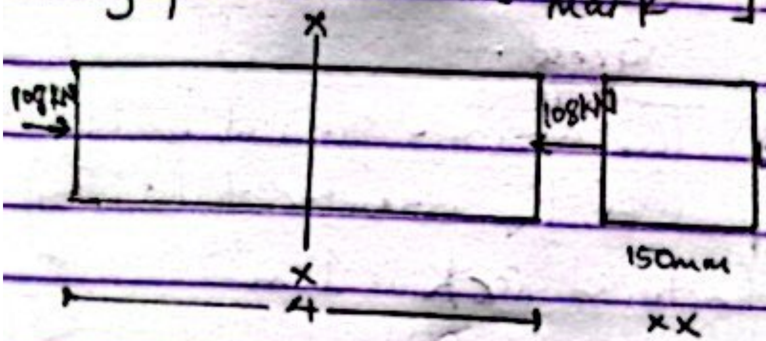
Example 1: A post of a timber is $150mm^2$ in cross-section and the length is 4m. "How much" will it shorten when an axial load of 108 kN is applied.

$\boxed{\text{Take } E = 8000 N/m^2}$

Solution.

Firstly you must drawn [it attracts mark]



$A = 150 \times 150 = 2500mm^2$

$l = 4m = 4000mm$

$P = 108kN = 108 \times 10^3 N$

Now

$$\delta l = \frac{Pl}{AE} = \frac{(108 \times 10^3) \times 4000}{22500 \times 8000}$$

$$\boxed{\delta l = 2.4mm}$$

Example 2: A steel rod of 20mm diameter and 500cm long is subjected to and axial pull of

Determine.

a) Stress

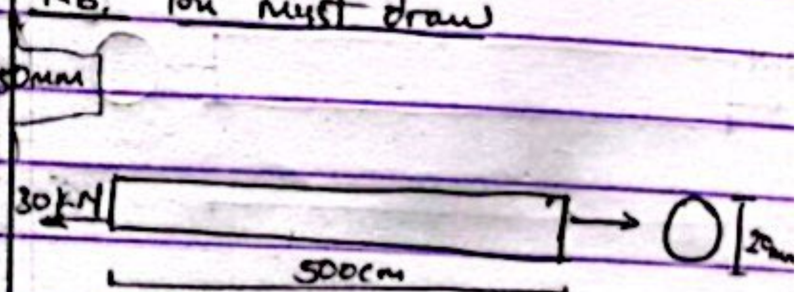
b) Strain

c) Elongation in the rod

Take $E = 2 \times 10^5 N/mm^2$

Solution.

NB: You must draw



X-section area of the rod A

$$= \pi r^2 = \frac{22}{7} \times 10^2$$

$$= 314.29 mm^2$$

a) $\sigma = \frac{P}{A} = \frac{30 \times 10^3}{314.29}$

$= 95.5 N/mm^2$

b) $\varepsilon = \frac{\sigma}{E} = \frac{9.55}{2 \times 10^5}$

$=$

c) Elongation $= \frac{PL}{AE} = \frac{30 \times 10^3 \times 500 \times 10}{314.29 \times 2 \times 10^5}$

$=$

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FEDERAL UNIVERSITY OYE-EKITI

B.Eng. (Civil Engineering) Degree Examination

Second Semester 2020/2021 Session

CVE 204: Strength of Materials I: **2 Units**

Time Allowed: 2½Hrs

November 2022

Instruction: Answer two questions each from both Sections A and B.

SECTION A

Question 1 (25 marks)

A) i. In simple stresses and strains analysis, show that the deformation "∂l" of a body due to force acting on it is given as, $\partial l = \frac{Pl}{AE}$, where P = load acting on the body; l = *length of the body*, A = Cross-sectional area of the body, and E = Modulus of elasticity for the material of the body. (10marks)

ii Distinguish diagrammatically, giving due explanation between the concept of tensile stress, compressive stress and their corresponding strains. (5 marks)

