GENERAL ENGINEERING SCIENCE I

Attempt ALL questions

Marks for each question are shown in brackets.

Section A

1. (a) The ratio of carbon : hydrogen : sulphur in a fuel is given as 26:4:1.

Express these proportions as percentages. (4)

(b) Simplify to the following giving the answer as the simplest mixed fraction:

$$\frac{1}{6} \div \frac{3}{4} + \frac{1}{2}$$ (4)

2. Simplify EACH of the following expressions:

(a) $(a+b)(a^2 - ab + b^2)$ (4)

(b) $\frac{X}{2} - \frac{4X}{3} + \frac{3X}{5}$. (4)

3. A function is given by the equation:

$y = 1.5 \times x^2 + 2$

(a) Determine a table of y value data for the range x = -2 to x = 2. (4)

(b) Sketch a graph of the data determined in Q3(a). (4)

(c) From the graph, sketched in Q3(b), estimate the values for x when y = 5. (2)

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4. For the triangles shown in FIG Q4 which is not to scale, determine the angles x and y giving the answer in radians when angle ADC is $\pi/4$ radians. (8)

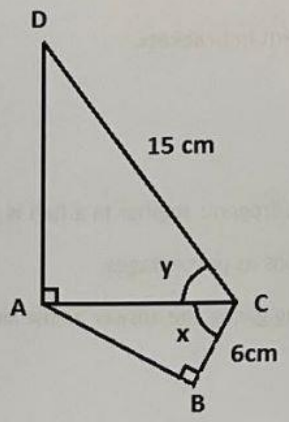


FIG Q4

5. 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)

6. Determine the area of the shaded sector in FIG Q6. (8)

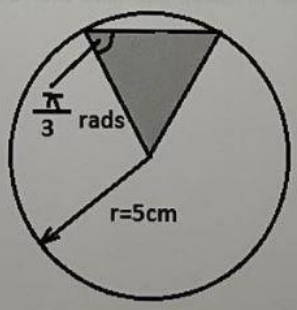


FIG Q6

Section B

7. (a) State an example of a derived unit explaining what it is derived from. (2)

   (b) State TWO fundamental units. (2)

   (c) A cylinder has a diameter of 80 mm and contains fluid to a depth of 6 cm. The fluid has a mass of 400 grams.

   Determine the density of the fluid. (4)

8. A car is pulling a trailer at 80 km/hour with a steady force of 700 N for 30 minutes.

   Determine EACH of the following:

   (a) the work done; (4)

   (b) the power required. (4)

9. (a) State what is meant by static equilibrium. (2)

   (b) In relation to the forces shown in FIG Q9, determine a third force vector needed to bring the system into static equilibrium. (8)

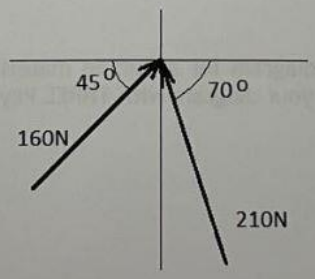


FIG Q9

10. A sliding hatch cover has a mass of 650 kg and has a force of 150 N applied to it which causes acceleration of the hatch cover in a horizontal plane.

The effects of friction can be ignored.

Calculate EACH of the following:

(a) the acceleration of the body; (3)

(b) the hatch cover needs to travel 12 m to close, determine how long will this take. (5)

11. Part of a deckhead support is made of a steel beam 8 m long, simply supported at the ends, points A and B. The beam has a mass of 1600 kg. The superstructure above the deckhead beam is supported by pillars which can be represented as point loads on the beam 1.5 m, 5 m and 6.5 m from the left end. These pillars carry loads of 4 tonnes, 3 tonnes and 6 tonnes respectively.

(a) Draw a simple sketch of the loaded beam. (1)

(b) Determine EACH of the following:

(i) the normal reaction force at point A; (4)

(ii) the normal reaction force at point B. (3)

12. (a) Describe Hookes Law. (2)

(b) Sketch a stress strain diagram for a ductile material exhibiting yield point phenomenon, labelling your diagram with THREE key points. (6)

1. (a) The ratio of carbon : hydrogen : sulphur in a fuel is given as 26:4:1.

