GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

Section A

1. Simplify EACH of the following giving the answer as a mixed number:

   (a) $\left(\frac{2}{5} + 3\frac{4}{3}\right) \times 2\,\frac{1}{6}$ (4)

   (b) $\left(3\frac{4}{7} \div 1\frac{4}{9}\right) \times 2\,\frac{1}{3}$ (4)

2. (a) Engine A has a cubic capacity of 21 litres, engine B has cubic capacity of 32 litres.

   Express as a percentage how much larger Engine B is compared to Engine A. (4)

   (b) Rearrange the following expression to make S the subject of the expression:

   $$P \times R^n = Q \times S^n$$ (4)

3. (a) Define Pythagoras' theorem. (2)

   (b) The triangle shown in Fig Q3 has two equal angles at A and C of 25°.

   Determine the length of the side AC. (6)

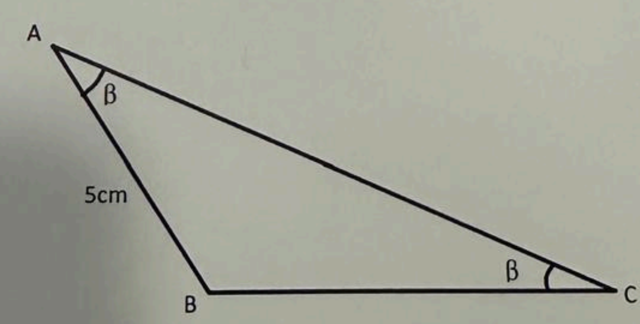


Fig Q3 (not to scale)

[OVER

√4. 200 ice cubes are put in an empty cylindrical container with a hemispherical base. The ice cubes have a side dimension of 3 cm. If the container has a diameter of 22 cm calculate the maximum depth of water remaining after the ice has melted. (8)

1295.47421m

Note: take the density of ice as 912 kg/m^3 and the density of water as 1000 kg/m^3

√5. (a) State the general expression for a straight line graph and explain the terms used. (2)

(b) Prepare a data table to plot an x,y graph in the range of $-3 \leq x \leq +3$ for the expression: (3)

$$Y = \frac{3}{2}x - 2$$

(c) Plot the graph of the data prepared in Q5(b). (3)

(d) Using the graph plotted in Q5(c) find the approximate Y value when x ≃ 2.3. (2)

y= 1.4

(8)

6. Fig Q6 shows an indicator diagram from a 2 stroke diesel engine to scale. The work done per cylinder is proportional to the area of the diagram.

(a) Using the mid ordinate rule, determine the area of the diagram. (6)

(b) Determine the mean height of the diagram. (2)

(2)

3)

