CERTIFICATES OF COMPETENCY IN THE MERCHANT NAVY - MARINE ENGINEER OFFICER

STCW 78 as amended CHIEF ENGINEER REG. III/2 - "YACHT 2"
STCW 78 as amended SMALL VESSEL CHIEF ENGINEER <3000 GT, <9000 kW UNLIMITED

058-11 - GENERAL ENGINEERING SCIENCE I

FRIDAY, 02 OCTOBER 2020

1400 - 1600 hrs

Materials to be supplied by examination centres

Candidate's examination workbook Graph paper

Examination Paper Inserts

Notes for the guidance of candidates:

1. Examinations administered by SQA on behalf of the Maritime & Coastguard Agency.
2. Candidates are required to obtain 50% of the total marks allocated to this paper to gain a pass **AND** also obtain a minimum 40% in Sections A and B of the paper.
3. Non-programmable calculators may be used.
4. All formulae used must be stated and the method of working and ALL intermediate steps must be made clear in the answer.

Maritime & Coastguard Agency

SQA

GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

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

Section A

1. Simplify EACH of the following expressions showing working:

   (a) $2\frac{3}{4} - 5\frac{3}{6} + 3\frac{2}{3}$ (4)

   (b) $2\frac{3}{4} \times 5\frac{3}{6} \div 3\frac{2}{3}$ (4)

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

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

   Determine the value for L to 2 decimal places when S = 4.65 and d = 40. (8)

   Note: Units can be ignored.

3. A round steel rod 30 cm long with a diameter of 50 mm is to have a flat surface 30 mm wide ground along its length as shown in Fig Q3.

Determine the remaining mass of the steel rod, If the steel has a density of 8750 kg/m^3.

(8)

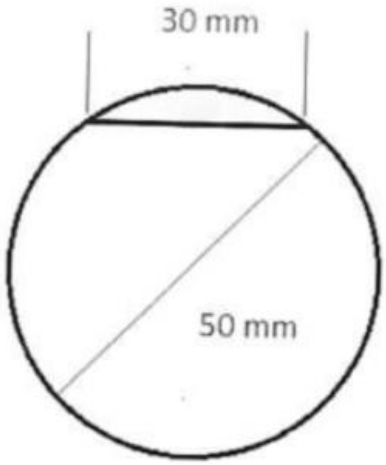


Fig Q3

4. (a) Plot the following (x, y) data on a graph:

x	3	2	1	0	-1	-2
y	-9.4	-6.6	-3.8	-1	1.8	4.6

(4)

(b) Determine an expression relating the x and y coordinates. (4)

(c) Determine the value of y when x = 1.5. (2)

5. Fig Q5 is a diagram of a crane jib AB with load suspended from a cable OB.

Determine the angle at A that the jib makes with the wall when the cable length OB is 7 m. (8)

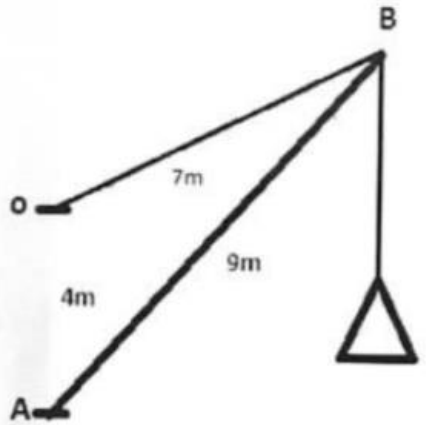


Fig Q5

6. A sphere and a cone have the same volumes. The radius of the sphere is the same as the radius of the cone base.

(a) Determine the ratio of cone height to sphere radius. (4)

(b) Check the answer to Q6(a) for a sphere of radius 2 cm. (4)

Section B

7. A force of 76 N is applied to a stationary mass of 28 kg which causes accelerated motion on a frictionless horizontal plane.

