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CHIEF DIRECTORATE:
CURRICULUM MANAGEMENT SERVICES

COVID-19 REVISION MATERIAL

FOR

CALCULATIONS FOR COLLECTABLE MARKS

GRADE 12

(2020)

ACTIVITY 1: STRESS AND STRAIN:

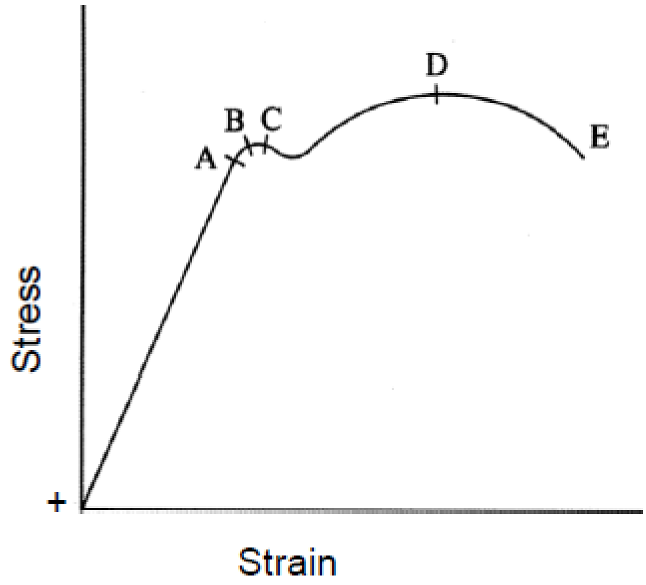


FIGURE 1.12

1.3 In the stress/strain diagram Point E represents:

A. Maximum stress
B. Limit of proportionality
C. Break stress
D. Elastic limit (1)

1.2 What do points **A–E** represent in FIGURE 1.12
1.3 What does point **D** denote in FIGURE 1.12
1.4 What is represented by point **E** on the graph?

ACTIVITY 2.1: FORCES – ACTING ON ONE POINT

2.1.1 Four forces of 3 kN, 2,1 kN, 2,5 kN and 3,6 kN respectively have the same acting point as shown in FIGURE 2.1.1.

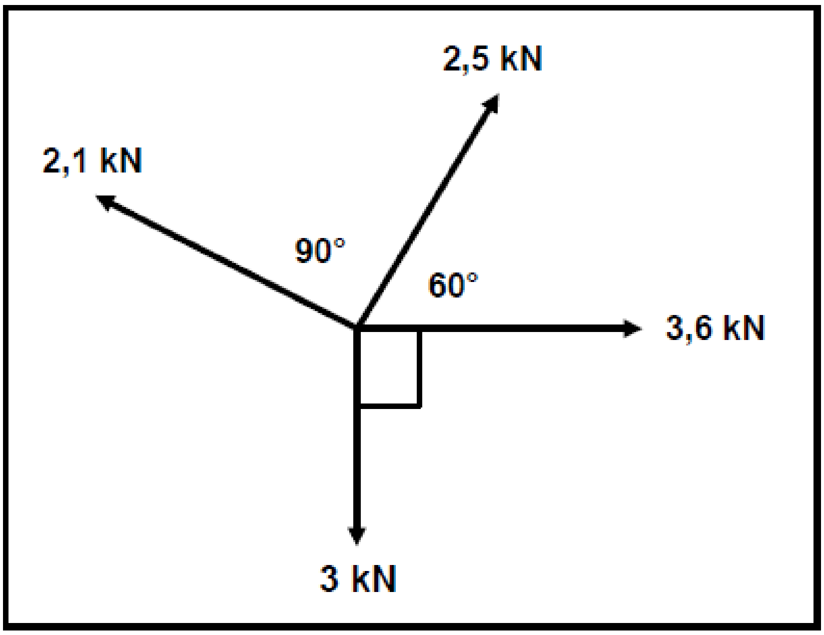


FIGURE 2.1.1

Determine by means of calculations:

(**HINT:** Redraw the force diagram above to show the horizontal and vertical component of each force.)

2.1.1 The sum of the horizontal components (6)

2.1.2 The sum of the vertical components (6)

2.1.2.1 A tensile force of 50 kN is exerted onto a round bar with a diameter of 50 mm and an original length of 3 m.

Determine by means of calculations:

2.1.2.1.1 The stress in the material (4)

2.1.2.1.1 The strain if the final length of the bar is 3,005 m (3)

2.2 Four forces of 150 N, 210 N, 250 N and 360 N respectively, as shown in FIGURE 2.2 below, act on the same point. Calculate the magnitude and direction of the equilibrant for this system of forces.

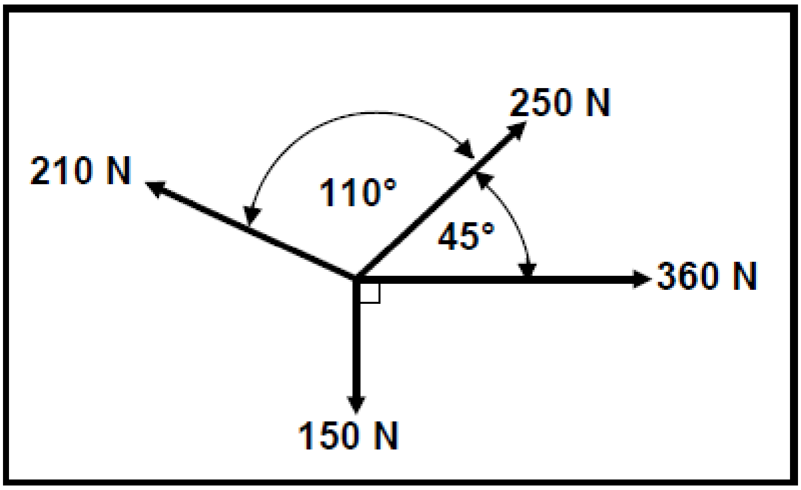


FIGURE 2.2

2.3 A square steel bar with 100 mm x 100 mm sides is subjected to compressive force of 80 kN. Determine, by means of calculations, the stress in the material. (5)