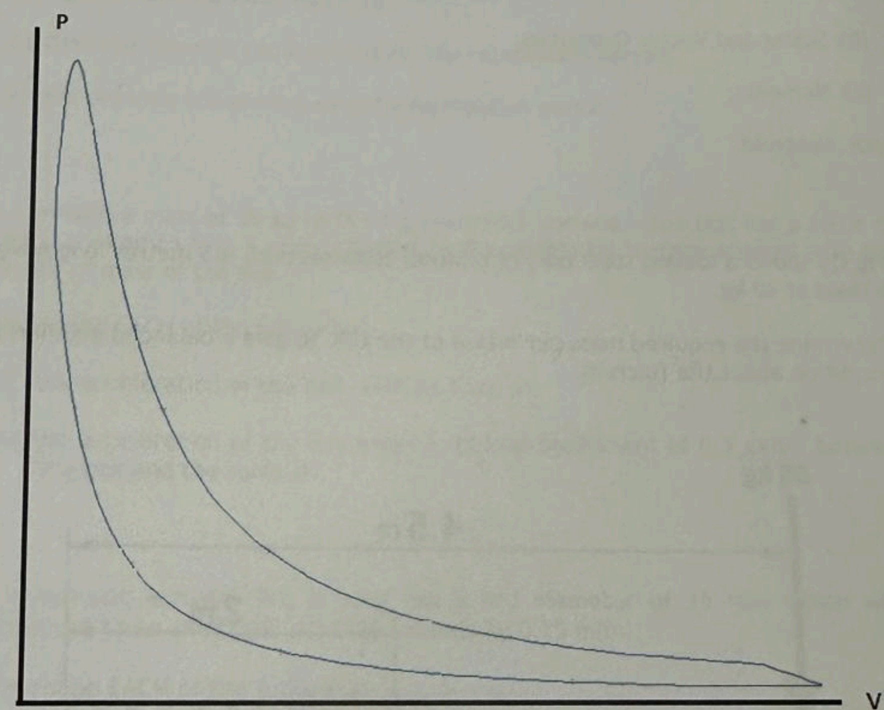


Fig Q6

Section B

✓ 7. Define EACH of the following terms with examples:

(a) Stable, Neutral and Unstable equilibrium; (2)

(b) Scalar and Vector Quantities; (2)

(c) Moments; (2)

(d) Centroid. (2)

✓ 8. Fig Q8 shows a loaded steel bar, of uniform cross section, 4.5 metres long having a mass of 40 kg.

3kg/m Determine the required mass per metre of the UDL to give a balanced equilibrium condition about the fulcrum. (8)

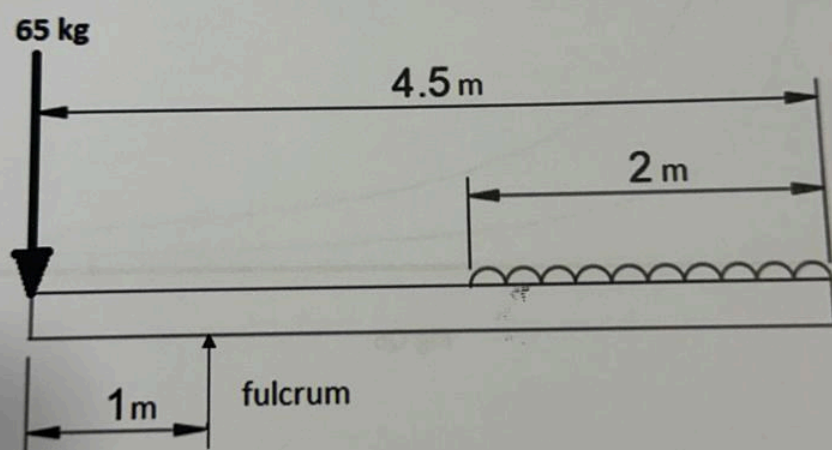


Fig Q8 (not to scale)

(2)
(2)
(2)
(2)
(8)

9. Ignoring any effects of friction, the velocity of a 60 kg mass is uniformly increased from 1.5 m/s to 3.0 m/s in 8 seconds. The mass is then uniformly retarded at 0.4 m/s^2 from 3.0 m/s until the mass just comes to rest.

Determine EACH of the following:

0.1875 (a) the accelerating force required; (2)

7.5 (b) the time taken to come to rest for the retardation period; (3)

11.25 (c) the distance travelled during the retardation period. (3)

10. A box with a mass of 35 kg rests on a horizontal surface. The box has a force of 130 N applied to it in a plane parallel to the horizontal surface aligned with the centre of mass of the box.

Determine EACH of the following:

3.7143 (a) the acceleration of the box with no friction; (3)

0.757 (b) the acceleration of the box when a friction coefficient of 0.3 exists between the box and the surface. (5)

11. A pneumatic actuator 0.6 m long has a rod diameter of 15 mm which when subjected to an axial pull of 13 kN extends by 0.25 mm.

Determine EACH of the following:

23111111.1 (a) the direct stress in the rod; (4)

$4.166666667 \times 10^{-4}$ (b) the direct strain in the rod; (4)

$5.546666666 \times 10^{+1}$ (c) the Modulus of Elasticity (E) for the rod. (2)

12. A power winch raises a mass of 1100 kg through a distance of 12 m in 20 seconds. The power input to the system in measured at 8 kW.

