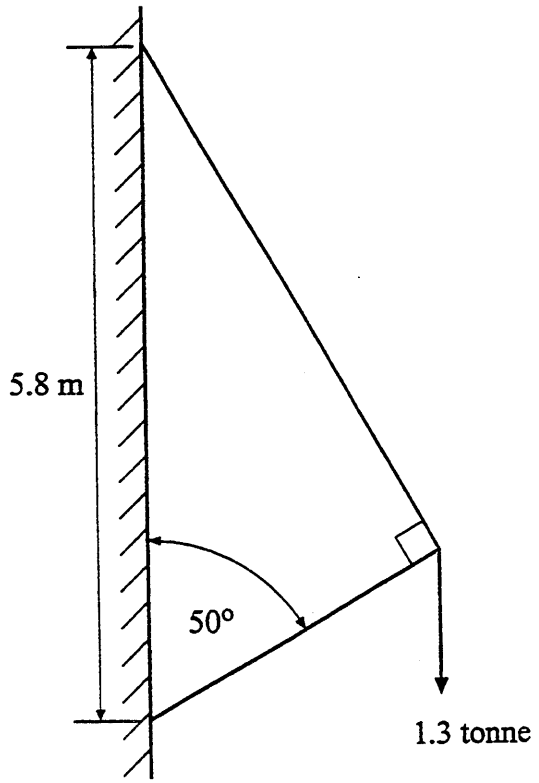

Fig Q12

GENERAL ENGINEERING SCIENCE I

June 2004

Attempt ALL questions

Marks for each question are shown in brackets

1. Given that y = 16 when x = 2, and that y is directly proportional to x^2.

   Calculate the value of y when x = 5 (8)

2. A sphere of diameter 9cm is recast into a solid right cone having a base radius of 4cm.

   Calculate the perpendicular height of the cone if 15% of the sphere volume is lost in the casting process. (8)

3. The following formula can be used to determine the minimum wall thickness in tubes.

   Transpose the formula to make P the subject:

$$T = \frac{PD}{2f + P}$$

   (8)

4. Calculate the area of an equilateral triangle having sides of length 11cm. (8)

5. The law of a straight line is given by $Y = aX + b$.

   (a) Define the term a in the expression. (2)

   (b) Define the term b in the expression. (2)

   (c) (i) Plot and join the pairs of points in Table Q.5 (4)

   (ii) Determine the values of a and b from the graph plotted in Q.5(c)(i) (2)

X	-1	0	1	2
Y	0.5	1.0	1.5	2.0

Table Q.5

[OVER

6. A steel rod 2.1cm diameter is subjected to an axial load of 495kg and extends by 0.07 mm. On removal of the load the rod assumes its normal length of 94cm.

Calculate EACH of the following:

(a) the stress in the rod when loaded; (4)

(b) the strain in the rod when loaded; (3)

(c) the value of the modulus of elasticity (E) for the material. (3)

7. A tank is 7 metres deep with sides of 3.1 metres and is 96% full of water having a density of 1015 kg/m^3.

Calculate EACH of the following:

(a) the pressure on the bottom of the tank; (4)

(b) the hydrostatic force on the sides of the tank. (4)

8. Pump A can fill a tank in 12 hours.

Pump B can fill the same tank in 8 hours.

Pump C can fill an identical tank in 9 hours.

Calculate the time in hours and minutes to fill the tank if all pumps are working together. (8)

9. A vessel has a displacement of 4900 tonne. Four double bottom tanks are now filled to 73% capacity with water of density 1022 kg/m^3, each tank having the following dimensions: length 8 metres; width 4.6 metres; depth 3.15 metres.

Calculate the position of G in the vessel if the original KG was 3.9 metres. (8)

10. A simple wheel and axle lifting machine has the following dimensions:

diameter of axle 75 mm
diameter of wheel 300 mm

Calculate EACH of the following:

(a) the movement ratio (velocity ratio) of the machine; (3)

(b) the efficiency of the machine if it requires an effort of 240 N to just lift a mass of 54kg. (5)

11. A vessel has a displacement of 4860 tonne and when a mass of 5 tonne, already on board, is moved 7 metres across the deck the vessel heels by 1^0.