2.4 Define *Hooke's law*. (3)

2.3. A system of forces is shown in FIGURE 2.3. Determine, by means of calculations, the magnitude and direction of the resultant for the system of forces in FIGURE 2.3

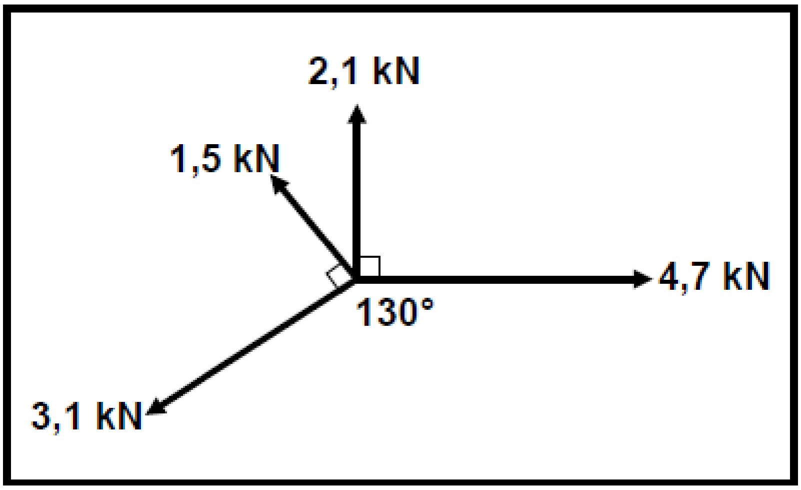


FIGURE 2.3

2.3.1.1 Calculate the resultant of the horizontal components. (4)

2.3.1.2 Calculate the resultant of the vertical components. (4)

2.3.1.3 Calculate the magnitude of the equilibrium force. (4)

2.3.1.4 Calculate the equilibrium angle with reference to the horizontal plane. (3)

2.4 In FIGURE 2.4 four forces of 200 N, 300 N, 280 N and 350 N are acting on the same point.

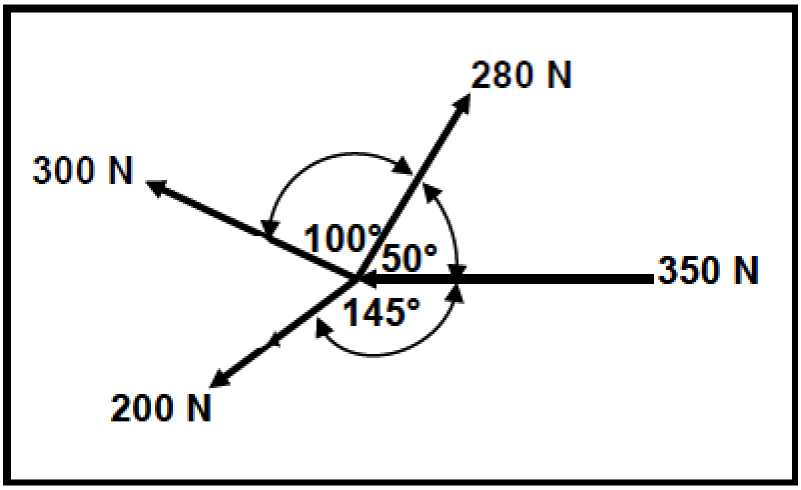


FIGURE 2.4

2.4.1 Calculate the resultant of the horizontal components (5)

2.4.2 Calculate the resultant of the vertical components (4)

2.4.3 Calculate the magnitude of the equilibrium force (3)
2.4.4 Calculate the equilibrium angle with reference to the horizontal plane (3)

2.5 An unknown force causes 3.5MPa stress in a 25mm round bar. Calculate the magnitude of the force. (4)

ACTIVITY 3.1: FORCES - BEAMS:

3.1The beam in FIGURE 3.1 below is in equilibrium. Calculate the distance between the support point and the 9 kN load.

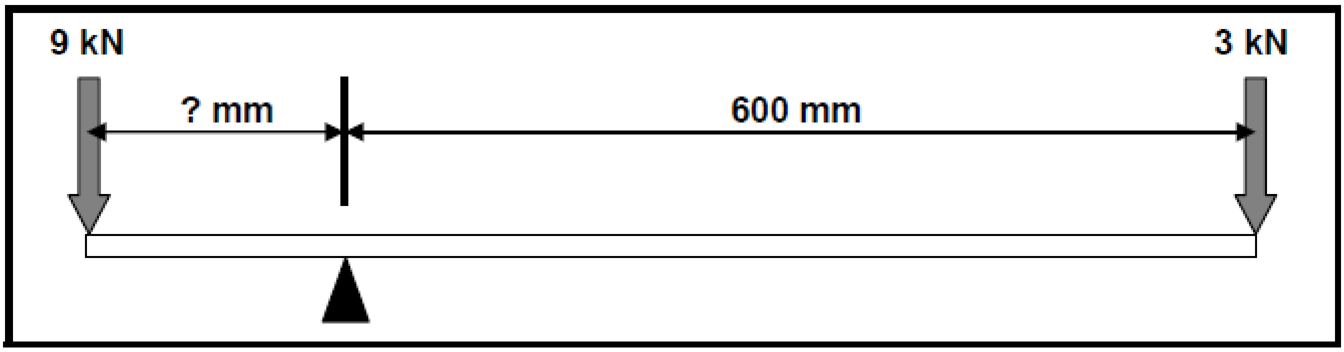


FIGURE 3.1

A 300 mm; B 200 mm; C 150 mm; D 600 mm (1)

