GENERAL ENGINEERING SCIENCE I July 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 2 parts Sulphur Dioxide, 40 parts Oxygen, 198 parts Carbon Dioxide and 770 parts Nitrogen.

   Calculate the percentage of EACH gas in the exhaust. (8)

2. (a) Plot the data in Table Q2 on a graph and derive the equation describing the data. (6)

x	-1	0	1	2	3	4
y	-1	2	5	8	11	14

Table Q2

(b) Determine the value of y when x is 2.5. (2)

3. (a) For the triangle shown in Fig Q3 determine the length AB. (4)

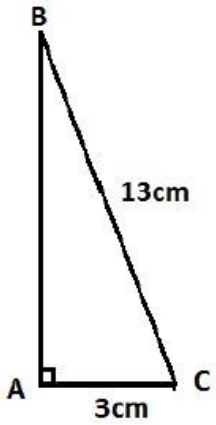


Fig Q3

(b) An engine crankshaft has an angular velocity of 628 rads/min. Determine the angle in degrees through which a crankpin rotates in 1 second. (4)

4. It is required to cast a new white metal bearing which can be considered to be of a hollow cylinder 80 mm long 150 mm internal diameter with a wall thickness of 8 mm.

A suitable mould is available together with some white metal bearing material which has been cast as flat bottomed cones of height 40 mm and base diameter 35 mm.

Calculate the minimum number of cones that will need to be melted down to provide sufficient material for the casting. (8)

5. Fig Q5 shows a loaded uniform beam with a mass 800 kg:

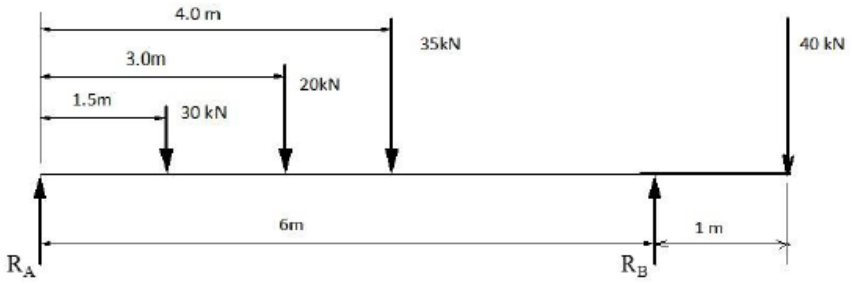


Fig Q5 (not to scale)

Calculate EACH of the following:

(a) the reaction, R_A; (6)
(b) the reaction, R_B. (4)

6. Fig Q6 shows a cross section of a bridge support column. The bridge assembly has an effective mass of 100 tonnes on top of the column. The column has a rectangular central section of length 2 m joined by semi-circular ends.

(a) If the compressive stress limit is 350 MN/m^2 determine whether the column can withstand the load; (5)

(b) Calculate the strain in the column given that the Modulus of Elasticity E for the material is 196 GN/m^2. (3)

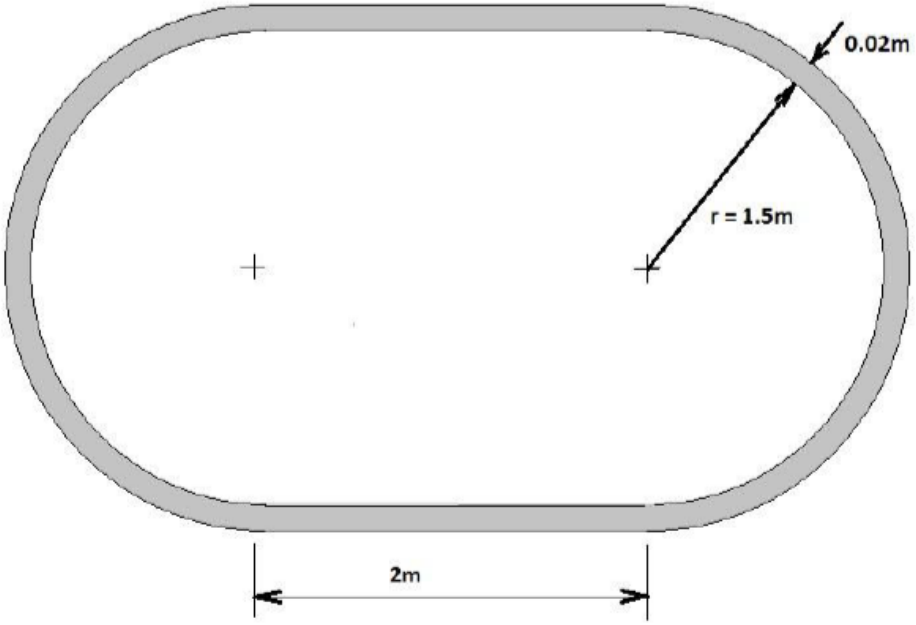


Fig Q6 (not to scale)