Determine EACH of the following:

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

(b) the distance the body will have travelled after 12 seconds. (4)

8. A uniform beam is loaded as shown in Fig Q8. The beam has a mass of 150 kg.

Determine the reaction forces at the supports A and B. (10)

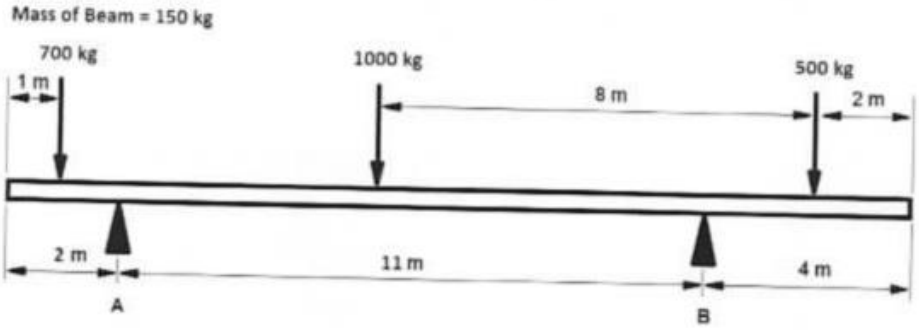


Fig Q8

9. (a) State the difference between *static* and *dynamic* friction. (2)

(b) A stone block has a mass of 4400 kg and is pulled across a horizontal surface with a constant acceleration of 0.25 m/s^2 by a force of 18 kN applied at an angle of 15° above the horizontal.

Determine the coefficient of friction. (6)

10. Fig Q10 shows a horizontal cross section of a steel support column 20 m high. The column has a mass of 7.2 tonnes on top of it. The density of steel is 7600 kg/m^3.

Calculate EACH of the following:

(a) the compressive stress at the top of the column; (4)

(b) the compressive stress at the column base. (4)

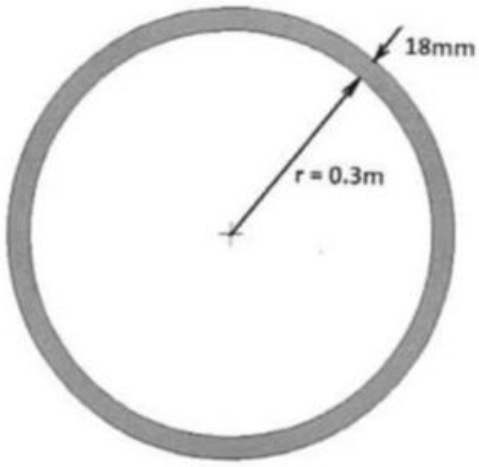


Fig Q10

11. (a) State what is meant by the term *centroid*. (2)

(b) Determine the position of the centre of area, for the shape shown in Fig Q11. (6)

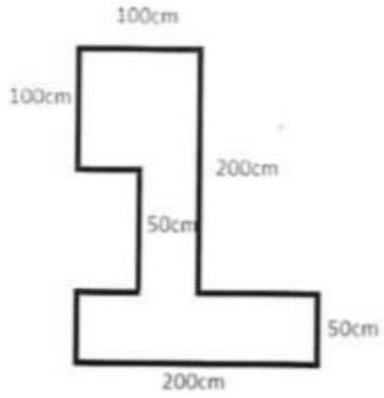


Fig Q11

12. 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)

1a) $2\frac{3}{4} - 5\frac{3}{6} + 3\frac{2}{3}$

Whole: $2 - 5 + 3 = 0$

Fractions: $\frac{3}{4} - \frac{3}{6} + \frac{2}{3}$

$\frac{18}{24} - \frac{12}{24}$

$\frac{6}{24} + \frac{2}{3}$

$\frac{1}{4} + \frac{2}{3}$

$\frac{3}{12} + \frac{8}{12} = \frac{11}{12}$

$2\frac{3}{4} \times 5\frac{3}{6} \div 3\frac{2}{3}$

$\frac{11}{4} \times \frac{33}{6} \div \frac{11}{3}$

$\frac{363}{24} \times \frac{3}{11}$

$\frac{121}{8} \times \frac{3}{11} = \frac{363}{88} = \frac{33}{8} \quad 4\frac{1}{8}$

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

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

Determine the value for L to 2 decimal places when S = 4.65 and d = 40. (8)

Note: Units can be ignored.

$$4.65^2 = \left(\frac{120(L-40)}{8}\right)$$

$$4.65^2 = 15(L-40)$$

$$4.65^2 = 15L - 600$$

$$L = 41.4415$$

3. A round steel rod 30 cm long with a diameter of 50 mm is to have a flat surface 30 mm wide ground along its length as shown in Fig Q3.