Express these proportions as percentages. (4)

(b) Simplify to the following giving the answer as the simplest mixed fraction:

$\frac{1}{6} \div \frac{3}{4} + \frac{1}{2}$ (4)

a)

carbon	hydrogen	sulphur	total
24	4	1	29

$\frac{24}{29} \times 100$ $\frac{4}{29} \times 100$ $\frac{1}{29} \times 100 =$

82.7586%. 13.7931%. 3.4483%.

b) $\frac{1}{6} \div \frac{3}{4} + \frac{1}{2}$

$\frac{1}{6} \times \frac{4}{3}$

$\frac{4}{18} + \frac{1}{2}$

$\frac{2 \times 2}{2 \times 9} + \frac{1 \times 9}{2 \times 9} = \frac{4}{18} + \frac{9}{18} = \frac{13}{18}$

2. Simplify EACH of the following expressions:

(a) $(a+b)(a^2-ab+b^2)$ (4)

(b) $\frac{x}{2}-\frac{4x}{3}+\frac{3x}{5}$. (4)

a) $a^2 - ab + b^2$

a	a^3	$-a^2b$	$+ab^2$
b	a^2b	$-ab^2$	$+b^3$

$a^3 - a^2b + ab^2 + a^2b - ab^2 + b^3$

$a^3 + b^3$

b) $\frac{3x}{3} - \frac{4x \cdot 2}{3 \cdot 2} + \frac{3x}{5}$

$\frac{3x}{6} - \frac{8x}{6}$

$5x - \frac{5x}{6} + \frac{3x}{5} \times 6$

$5x \quad 6 \quad 5 \times 6$

$\frac{-25x}{30} + \frac{18x}{30}$

3. A function is given by the equation:

$y = 1.5 \times x^2 + 2$

(a) Determine a table of y value data for the range x = -2 to x = 2. (4)

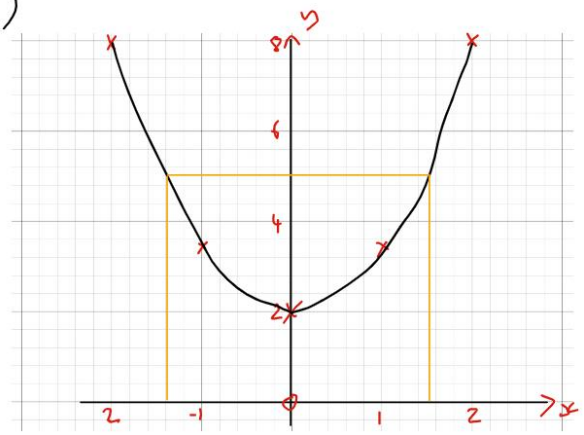
(b) Sketch a graph of the data determined in Q3(a). (4)

(c) From the graph, sketched in Q3(b), estimate the values for x when y = 5. (2)

a)

x	y
-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) $x = -1.4$

$x = 1.5$

check

$y = 1.5(-1.4)^2 + 2 = 4.94$

$y = 1.5(1.5)^2 + 2 = 5.375$

4. For the triangles shown in FIG Q4 which is not to scale, determine the angles x and y giving the answer in radians when angle ADC is π/4 radians. (8)

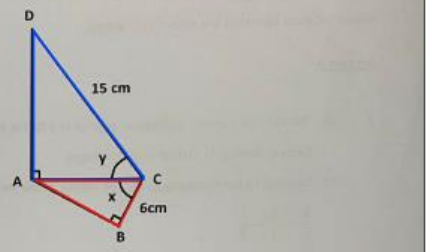
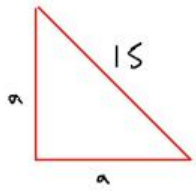