Determine EACH of the following:

129492 J (a) the work done; (3)

6474.6 W (b) the power; (3)

80.9325% (c) the system efficiency. (2)

1. Simplify EACH of the following giving the answer as a mixed number:

(a) $\left(\frac{2}{5} + 3\frac{1}{3}\right) \times 2\frac{1}{6}$ (4)

(b) $\left(3\frac{4}{7} \div 1\frac{4}{9}\right) \times 2\frac{1}{3}$ (4)

a) $\left(\frac{2\times3}{5\times3} + \frac{13\times5}{3\times5}\right) \times \frac{13}{6}$

$\left(\frac{6}{15} + \frac{65}{15}\right) \times \frac{13}{6}$

$\frac{71}{15} \times \frac{13}{6} = \frac{923}{90} = 10\frac{23}{90}$

b) $\left(3\frac{4}{7} \div 1\frac{4}{9}\right) \times 2\frac{1}{3}$

$\left(\frac{25}{7} \div \frac{13}{9}\right) \times \frac{7}{3}$

$\left(\frac{25}{7} \times \frac{9}{13}\right) \times \frac{7}{3}$

$\frac{225}{91} \times \frac{7}{3} = \frac{1575}{273}$

$= \frac{75}{13} = 5\frac{10}{13}$

2. ✓ (a) Engine A has a cubic capacity of 21 litres, engine B has cubic capacity of 32 litres.

Express as a percentage how much larger Engine B is compared to Engine A. (4)

(b) Rearrange the following expression to make S the subject of the expression:

$$P \times R^n = Q \times S^n$$ (4)

a) $A = 21\ L$

$B = 32\ L$

$$\text{Percent change} = \frac{\text{New} - \text{old}}{\text{old}} \times 100$$

$$\frac{B - A}{A} \times 100$$

$$\frac{32 - 21}{21} \times 100$$

$= 52.380\%$ bigger

2. (a) Engine A has a cubic capacity of 21 litres, engine B has cubic capacity of 32 litres.

Express as a percentage how much larger Engine B is compared to Engine A. (4)

(b) Rearrange the following expression to make S the subject of the expression:

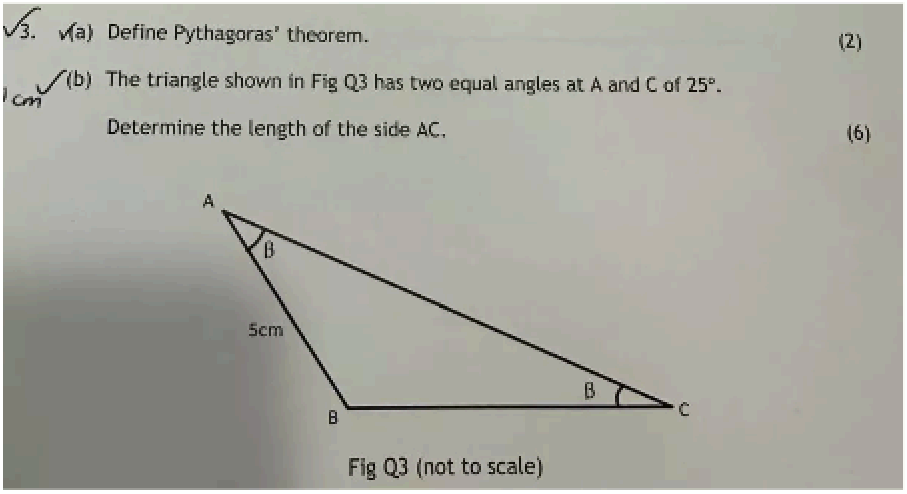
$$P \times R^n = Q \times S^n \quad (4)$$

b)

