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, 18 JUNE 2021

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.

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. (a) Simplify the following showing all working:

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

(b) Simplify the following showing all working, show the solution in its simplest mixed number form:

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

2. Simplify EACH of the following:

(a) $\dfrac{x^2\left(x^2yz+xyz\right)}{y(x^3z+y^2x^4z)}$ (4)

(b) $\dfrac{4xy}{2y} - \left(\dfrac{2y}{4} \times \dfrac{4x}{2}\right)$ (4)

3. The equation for a straight line graph is given by the following expression.

$Y = m x + c$

Where m is the slope of the graph and c is the intercept with the y axis:

(a) plot points shown in Table Q3 using the given scales and draw the best fit line; (4)

(b) determine the values of m and c from your graph; (4)

(c) state the law of the plotted straight line. (2)

X	-1	1	3	5
Y	-1	3	7	11

Table Q3

4. For the shape shown in FIG Q4, determine EACH of the following:

(a) the length of the side AB; (4)

(b) the area of the shape. (4)

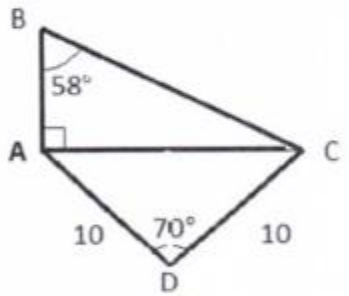

FIG Q4

Note: units may be ignored

5. Describe EACH of the following with the aid of a diagram:

(a) an equilateral triangle; (2)

(b) a scalene triangle; (2)

(c) an isosceles triangle; (2)

(d) a tangent to a circle. (2)

6. TWO solid objects are compared to each other. The first is a cone with a height of 1.2 m and a base diameter of 1 m. The second is a sphere with a diameter of 0.8 m.

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

Section B

7. A motor is uniformly accelerated from 450 rev/min to 800 rev/min in 10 seconds.

   Determine EACH of the following:

   (a) the angular acceleration in rad/s^2; (4)

   (b) the number of revolutions turned during the acceleration period. (4)

8. A piston has a mass of 30 kg, its velocity increases uniformly in part of its stroke from 1.0 m/s to 2.4 m/s in 0.4 seconds.

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

   (b) The piston is now uniformly retarded at 6 m/s^2 from 2.4 m/s until the mass just comes to rest. Calculate for the retardation period EACH of the following:

   (i) the time taken to come to rest; (3)

   (ii) the distance travelled. (3)

9. A beam, 5 m long, is supported at points A and B as shown in FIG Q9. The beam has a mass of 1.5 tonne and carries a UDL of 4 kN/m over a length of 3 m as shown in FIG Q9.

   Determine EACH of the following:

   (a) normal reaction at point A; (6)

   (b) normal reaction at point B. (2)

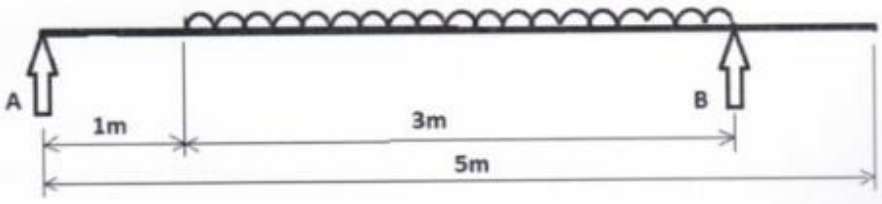

FIG Q9

10. A stationary body with a mass of 15 kg has a force of 100 N applied to it which causes acceleration in a horizontal plane. The coefficient of friction between the body and the plane is 0.35.