3.2 FIGURE 3.2 below shows a uniform beam that is supported by two vertical supports, A and B. Two vertical point loads are exerted onto the beam, as well as a uniformly distributed load of 100 N/m, over a length of 6 metres of the beam. Determine, by means of calculations and using the turning points method, the magnitudes of the reactions in supports **A** and **B**. (6)

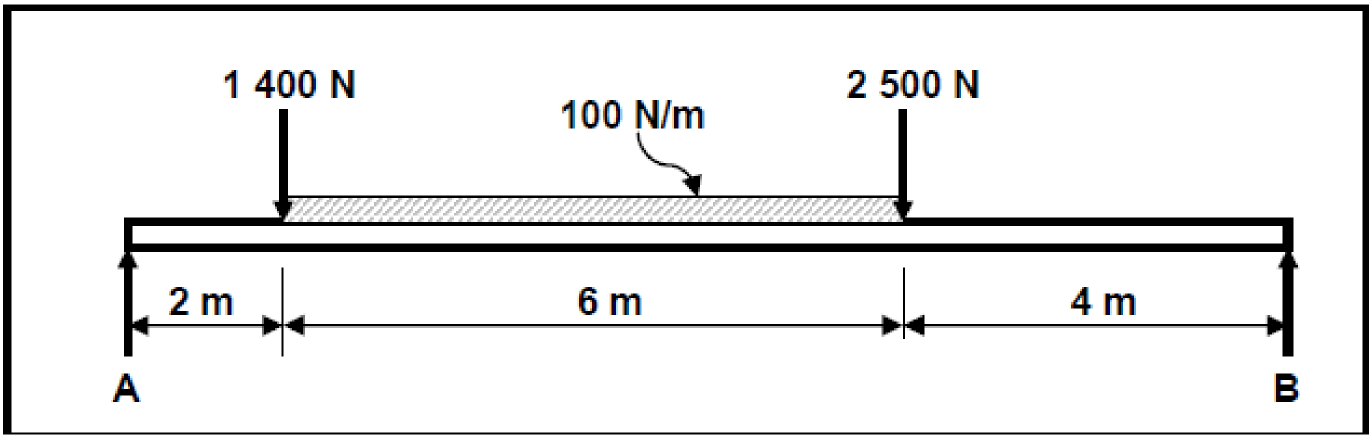


FIGURE: 3.2

3.3 FIGURE 3.3 below shows a uniform beam that is supported by two vertical supports, **A** and **B**. Two vertical point loads are exerted onto the beam, as well as a uniformly distributed load of 50 N/m, over the total left half of the beam. Determine, by means of calculations, the magnitudes of the reactions in supports **A** and **B**.

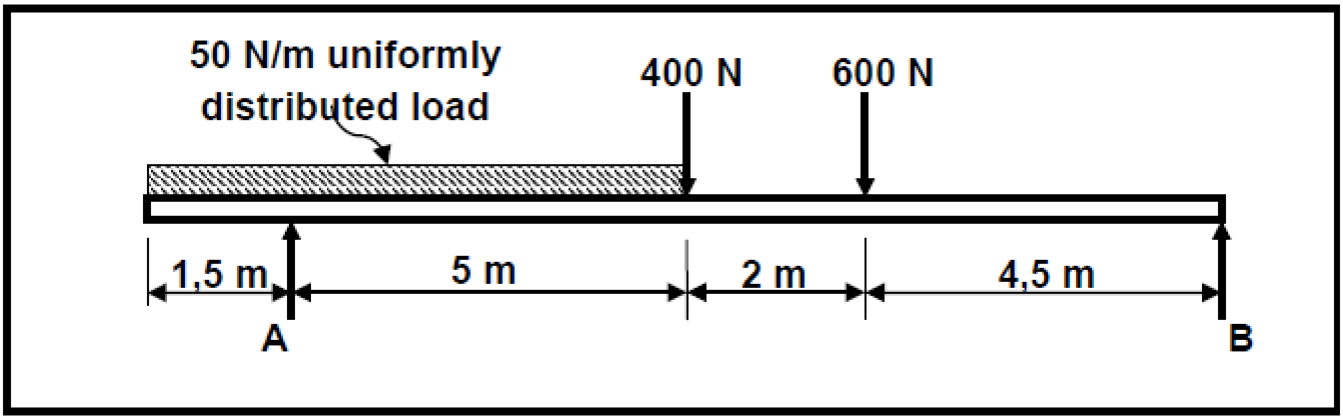


FIGURE: 3.3

3.4 FIGURE3.4 shows a uniform beam that is supported by two vertical supports, A and B, Two vertical points loads are exerted onto the beam, as well as a uniformly distributed force of 60N/m, over the distance between the two vertical points loads.

