#سيفلتيي العز

ملخص لاب المقاومة **الجديد** والذي قمت بإعداد الملخص من البداية بحيث تعديل كافة الأخطاء و إضافة أسئلة السنوات وفي حال وجود خطأ ي حبذا إبلاغي به وجل من لا يسهو .

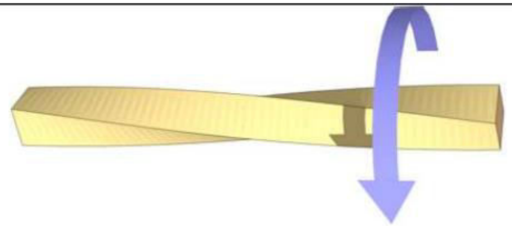
يشمل هذا الملخص : شرح التجربة ب إختصار وعدد صفحات قليل إضافة إلى ملحق سنوات بعد كل تجربة وسيتم تحديث الملخص **باستمرار** لكي نضيف كامل السنوات إن شاء الله وسأضع تقارير محلولة , أي يعني بعد كل تجربة سيكون التقرير مرفق بها

هذا الملخص سيكون متوفرا على موقع لجنة **الهندسة المدنية – سيفلتيي** إن شاء الله .

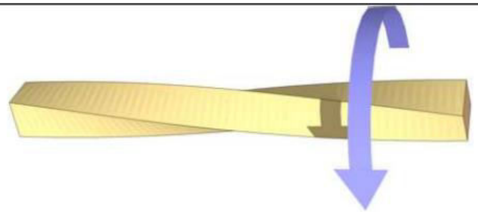
وما قبل البدء ب الملخص هذا , هذا العمل صدقة جارية على روح كل من فقدناهم من أحباء أصدقاء ونسأل الله القبول ولا تنسوني من صالح الدعاء .

Exp	Slides	Years
Torsion test	(4-6)	(7-15)
Strain Measurement with Strain Gauges	(16-18)	(19-20)
Hardness Test	(21-24)	(25-27)
Compression test	(28-30)	(31-32)
Tensile Test	(33-38)	(39-58)
THIN WALL CYLINDER	(59-61)	(62-67)
Stability Of Columns	(68-72)	(73-82)
Deflection of Beams	(83-86)	(87-95)

Exp	Slides	Years
Impact Test	(96-98)	(99-104)
Fatigue Test	(105-107)	(108-117)
Creep Test of Metallic Materials	(118-120)	(121-125)



❑Exp: Torsion test



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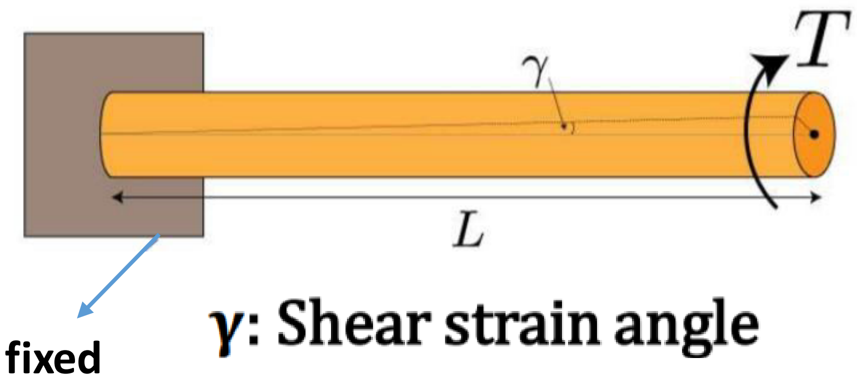
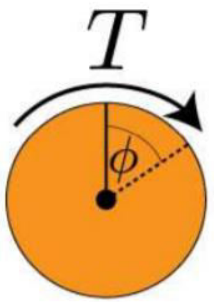
اللجنة الأكاديمية لقسم الهندسة المدنية



γ: Shear strain angle



ϕ = Angle of twist

نتجت الزاويه عندما تحركت من نقطة إلى نقطه

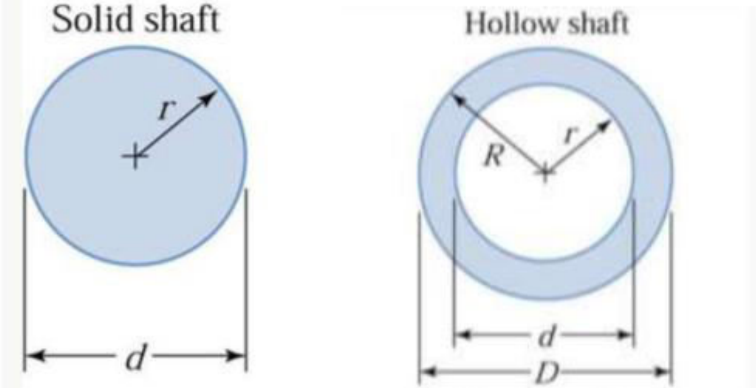
$$\tau_{max} = \frac{Tr}{J}$$

τ : Shear stress

T: Torque (N.m)

r: Radius of shaft (m)