$$PR^n = QS^n$$

$$\left(\frac{PR^n}{Q}\right) = S^n$$

$$\sqrt[n]{\left(\frac{PR^n}{Q}\right)} = S$$

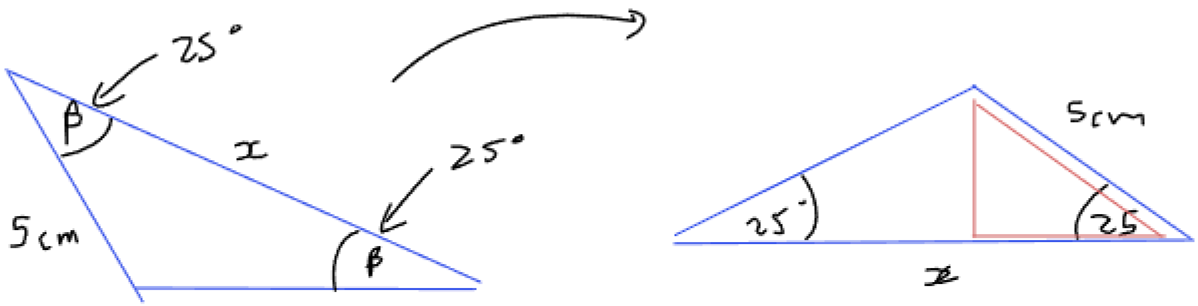


3. (a) Define Pythagoras' theorem. (2)

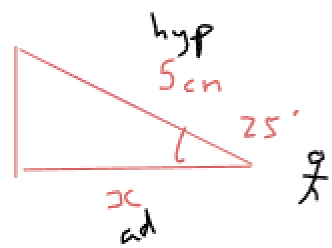
(b) The triangle shown in Fig Q3 has two equal angles at A and C of 25°.

Determine the length of the side AC. (6)

Fig Q3 (not to scale)



SOH
CAH
TOA



$\cos \theta = \frac{A}{H}$

$\cos 25 = \frac{x}{5}$

$5 \cos 25 = x$

4.5315389 cm

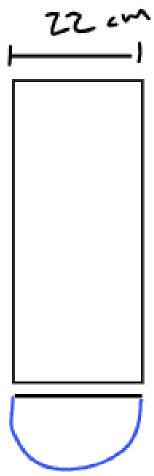
↓ ×2

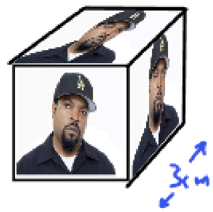
AC = 9.0630778 cm

√4. 200 ice cubes are put in an empty cylindrical container with a hemispherical base. The ice cubes have a side dimension of 3 cm. If the container has a diameter of 22 cm calculate the maximum depth of water remaining after the ice has melted. (8)

1245.47421m

Note: take the density of ice as 912 kg/m³ and the density of water as 1000 kg/m³





$Vol = w \times L \times h$

$3 \times 3 \times 3$

$27 cm^3$

$200 \times 27 = 5400 cm^3$

5.4 Litres of ice

$0.0054 m^3$

Mass of ice

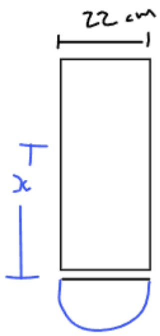
d m v

$m = 912 \times 0.0054 m^3$

$m = 4.9248 kg$

Volume of water $v = \frac{m}{d}$

$$\text{vol} = \frac{4.9248}{1000} = 4.9248 \times 10^{-3}\ m^3$$



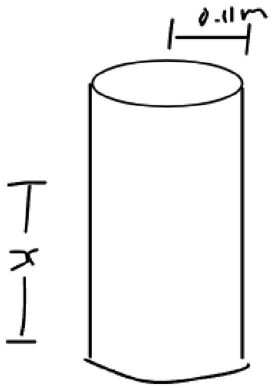
$$\text{vol} = \pi r^2 h$$

$$\text{vol} = \frac{\frac{4}{3}\pi r^3}{2} = \frac{\frac{4}{3}\pi (0.11)^3}{2} = 2.787639 \times 10^{-3}\ m^3$$

Find x

$$4.9248 \times 10^{-3}\ m^3 - 2.787639 \times 10^{-3}\ m^3 = \boxed{2.13716 \times 10^{-3}\ m^3}$$

total water − hemi sphere = cylinder vol



$$vol = \pi r^2 h$$

$$2.13716 \times 10^{-3} = \pi (0.11)^2 x$$

$$2.13716 \times 10^{-3} = 0.03801327 x$$

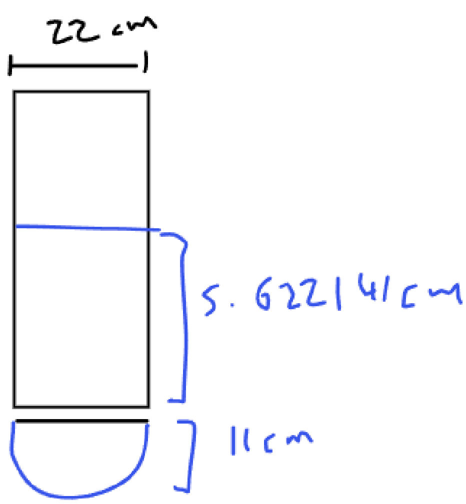
$$\frac{2.13716 \times 10^{-3}}{0.03801327} = x$$