FIG Q4

$\frac{\pi}{4} = 45°$ $y = 45°$

$y = \frac{\pi}{4}$

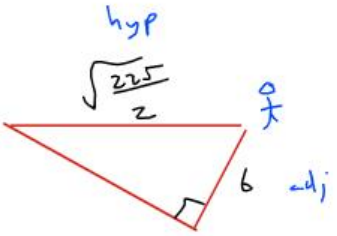
We can use pythag



$15^2 = a^2 + a^2$

$225 = 2a^2$

$\sqrt{\frac{225}{2}} = a$



CAH

$\cos\theta = \frac{adj}{hyp}$

$\cos\theta = \frac{6}{\sqrt{\frac{225}{2}}}$

$\theta = \cos^{-1}\left(\frac{6}{\sqrt{\frac{225}{2}}}\right)$

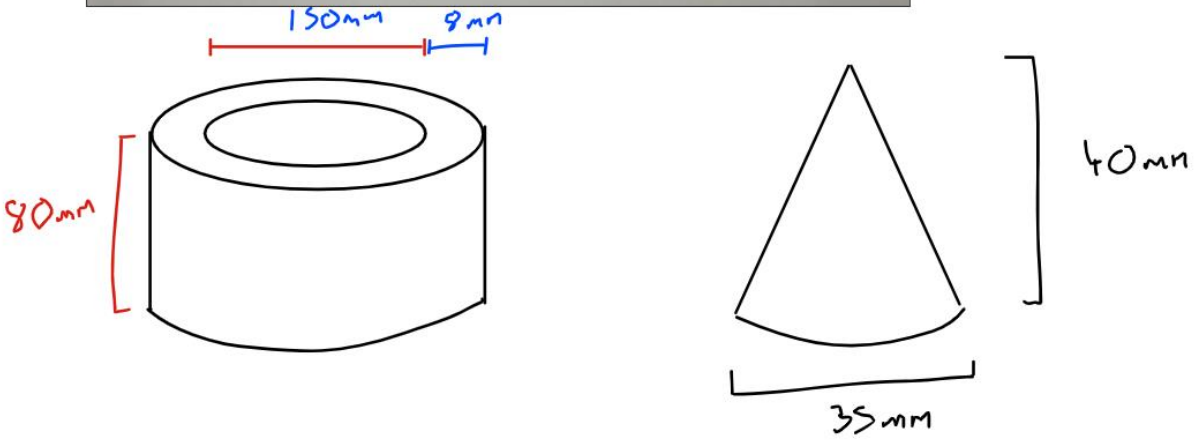
$\theta = 0.969532101$

$x = 0.96953$ Rads

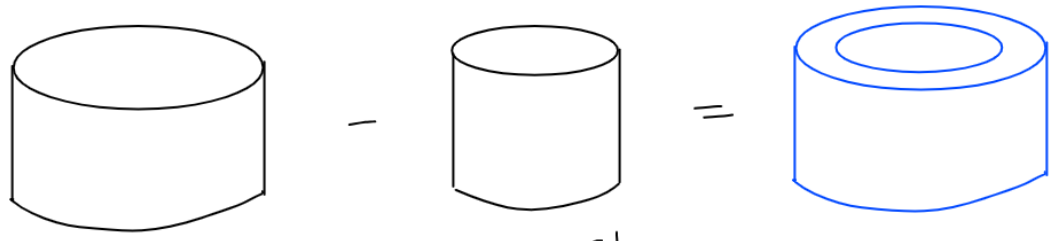
5. It is required to cast a new white metal bearing which can be considered to be of a hollow cylinder 80 mm long 150 mm internal diameter with a wall thickness of 8 mm.

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)