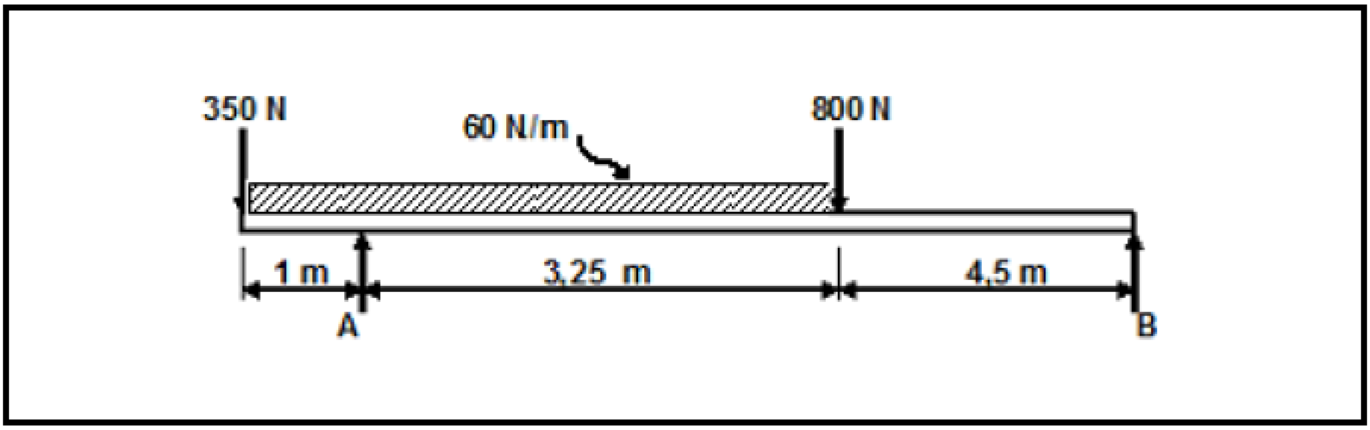


FIGURE 3.4

Determine by means of calculations, the magnitude of the reactions in support ‘A’ and support ‘B’ (6)

3.5 FIGURE 3.5 below shows a uniform beam that is supported by two vertical supports, **A** and **B**. Two vertical point loads, 1 400 N and 1 600 N, are exerted onto the beam, as well as a uniformly distributed force of 350 N/m over the total length of the beam. Determine, by means of calculations, the magnitude of the reactions in supports **A** and **B**.

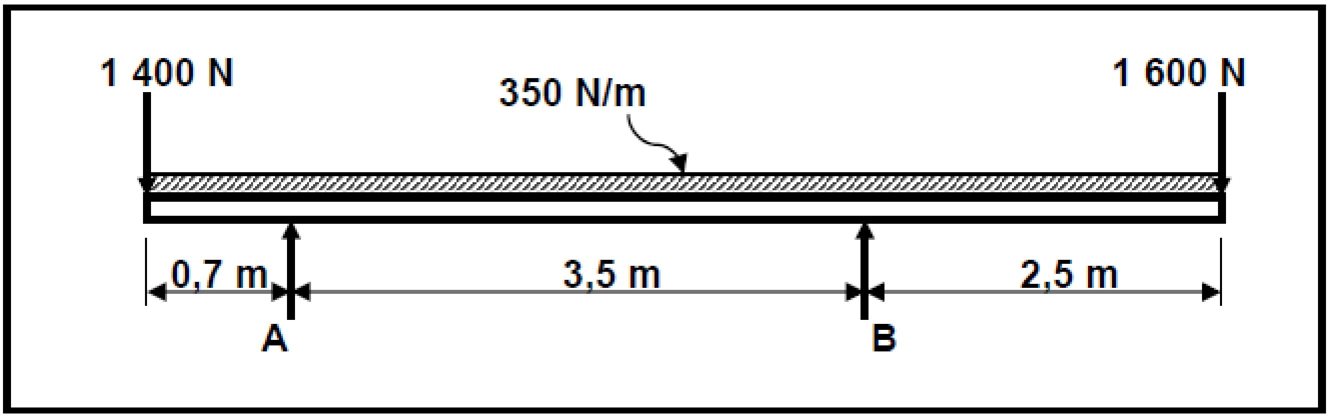


FIGURE: 3.5

3.6
The diagram in FIGURE 8.2 below shows a beam with two vertically applied point loads of 20 kN and 30 kN and also a 5 kN/m uniformly distributed load on it.

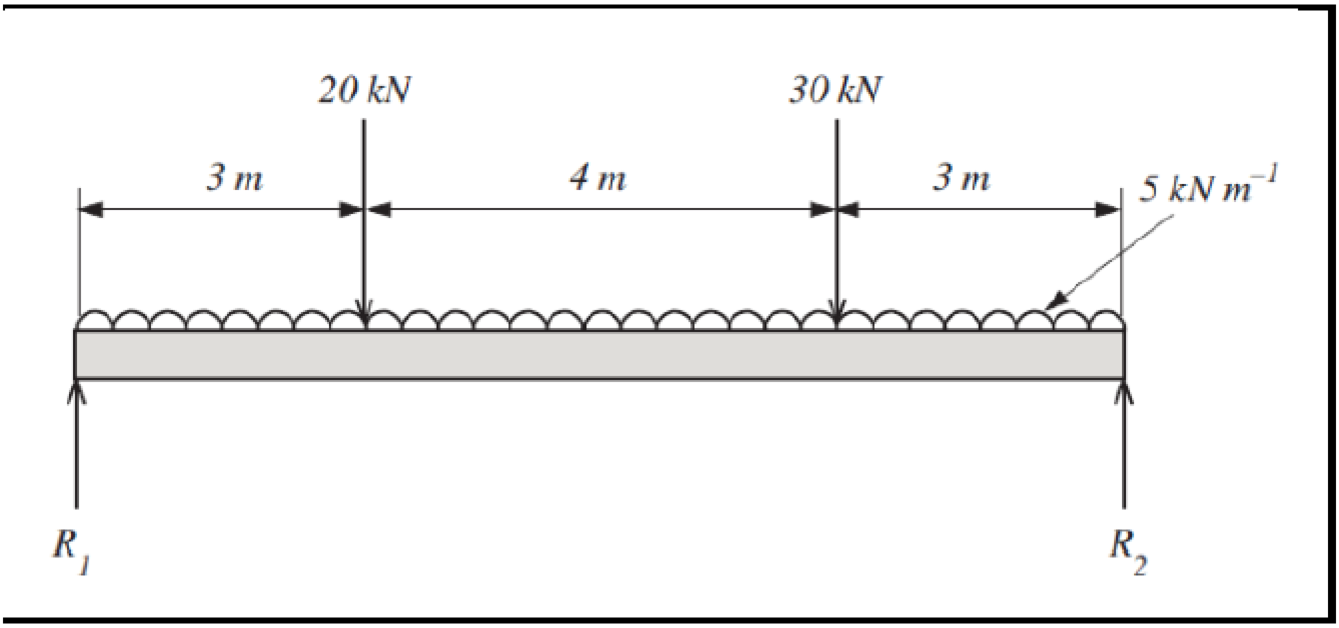


FIGURE 8.2

Calculate the magnitude of reactions R_1 and R_2. (5)

A load of 12 Kn causes a tensile stress of 24,5 MPa in a brass round bar. The original length of the bar is 250 mm and Young's modulus for brass is 90 GPa.