0.056214 m

√4. 200 ice cubes are put in an empty cylindrical container with a hemispherical base. The ice cubes have a side dimension of 3 cm. If the container has a diameter of 22 cm calculate the maximum depth of water remaining after the ice has melted. (8)

1295.47421m

Note: take the density of ice as 912 kg/m³ and the density of water as 1000 kg/m³



max depth = 16.62214 cm

5. (a) State the general expression for a straight line graph and explain the terms used. (2)

(b) Prepare a data table to plot an x,y graph in the range of $-3 \le x \le +3$ for the expression: (3)

$$Y = \frac{3}{2}x - 2$$

(c) Plot the graph of the data prepared in Q5(b). (3)

(d) Using the graph plotted in Q5(c) find the approximate Y value when $x \approx 2.3$. (2)

$y = 1.4$

5 a) $y = mx + c$

$m = \text{gradient} = \frac{\Delta y}{\Delta x} = \frac{\text{Rise}}{\text{Run}} = \frac{y_2 - y_1}{x_2 - x_1}$

$c = y$ intercept

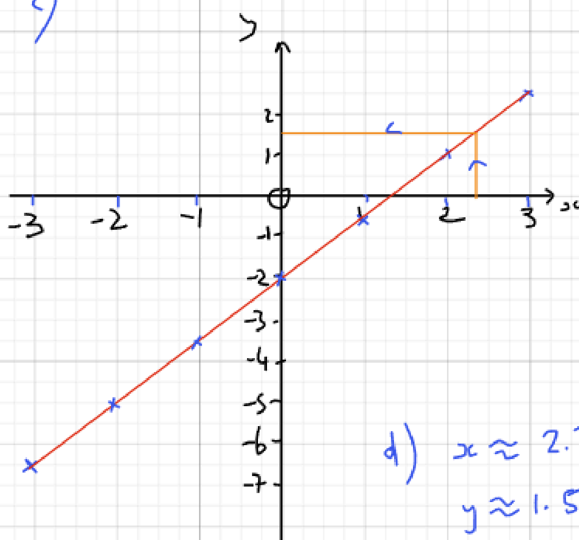
b)

1.5×(-3)-2

-6.5

x	y
-3	$\frac{3}{2}(-3) - 2 = -6.5$
-2	$\frac{3}{2}(-2) - 2 = -5$
-1	$\frac{3}{2}(-1) - 2 = -3.5$
0	$\frac{3}{2}(0) - 2 = -2$
1	$\frac{3}{2}(1) - 2 = -0.5$
2	$\frac{3}{2}(2) - 2 = 1$
3	$\frac{3}{2}(3) - 2 = 2.5$

c)



d) $x \approx 2.3$

$y \approx 1.5$

6. Fig Q6 shows an indicator diagram from a 2 stroke diesel engine to scale. The work done per cylinder is proportional to the area of the diagram.

(a) Using the mid ordinate rule, determine the area of the diagram. (6)

(b) Determine the mean height of the diagram. (2)