Calculate EACH of the following:

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

(b) the distance the body will travel from rest in 5 seconds. (4)

11. 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 hoist with dimensions; (2)

(b) determine EACH of the following:

(i) the movement ratio (velocity ratio) of the machine; (2)

(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; (2)

(iii) the efficiency of the machine under the conditions described in Q11(b)(ii). (2)

12. Steel plate 25 mm thick requires a hole 20 mm diameter. A hydraulic press punch is to be used for this purpose.

The steel has an ultimate shear stress of 380 N/mm^2:

(a) determine the force required to punch the hole; (4)

(b) briefly describe EACH of the following terms;

(i) *compressive stress*; (2)

(ii) *tensile stress*. (2)

1. (a) Simplify the following showing all working:

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

(b) Simplify the following showing all working, show the solution in its simplest mixed number form:

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

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

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

$\left(\frac{9}{1} + \frac{5}{8} \div \frac{2}{1} + \frac{3}{4}\right)$

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

$\left(\frac{77}{8} \times \frac{4}{11}\right)$

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

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

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

2. Simplify EACH of the following:

(a) $\dfrac{x^2(x^2yz+xyz)}{y(x^3z+y^2x^4z)}$ (4)

(b) $\dfrac{4xy}{2y} - \left(\dfrac{2y}{4} \times \dfrac{4x}{2}\right)$ (4)

a) $\dfrac{x^2(x^2yz+xyz)}{y(x^3z+y^2x^4z)} = \dfrac{x^4yz+x^3yz}{yx^3z+yx^2z}$

Dont expand out the brackets!

DO factorize out like terms

$$\frac{x^2 \times x(xyz+yz)}{y x^3(z+y^2xz)}$$

$$\frac{x^2 \times x \times y\left(xz + z\right)}{y\,x^3\,z\left(1 + y^2x\right)}$$

Fully simplify

$$\frac{x^2 x y z\left(x + 1\right)}{y\,x^3\,z\left(1 + y^2x\right)} = \frac{x+1}{1+y^2x}$$

(b) $\frac{4xy}{2y} - \left(\frac{2y}{4} \times \frac{4x}{2}\right)$

b)

$$\frac{4xy}{2y} - \left(\frac{2y}{4} \times \frac{4x}{2}\right)$$

$$\frac{2 \not{4} xy}{1 \not{2} y} - \left(\frac{xy}{1}\right)$$

$$2x - xy$$

3. The equation for a straight line graph is given by the following expression.

$Y = m x + c$

Where m is the slope of the graph and c is the intercept with the y axis:

(a) plot points shown in Table Q3 using the given scales and draw the best fit line; (4)

(b) determine the values of m and c from your graph; (4)

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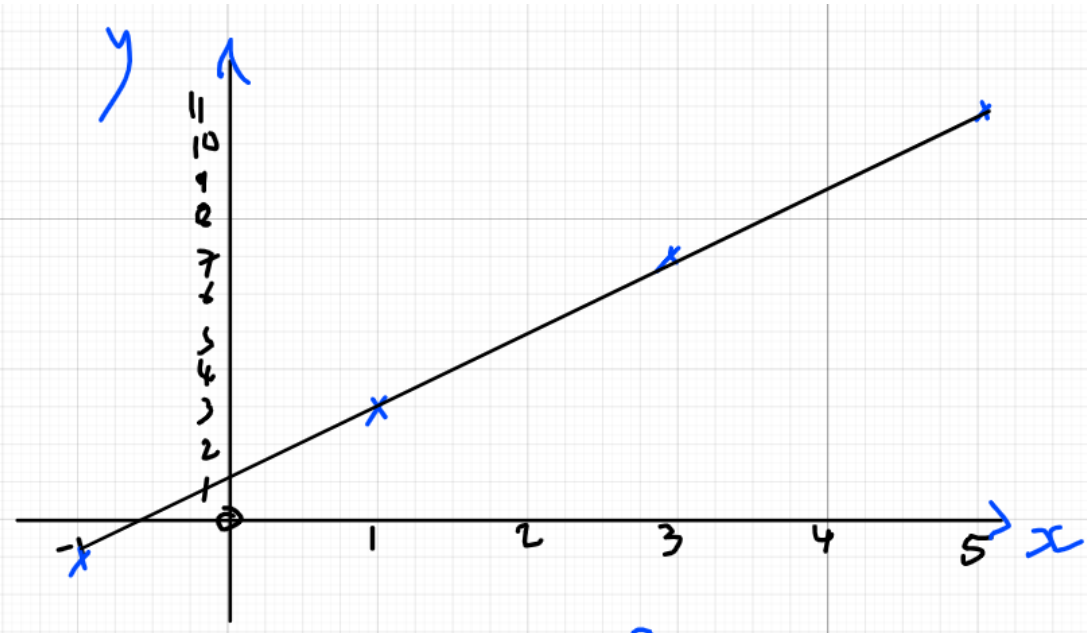
Y	-1	3	7	11