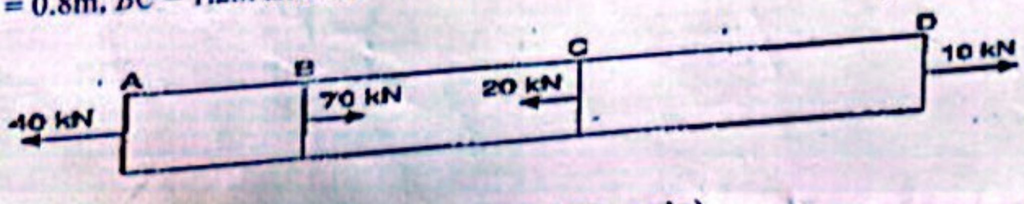
B) A hollow cylinder 2 m long has an outside diameter of 50 mm and inside diameter of 30 mm. If the cylinder is carrying load of 25 kN, find the stress in the cylinder. Also find the deformation of the cylinder, if the value of modulus of elasticity for the cylinder material is 100 GPa. (10 marks)

Question 2 (25 marks)

A) i. Define a composite bar. How will you find the stresses and load carried by each member of a composite bar? (5 marks)

ii. A steel rod of 3cm diameter and 5m long is connected to two grips and the rod is maintained at a temperature of 95° C. Determine the stress and pull exerted when the temperature falls to 30° C, if (i) the ends do not yield, and (ii) the ends yield by 0.12 cm. Take E = 2 x 10^5 MN/m² and $\alpha = 12 \times 10^{-6}$/ C. (10 marks)

B) A brass bar having cross-section area of 1200 mm² is subjected to an axial force as shown below in which $AB = 0.8$m, $BC = 1.2$m and $CD = 1.4$m. Find the total elongation of the bar take $E = 1 \times 10^5$ N/mm² (10 marks)



Question 3 (25 marks)

A) Define modular ratio, tensile stresses, thermal stresses, thermal strains, and Poisson's ratio. (5 marks)

B) Three bars made of copper, zinc and aluminum are of equal length and cross-section 500, 750 and 1000 square mm respectively. They are rigidly connected at their ends as shown below, the compound member is subjected to a longitudinal pull of 250 kN, estimate the proportional of the load carried on each rod and the induced stresses. Take the value of E for copper = 1.3 x 10^5 N/mm², for zinc = 1.0 x 10^5 N/mm² and for aluminum = 0.8 x 10^5 N/mm². (20 marl

$$= \frac{80\times10^3}{314.21}$$

$=$

b) σ ultimate tensile strength

$$= \frac{P_{ult}}{\text{Original Area}}$$

$$= \frac{150\times10^3}{314.29}$$

c.) The breaking point σ

$$= \frac{P_b}{\text{fracture area}}$$

fracture area $= \pi r^2$

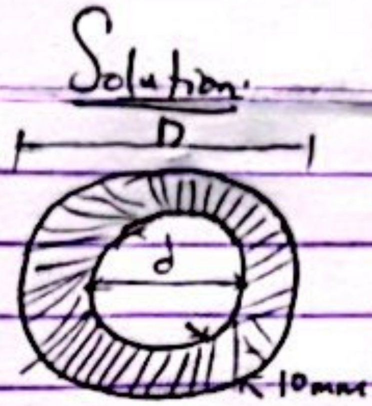
$$= \frac{22}{7} \times 5^2$$

$$= 78.5\,mm^2$$

$$= \frac{70\times10^3}{78.5} =$$

Example 5: A Hollow cast iron Cylinder of 1cm in thickness carries a compressive load of 600 kN. Determine the outside diameter if the ultimate crushing stress is 500 ~~kN~~ N/mm^2

Solution.



Let

d = inner diameter

D = Outer diameter

$$d = D - \boxed{20mm = 10mm + 10mm}$$

$$X\text{-Area} = \pi r^2 = \pi\left[\frac{D^2}{4} - \frac{(D-20)^2}{4}\right]$$

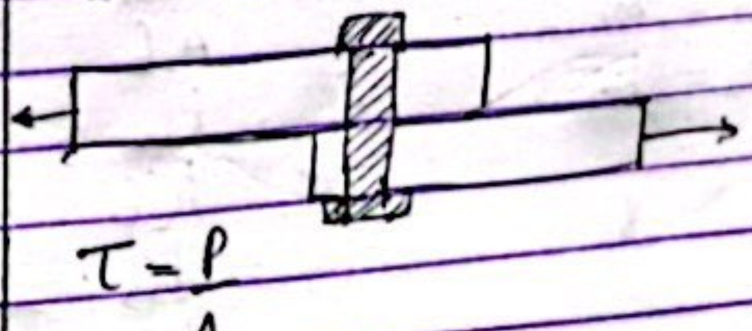
$$= (10D - 100)\,mm^2$$

Now $\sigma = \frac{P}{A}$; $P = \sigma A$

$$600\times10^3 = 500\times\cancel{10^3}\times\pi(10D - 100)$$

$$D = 130mm$$

Shear Stress C



$$\tau = \frac{P}{A}$$

Course Synopsis [Strength Of Materials]