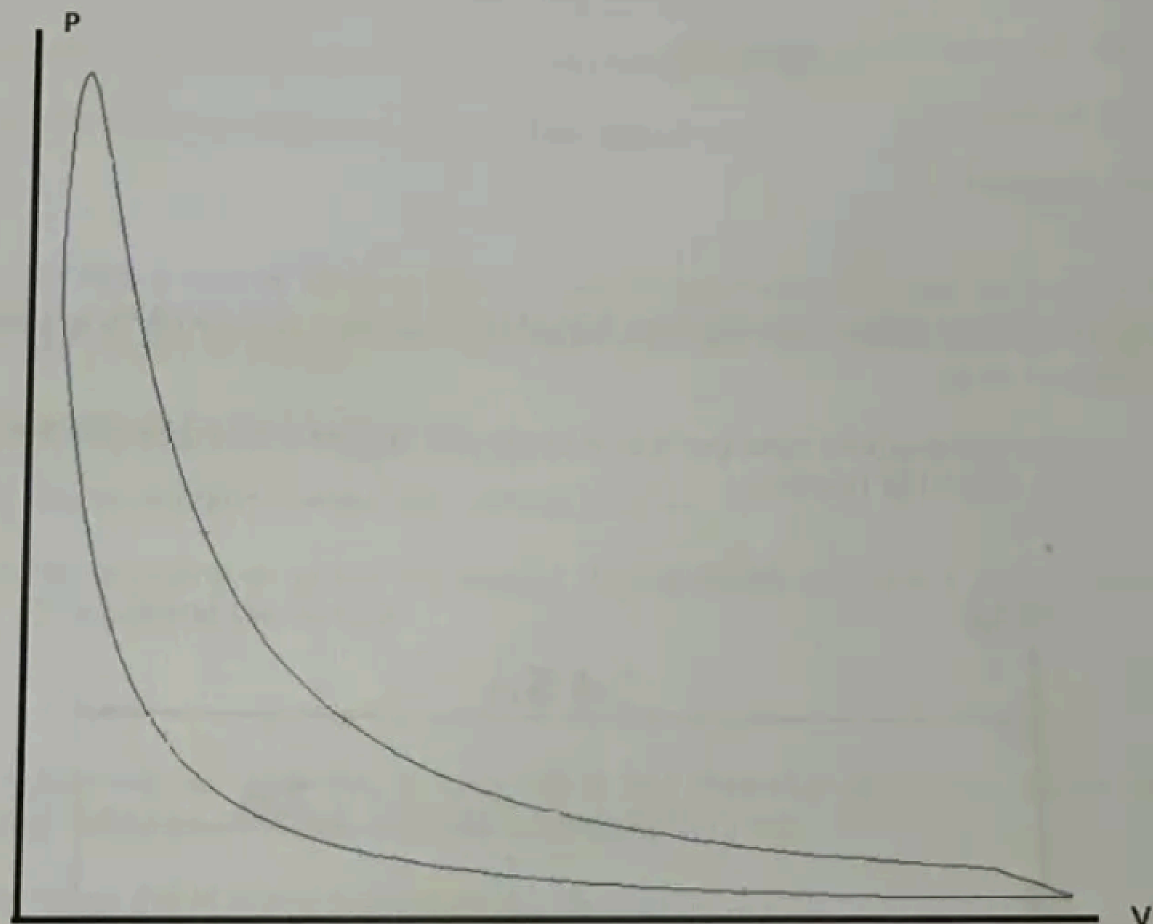
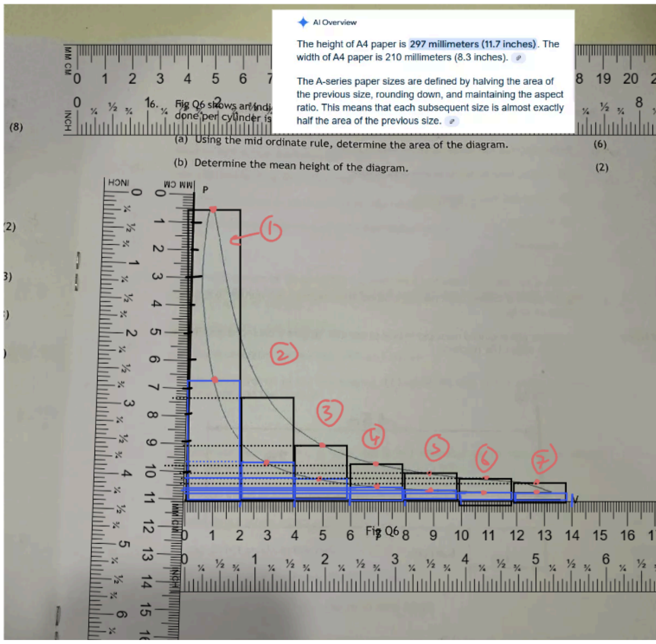