Calculate the value of KG given that KM = 4.75 metres and

$$m \times d = \Delta GM \tan \theta$$ (8)

12. Fig Q.12 shows two forces acting at a point P.

Determine the resultant force in EACH of the following:

(a) magnitude; (4)

(b) direction. (4)

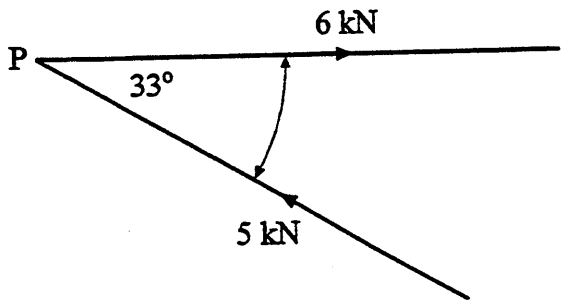

Fig Q12

GENERAL ENGINEERING SCIENCE I

FEB 2004

Attempt ALL questions

Marks for each question are shown in brackets

1. Simplify EACH of the following:

   (a) $1\frac{1}{3}+2\frac{3}{4}-1\frac{9}{16}$ (3)

   (b) $6a-\{3a-[4a-(7-2a)]\}$ (5)

2. A right angled triangle has an area of 2 m^2. The sides are in the ratio of 5:12:13 and the triangle stands with the shortest side as the base.

   Calculate EACH of the following:

   (a) the perpendicular height; (6)

   (b) the length of the hypotenuse. (2)

3. (a) Define the radian. (2)

   (b) Calculate the number of degrees in 1.75 radian. (2)

   (c) Calculate the angular velocity of a flywheel if a point on the rim passes a counter 16 times in 25 seconds. (4)

4. Calculate the mass of a piece of steel tube 2.85m long having an inside diameter of 25mm and a tube wall thickness of 6mm. (8)

   Note: Steel is 7.6 times heavier than an equal volume of fresh water.

5. In a test on a lifting machine the following results were obtained:

W = Load = 10.193kg P = Effort = 10N

Load = 20.38kg Effort = 15N

Movement ratio (velocity ratio) = 40

b = Slope
a = y Axis Intercept.

$b = \frac{Y}{x}$

Calculate EACH of the following:

(a) the linear law of the machine; $P = a + b(W)$ (6)

(b) the force ratio (mechanical advantage) and efficiency when the load is 81.55kg. (4)

6. (a) Draw the graph of $y = x^2$ for values of x between –1 and +2 (4)

(b) Using the same axes draw the graph of $y = x + 1.5$ (4)

(c) Determine the co-ordinates of the points of intersection of the graphs drawn in Q6(a) and (b). (2)

Suggested scale: 4cm = 1 unit X

4cm = 1 unit Y

7. A box barge 22 metres long and 12 metres beam, has a mass of 960 tonne and floats in water of density 1017 kg/m^3.

Calculate the absolute pressure on the bottom plating if the atmospheric pressure is 1.013 bar. [1·37 BAR] (8)

8. A bulkhead 29 metres wide and 18 metres deep is flooded to the top, on one side only, with water of density 1025kg/m^3.

Calculate the hydrostatic force on the bulkhead in MN. (8)

9. When a mass of 12 tonne is moved 5.2 metres across the deck it causes a vessel to heel by 0.6^0.

Calculate the displacement of the vessel given that KM = 5.8m, KG = 4.9m and that

$$m \times d = \Delta GM \tan\theta$$

(8)

10. A body laying on a horizontal surface has a mass of 11.8kg and requires a horizontal force of 66N to just cause motion.

Calculate EACH of the following:

(a) the value of the coefficient of friction; (3)

(b) the acceleration that would result if a horizontal force of 122N was applied. (5)

11. A uniform simply supported beam AB, having a mass of 1.07 tonne, is shown in Fig. Q.11

Calculate EACH of the following:

(a) the value of the reaction R_A; (5)

(b) the value of the reaction R_B. (3)

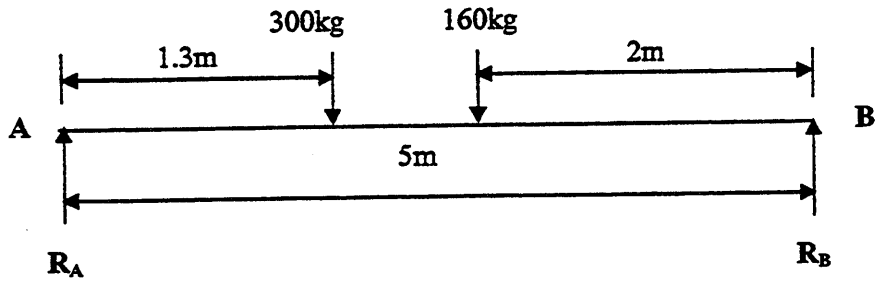

Fig. Q11

12. A pile is to be sunk 4 metres into the seabed.

Calculate the length of the pile if 33% of the pile length is to be immersed in the water and one quarter of the pile length is to be above the water surface. (8)