8.3.1 Calculate the diameter, in millimetres, of the brass bar. (5)

8.3.2 Calculate the change in length, in millimetres, caused by the load. (5)

4. SYSTEMS AND CONTROL: HYDRAULIC SYSTEMS

5. MATERIALS: IRON-CARBON EQUILIBRIUM DIAGRAM

5.1 FIGURE 5.1 below shows an iron-carbon equilibrium diagram. Answer the questions that follow.

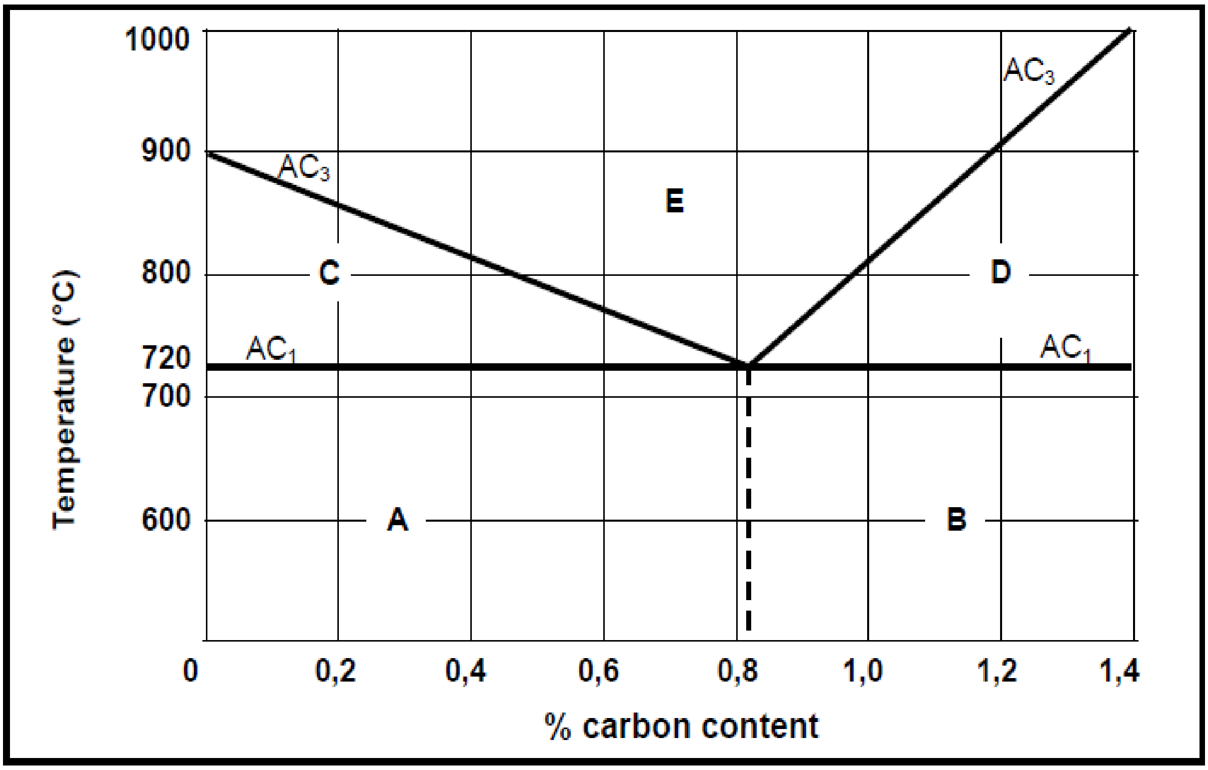


FIGURE 5.1

5.1.1 Label parts **A-E**. (5)

5.1.2 What does the critical point **AC₁** represent? (2)

5.1.3 Name TWO characteristics of each of the following microscopic structures:

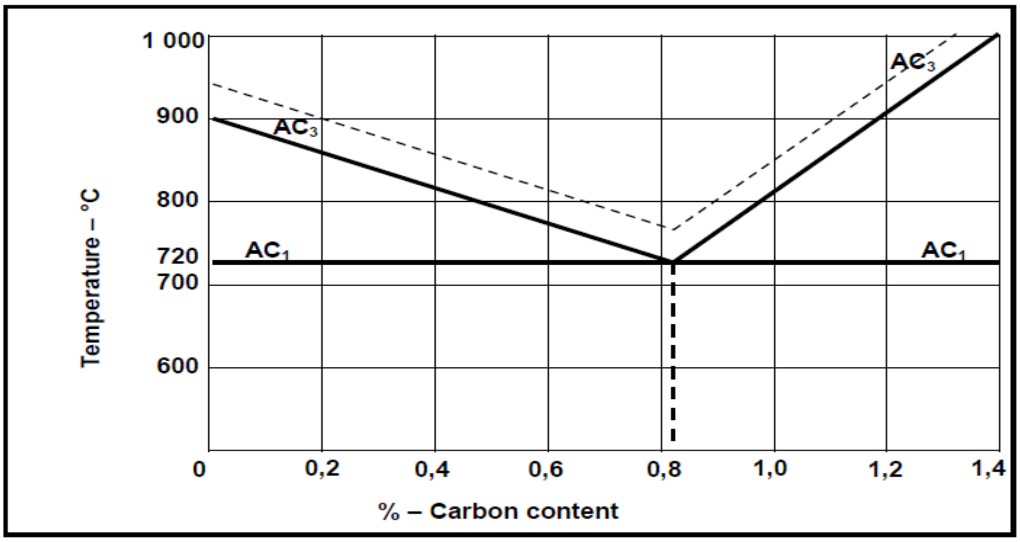
5.2.3.1 Cementite (2)