Table Q3

a)



b) $c = 1$ $m = 2$

c) $y = mx + c$

$y = 2x + 1$

4. For the shape shown in FIG Q4, determine EACH of the following:

(a) the length of the side AB; (4)

(b) the area of the shape. (4)

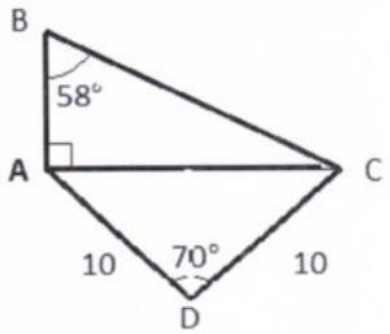
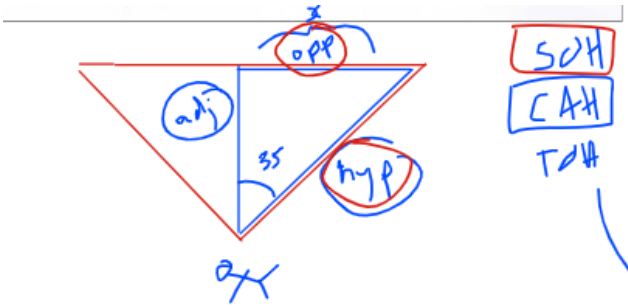
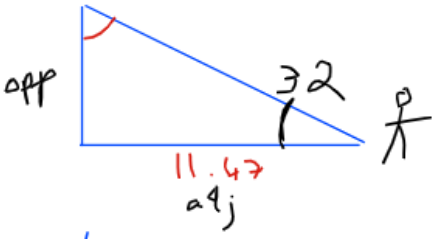


FIG Q4

Note: units may be ignored





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

$\sin 35 = \frac{x}{10}$

$10 \sin 35 = 5.73$

$AC = 11.47\ cm$

height $= 8.1915\ cm$

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

$\tan 32 = \frac{x}{11.47}$

$11.47 \tan 32 = 7.167\ cm$

$AB = 7.167$

Area top + bottom

$41.1 + 46.97 = 88.07$

5. Describe EACH of the following with the aid of a diagram:

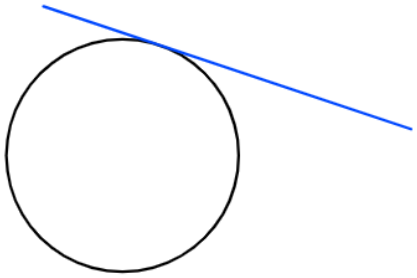
(a) an equilateral triangle; (2)

(b) a scalene triangle; (2)

(c) an isosceles triangle; (2)

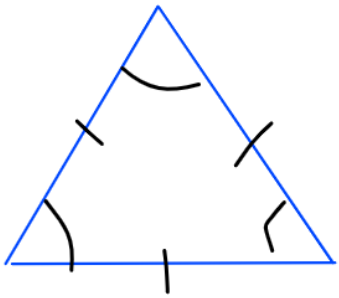
(d) a tangent to a circle. (2)

d)



a tangent touches a circle

a)

