GENERAL ENGINEERING SCIENCE I March 2017

Attempt ALL questions

Marks for each question are shown in brackets.

1. A sample of exhaust gas was analysed by volume and was found to be made up of 1 part Sulphur Dioxide, 38 parts Oxygen, 200 parts Carbon dioxide and 750 parts Nitrogen.

   Calculate the volume of EACH gas in 10 m^3 of exhaust. (8)

2. A cable stretched between TWO fixings sags under its own weight. The amount by which it sags is given by the approximate expression:

$$s = \sqrt{\left(\frac{3d(L-d)}{8}\right)}$$

   Determine the value for L when s = 0.75 and d = 1.15. (8)

3. A function is given by the equation:

$$y = 1.5\,x^2 + 2$$

   (a) determine a table of data for the range x = -2 to x = 2 showing the method used; (4)

   (b) sketch a graph of the data determined in 3 (a); (4)

   (c) from the graph estimate the value for x when y = 5. (2)

4. A gas bottle, Fig Q4, can be approximated to a cylinder with flat circular base of diameter 23 cm with a hemi-spherical top. The overall height is 164 cm. The thickness of the bottle can be neglected. The mass of the bottle when filled is 87 kg of which 20% is the mass of the empty bottle.

Determine the density of the contents when the bottle is full. (8)

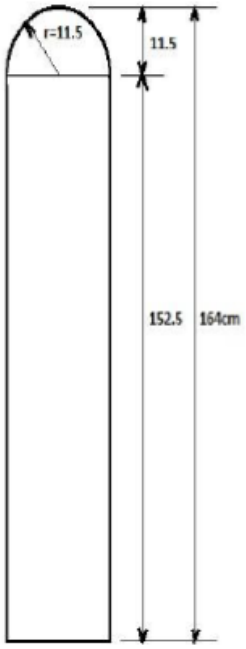


Fig Q4

5. Using Pythagoras Theorem determine the length AC from Fig Q5. (10)

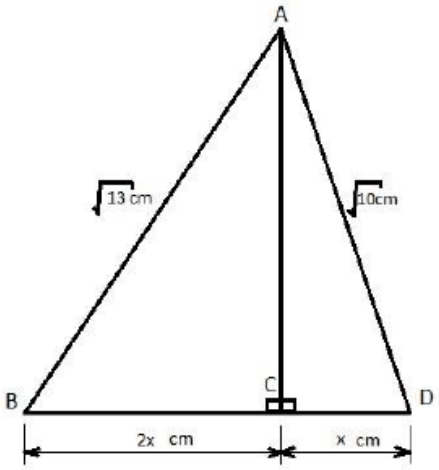


Fig Q5

6. Fig Q6 shows a section of a wind turbine support column. The turbine and nacelle assembly has a combined mass of 4.9 tonnes on top of the column.

$g = 9.81\ m/s^2$

Calculate EACH of the following:

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

(b) the direct strain in the column given that the modulus of elasticity E for the material is 196 GN/m^2. (4)

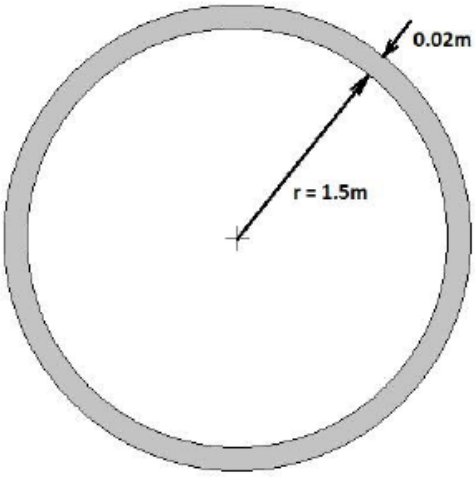


Fig Q6

5. A simple hoist has a pulley and axle with a pulley diameter of 220 mm on an axle of 55 mm diameter:

(a) Sketch the basic hoist with dimensions. (2)

(b) Determine EACH of the following:

(i) the movement ratio (velocity ratio) of the machine; (3)

(ii) the force ratio (mechanical advantage) of the machine if it requires an effort of 300 N to just lift a mass of 100 kg; (3)

(iii) the efficiency of the machine under the conditions described in 5(bii). (2)

6. A mass of 80 kg has a velocity of 1.5 m/s. Its velocity is uniformly increased to 3.0 m/s in 15 seconds. The effects of friction can be ignored.

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

(b) A brake is applied and the velocity of the mass is now uniformly retarded at 0.5 m/s^2 from 3.0 m/s until the mass just comes to rest.