7. A box with a mass of 20 kg rests on a horizontal surface. The box has a force of 75 N applied to it in a direction parallel to the horizontal surface.
Determine EACH of the following:

(a) the acceleration of the box with no friction; (3)

(b) the acceleration of the box when a friction coefficient of 0.35 exists between the box and the surface. (5)

8. A power winch raises a mass of 1000 kg through a distance of 9 m in 16 seconds.

The power input to the system in measured at 6.5 kW.

Calculate the system efficiency. (8)

11. A press is used to punch rivet holes in steel plate. The plate is 25 mm thick and the holes required should have a diameter of 20 mm. The steel has an ultimate shear strength of $380N/mm^2$.

a. Calculate the force required to punch each hole. (4)
b. Briefly describe the following terms:

i. Compressive stress; (2)

ii. Tensile stress. (2)

12. Simplify the following showing all working :

(a)

$$\frac{A^2D^2\sqrt{B}}{C^2} \div \frac{A^2}{\sqrt{B}\,DC^2} \quad (4)$$

(b)

$$\left(9\frac{5}{8} \div 2\,{}^{3}/_{4}\right) + 2\frac{2}{3} \quad (4)$$

1. A sample of exhaust gas was analysed by volume and was found to be made up of 2 parts Sulphur Dioxide, 40 parts Oxygen, 198 parts Carbon Dioxide and 770 parts Nitrogen.

Calculate the percentage of EACH gas in the exhaust. (8)

S $2/1010 \times 100 = 0.1980\%$

O $40/1010 \times 100 = 3.9604\%$

C $198/1010 \times 100 = 19.604\%$

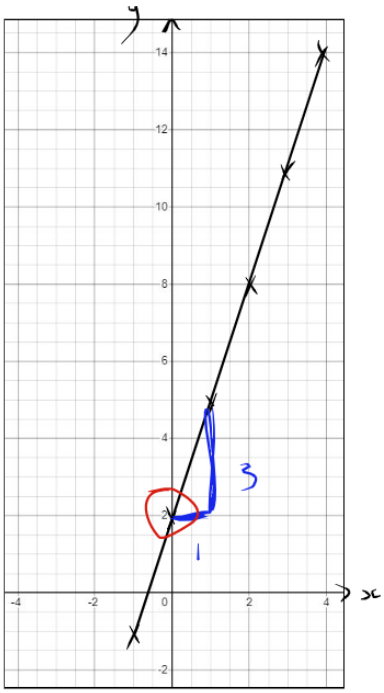
N $770/1010 \times 100 = 76.238\%$

2. (a) Plot the data in Table Q2 on a graph and derive the equation describing the data. (6)

x	-1	0	1	2	3	4
y	-1	2	5	8	11	14

Table Q2

(b) Determine the value of y when x is 2.5. (2)



$y = mx + c$

$m = \frac{3}{1}$ $c = 2$

a) $y = 3x + 2$

b) $x = 2.5$ $y = 3 \times 2.5 + 2 = 9.5$

3. (a) For the triangle shown in Fig Q3 determine the length AB. (4)

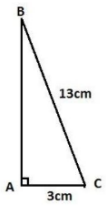


Fig Q3

(b) An engine crankshaft has an angular velocity of 628 rads/min. Determine the angle in degrees through which a crankpin rotates in 1 second. (4)

a) $\sqrt{13^2 - 3^2}$

$\sqrt{169 - 9}$ $\sqrt{160}$ $= 12.649$ cm

$2\pi = 360$

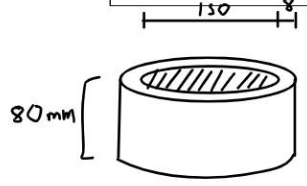
$\div 2\pi \times 360$

b) $\frac{628 \text{ rads}}{60 \text{ sec}} = \frac{10.46667 \text{ rad}}{1 \text{ sec}} \div 2\pi \times 360 = 599.6958°/\text{sec}$

4. It is required to cast a new white metal bearing which can be considered to be of a hollow cylinder 80 mm long 150 mm internal diameter with a wall thickness of 8 mm.

