GENERAL ENGINEERING SCIENCE I

Attempt ALL questions.

Marks for each question are shown in brackets.

Section A

1. (a) Simplify the following giving your answer as a mixed number: (4)

$$6\frac{1}{4} \div 2\frac{1}{2} + 5$$

(b) Prove whether the statement is True or False "two thirds of twelve fifths is the same as twelve fifths of two thirds". (4)

2. A mooring rope is held firmly at each end and 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 Q3(a); (4)

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

4. FIG Q4 shows a right-angled triangle with a rectangle inscribed within it.

Determine the area of the rectangle: (8)

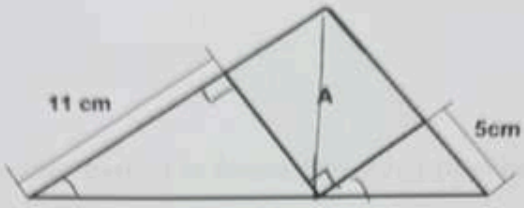


FIG Q4

5. Using Pythagoras' Theorem, determine the length AC as shown in FIG Q5: (8)

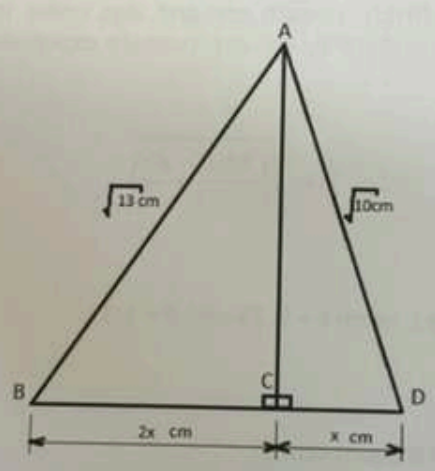


FIG Q5

6. Two solid objects are compared to each other. The first is a cone with a height of 1.1 m and a base diameter of 0.9 m. The second is a sphere with a diameter of 0.9 m.

Show which object has the greater total surface area. (8)

Section B

7. A box with a mass of 30 kg has a steady force of 95 N applied to it, at an angle of 20° above the horizontal. There is a friction coefficient of 0.22 between the box and the surface.

   Determine EACH of the following:

   (a) the acceleration of the body; (4)

   (b) the distance the body will have travelled in 10 seconds. (4)

8. A hoist has a mechanical efficiency of 72%. The motor power is measured at 8 kW when raising a mass of 1000 kg through a distance of 12 m.

   Determine EACH of the following:

   (a) the work done; (4)

   (b) power output; (4)

   (c) the time taken to raise the load. (2)

9. A mass of 97 kg has its velocity uniformly increased from stationary to 4.2 m/s in 12 seconds. The mass is then decelerated at $0.3 m/s^2$ until it comes to a stop.

   Determine EACH of the following:

   (a) the accelerating force required; (3)

   (b) the time taken in the deceleration phase; (3)

   (c) the total distance travelled. (2)

   Note: any effects of friction may be ignored.

10. A replenishment at sea operation is taking place as shown in FIG Q10 where the two cables form an effective right angle at M and can be considered straight. The mass of the cable does not need to be accounted for. Point A and Point B are at the same height.

Determine EACH of the following:

(a) the tensile force in cable AM; (4)

(b) the tensile force in cable BM. (4)

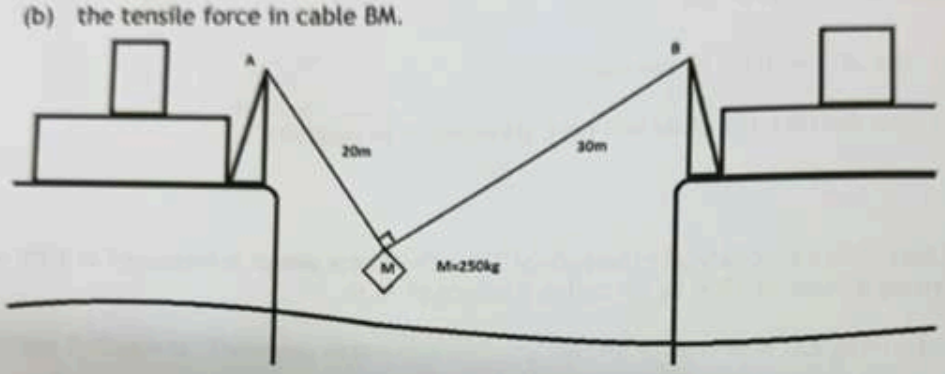


FIG Q10

11. A piston rod 0.9 m long has a diameter of 95 mm with a material stress limit of 580 MPa and a Youngs Modulus of 200 GPa. The piston diameter is 400 mm and may be subjected to peak pressures of 150 bar.