Bearing



$Vol = \pi r^2 h$

$r = 75 + 8 = 83mm$

$h = 80$

$Vol = \pi (83)^2 80$

1731394.543 −

$Vol = \pi r^2 h$

$r = 75mm$

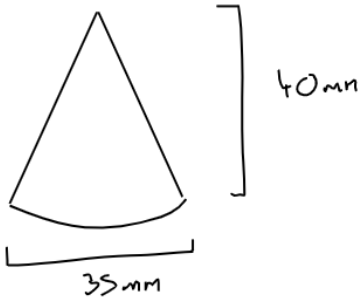
$h = 80$

$Vol = \pi (75)^2 80$

1413716.694 =

$317677.8491\ mm^3$

Cone



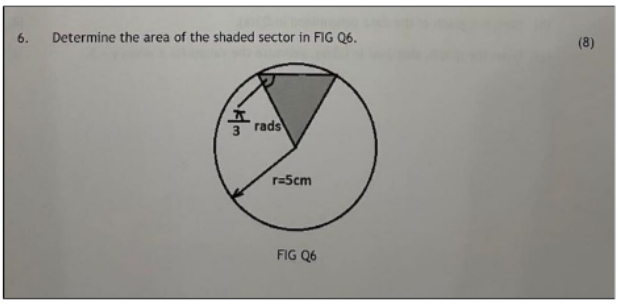
$Vol = \frac{1}{3}\pi r^2 h$

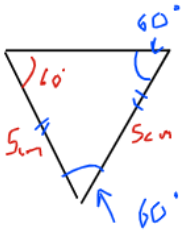
$r = 17.5$

$Vol = \frac{1}{3}\pi (17.5)^2 (40) = 12828.17\ mm^3$

Total $\frac{317677.8491}{12828.17} = 24.764$

25 cones needed



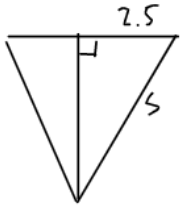


$\frac{\frac{\pi}{3}}{2\pi} \times 360 = 60°$

Version 1

$\frac{1}{2} ab\sin C = \frac{1}{2} \times 5 \times 5 \sin 60 = 10.8253\ cm^2$

Version 2



$\sqrt{5^2 - 2.5^2} = \text{height}$

$= 4.33\ cm$

$\text{Area} = \frac{b \times h}{2} = 2.5 \times 4.330127$

$= 10.8253\ cm^2$

Section B

7. (a) State an example of a derived unit explaining what it is derived from. (2)

(b) State TWO fundamental units. (2)

(c) A cylinder has a diameter of 80 mm and contains fluid to a depth of 6 cm. The fluid has a mass of 400 grams.

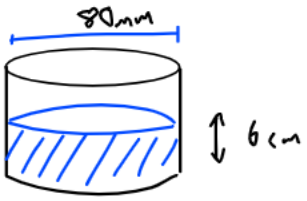
Determine the density of the fluid. (4)

7a) m/s metres per second

derived from the distance travelled measured in meters, divided by the time taken to travel said distance measured in seconds

b) kg, Newton, Second, meter

c)



$r = 40mm = 0.04m$

$h = 0.06\ m$

$$\text{Density} = \frac{\text{Mass}}{\text{Vol}}$$

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

$$= \pi (0.04)^2 (0.06)$$

$$= 3.0159 \times 10^{-4}\ m^3$$

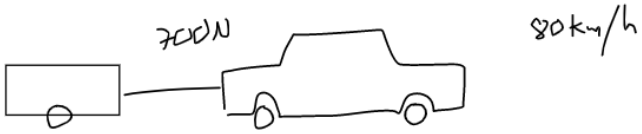
$$\text{Density} = \frac{0.4\ kg}{3.0159 \times 10^{-4}} = 1326.3\ kg/m^3$$

8. A car is pulling a trailer at 80 km/hour with a steady force of 700 N for 30 minutes.

Determine EACH of the following:

(a) the work done; (4)

(b) the power required. (4)



a) Work = F x d

700 x 40,000 = 28,000,000 J = 28 MJ

distance = 80 km x 0.5 = 40 km = 40,000

b) Power = $\frac{F \times d}{time}$ = Force x Velocity $\frac{m}{s}$

$700 \times \frac{80,000}{3600}$ = 15,555.5 Watts

15.556 kW

÷746

20.85 Hp

9. (a) State what is meant by static equilibrium. (2)

(b) In relation to the forces shown in FIG Q9, determine a third force vector needed to bring the system into static equilibrium. (8)

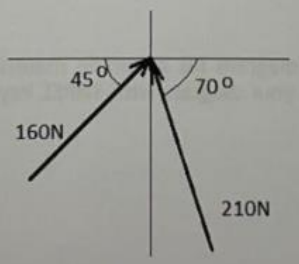
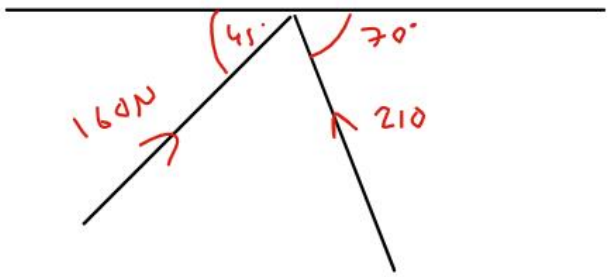
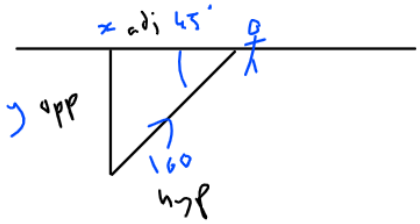


FIG Q9

a) A system in static equilibrium is not moving, it is static. All of the horizontal forces are equal, and all of the vertical forces are equal. (The sum of)

b)