5.2.3.2 Ferrite (2)

5.1.4. Explain the composition of austenite. (2)

5.2 Steel can be hardened and annealed at a temperature between 885 °C and 925 °C.

5.2.1 What percentage carbon content will allow for this hardening and annealing? Use the Iron Carbon Equilibrium diagram in FIGURE 5.2 below.



A 0,60%
B 0,20%
C 0,80%
D 0,40% (1)

5.2.2 Name TWO characteristics of each of the following microscopic structures of steel:

6.2.1 Ferrite (2)
6.2.2 Pearlite (2)

5.2.3 Determine the microscopic structure that best describes the compound of iron and carbon (iron carbide) by analysing steel and cast iron. (2)

5.2.4 The table below indicates the carbon content, typical uses, heat treatment and properties of steel. Write your answers for QUESTIONS 4.3.1, 4.3.2 and 4.3.3 in the ANSWER BOOK.

CARBON CONTENT	TYPICAL USES	HEAT TREATMENT	PROPERTIES
Low 0,1–0,25%	**4.3.1**	Annealing	Strong; durable
Medium 0,25–0,55%	Crankshafts; pliers; screwdrivers	**4.3.2**	Tough; hard surface
High 0,55–1,00%	Cutting tools; springs; hammers	Hardening	**4.3.3**

(3)

5.2.5 Define the terms below with reference to the iron-carbon equilibrium diagram:

5.2.5.1 Lower critical point (AC_1) (2

5.2.5.2 Critical temperature (2)

XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

MEMO - CALCULATIONS COVID-19 REVISION MATERIAL: 2020

ACTIVITY 1.1

1.1 E = Break stress / Break point✓

1.2 Stress/ strain diagram

A = Limit of proportionality✓
B = Limit of elasticity✓
C = Yield point✓
D = Maximum stress✓
E = Break stress / Break point✓

1.3 Maximum stress✓

1.4 Break stress / Break point✓

ACTIVITY 2.1 FORCES: ACTING ON ONE POINT

2.1 (FIGURE 2.1)

2.1.1 The sum of the horizontal Components:

$$\sum HC = 3{,}6 + 2{,}5\cos 60^\circ - 2{,}1\cos 30^\circ \quad ✓✓✓$$
$$= 3{,}6 + 1{,}25 - 1{,}82 \quad ✓$$
$$= 3{,}03 \text{ kN} \quad ✓✓$$

2.1.2The sum of the vertical components

$$\sum VC = 2{,}5\sin 60^\circ + 2{,}1\sin 30^\circ - 3 \quad ✓✓✓$$
$$= 2{,}17 + 1{,}05 - 3 \quad ✓$$
$$= 0{,}22 \text{ kN} \quad ✓✓$$

OR

Horizontal component	**Magnitudes**	**Vertical component**	**Magnitudes**
$2{,}1\cos 30^0$ ✓	-1,82 kN	$2{,}1\sin 30^0$ ✓	1,05 kN
$2{,}5\cos 60^0$ ✓	1,25 kN ✓	$2{,}5\sin 60^0$ ✓	2,17 kN ✓
3,6 kN ✓	3,6 kN	-3 kN ✓	-3 kN
TOTAL	**3,03 kN** ✓✓	**TOTALress:**	**0,22 kN**✓✓

(12)

A

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t

2.1.2.1 The stress in the material:

$$A = \frac{\pi(0.05)^2}{4} \checkmark$$

$$A = 1{,}963495 \times 10^{-3}\ m^2 \checkmark$$

$$\text{Stress} = \frac{\text{Load}}{\text{Area}} \checkmark$$

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

$$= \frac{50\times10^{3}}{1{,}96\times10^{-3}} \checkmark$$

$$= 25{,}51\times10^{6}\ \text{Pa}$$

OR

$$= 25{,}51\ \text{MPa}$$

No or wrong unit - no mark (4)

2.1.2.2 **Strain:**

$$\text{Strain} = \frac{\text{Change in Length}}{\text{Original length}} \checkmark$$

$$\text{Strain} = \frac{0{,}005}{3} \checkmark$$

$$= 1{,}6667\times10^{-3}$$

2.2 EQUILIBRANT: (FIGURE 2.2)

$$\sum HC = 360 + 250\cos45° - 210\cos25° \checkmark\checkmark$$

$$= 346{,}45\text{N} \checkmark$$

$$\sum VC = 250\sin45° + 210\sin25° - 150 \checkmark\checkmark$$

$$= 115{,}53\text{N} \checkmark$$

OR

HORIZONTAL COMPONENT	**MAGNITUDES**	**VERTICAL COMPONENT**	**MAGNITUDES**
-210 $\cos25^0$ ✓	-190,32N	210 $\sin25^0$ ✓	88,75 N
250 $\cos45^0$ ✓	176,78N	250 $\sin45^0$ ✓	176,78 N
360	360 N	-150	-150 N
TOTAL	**346,45 N** ✓	**TOTAL**	**115,53 N**✓