Determine the remaining mass of the steel rod, If the steel has a density of 8750 kg/m^3.

(8)

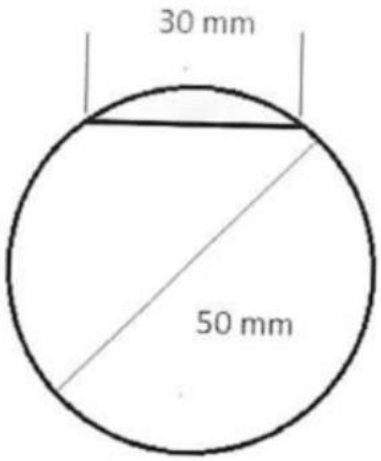


Fig Q3

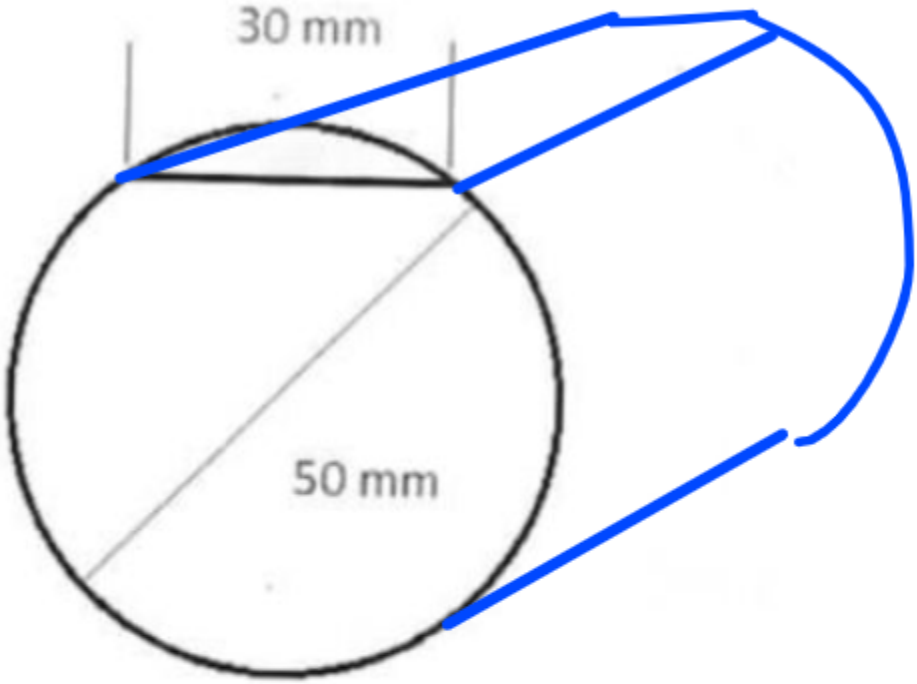
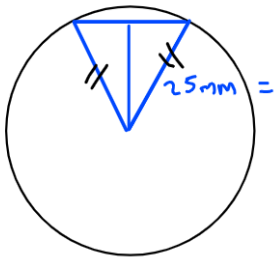
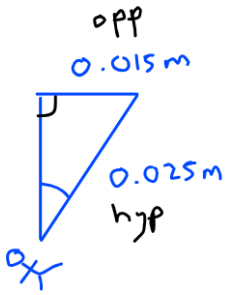


Fig Q3

Vol = Area x Length

Cross sec



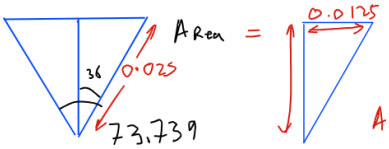


SOH

$$\sin\theta = \frac{opp}{hyp}$$

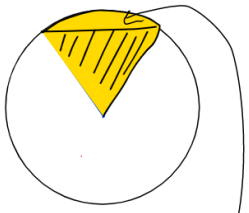
$$\sin\theta = \frac{0.015}{0.025}$$

$$\theta = \sin^{-1}\left(\frac{0.015}{0.025}\right) = 36.86989$$



$\sqrt{0.025^2 - 0.0125^2} = 0.02165\ m$ = height

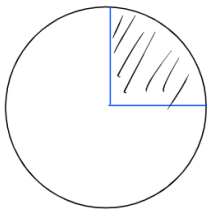
$$\text{Area} = \frac{b \times h}{2} = \frac{0.0125 \times 0.02165}{2} = 2.706329 \times 10^{-4}\ m^2$$