Wk1 - Registration

Wk2 - General introduction, Force equillibrium - Free body diagrams. Concept of Stress, Strain; Tensile test. Young's moduli and other Strength factors.

Wk3 - Deformation of bodies: Axially loaded bars, Due to self-weight. Principle of Superposition.

Wk4 - Varying sections

Wk5 - Composite bars, Temperature Stresses

Wk 6 - Hoop stresses in cylinders, etc

Wk 7 - Mid-Term Test / Semester Project

Wk 8 - Determinate and indeterminate Structure. Determinate beams: Bending moment, Shear force and axial force diagrams for simple cases

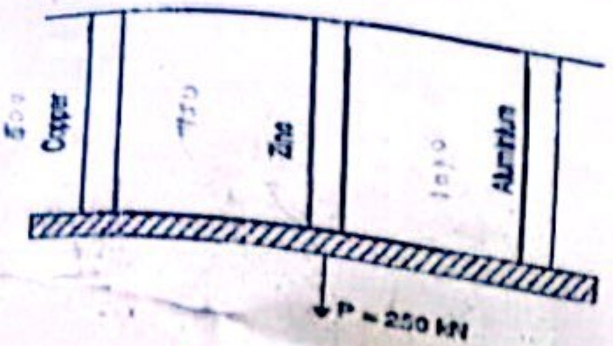
Wk[9&10 &11] - Bending moment, shear force and axial force diagrams for simple cases - (beam with over hangs)

Wk 12 - Submission of Project.

Wk 13 - Simple torsion and application

Wk 14 - REVISION

Recommended text - SOM by Ryder
SOM by Khurmi R.S
SOM by Surendra Singh
Structural mechanics - Loads, Analysis, Materials and Design of structural elements by Nagoim, Durka...

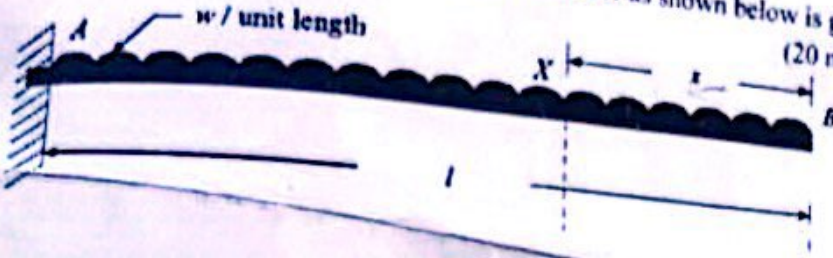


SECTION B

Question 4 (25 marks)

A) Define the following terms: (i) Shear force, (ii) Shear force diagram, (iii) Bending moment, (iv) Bending moment diagrams, (v) Cantilever beam. (5 marks)

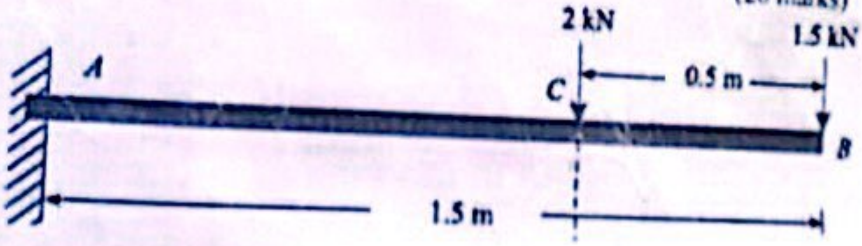
B) Show that the maximum bending moment of a cantilever AB of length l and carrying a uniformly distributed load of w per unit length, over the entire length of the cantilever as shown below is given as $-\frac{wl^2}{2}$ (20 marks)