2.2.2 The magnitude and the direction:

$$E^2 = HC^2 + VC^2$$ ✓
$$E = \sqrt{346,45^2 + 115,53^2}$$ ✓
$$E = 365,21\ N$$ ✓

$$\text{Tan}\,\theta = \frac{VC}{HC}$$ ✓
$$= \frac{115,53}{346,45}$$ ✓
› $= 18,44^0$ ✓

$E = 365,21\ N$ at $18,44^0$ south from west ✓ (15)

2.2.3 **Stress and Strain:**

Stress:

$A = L^2$ ✓
$A = 0,1^2$
$A = 0,01\ m^2$ ✓

› $= \frac{F}{A}$ ✓

› $= \frac{80 \times 10^3}{0,01}$ ✓

› $= 8 \times 10^6\ Pa$ ✓

› $= 8\ MPa$ (5)

2.2.4 **Strain** is **directly proportional** ✓ to the **stress** ✓ that causes it, provided

2.3 (FIGURE 2.3):

2.3.1 $\sum HC = 4,7 - 3,1Cos50^0 - 1,5Cos40^0$
$= 4,7 - 1,99 - 1,5$ ✓✓✓
$= 1,56kN$ ✓

2.3.2 $\sum VC = 2,1 + 1,5Sin40^0 - 3,1Sin50^0$
$= 2,1 + 0,96 - 3,27$ ✓✓✓
$= 0,69kN$ ✓

OR

HC	Magnitudes	VC	Magnitudes
4,7kN	4,7kN ✓	2,1Kn	2,1kN ✓
3,1kNCos50^0	- 1,99kN ✓	1,5kNSin40^0	0,96kN ✓
1,5kNCos40^0	- 1,15kN ✓	3,1kNSin50^0	-2,37kN ✓
TOTAL	**1,56kN** ✓	**TOTAL**	**0,69kN** ✓

2.3.3 $E^2 = HC^2 + VC^2$

$E = \sqrt{1,56^2 + 0,69^2}$

$E = 1,71kN$

2.3.4 $\tan\Theta = \frac{VC}{HC}$

$= \frac{0.69}{1,56}$

$= 23,86^0$

E = 1,71kN at 23,86^0 north from east.

2.4 (FIGURE 2.4);

2.4.1 $\sum HC = 280Cos50^0 - 200Cos35^0 - 300Cos30^0 - 350$

$= 179,98 - 163,83 - 350$ ✓✓✓✓

$= - 593,66N$ ✓

2.4.2 $\sum VC = 280Sin50^0 + 300Sin30^0 - 200Sin35^0$

$= 214,49 + 150,0 - 114,72$ ✓✓✓✓

$= 249,77N$ ✓

OR

HC	Magnitudes	VC	Magnitudes
300NCos30^0	- 259,81N	280NSin50^0	214,49N
200NCos35^0	- 163,83N	300NSin30^0	150,0N
350N	- 350N	0N	0N
280NCos50^0	179,98N	200NSin35^0	-114,72N
TOTAL	**-593,66N**	**TOTAL**	**249,77N**

2.4.3 $E2 = HC^2 + VC^2$

$E = \sqrt{HC^2 + VC^2}$

$= -593{,}66^2 + 249{,}77^2$

$E = 644{,}06N$

2.4.4 $\tan\Theta = \frac{VC}{HC}$

$= \frac{249{,}77}{593{,}66}$

$\Theta = 22{,}82^0$

E = 644,06N at $22{,}82^0$ South of East ***/OR/*** = 22^0 49 minutes South of East

2.5 The Magnitude of the Force:

Stress = Pa
Diameter = M
Force= N
Force = ?

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

Force = Stress x Area ✓

$= \text{Stress} \times \frac{\pi d^2}{4}$ ✓

$= 3500\,000 \times \frac{\pi 0.025^2}{4}$ ✓

Force $= 3{,}5 \times 10^6 \times 4{,}90873852 \times 10^{-4}$
$= 1718{,}06N$
Force = 1,72kN ✓

ACTIVITY 3: FORCES – BEAMS:

3.1 (FIGURE 3.1): ANSWER B = 200mm

3.2 (FIGURE 3.2)

❖ Calculate 'A' - Take moments about B:

A x 12 = (2 500 x 4) + (600 x 7) + (1 400 x 10) ✓
A x12 = 10 000 + 14 000 + 4 200

$$\frac{A \times \cancel{12}}{\cancel{12}} = \frac{28\,200}{12}$$ ✓

A = 2 350N ✓

- Calculate 'B' - Take moments at 'A':

B x 12 = (1 400 x 8) + (600 x 5) + (2 500 x 8) ✓

B x 12 = (2 800 + 3 000 + 20 000

$$\frac{B \times \cancel{12}}{\cancel{12}} = \frac{25\,800}{12}$$ ✓

B = 2 150N ✓

3.3 (FIGURE 3.3):

- Calculate 'A' – Take moments about 'B':

A x 11,5 = (600 x 4,5) + (400 x 6,5) + (325 x 9,75) ✓

A x 11,5 = 2 700 + 2 600 + 3 168,75

$$\frac{A \times \cancel{11{,}5}}{\cancel{11{,}5}} = \frac{8\,468{,}75}{11{,}5}$$ ✓

A = 736,41N ✓

- Calculate 'B' – Take moments about 'A':

B x 11,5 = (325 x 1,75) + (400 x 5) + (600 x 7) ✓

B x 11,5 = 568,75 + 2 000 + 4 200

$$\frac{B \times \cancel{11{,}5}}{\cancel{11{,}5}} = \frac{6768{,}75}{11{,}5}$$ ✓

B = 588,59N ✓

3.4 (FIGURE 3.4):

- Calculate 'B' - Take moments about 'A'