$$\frac{73.739}{360} \times \text{Area of circle}$$

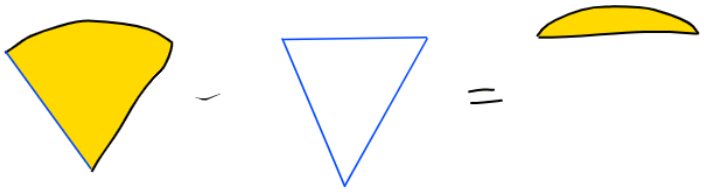
$$\frac{\theta}{360} \times \pi r^2$$

$$\frac{73.739}{360} \times \pi (0.025)^2 =$$

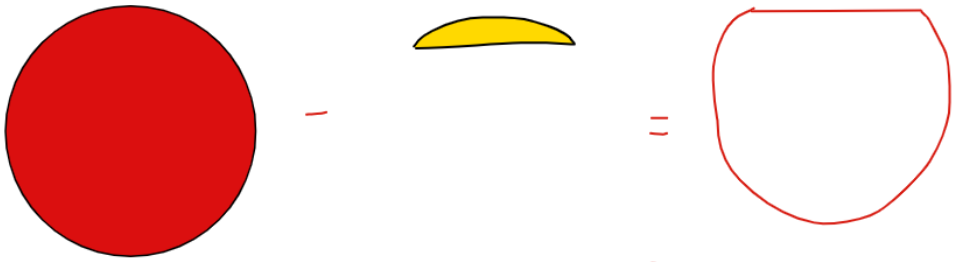


$$\pi r^2 \times \frac{90}{360}$$

$$4.021881931 \times 10^{-4}\ m^2$$



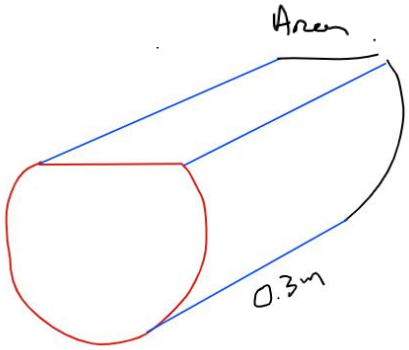
$4.02188193 \times 10^{-4} - 2.706329 \times 10^{-4} = 1.31555 \times 10^{-4}\ m^2$



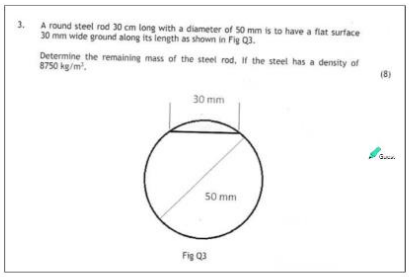
$\pi r^2 - 1.31555 \times 10^{-4}\ m^2$

$\pi (0.025)^2 - 1.31555 \times 10^{-4}\ m^2 = 1.83194 \times 10^{-3}\ m^2$

cross section Area



$A \times L = Vol$



3. A round steel rod 30 cm long with a diameter of 50 mm is to have a flat surface 30 mm wide ground along its length as shown in Fig Q3.

Determine the remaining mass of the steel rod, if the steel has a density of 8750 kg/m³. (8)

Fig Q3

$1.83194 \times 10^{-3} \times 0.3$

$Vol \times density = Kg$

$1.83194 \times 10^{-3} \times 0.3 \times 8750 = 4.8058\ kg$

5. Fig Q5 is a diagram of a crane jib AB with load suspended from a cable OB.

Determine the angle at A that the jib makes with the wall when the cable length OB is 7 m. (8)