Horizontal

hyp, adj

CAH

$\cos 45 = \frac{x}{160}$

$160 \cos 45 = x$

$113.137 = x$

Push Right

Vertical

opp, hyp

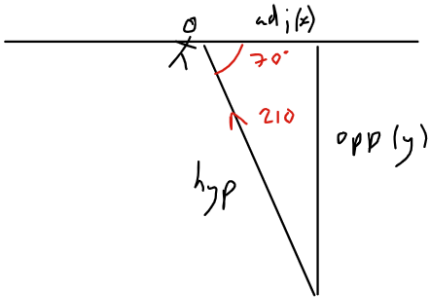
SOH

$\sin 45 = \frac{y}{160}$

$160 \sin 45 = y$

$113.137 = y$

Push ~~up~~



Horizontal

hyp , adj

CAH

$\cos 70 = \frac{x}{210}$

$210 \cos 70 = x$

$x = 71.8242$ N

Left

Vertical

opp , hyp

SOH

$\sin 70 = \frac{y}{210}$

$210 \sin 70 = y$

$y = 197.335$ N

Up

Net horizontal

Right → +

Left ← −

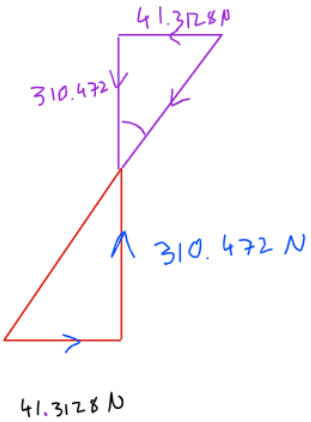
$113.137 - 71.8242 = 41.3128$ N (Right)

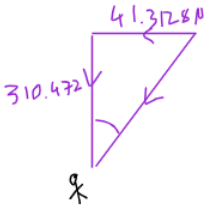
Net Vertical

Up + Up

$113.137 + 197.335 = 310.472$ (Up)

To bring system into equilibrium we need to counter act Net forces





toa

$\tan\theta = \frac{41.3128}{310.472}$

$\theta = \tan^{-1}\left(\frac{41.3128}{310.472}\right)$

$\theta = 7.5795°$

Magnitude $\sqrt{(41.3128)^2 + (310.472)^2} = 313.2\ N$

to bring the system into equilibrium we need a force of 313.2N on a bearing of 007.5795

10. A sliding hatch cover has a mass of 650 kg and has a force of 150 N applied to it which causes acceleration of the hatch cover in a horizontal plane.

The effects of friction can be ignored.

Calculate EACH of the following:

(a) the acceleration of the body; (3)

(b) the hatch cover needs to travel 12 m to close, determine how long will this take. (5)

a) $F = ma$

$150 = 650\,a$

$\frac{150}{650} = a = 0.230769\ m/s^2$

b) $s = 12$

$u = 0$

v

$a = 0.230769$

$t =$

$v = u + at$

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

$12 = 0 + \frac{1}{2}(0.230769)t^2$

$104 = t^2$

$\sqrt{104} = 10.198\ sec$

11. Part of a deckhead support is made of a steel beam 8 m long, simply supported at the ends, points A and B. The beam has a mass of 1600 kg. The superstructure above the deckhead beam is supported by pillars which can be represented as point loads on the beam 1.5 m, 5 m and 6.5 m from the left end. These pillars carry loads of 4 tonnes, 3 tonnes and 6 tonnes respectively.

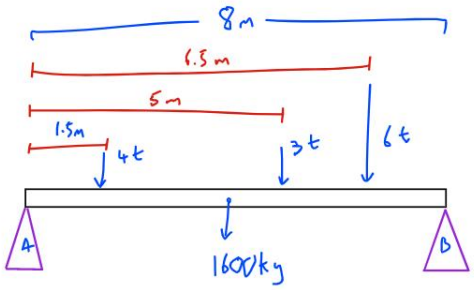
(a) Draw a simple sketch of the loaded beam. (1)

(b) Determine EACH of the following:

(i) the normal reaction force at point A; (4)

(ii) the normal reaction force at point B. (3)

a)



b)