Determine EACH of the following:

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

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

(c) the factor of safety in the rod. (2)

12. (a) State 2 fundamental units. (2)

(b) What are derived units, give an example. (2)

(c) A cylinder with an internal cross-sectional area of 4250 mm^2 contains fluid with a depth of 6 cm. The fluid has a mass of 300 grams.

Determine the density of the fluid and illustrate how the units were formed. (4)

1. (a) Simplify the following giving your answer as a mixed number: (4)

$$6\frac{1}{4} \div 2\frac{1}{2} + 5$$

(b) Prove whether the statement is True or False "two thirds of twelve fifths is the same as twelve fifths of two thirds". (4)

a) $6\frac{1}{4} \div 2\frac{1}{2} + 5$

$\frac{25}{4} \div \frac{5}{2} + 5$

$\frac{5}{2} \frac{25}{4} \times \frac{2}{5}$

$\frac{5}{2} + \frac{5}{1} \times 2$

$\frac{5}{2} + \frac{10}{2} = \frac{15}{2}$

$= 7\frac{1}{2}$

1. (a) Simplify the following giving your answer as a mixed number: (4)

$$6\frac{1}{4} \div 2\frac{1}{2} + 5$$

(b) Prove whether the statement is True or False "two thirds of twelve fifths is the same as twelve fifths of two thirds". (4)

b) $\frac{2}{3} \times \frac{12}{5} = \frac{12}{5} \times \frac{2}{3}$

$\frac{24}{15} = \frac{24}{15}$

True

2. A mooring rope is held firmly at each end and 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)

$$0.75^2 = \frac{3 \times 1.15 (L - 1.15)}{8}$$

$$0.75^2 \times 8 = 3.45 (L - 1.15)$$

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

$$\frac{4.5}{3.45} = L - 1.15$$

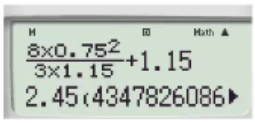
$$\frac{30}{23} + 1.15 = L$$

$$\frac{1129}{460} = L$$

$$2.4543478 = L$$

check

$$\frac{8s^2}{3d} + d = L$$



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)

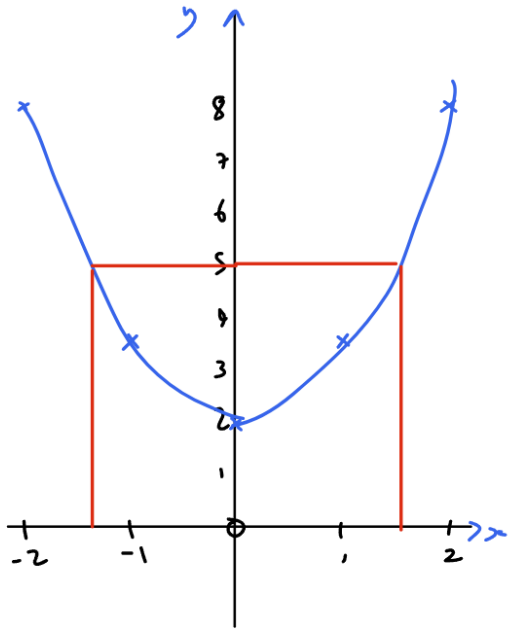
(b) sketch a graph of the data determined in Q3(a); (4)

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

a)

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

b)



c) $x \approx -1.4$

$x \approx 1.5$

4. FIG Q4 shows a right-angled triangle with a rectangle inscribed within it.

Determine the area of the rectangle: (8)