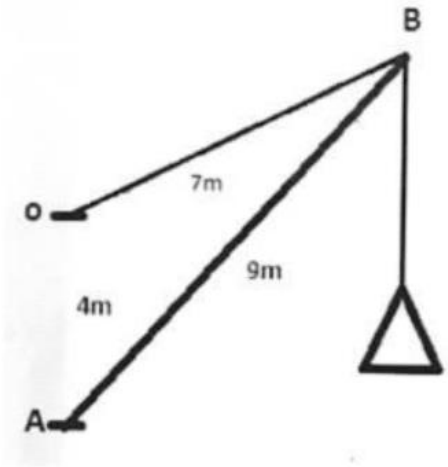
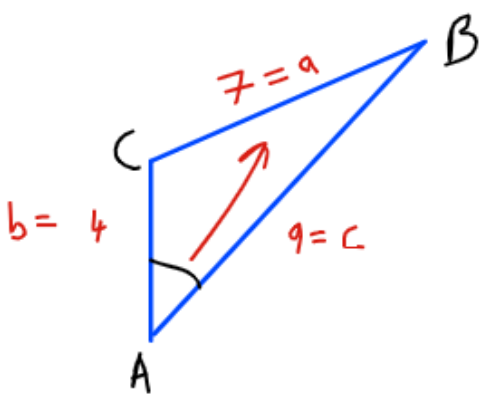


Fig Q5



$a^2 = b^2 + c^2 - 2bc\cos A$

$7^2 = 4^2 + 9^2 - 2 \cdot 4 \cdot 9 \cos A$

$49 = 97 - 72\cos A$

$49 - 97 = -72\cos A$

$\frac{-48}{-72} = \frac{-72\cos A}{-72}$

$\frac{2}{3} = \cos A$

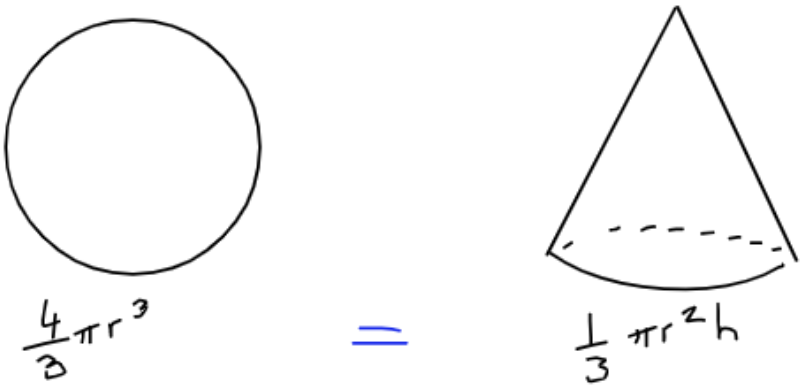
$\cos^{-1}\left(\frac{2}{3}\right) = A$

$48.1896^\circ = A$

6. A sphere and a cone have the same volumes. The radius of the sphere is the same as the radius of the cone base.

(a) Determine the ratio of cone height to sphere radius. (4)

(b) Check the answer to Q6(a) for a sphere of radius 2 cm. (4)



$\frac{4}{3}\pi r^3 = \frac{1}{3}\pi r^2 h$

$\frac{4}{3}\cancel{\pi} r^3 = \frac{1}{3}\cancel{\pi} r^2 h$ divide by pi

$\frac{4}{3} r^{\cancel{3}} = \frac{1}{3}\cancel{r^2} h$ divide by r^2

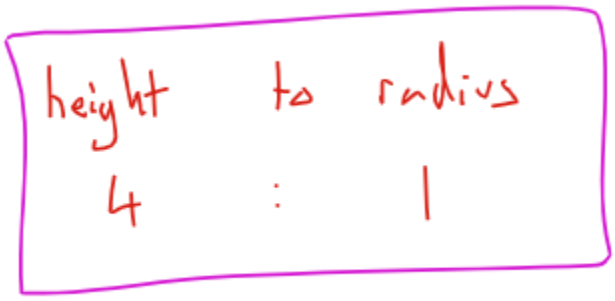
$\frac{4}{\cancel{3}} r = \frac{1}{\cancel{3}} h$ mult by 3