Question 5 (25 marks)

A) What are the different types of loads acting on a beam? (5 marks)

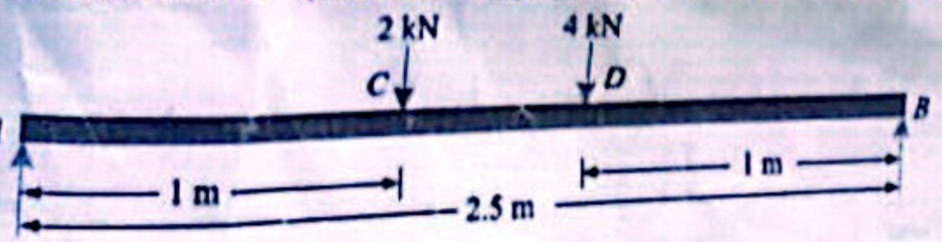
B) Draw shear force and bending moment diagrams for a cantilever beam of span 1.5 m carrying point loads as shown below. (20 marks)



Question 6 (25 marks)

A) Diagrammatically, list the various types of support in Civil Engineering structures. (5 marks)

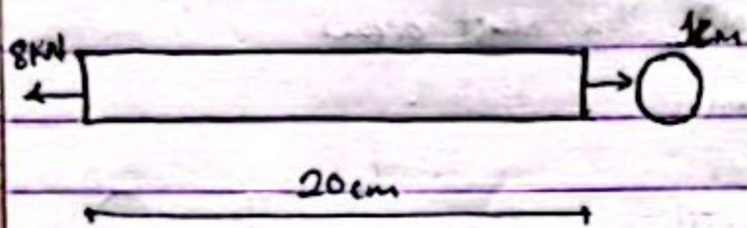
B) A simply supported beam AB of span 2.5 m is carrying two-point loads as shown below (20 marks)



Calculate and d-

Example 3: A circular rod of 1cm diameter is loaded in tension. When the tensile load is 8kN, the extension in the 20cm long rod is 0.029cm. Determine the Young's modulus of elasticity in the material.

Solution



$\delta L = 0.029cm$

Area of the rod (1cm diameter)

$$= \pi r^2 = \frac{22}{7} \times 5^2$$

$$= 78.57 m^2$$

Tensile stress $= \frac{P}{A} = \frac{8 \times 10^3}{78.57}$

$$= 101.86 N/m^2$$

$$= \frac{\delta L}{L} = \frac{0.29}{200}$$

$$=$$

$$E = \frac{\sigma}{\varepsilon} = \frac{101.82}{0.0}$$

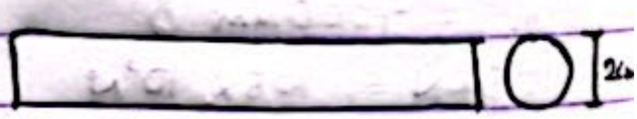
Example 4: A mild steel bar of 2cm diameter is subjected to a tensile test. The bar yiel under a load of 80kN. It the reaches a maximum load of 15 and finally breaks at a load of Estimate:

a) Average stress at yield point

b) Ultimate ~~tenth~~ tensile stress.

c) The average stress at breaking point if the diameter of the fractured neck is 1cm

Soln.



Original X-section area $= \pi r^2$

$$= \frac{22}{7} \times 10^2$$

$$= 314.3 mm^2$$

a.) σ at yieds at point $= \frac{P_{yield}}{\text{Original Ar}}$

Sketch of the structure showing the position, direction and point of application of all externally forces.

Example of A free body diagram for a human being —

A typical example of a FBD of a human being

Material (2)

Notes

What is stress? σ (Sigma)

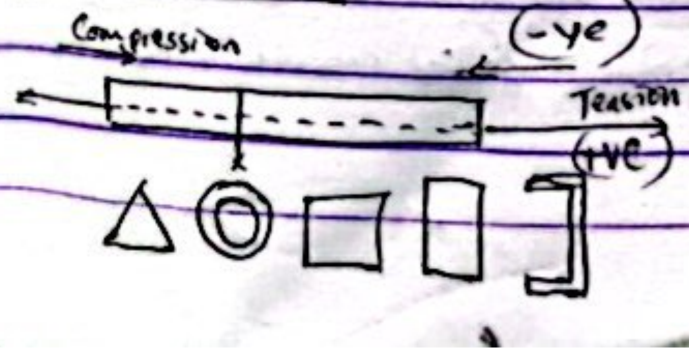
- Resulting force is called stress
- Load/Area = Stress. σ
- Internal resistance.