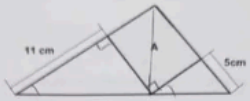
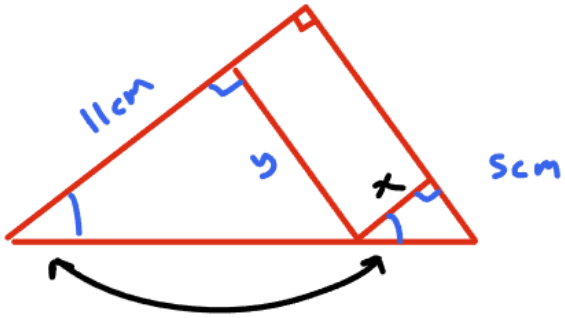


FIG Q4



$\tan\theta = \frac{opp}{adj}$

$\tan\theta_1 = \tan\theta_2$

$\frac{y}{11} = \frac{5}{x}$

$yx =$ **55 cm² Area**

5. Using Pythagoras' Theorem, determine the length AC as shown in FIG Q5: (8)

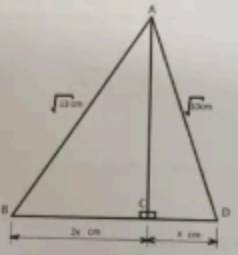
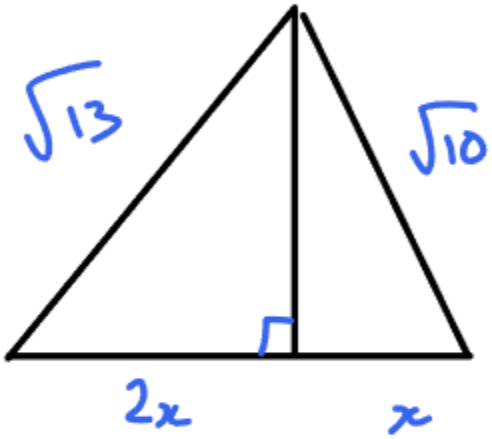
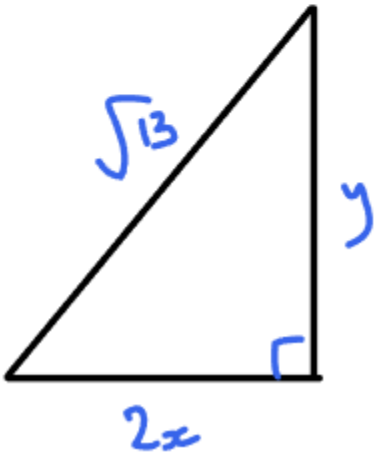


FIG Q5





$y^2 = \sqrt{13}^2 - (2x)^2$ $\quad y^2 = \sqrt{10}^2 - x^2$

$y^2 = 13 - 4x^2$ $\quad y^2 = 10 - x^2$

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

$$3 = 3x^2$$

$$1 = x^2$$

$$1 = x$$

$$y = \sqrt{13 - 4}$$

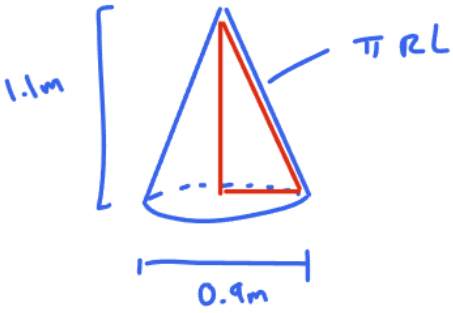
$$y = \sqrt{9}$$

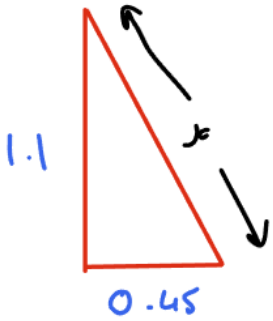
$$y = 3$$

$$\boxed{AC = 3 \text{ units}}$$

6. Two solid objects are compared to each other. The first is a cone with a height of 1.1 m and a base diameter of 0.9 m. The second is a sphere with a diameter of 0.9 m.