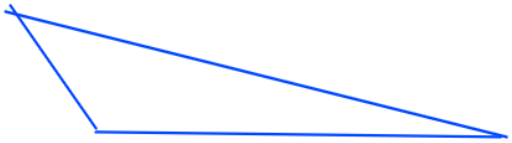


all sides the same, all angles the same

c)

c) 2 sides the same, 2 angles the same

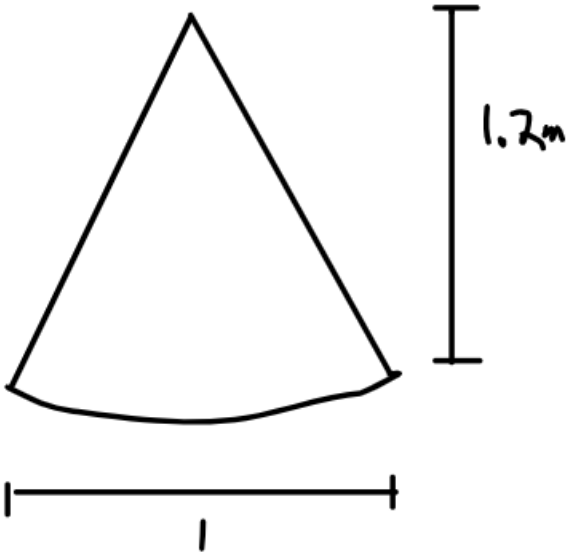
b) Scalene



all angles differnt, all side different

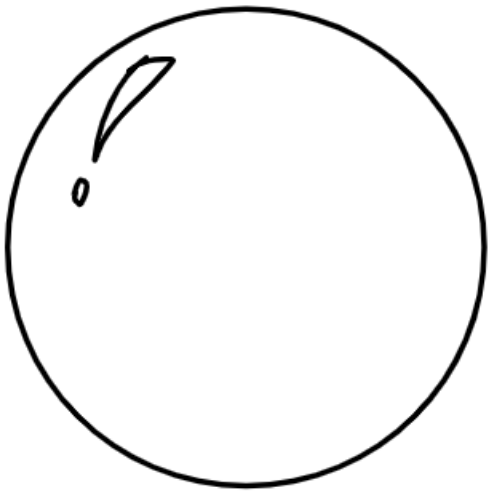
6. TWO solid objects are compared to each other. The first is a cone with a height of 1.2 m and a base diameter of 1 m. The second is a sphere with a diameter of 0.8 m.

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



Surface Area

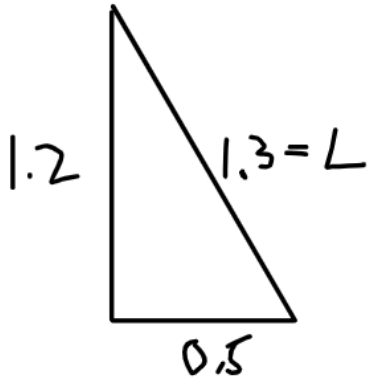
$\pi r L + \pi r^2$



Surface Area

$4\pi r^2$

$r = 0.4$



$\pi \times 0.5 \times 1.3 + \pi (0.5)^2$

$2.827433388 m^2$ $2.0106 m^2$

Section B

7. A motor is uniformly accelerated from 450 rev/min to 800 rev/min in 10 seconds.

Determine EACH of the following:

(a) the angular acceleration in rad/s^2; (4)

(b) the number of revolutions turned during the acceleration period. (4)

$d =$

$u = 450$ Rev/min $\Rightarrow$ 7.5 Rev/sec

$v = 800$ Rev/min $\Rightarrow$ 13.33333 Rev/sec

$a =$

$t = 10$

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

$$v = u + at$$

$$\frac{V-u}{t} = a$$

$$\frac{13.3333 - 7.5}{10} = a = \text{Rev/sec}^2 = 0.58333333$$

$0.5833333 \times 2\pi$

3.665 rads

d = ?
u
v
a
t

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

$0.5 \times 0.583333 \times 10^2$

75 29.1666

$d = 104.1666$

8. A piston has a mass of 30 kg, its velocity increases uniformly in part of its stroke from 1.0 m/s to 2.4 m/s in 0.4 seconds.