$4r = h$

lets check if $r = 1$ $h = 4$

$4 \times 1 = 4$

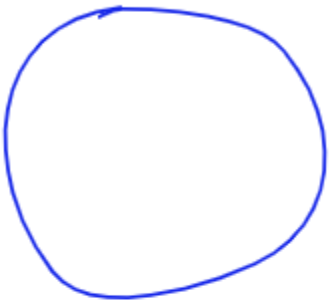
radius : height
1 : 4


height to radius
4 : 1

$4r = h$

b) Radius = 2 cm

height = 8 cm



$r = 2$

$r = 2 \quad h = 8$

$\frac{4}{3}\pi r^3$

$\frac{4}{3}\pi (2)^3$

$\frac{32\pi}{3}$

$33.5103 \text{ cm}^3 = 33.5103 \text{ cm}^3$

checked

Section B

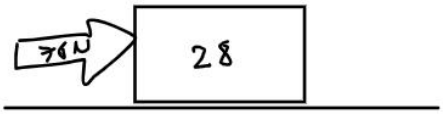
7. A force of 76 N is applied to a stationary mass of 28 kg which causes accelerated motion on a frictionless horizontal plane.

Determine EACH of the following:

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

(b) the distance the body will have travelled after 12 seconds. (4)

a)



$F = ma$

$\frac{76}{28} = 2.714285\ ms^{-2}$

b)

$s =$
$u = 0$
$v =$
$a = 2.714285$
$t = 12$

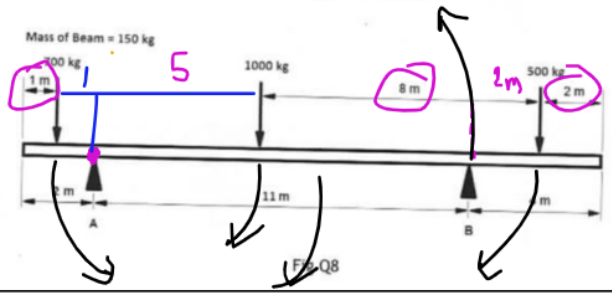
$s = ut + \frac{1}{2}at^2$

$s = 0 + \frac{1}{2}(2.714285)12^2$

$s = 195.43\ m$

8. A uniform beam is loaded as shown in Fig Q8. The beam has a mass of 150 kg.

Determine the reaction forces at the supports A and B. (10)



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17

Name	Mass kg	Force (N)	Distance to A (m)	Moment (Nm)	direction
W_1	700	6867	1	6867	A
W_2	1000	9810	5	49050	C
W_3	500	4905	13	63765	C
Beam	150	1471.5	6.5	9564.75	C
R_B		x	11	11x	A

the sum of the anticlockwise moments should be equal to the sum of the clockwise moments

$6867 + 11x = 49050 + 63715 + 9564.75$

122379.75

$11x = 115512.75$

$R_B = 10501.1590$

$10501\ N$

the sum of the downwards forces must equal the sum of the upwards forces:

$6867 = 10501 + R_A$

9810

4905

1471.5

$23053.5 = 10501 + R_A$

$\boxed{R_A = 12552.5\ N}$

9. (a) State the difference between *static* and *dynamic* friction. (2)

(b) A stone block has a mass of 4400 kg and is pulled across a horizontal surface with a constant acceleration of 0.25 m/s^2 by a force of 18 kN applied at an angle of 15° above the horizontal.

Determine the coefficient of friction. (6)

10. Fig Q10 shows a horizontal cross section of a steel support column 20 m high. The column has a mass of 7.2 tonnes on top of it. The density of steel is 7600 kg/m^3.

Calculate EACH of the following:

(a) the compressive stress at the top of the column; (4)

(b) the compressive stress at the column base. (4)