Calculate, for the retardation period of EACH of the following:

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

(ii) the distance travelled. (2)

1. A sample of exhaust gas was analysed by volume and was found to be made up of 1 part Sulphur Dioxide, 38 parts Oxygen, 200 parts Carbon dioxide and 750 parts Nitrogen.

   Calculate the volume of EACH gas in 10 m^3 of exhaust. (8)

S $1/989 \times 10 \simeq 0.01\ m^3$

O $38/989 \times 10 = 0.38423\ m^3$

C $200/989 \times 10 = 2.0222\ m^3$

N $750/989 \times 10 = 7.58\ m^3$

2. A cable stretched between TWO fixings sags under its own weight. The amount by which it sags is given by the approximate expression:

$$s = \sqrt{\left(\frac{3d(L-d)}{8}\right)}$$

Determine the value for L when s = 0.75 and d = 1.15. (8)

$$S = \sqrt{\frac{3d(L-d)}{8}}$$

$$0.75 = \sqrt{\frac{3.45(L-1.15)}{8}}$$

$$0.5625 = \frac{3.45(L-1.15)}{8}$$

$$4.5 = 3.45(L-1.15)$$

$$\left(\frac{4.5}{3.45}\right) + 1.15 = 2.5543$$

3. A function is given by the equation:

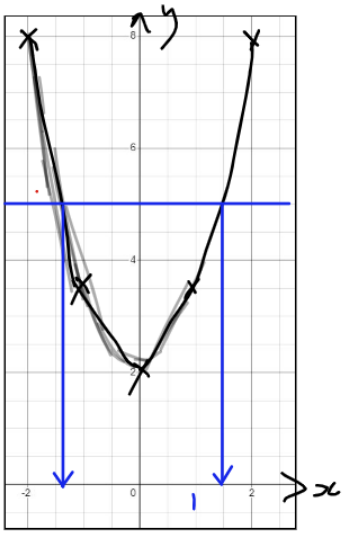
$$y = 1.5x^2 + 2$$

(a) determine a table of data for the range x = -2 to x = 2 showing the method used; (4)

(b) sketch a graph of the data determined in 3 (a); (4)

(c) from the graph estimate the value for x when y = 5. (2)

x	y
-2	$1.5(-2)^2+2 = 8$
-1	$1.5(-1)^2+2 = 3.5$
0	$1.5(0)^2+2 = 2$
1	$1.5(1)^2+2 = 3.5$
2	$1.5(2)^2+2 = 8$

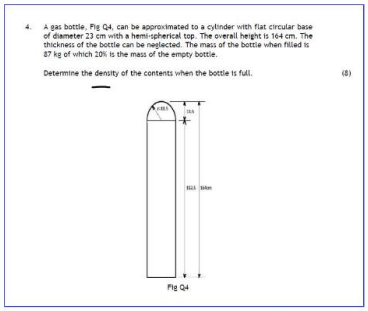


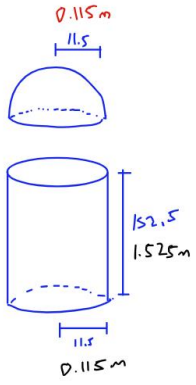
c) when $y = 5$

$x = 1.5$ or $x = -1.5$

4. A gas bottle, Fig Q4, can be approximated to a cylinder with flat circular base of diameter 23 cm with a hemi-spherical top. The overall height is 164 cm. The thickness of the bottle can be neglected. The mass of the bottle when filled is 87 kg of which 20% is the mass of the empty bottle.

Determine the density of the contents when the bottle is full. (6)





Volume

$$\frac{\frac{4}{3}\pi r^3}{2} = \frac{\frac{4}{3}\pi(0.115)^3}{2} = 3.18531 \times 10^{-3}\ m^3$$

$$b \times h = \pi r^2 h = \pi(0.115)^2(1.525) = 0.06336\ m^3$$

total volume $= 0.066543534\ m^3$

Mass of Gas

$87\ kg \times 0.8 = 69.6\ kg$

$$\text{Density} = \frac{\text{mass}}{\text{Vol}} = \frac{69.6\ kg}{0.066543534\ m^3} = 1045.9\ kg/m^3$$