Show which object has the greater total surface area. (8)





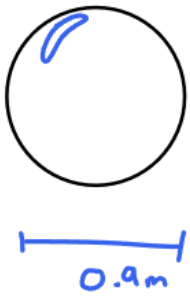
$$x = \sqrt{1.1^2 + 0.45^2}$$

$$x = 1.188486 \text{ m}$$

curved SA : $\pi RL = \pi\ 0.45 \times 1.188486 = 1.680183\ m^2$

base : $\pi r^2 = \pi\ 0.45^2 = 0.6361725\ m^2$

total = $2.3163555\ m^2$



$SA = 4\pi r^2$

$4\pi\ 0.45^2$

$= 2.54469\ m^2$

Sphere has larger SA

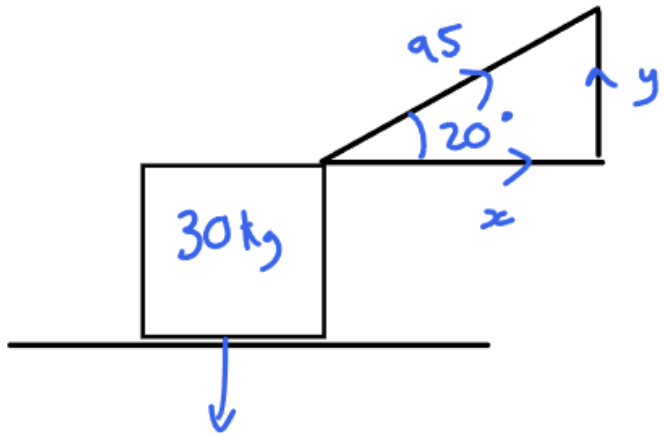
7. A box with a mass of 30 kg has a steady force of 95 N applied to it, at an angle of 20° above the horizontal. There is a friction coefficient of 0.22 between the box and the surface.

Determine EACH of the following:

(a) the acceleration of the body; (4)

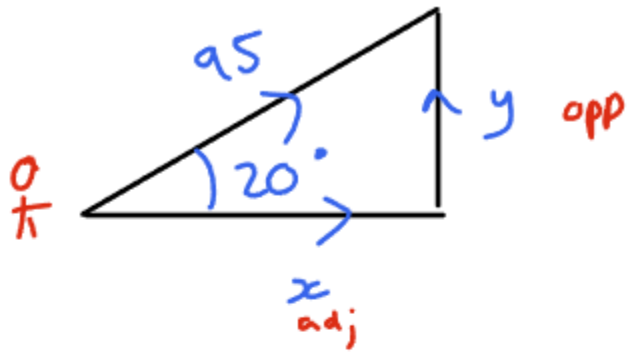
(b) the distance the body will have travelled in 10 seconds. (4)

7)



mg

$30 \times 9.81 = 294.3\ N$



SOH
CAH
TOA

Horizontal

CAH

$\cos 20 = \frac{x}{95}$

$95 \cos 20 = x$

89.2708

Push

Vertical

SOH

$\sin 20 = \frac{y}{95}$

$95 \sin 20 = y$

32.4919 N

UP

Net Vertical

Down - up

$294.3\ N - 32.4919\ N = 261.8081\ N$

$\text{Friction} = \mu N$

$= 0.22 \times 261.8081$

$= 57.597782\ N$

Net Horizontal

Push - Fric

$89.2708 - 57.597782 = 31.673\ N$

Accel $F = ma$

$31.673 = 30x$

$\frac{31.673}{30} = x$

$1.055767\ m/s^2$

8. A hoist has a mechanical efficiency of 72%. The motor power is measured at 8 kW when raising a mass of 1000 kg through a distance of 12 m.

Determine EACH of the following:

(a) the work done; (4)

(b) power output; (4)

(c) the time taken to raise the load. (2)

$$Eff = \frac{Theo}{Actual}$$

a) work = Force x dis

$1000 \times 9.81 \times 12$

117720 J

b) $P = \frac{mgh}{t} = \frac{117720}{x}$

$0.72 \times 8000 = 5760$ watts

c) $\frac{117720}{x} = 5760$

$\frac{117720}{5760} = x$

20.4375 sec

9. A mass of 97 kg has its velocity uniformly increased from stationary to 4.2 m/s in 12 seconds. The mass is then decelerated at $0.3 m/s^2$ until it comes to a stop.