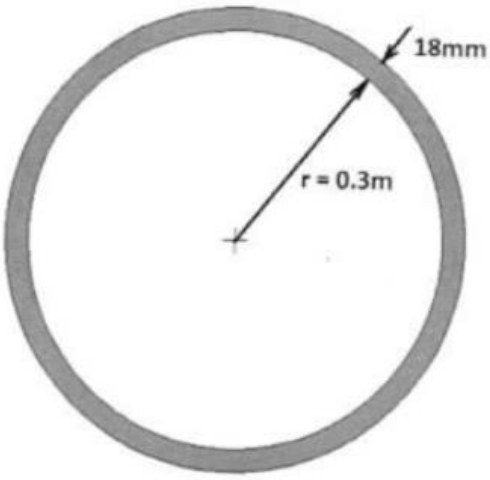
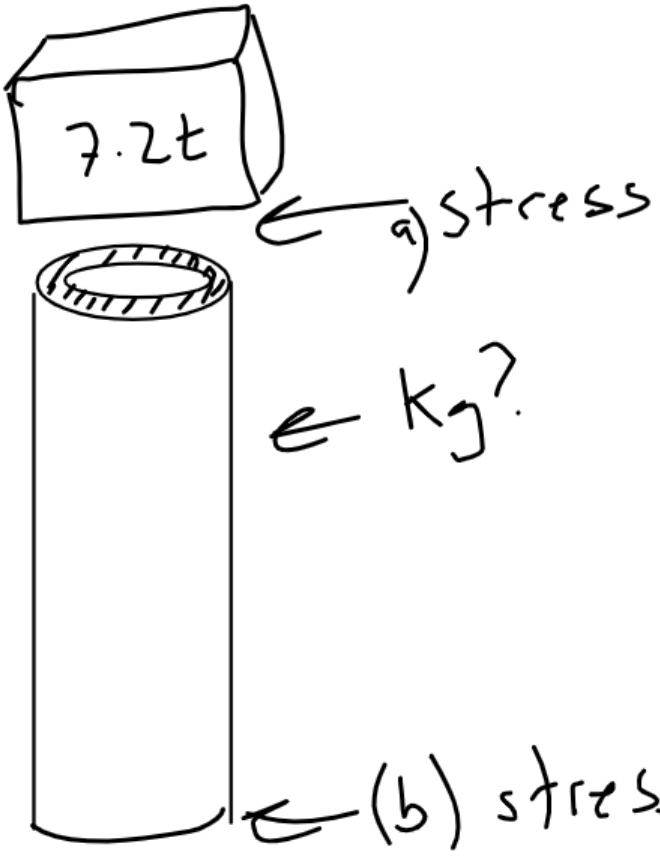
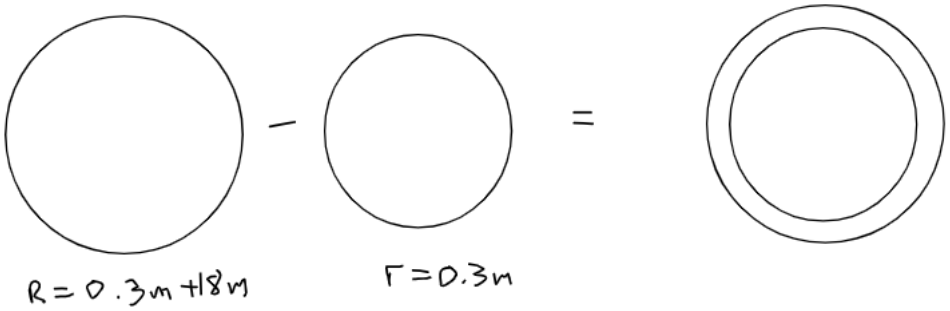


Fig Q10


7.2t
(a) stress
kg?
(b) stress = Force / Area

a) $\text{stress} = \frac{7200 \times 9.81}{\text{Area}}$

Area =



$R = 0.3\text{m} + 18\text{m}$

$R = 0.318$

$\pi(0.318)^2 - \pi(0.3)^2 = 0.034947\ m^2$

$r = 0.3\text{m}$

$\text{Stress} = \frac{7200 \times 9.81}{0.034947} = 2021113.258\ N/m^2$

b) Vol of column x density

Area x h x 7600

$0.034947 \times 20 \times 7600 = 5311.944\ kg$

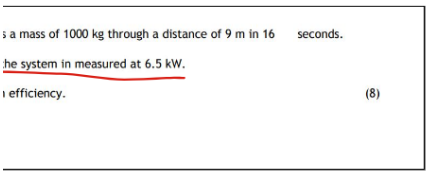
$\text{Force} = 9.81 \times 5311.944 = 52110.17064\ N$

$\text{Stress} = \frac{7200 \times 9.81 + 52110.17}{0.034947} = 3512237.7\ N/m^2$

12. 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)



Energy

work = F x d

Work = 9.81 x 1000 x 9 = 88290 J

16 sec

9m

1000kg

Power = Work / time = F x d / t = mgh / t

Power = 88290 / 16 = 5518.125 Watts

5.518 kW theoretical Power

Eff = theoretical / Actual = 5.518 / 6.5 x 100 = 84.894 %