5. Using Pythagoras Theorem determine the length AC from Fig Q5. (10)

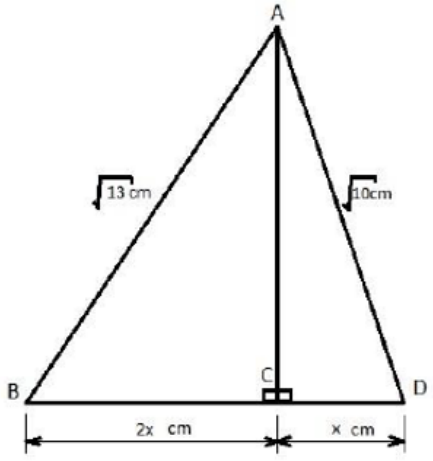
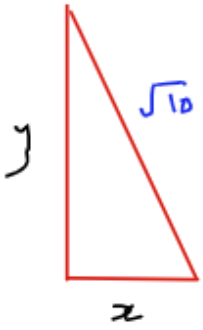


Fig Q5



$y^2 = (\sqrt{13})^2 - (2x)^2$

$13 - (2x)(2x)$

$y^2 = 13 - 4x^2$

$y^2 = (\sqrt{10})^2 - (x)^2$

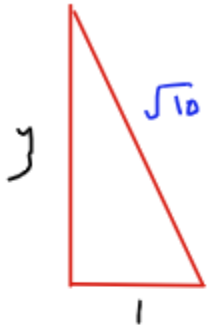
$y^2 = 10 - x^2$

$13 - 4x^2 = 10 - x^2$

$3 = 3x^2$

$1 = x^2$

$1 = x$



$$y = \sqrt{\left(\sqrt{10}\right)^2 - 1^2}$$

$$y = \sqrt{10 - 1}$$

$$y = \sqrt{9} = 3$$

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$g = 9.81\ m/s^2$

Calculate EACH of the following:

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

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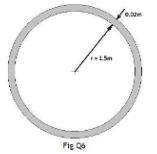

Fig Q6

[OVER

stress = $\frac{F}{A}$

strain = $\frac{\epsilon x}{orig}$

Elq = $\frac{Stress}{Strain}$

a) Area $\pi R^2 - \pi r^2$ $R = 1.52$ $r = 1.5$

$\pi(1.52)^2 - \pi(1.5)^2 = 0.18775219\ m^2$

Force $4900 \times 9.81 = 48069$

Stress $\frac{48069\ N}{0.18775219\ m^2} = 253325\ N/m^2$

b) $196 \times 10^9 = \frac{253325}{strain}$

$strain = \frac{253325}{196 \times 10^9} = 1.29 \times 10^{-6}$

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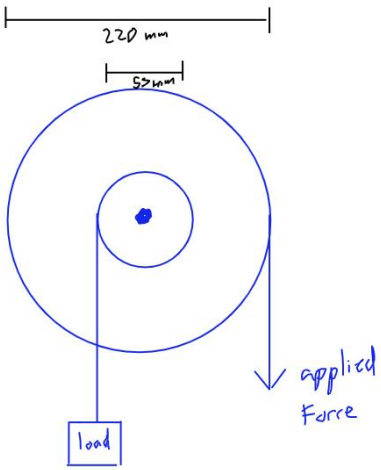

$E = \frac{F}{M}$

b) Movement = $\frac{Distance\ I\ travel}{Distance\ load\ travels} = \frac{\pi D}{\pi d} = \frac{\pi 220}{\pi 55} = 4$

ii) Force Ratio = $\frac{Force\ lifted}{Force\ Applied} = \frac{100 \times 9.81}{300} = \frac{981}{300} = 3.27$

iii) $E = \frac{3.27}{4} \times 100 = 81.75\ \%$

6. A mass of 80 kg has a velocity of 1.5 m/s. Its velocity is uniformly increased to 3.0 m/s in 15 seconds. The effects of friction can be ignored.

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

(b) A brake is applied and the velocity of the mass is now uniformly retarded at 0.5 m/s² from 3.0 m/s until the mass just comes to rest.

Calculate, for the retardation period of EACH of the following:

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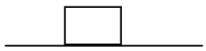

$s =$
$u = 1.5$
$v = 3.0$
$a =$
$t = 15$

$v = u + at$

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

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

Calculate a first

$3.0 = 1.5 + 15a$

$\frac{1.5}{15} = a = 0.1 \text{ m/s}^2$

$F = ma$

$F = 80 \times 0.1 = 8 \text{ N}$

b)

s
$u = 3.0$
$v = 0$
$a = -0.5$
t

$v = u + at$

$0 = 3 - 0.5t$

$t = 6$

$s = 6 \times 3 + \frac{1}{2}(-0.5)6^2$

$s = \frac{3}{2} \times 6 = 9 \text{ m}$