OCT 2003

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

1. Calculate the value of y when $x = 1.957$, given that y varies as the cube of x, and that $y = 18$ when $x = 3$. (8)

2. Fig. Q2 shows a triangular plate ABC.

   Calculate EACH of the following:

   (a) The length of side BC; (4)

   (b) The area of the plate in m^2. (4)

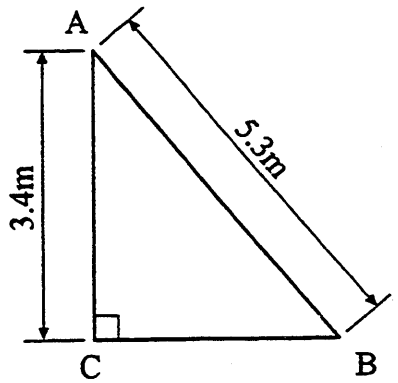

Fig Q2

3 Table Q3 gives the mass lifted W(kg) and the corresponding effort E(Newtons) for a lifting machine.

W (kg)	3	9	15	18
E (N)	45	73	105	118

Table Q3

(a) Draw a graph for load values between 0 and 20 kg from the data given in Table Q3. (6)

(b) Determine, using the graph drawn in Q3(a) the effort needed to lift a mass of 13kg. (2)

(c) State the significance of the point where the graph in Q3(a) cuts the 0 kg load axis. (2)

Note. *Suggested scale W axis 1 cm = 2kg*
E axis 1cm = 5N

(6)

4. A hollow shaft has the following dimensions:

Length 3.36m, outside diameter 45mm and inside diameter 83% of the outside diameter.

Calculate the mass of the shaft given that the material has a relative density of 7.3. (10)

5. An accelerating force of 35N is applied to a body of mass 18kg in a horizontal plane.

Calculate EACH of the following:

(a) the acceleration of the body; (3)

(b) the distance the body will travel from rest in 12 seconds. (5)

6. Calculate the draught of a loaded box barge floating in water of density $1018kg/m^3$ given that the external pressure on the bottom plating is $51.7kN/m^2$. (8)

7. A solid sphere has a diameter of 15cm and is melted down and recast into a rectangular block.

Calculate the length of the block to the nearest cm given that the width is to be 95mm and the height is to be 124mm. (8)

8. (a) Define the radian and express its value in degrees. (4)

(b) Calculate EACH of the following:

(i) the angular velocity in radians/second for the hour hand of a clock; (2)

(ii) the angular velocity in radians/second for the minute hand of a clock. (2)

9. (a) Indicate on a simple transverse sketch of a box barge the position of EACH of the following:

(i) centre of gravity; (1)

(ii) centre of buoyancy; (1)

(iii) metacentre. (1)

(b) Calculate the value of GM for a box barge floating at a draft of 5m, given that KG = 3.83m and BM = 2.79m. (5)

10. Calculate the distance a mass of 15 tonne, already loaded on the vessel, must be moved across the deck to cause the vessel to heel by 1.3°.

Displacement =5333 tonne KM = 4.8m KG =3.9m.

Given that $m \times d = \Delta GM \tan\theta$. (8)

11. Fig Q11 shows a simply supported beam AB.

The value of the uniformly distributed load is 1.5kg/m.

Calculate the values of reaction forces R_A and R_B (8)

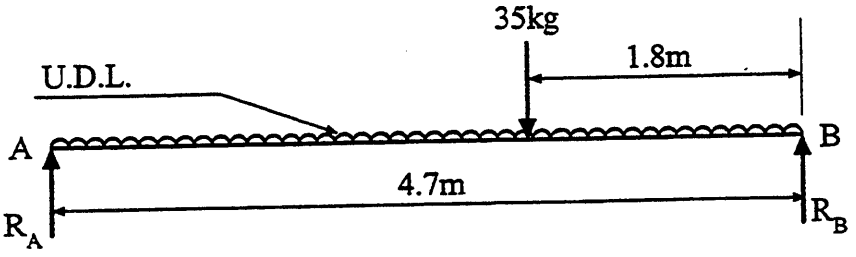

Fig Q11

12. Fig Q12 shows a circle with two tangents at right angles. Given that the radius of the circle is x, prove that the shaded area is equal to $x^2\left(1 - \frac{\pi}{4}\right)$ (8)

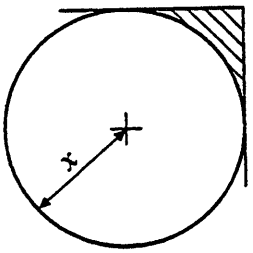

Fig Q12