Fig Q6



Section	top	under	Diff	width	
①	10.5	4.2	6.1	× 2	= 12.2 cm²
②	3.5	1.4	2.1	× 2	= 4.2 cm²
③	2	0.7	1.3	× 2	= 2.6 cm²
④	1.5	0.4	1.1	× 2	= 2.2 cm²
⑤	1	0.3	0.7	× 2	= 1.4 cm²
⑥	0.7	0.2	0.5	× 2	= 1.0 cm²
⑦	0.6	0.2	0.4	× 2	0.8 cm²

total area = 24.4 cm²

b) $A = L \times h$

$h = \frac{A}{L} = \frac{24.4}{14} = 1.74285$ cm mean height of diagram

17.4285 mm

for a spring coeff of 1mm= 1bar, this is reasonable

Section B

✓ 7. Define EACH of the following terms with examples:

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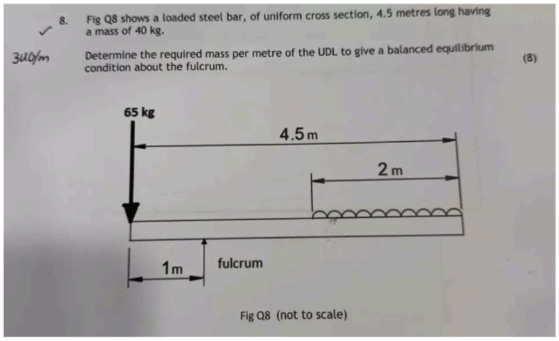
(b) Scalar and Vector Quantities; (2)

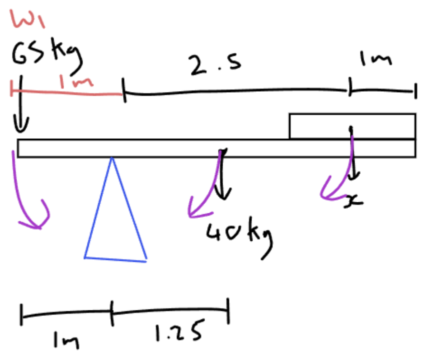
(c) Moments; (2)

(d) Centroid. (2)


8. Fig Q8 shows a loaded steel bar, of uniform cross section, 4.5 metres long having a mass of 40 kg.

Determine the required mass per metre of the UDL to give a balanced equilibrium condition about the fulcrum. (8)

Fig Q8 (not to scale)



$$\frac{\text{Beam}}{2} - \text{overhung}$$

$$\frac{4.5}{2} - 1$$

$$2.25 - 1 = 1.25$$

Name	Mass (kg)	Force (N)	distance (m)	Moment (Nm)	Dir A/C
W1	65	637.65	1	637.65	A
Beam	40	392.4	1.25	490.5	C
UDL	x	9.81x	2.5	24.525x	C

sum of anticlock wise moments = sum of clockwise moments

$$637.65 = 490.5 + 24.525x$$

$$\frac{637.65 - 490.5}{24.525} = x$$

$$6 = x$$

$$6\text{ kg}/2 = \boxed{3\text{ kg / metre}}$$

9. Ignoring any effects of friction, the velocity of a 60 kg mass is uniformly increased from 1.5 m/s to 3.0 m/s in 8 seconds. The mass is then uniformly retarded at 0.4 m/s² from 3.0 m/s until the mass just comes to rest.

Determine EACH of the following:

0.1875 (a) the accelerating force required; (2)

7.5 (b) the time taken to come to rest for the retardation period: (3)

11.25 (c) the distance travelled during the retardation period. (3)

$v = u + at$

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

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

a)

s =

u = 1.5 m/s

v = 3.0 m/s

a = x

t = 8 sec

$v = u + at$

$3 = 1.5 + 8x$

$\frac{1.5}{8} = x$

$0.1875\ m/s^2 = accel$

$F = ma$

$F = 60 \times 0.1875$

$F = 11.25\ N$

9. Ignoring any effects of friction, the velocity of a 60 kg mass is uniformly increased from 1.5 m/s to 3.0 m/s in 8 seconds. The mass is then uniformly retarded at 0.4 m/s² from 3.0 m/s until the mass just comes to rest.