Name	Mass (t)	Force (kN)	Distance (m)	Moment (kNm)	Direction A/C
W_1	4	39.24	1.5	58.86	C
W_2	3	29.43	5	147.15	C
W_3	6	58.86	6.5	382.59	C
Beam	1.6	15.696	4	62.784	C
R_B		x	8	$8x$	AC

sum of clockwise moments = sum of anticlockwise moments

$58.86 + 147.15 + 382.59 + 62.784 = 8x$

$651.384 = 8x$

$81.423 = x$

$81.423\ kN \quad R_B$

sum of downwards forces = sum of upwards forces

39.24

29.43 $= R_A + R_B$

58.86

15.696

$143.226 = R_A + 81.423$

$61.803\ kN = R_A$

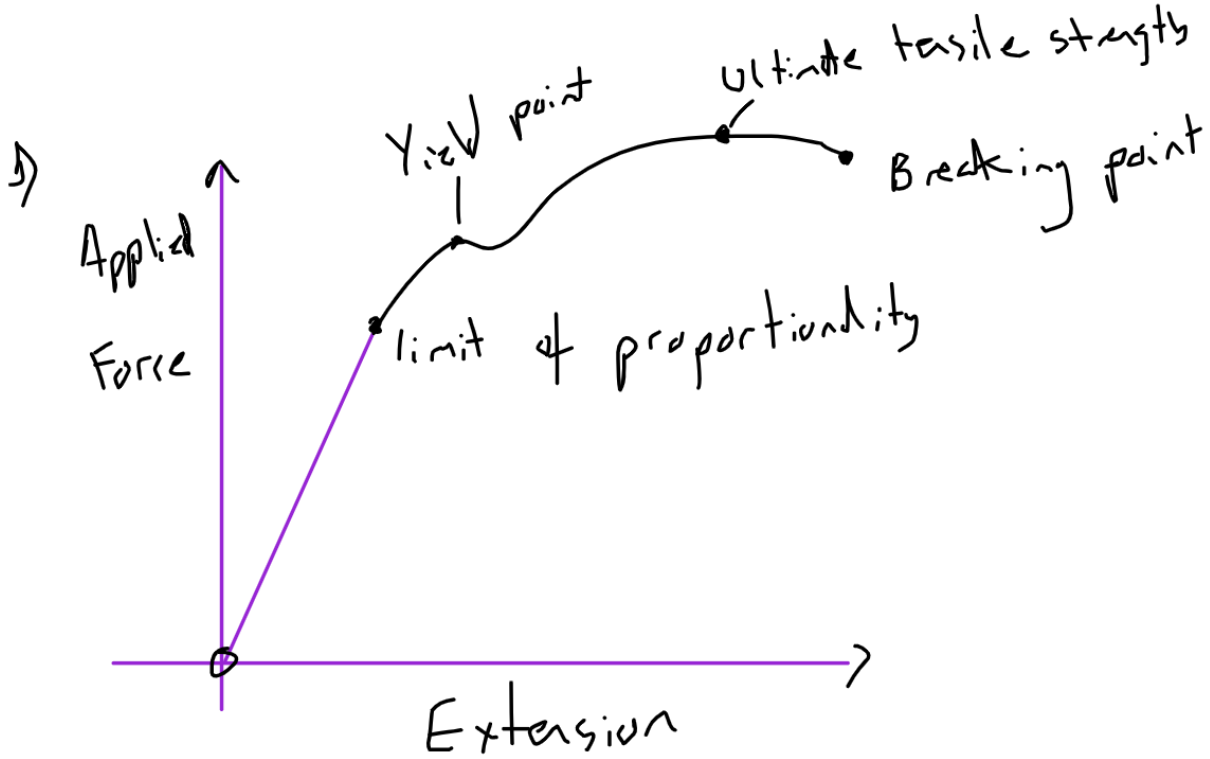
12. (a) Describe Hookes Law. (2)

(b) Sketch a stress strain diagram for a ductile material exhibiting yield point phenomenon, labelling your diagram with THREE key points. (6)

a) hookes law describes the directly proportional relationship between load and extention. It shows a linear (and very predictable) relationship between the two. By adding weights of a known amount, and measuring the extension of a spring we can calculate the elesticity constnat for that spring. Without this, the industrial revolution wouldnt have been possible!

$$\text{Extension} = k(\text{load})$$

$$m = k(N)$$


Ultimate tensile strength
Yield point
Breaking point
Applied Force
limit of proportionality
Extension