Determine EACH of the following:

(a) the accelerating force required; (3)

(b) the time taken in the deceleration phase; (3)

(c) the total distance travelled. (2)

Note: any effects of friction may be ignored.

a)

s

$u = 0$

$v = 4.2$ m/s

$a = x$

$t = 12$ sec

$v = u + at$

$4.2 = 0 + 12x$

$\frac{4.2}{12} = x$

$0.35 m/s^2 = accel$

$F = ma$

$F = 97 \times 0.35$

$F = \boxed{33.95 N}$

b)

s

$u = 4.2$

$v = 0$

$a = -0.3$

$t = x$

$v = u + at$

$0 = 4.2 - 0.3x$

$\frac{4.2}{0.3} = x$

$\boxed{14 \text{ sec}}$

c)

s

$u = 0$

$v = 4.2$ m/s

$a = x$

$t = 12$ sec

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

$$s = \left(\frac{4.2}{2}\right) 12 = 25.2 \text{ m}$$

s

$u = 4.2$

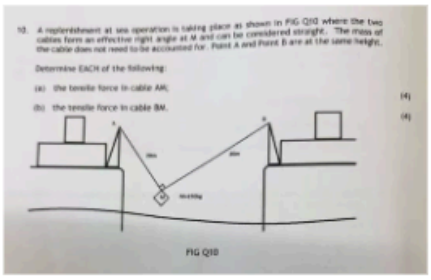
$v = 0$

$a = -0.3$

$t = x$

$$s = \left(\frac{4.2}{2}\right) 14 = 29.4 \text{ m}$$

54.6m total distance



10. A replenishment at sea operation is taking place as shown in FIG Q10 where the two cables form an effective right angle at M and can be considered straight. The mass of the cable does not need to be accounted for. Point A and Point B are at the same height.

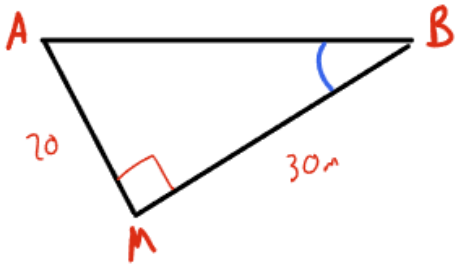
Determine EACH of the following:

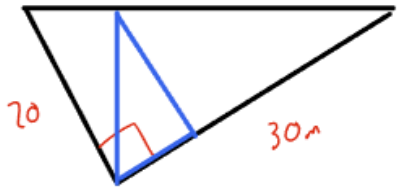
(a) the tensile force in cable AM. (4)

(b) the tensile force in cable BM. (4)