Strain

- Deformation

Types of Stresses

1) Tensile Stress.



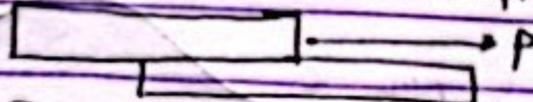
N goes with mm

kN goes with m

$\sigma = \frac{P}{A}$

Tension is the opposite of Compression

Normal Stress < Tensile / Compressive



2) Shear Stress, tangential stress or Sliding Stress. τ (tahr)

$$\tau = \frac{P}{A}$$

- Tensile stress application of load along the axis of action.

STRAIN

- Cause by applying load on a rigid body.
- Measure of deformation produced
- Could be Tensile (+ve) and Compressive (-ve)
- It is represented by ε (epsilon)

$$\varepsilon = \frac{\delta l}{l}$$

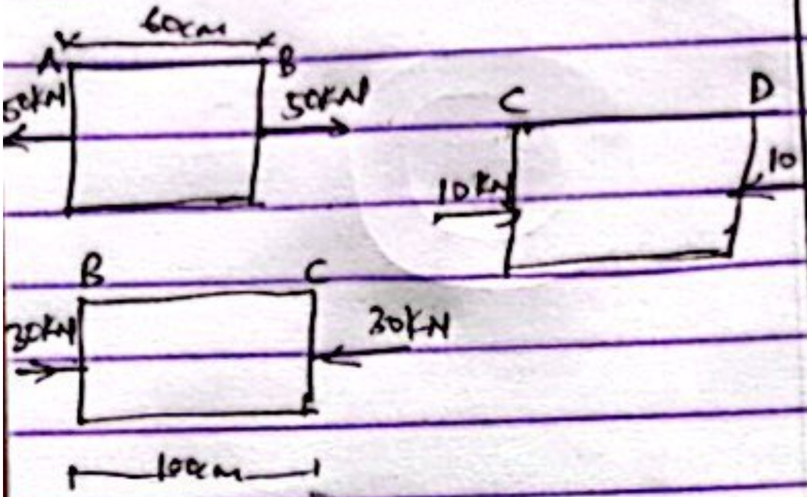
Homogenous = omo + genous

omo ↓ likeness

genous ↓ gene.

Of the same nature.

Solution :



$E = 105\, GN/m^2$

$$105 \frac{GN}{m^2} = \frac{105 \times 10^9 N}{(1000 \times 1000) mm}$$

$$= 105 \times 10^3 N/mm^2$$

$$= 1 \times 10^5 N/mm^2$$

$$\delta l_{AB} = \frac{P l_{AB}}{A_{AB} E}$$

$$\delta l_{BC} = \frac{P l_{BC}}{A_{BC} E} =$$

$$\delta l_{CD} = \frac{P l_{DC}}{A_{DC} E} =$$

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Total elong

$$= \frac{Pl_1}{A_1E} + \frac{Pl_2}{A_2E} + \frac{Pl_3}{A_3E}$$

Continuation/Solution

Principle of Superposition.

When an elastic body is subjected to the simultaneous action of various loads then their effect at a point on a given plane is the algebraic sum of the individual effect of each of the load.

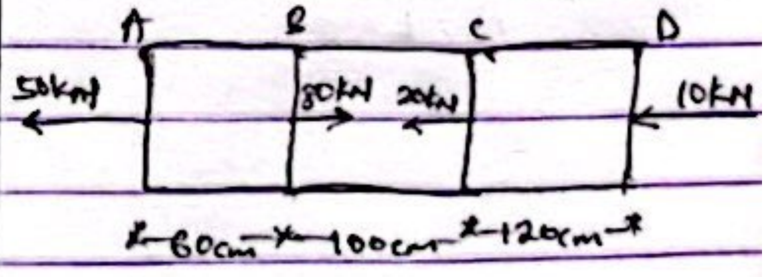
The principle of ~~sy~~ superposition is valid only if:

1.) Stresses are within the elastic limit
2.) Deflection does not affect the applied load.
3.) Stability of the Structure is not affected

~~Free Body Diagram~~

Example 1: A brass bar whose area is $10\,cm^2$, is subjected to axial forces as shown. Find the total change in length of the bar.