(255 x 1,125) + (800 x 3,25) = (B x7,75) + (350 x 1) ✓

286,88 + 2 600 = 7,75B + 350

286,88 + 2 600 – 350 = 7,75B

$$\frac{\cancel{7{,}75}B}{\cancel{7{,}75}} = \frac{2\,536{,}88}{7{,}75}$$ ✓

B = 327,34N ✓

- Calculate 'B' – take moments about 'B'

A x 7,75 = (800 x 4,5) + (255 x 6,625) + (350 x 8,75) ✓

A x 7,75 = 3 600 + 1 689,38 + 3 062,5

$$A = \frac{8\,351{,}88}{7{,}75}$$ ✓

A = 1 077,66N ✓

3.5 (FIGURE 3.5):

- ❖ Calculate 'B' – Take moments about 'A'

$(B \times 3{,}5) + (1\ 400 + 0{,}7) = (350 \times 6{,})\ 2{,}65 + (1\ 600 \times 6)$ ✓

$B \times 3{,}5 + 980 = 6\ 214{,}25 + 9\ 600 - 980$

$3{,}5B = 15\ 814 - 980$

$\frac{3{,}5B}{3{,}5} = \frac{14\ 834{,}25}{3{,}5}$ ✓

$\mathbf{B = 4\ 238{,}36N}$ ✓

- ❖ Calculate 'A' - Take moments about 'B'

$(A \times 3{,}5) + (1\ 600 + 2{,}5) = (350 \times 6{,}7)0{,}85 + (4{,}2 \times 1\ 400)$ ✓

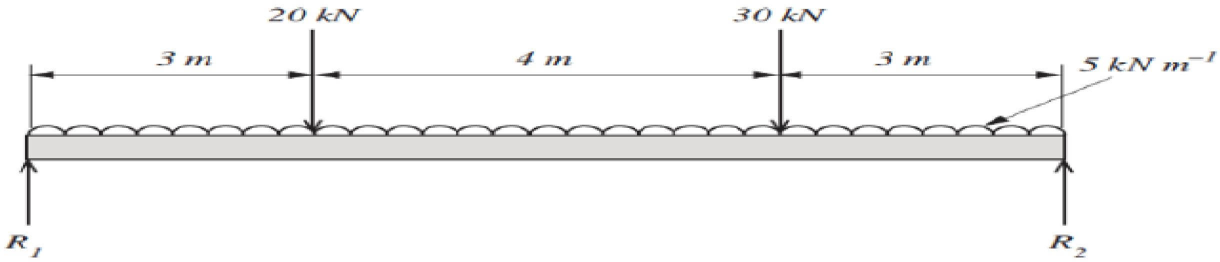
$3{,}5A + 4\ 000 = 1\ 993{,}25 + 5\ 880$

$3{,}5A = 1\ 993{,}25 + 5\ 880 - 4\ 000$ ✓

$\frac{3{,}5\ A}{3{,}5} = \frac{3\ 873{,}25}{3{,}5}$

$\mathbf{A = 1\ 106{,}64N}$ ✓

8.2 **Moments:**



Converting the UDL to Point Load
5 x 10 = 50 kN @ 5m ✓
Calculation of the Reactions Taking moments:

R2 x 10 = (30 x 3) + (50 x 5) + (20 x 7) ✓
= 48 kN ✓
R1 x 10 = (20 x 3) + (50 x 5) + (30 x 7) ✓
= 52 kN ✓ (5)

8.3 **Stress Calculations**

8.3.1 Tensile stress calculations

F = 12 kN; δ = 24,5 MPa: L = 250 mm: E= 90 PGa

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

$= 12 \times 10^{3} / 24{,}5 \times 10^{6}$ ✓

$A = 4{,}898 \times 10^{-4} m^2$ ✓

$A = \pi r^2$

$d = \sqrt{4\ A/\pi}$ ✓

d = 0,02494 m ✓

d = 24,97 mm ≈ 25 mm ✓ (5)

8.3.2 The change in length calculations

ΔL = ?; E = 90 GPa; F = 12 Kn; L = 250 mm; σ = 24,5 MPa

$\Delta L = \frac{S \times L}{E}$ ✓

$= (24{,}5 \times 10^{6} \times 0{,}25) / 90 \times 10^{9}$ ✓✓

= <u>0,0681 mm</u> ✓✓ (5)

5. MATERIALS: IRON-CARBON EQUILIBRIUM DIAGRAM

5.1

5.1.1 A: Ferrite + Pearlite

B: Pearlite + Cementite

C: Ferrite + Austenite

D: Cementite + Austenite

E: Autenite

5.1.2 AC1 represents:

- The lowest temperature to which steel must be heated to be hardened
- The temperature where the first change in structure takes place

5.1.3 two (2) characteristics of:
5.1.3.1 Cementite: Intensely hard; Brittle
5.1.3.2 Ferrite: soft; Ductile/ Malleable

5.1.4 Composition of Austenite:

- It is a combination of Iron and Carbon which is called Iron – Carbide.

5.2

5.2.1 Answer B: 0.20%
5.2.2 Two characteristics of the following microscopic structure:
5.2.2.1 Ferrite:

- ✓ Soft
- ✓ Ductile
- ✓ Grey or white in colour (any 2 answers)

5.2.2.2 Pearlite:

- ✓ Ductile
- ✓ Hard
- ✓ Strong and tough
- ✓ Resistant to deformation (any 2 answers)

5.2.3 Cementite

5.2.4 (4.3.1): bolts, nut, screws and rivets
(4.3.2): surface hardening (case hardened); hardening and tempering
(4.3.3): brittle; poor weldability

5.2.1.1 Lower Critical Point (AC1): The lowest temperature to which the steel must be heated to be Hardened.
5.2.1.2 Critical Temperature: The temperature where a structural change take place.

"NOTHING GREAT HAS EVER BEEN ACCOMPLISHED WITHOUT PASSION = GOOD LUCK"