A suitable mould is available together with some white metal bearing material which has been cast as flat bottomed cones of height 40 mm and base diameter 35 mm.

Calculate the minimum number of cones that will need to be melted down to provide sufficient material for the casting. (8)

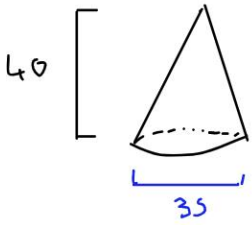


Outer − Inner

$\pi r^2 h - \pi r^2 h$

$R = 83$ $r = 75$

$\pi (83)^2 80 - \pi (75)^2 80 = 31767 \text{ mm}^3$



$V_{ol} = \frac{bh}{3} = \frac{\pi r^2 h}{3} = \frac{\pi (17.5)^2 \times 40}{3} = 12828.7 \text{ mm}^3$

24.7 cones

25 cones

5. Fig Q5 shows a loaded uniform beam with a mass 800 kg:

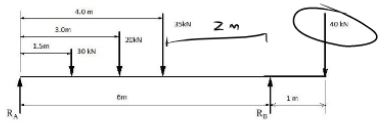
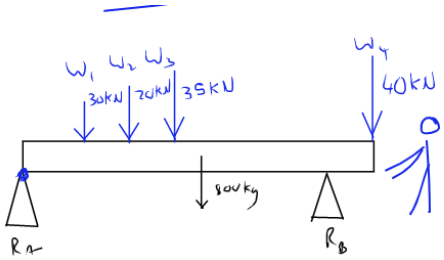


Fig Q5 (not to scale)

Calculate EACH of the following:

(a) the reaction, R_A; (6)
(b) the reaction, R_B. (4)



"Pivot at A" - taking moments about A

the sum of clockwise moments= sum of the anticlock wise moments

total downwards force = total upwards force

Name	Mass kg	Force (N)	Distance (m)	Moment (Nm)	Anti/Clock
W_1		30,000	1.5	45,000	C
W_2		20,000	3	60,000	C
W_3		35000	6	140,000	C
W_4		40000	7	280,000	C
Beam	800	7848	3.5	27468	C
R_B		x	6	6x	A

the sum of clockwise moments= sum of the anticlock wise moments

45,000
60,000
140,000
280,000
27468
$= 6x$

$x = 92,078\ N$

$R_B =$

total downwards force = total upwards force

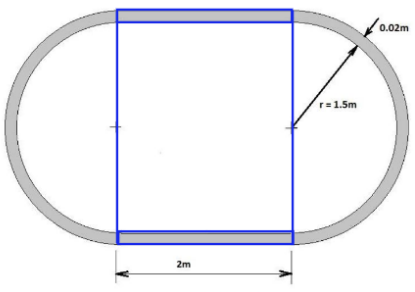
30,000
20,000
35000
40000
7848
$= 92,078 + R_A$

$R_A = 40770\ N$

6. Fig Q6 shows a cross section of a bridge support column. The bridge assembly has an effective mass of 100 tonnes on top of the column. The column has a rectangular central section of length 2 m joined by semi-circular ends.

(a) If the compressive stress limit is 350 MN/m² determine whether the column can withstand the load; (5)

(b) Calculate the strain in the column given that the Modulus of Elasticity E for the material is 196 GN/m². (3)