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

(b) The piston is now uniformly retarded at 6 m/s^2 from 2.4 m/s until the mass just comes to rest. Calculate for the retardation period EACH of the following:

(i) the time taken to come to rest; (3)

(ii) the distance travelled. (3)

30Kg

$F = ma$

$F = 30 \times 3.5$

$F = 105\ N$

$d =$

$u = 1$

$v = 2.4$

$a =$

$t = 0.4$

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

$v = u + at$

$\frac{v-u}{t} = a$

$\frac{2.4-1}{0.4} = a$

$3.5 = m\,s^{-2}$

b i) find

$d =$

$u = 2.4$

$v = 0$

$a = -6$

$t = 0.4\ sec$

$v = u + at$

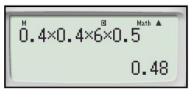
$0 = 2.4 - 6t$

$\frac{-2.4}{-6} = t = 0.4\ sec$

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

$0.5 \times (-6) \times (0.4^2)$

$s = (2.4)(0.4) + 0.5(-6)(0.4)^2$



$s = 0.96 - 0.48$

$s = 0.48\ m$

9. A beam, 5 m long, is supported at points A and B as shown in FIG Q9. The beam has a mass of 1.5 tonne and carries a UDL of 4 kN/m over a length of 3 m as shown in FIG Q9.

Determine EACH of the following:

(a) normal reaction at point A; (6)

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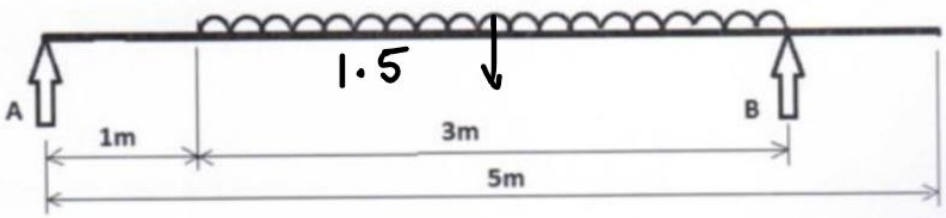


FIG Q9

A is the Pivot

		W	F	D	M	A/C
W_1	UDL		12000	2.5	30,000	C
W_2	Beam	1500	14715	2.5	36787.5	C
R_B	Reaction at B		x	4	4x	A

$$\frac{66787.5}{4} = \frac{4x}{4}$$

$$R_B = 16696.875 \text{ N}$$

Reaction at A

Total down Force = total up Force

Force From weights = $R_B + R_A$

$12,000 + 14715 = 16696.875 + x$

$26715 - 16696.875 = x$

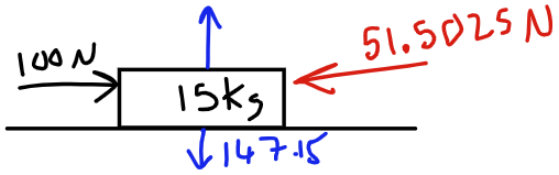
$10018.125 =$ Reaction at A Force

10. A stationary body with a mass of 15 kg has a force of 100 N applied to it which causes acceleration in a horizontal plane. The coefficient of friction between the body and the plane is 0.35.

Calculate EACH of the following:

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

(b) the distance the body will travel from rest in 5 seconds. (4)

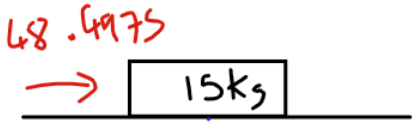


Friction Force = Normal (Vertical Force) × coefficient of friction

15×9.81

$51.5025 = 147.15 \times 0.35$

Net Force $100 - 51.5025 = 48.4975\text{N}$



$F = ma = 48.49 = 15a$

$\frac{48.49}{15} = a = 3.233 \text{ m/s}^2$

$d =$

$u = 0$

$v =$

$a = 3.233$

$t = 5$

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

$v = u + at$

$d = 0.5(3.233)(25)$

$d = 40.41458\ m$

11. 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 hoist with dimensions; (2)