Take $E = 1056\,N/m^2$



15th May, 2023.

Lecture 1 (WK 2)

Dr. Fapohunda.

Notes. (material 1)

- Any load that is static and will not move is a "Dead Load"

- Any load that will move is "Live load"

- The weight of the (an) object itself is the "Dead load"

Added knowledge

Out of topic applications

- Academic load
- Financial load
- Emotional load

Read more on

- Seismic load [Cannot predict
- Wind load

Types of forces

I) Coplanar forces < Concurrent / Parallel

II) Non coplanar "

a) Concurrent "

b) Parallel forces.

- Resultant of forces.
- Polygon = polus + agon

  polus → many; agon → angles

  Derived from Greek word

(Added knowledge)

NB: key into a language of universal education.

Use international standard to train/learn

Engineering is an international course

- Condition of Equilibrium:

Equilibrium — In a state of rest

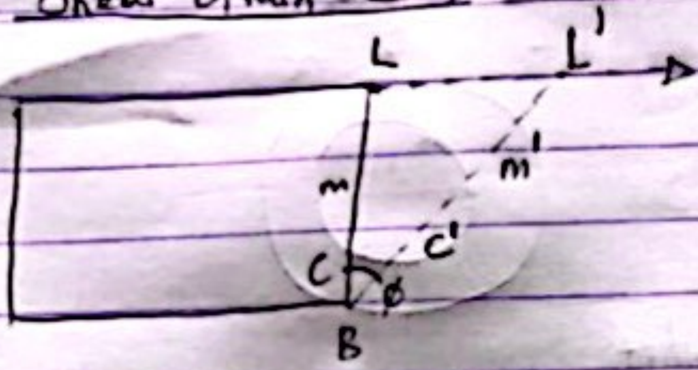
Evaluate all the forces at all conceivable directions

Added knowledge

Money & Character are vector quantities

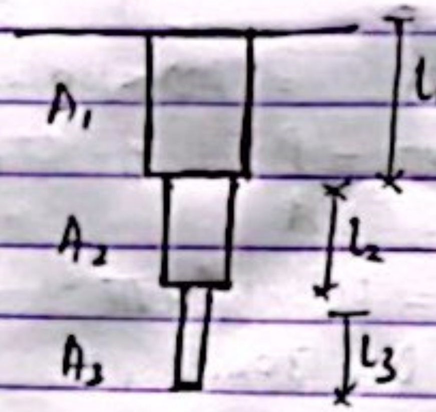
- Moment of forces
- Free body diagram: a "simplified

Shear Strain (ϕ)



$$\phi = \frac{LL'}{BL} = \frac{MM'}{BM} = \frac{CC'}{BC} \tan\phi = \approx \phi \left\{ \begin{matrix} \text{for small} \\ \text{value} \end{matrix} \right\}$$

Elongation of bars of Varying



l_1 = bar 1

l_2 = bar 2

l_3 = bar 3

$$\delta l_1 = \frac{Pl_1}{A_1 E}$$

$$\delta l_2 = \frac{Pl_2}{A_2 E}$$

$$\delta l_3 = \frac{Pl_3}{A_3 E}$$

$$\delta l = \delta l_1 + \delta l_2 + \delta l_3$$

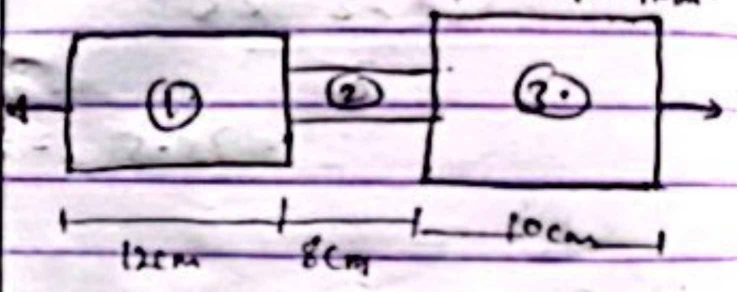
$$= \frac{Pl_1}{A_1 E} + \frac{Pl_2}{A_2 E} + \frac{Pl_3}{A_3 E}$$

$$= \frac{P}{E}\left[\frac{l_1}{A_1} + \frac{l_2}{A_2} + \frac{l_3}{A_3}\right]$$

Example : A 30cm long bar is made up of 3 bars as shown (Fig 1)

Calculate the stress and total elongation in the bar.