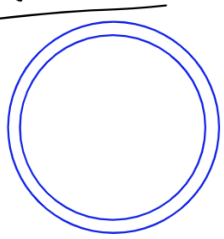
$Stress = \frac{Force}{Area}$

$F = 100,000 \times 9.81$
$= 981,000\ N$

$Strain = \frac{Extension}{original}$

$Elasticity = \frac{stress}{strain}$

Cross Sectional Area



R=1.52 r=1.5

Area

$\pi R^2 - \pi r^2$

$\pi (1.52)^2 - \pi (1.50)^2$

$0.18975219 63 m^2$ + $0.08 m^2$

$= \boxed{0.26\,97521963\ m^2}$

Area

$2 \times 0.02 \times 2$

Stress $= \frac{9\,81,000\ N}{0.26\,97521963\ m^2}$

Stress $= 3,636671\ N/m^2$

Limit is $350,000,000\ Nm^2$

Yes can support load

$3.6\ MNm^2 < 350\ MNm^2$

$$\text{Elasticity} = \frac{\text{stress}}{\text{strain}}$$

$$196 \times 10^9 = \frac{3.6 \times 10^6}{\text{Strain}}$$

$$\text{strain} = \frac{3.6 \times 10^6}{196 \times 10^9} = 1.8367 \times 10^{-5}$$

7. A box with a mass of 20 kg rests on a horizontal surface. The box has a force of 75 N applied to it in a direction parallel to the horizontal surface.
Determine EACH of the following:

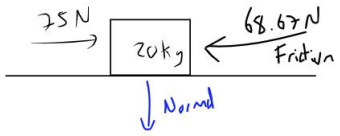
(a) the acceleration of the box with no friction; (3)

(b) the acceleration of the box when a friction coefficient of 0.35 exists between the box and the surface. (5)

a) $F = ma$

$75 = 20\,a$

$\frac{75}{20} = 3.75\ m/s^2$



b) $Friction = \mu N$

$\mu = 0.35$

$N = 9.81 \times 20$

$N = 196.2\ N$

$Friction = 0.35 \times 196.2$

$F = 68.67\ N$

Net horizontal Force

$75 - 68.67 = 6.33\ N$

$F = ma$

$\frac{6.33}{20} = 0.3165\ m/s^2$

8. A power winch raises a mass of 1000 kg through a distance of 9 m in 16 seconds.
The power input to the system in measured at 6.5 kW.
Calculate the system efficiency. (8)

$P = \frac{W}{t} = \frac{F \times d}{t}$

$F = mg = 1000 \times 9.81 = 9810\ N$

$d = 9$

$t = 16$

Theoretical Power $P = \frac{9810 \times 9}{16} = 5518.125$ Watts

$Eff = \frac{Theoretical}{Actual} = \frac{5518.125}{6500} \times 100 = 84.894\%$

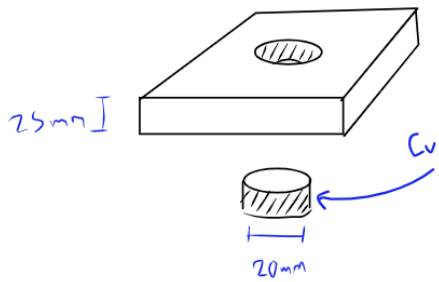
11. A press is used to punch rivet holes in steel plate. The plate is 25 mm thick and the holes required should have a diameter of 20 mm. The steel has an ultimate shear strength of 380N/mm².

a. Calculate the force required to punch each hole. (4)
b. Briefly describe the following terms:

i. Compressive stress; (2)

ii. Tensile stress. (2)

$$\text{Stress} = \frac{\text{Force}}{\text{Area}}$$



$$\text{Curved Area} = \pi dh$$
$$= \pi(20)(25) = 1570.796 \text{ mm}^2$$

$$380 = \frac{x}{1570.796}$$

$$380 \times 1570.796 = x = \boxed{596902.6 \text{ N}}$$

12. Simplify the following showing all working :

KFC

(a) $\frac{A^2D^2\sqrt{B}}{C^2} \div \frac{A^2}{\sqrt{B}\,DC^2}$ (4)

(b) $\left(9\frac{5}{8} \div 2\,{}^{3}/_{4}\right) + 2\frac{2}{3}$ (4)

a) $\frac{A^2D^2\sqrt{B}}{C^2} \times \frac{\sqrt{B}\,DC^2}{A^2} = D^3B$

b) $\left(9\frac{5}{8} \div 2\frac{3}{4}\right) + 2\frac{2}{3}$

$\left(\frac{77}{8} \div \frac{11}{4}\right) + \frac{8}{3}$

$\frac{7}{2}\left(\frac{77}{8} \times \frac{4}{11}\right) + \frac{8}{3}$

$\frac{7}{2} + \frac{8}{3}$

$\frac{21}{6} + \frac{16}{6} = \frac{37}{6} = 6\frac{1}{6}$