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$v = u + at$

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

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

b)

$s =$

$u = 3$

$v = 0$

$a = -0.4$

$t = x$

$v = u + at$

$0 = 3 - 0.4x$

$0.4x = 3$

$x = \frac{3}{0.4} = 7.5$ sec

c)

$s = \left(\frac{u+v}{2}\right)t = \left(\frac{3+0}{2}\right)7.5$

$s = 11.25$ metres

10. A box with a mass of 35 kg rests on a horizontal surface. The box has a force of 130 N applied to it in a plane parallel to the horizontal surface aligned with the centre of mass of the box.

Determine EACH of the following:

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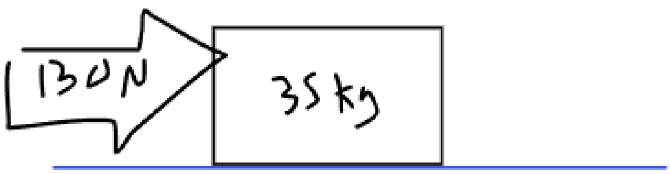
0.757 (b) the acceleration of the box when a friction coefficient of 0.3 exists between the box and the surface. (5)

a)



$F = ma$

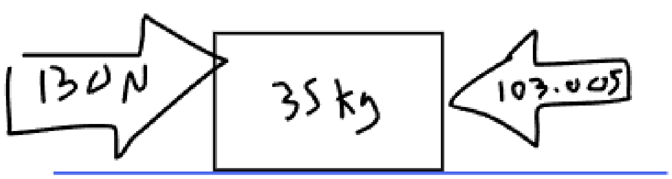
$130 = 35x$

$\frac{130}{35} = x$

$3.714285 \ m/s^2$

b) $Fric = \mu N = 0.3 \times (9.81 \times 35)$

$= 103.005 \ N$



Net Horizontal

$130 - 103.005 = 26.995\ N$

$F = ma$

$\frac{26.995}{35} = a$

$0.7712857\ m/s^2$

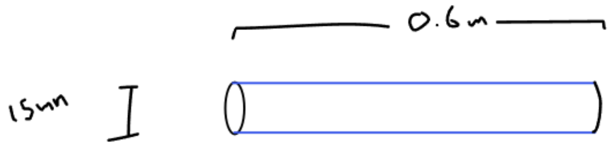
11. A pneumatic actuator 0.6 m long has a rod diameter of 15 mm which when subjected to an axial pull of 13 kN extends by 0.25 mm.

Determine EACH of the following:

23111111.1 (a) the direct stress in the rod; (4)

$4.16666667 \times 10^{-4}$ (b) the direct strain in the rod; (4)

$5.546666666 \times 10^{+1}$ (c) the Modulus of Elasticity (E) for the rod. (2)



a) $\text{stress} = \frac{\text{Force}}{\text{Area}} = \frac{13,000}{\pi \left(\frac{15}{2000}\right)^2} = \frac{13000}{1.76714 \times 10^{-4}} = 73,564,951.47 \ N/m^2$

b) $\text{strain} = \frac{\Delta L}{L} = \frac{0.25 \text{ mm}}{600 \text{ mm}} = 0.000416666$

c) $E_{ks} = \frac{\text{stress}}{\text{strain}} = \frac{73,564,951.47}{0.000416666} = 1.765589 \times 10^{11} \ N/m^2$

12. A power winch raises a mass of 1100 kg through a distance of 12 m in 20 seconds. The power input to the system in measured at 8 kW.

Determine EACH of the following:

(a) the work done; (3)

(b) the power; (3)

(c) the system efficiency. (2)

a) $P = \frac{mgh}{t}$ ← work

$= 1100 \times 9.81 \times 12$

$= 129{,}492$ J

b) $P = \frac{129492}{20} = 6474.5$ watts

c) $Eff = \frac{\text{theoretical}}{\text{Actual}} \times 100$

$\frac{6474.5}{8000} \times 100$

80.9325 %