$E = 2 \times 10^5 \, N/mm^2$



Section 1 = Square (5×5cm)

Section 2 = Circular (2.5cm diameter)

Section 3 = Circular (4cm diameter)

Solution.

Areas

Section 1 = $A_1 = 50 \times 50 = 2500 \, mm^2$

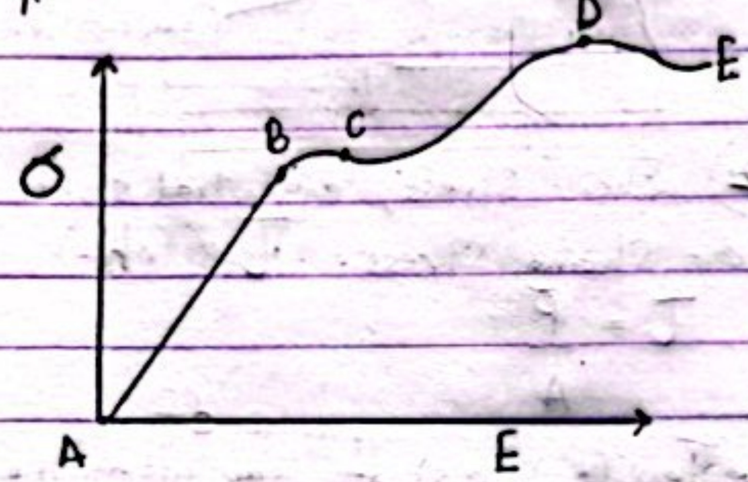
Section 2 = $A_2 = \pi r^2 = \pi \left(\frac{25}{2}\right)^2$

Section 3 = $A_3 = \pi r^2 = \pi (20)^2$

$\sigma_1 = P/A$; $\sigma = P$ ...

Relationship btw Stress and Strain.

Typical Stress-strain curve.



E ⟶ Necking (Read up)
The breaking point where the area is reduced.

* The usual material used for finding relationship btw material is steel.

HOOKE'S LAW (For ductile material)
Stress ∝ Strain. It applies only in region AB.

$$E = \frac{\sigma}{\varepsilon} \; ; \text{ But } \sigma = \frac{P}{A}$$

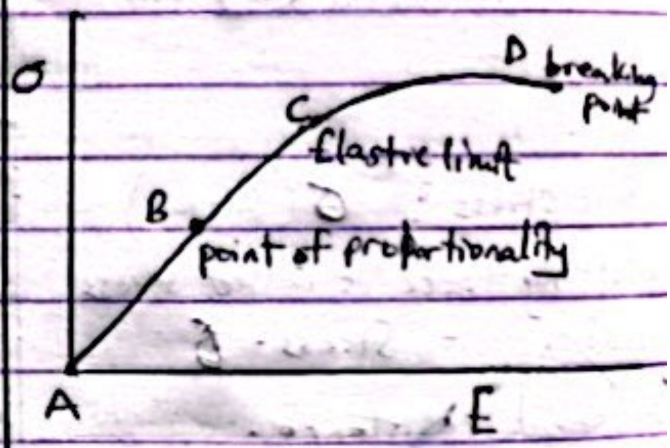
$$\text{and } \varepsilon = \frac{\delta L}{L}$$

$$E = \frac{P/A}{\delta L / L} \; ; \quad \delta L = \frac{PL}{AE}$$

where P = load of the material
L = length of the material
A = Area of the Cross-section
E = Young moduli

* Brittle -

* Stress - strain for brittle material



$$\sigma_t = \frac{P_B}{A_B}, \frac{P_C}{A_C}, \frac{P_D}{A_D}, \frac{P_E}{A_E}$$

Modulus of Rigidity (G)
Ratio of Shear Stress to Shear Strain is called modulus of rigidity