(b) determine EACH of the following:

(i) the movement ratio (velocity ratio) of the machine; (2)

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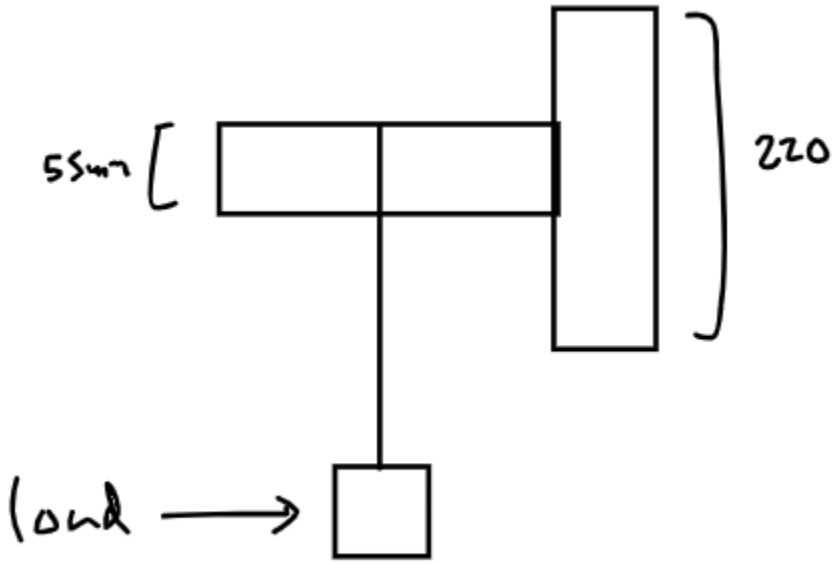
(iii) the efficiency of the machine under the conditions described in Q11(b)(ii). (2)



$$\text{Force Ratio} = \frac{\text{Load}}{\text{Effort}} \quad \frac{9.81 \times 100}{300} = \frac{981}{300} = 3.27 : 1$$

$$\text{Movement Ratio} = \frac{\pi d}{\pi d} = \frac{\pi\, 0.22}{\pi\, 0.055} = 4 : 1$$

$$E = \frac{F}{M} \times 100 = \frac{3.27}{4} \times 100 = 81.75\ \%$$

12. Steel plate 25 mm thick requires a hole 20 mm diameter. A hydraulic press punch is to be used for this purpose.

The steel has an ultimate shear stress of 380 N/mm^2:

(a) determine the force required to punch the hole; (4)

(b) briefly describe EACH of the following terms;

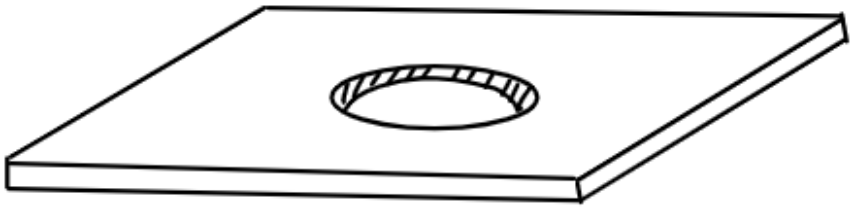
(i) *compressive stress*; (2)

(ii) *tensile stress*. (2)

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

$$\text{Strain} = \frac{\text{Extension}}{\text{Original}}$$

$$\text{Elasticity} = \frac{\text{Stress}}{\text{Strain}}$$



9) $$\text{Stress} = \frac{F}{A}$$

$$380 = \frac{F}{A}$$

Cross sectional Area of the hole to be punched

$$\pi d \times h = \pi \times 20 \times 25 = 1570.796 \text{ mm}^2$$

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

$$380 \times 1570.796 = F = 596902.60 \text{ N}$$