FIG Q10

SOH
CAH
TOA

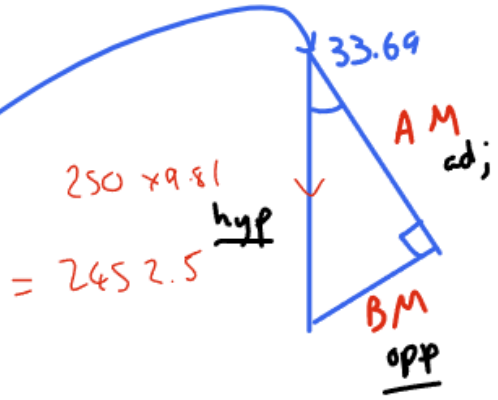




$\tan^{-1}\left(\frac{opp}{Adj}\right)$

$\tan^{-1}\left(\frac{20}{30}\right)$

$\theta = 33.69°$



BM: SOH

$\sin 33.69 = \frac{BM}{2452.5}$

$2452.5 \sin(33.69) = BM$

1360.4 N = BM Tension

AM: CAH

$\cos 33.69 = \frac{AM}{2452.5}$

$2452.5 \cos(33.69) = AM$

2040.6 N = AM tension

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

$$Strain = \frac{\Delta L}{L}$$

$$Elas = \frac{Stress}{strain}$$

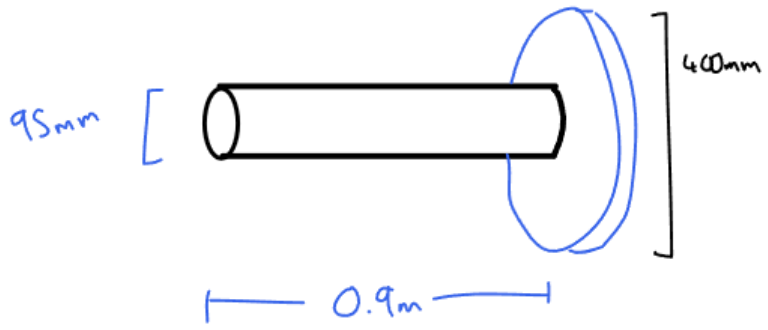
11. A piston rod 0.9 m long has a diameter of 95 mm with a material stress limit of 580 MPa and a Youngs Modulus of 200 GPa. The piston diameter is 400 mm and may be subjected to peak pressures of 150 bar.

Determine EACH of the following:

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

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

(c) the factor of safety in the rod. (2)



$150 \text{ bar} = 150 \times 100{,}000 = N/m^2$

$15 \times 10^6 \ N/m^2$

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

$$P \times A = F$$

$$15 \times 10^6 \times \pi (0.2)^2 = F$$

$$1{,}884{,}955.95 \ N$$

$d = 95mm = 0.095m$

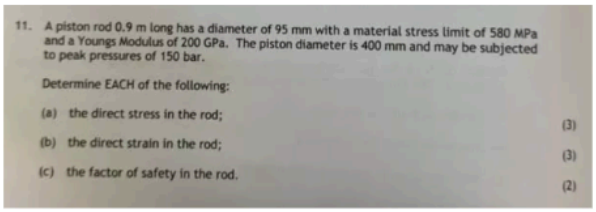
$R = 0.0475m$

$$Stress = \frac{F}{A} = \frac{1{,}884{,}955.95 \ N}{\pi R^2}$$

$$\frac{1{,}884{,}955.95 \ N}{\pi (0.0475)^2}$$

$$= 265928028.3 \ N/m^2$$

$$265.928 \ MN/m^2$$



11. A piston rod 0.9 m long has a diameter of 95 mm with a material stress limit of 580 MPa and a Youngs Modulus of 200 GPa. The piston diameter is 400 mm and may be subjected to peak pressures of 150 bar.

Determine EACH of the following:

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

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

(c) the factor of safety in the rod. (2)

b) $E_{las} = \frac{stress}{Strain}$

$200 \times 10^9 = \frac{265928028.3}{x}$

$x = \frac{265928028.3}{200 \times 10^9}$

strain = 0.0013296

1.3296×10^{-3}

c) $FOS = \frac{limit}{stress}$

$\frac{580 \times 10^6}{265928028.3}$

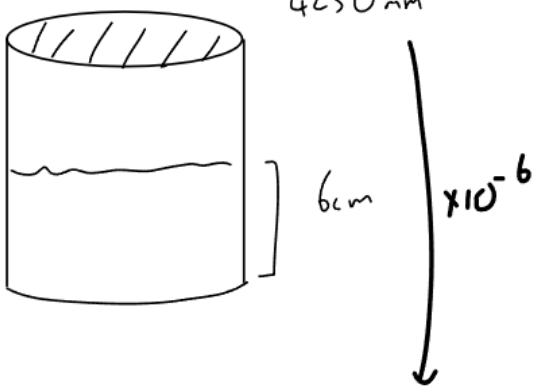
2.181

12. (a) State 2 fundamental units. (2)

(b) What are derived units, give an example. (2)

(c) A cylinder with an internal cross-sectional area of 4250 mm^2 contains fluid with a depth of 6 cm. The fluid has a mass of 300 grams.

Determine the density of the fluid and illustrate how the units were formed. (4)



$\text{density} = \frac{\text{mass}}{\text{vol}}$

$\text{mass} = 0.3\,kg$

$\text{vol} = \pi R^2 h = 4250 \times 10^{-6} \times 0.06 = 2.55 \times 10^{-6}\ m^3$

$m^2 \times m = m^3$

$\text{density} = \frac{0.3\,kg}{2.55 \times 10^{-6}\ m^3}$

$1176.47\ kg/m^3$