J: Polar moment of inertia



$$J = \frac{\pi r^4}{2} = \frac{\pi d^4}{32}$$

$$J = \frac{\pi}{2}(R^4 - r^4) = \frac{\pi}{32}(D^4 - d^4)$$

$$\gamma = \frac{Tr}{GJ}$$ γ : Shear strain

$$\gamma = \frac{r\phi}{L} \qquad \phi = \frac{TL}{GJ}$$

γ : Shear strain angle (Rad)

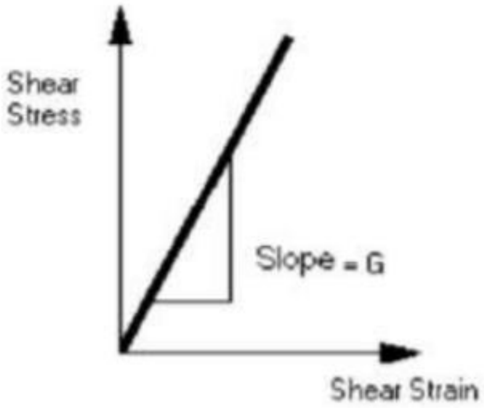
r : Radius of shaft (m)

ϕ: Angle of twist (degree)

L: length of shaft (m)

- **The Modulus of Rigidity(G)** :

Slope of the $\tau - \gamma$ curve in the elastic range $\tau = G*\gamma$ γ(Rad)



- **The Modulus of Resilience** : Area under the **elastic** portion **represent** the **energy** absorbed by the material in the elastic region $= \frac{1}{2}\tau_y\gamma_y$

- **The Modulus of Rupture (Toughness)** : **Total area represents** the total energy absorbed by the material before fracture $= \frac{2}{3}\tau_u\gamma_{Max}$.

Brittle (Pure)

Caused by : Normal stress

Fracture at angle 45°

Ductile

Caused by : Shear stress

Fracture at angle 90°

Note : Not pure Brittle it's the **same** Ductile

❑**Q1(Years).** Two steel shafts with modulus of rigidity G=80GPa , diameters D1=20mm , D2=10mm for the **same torque** applied , the **ratio of shear angle** of the first to the second is $\frac{\gamma_1}{\gamma_2}$?

$$\gamma_1 = \frac{T_1 r_1}{G_1 J_1} \qquad \gamma_2 = \frac{T_2 r_2}{G_2 J_2} \quad \rightarrow \quad \gamma_1 = \frac{r_1}{J_1} \qquad \gamma_2 = \frac{r_2}{J_2}$$

$$\gamma_1 = \frac{0.01}{\frac{\pi * (0.02)^4}{32}} \qquad \gamma_2 = \frac{0.005}{\frac{\pi * (0.01)^4}{32}} \qquad \frac{\gamma_1}{\gamma_2} = 0.125$$

❑**Q2(Years).** An aluminum bar of solid circular cross section of **diameter** of 30mm is subjected to torque T=1.5N.m , the length of the bar is 1.2m and its shear modulus of elasticity is 28GPa , Find :

1- The maximum **<u>shear stress</u>** in the bar .

2- The maximum **<u>shear strain</u>** in the bar .

$$\tau_{max} = \frac{Tr}{J} = \frac{1.5 * 0.015}{\frac{\pi * (0.03)^4}{32}} = 283kPa$$

$$\gamma = \frac{Tr}{GJ} = \frac{1.5 * 0.015}{28 * \frac{\pi * (0.03)^4}{32}} = 10.1 * 10^{-6}$$

❑**Q3(Years) .**

- 1- Ductile material in torsion test fail due to **(shear stress)**
- 2- Brittle material in torsion test will fail at angle of **(45°)**
- 3- The elastic modulus calculated from shear stress strain diagram is called modulus of **(rigidity)**
- 4- The modulus of resilience can be defined as the amount of energy per unit volume absorbed during **(elastic)** deformation of the material .
- 5- Failure due to shear stress is characterized by **(smooth shiny)**

❑**Q4(Years).** In torsion test , we use τ, γ, G respectively to represent ?

Ans. Shear stress , shear strain , modulus of rigidity

❑Q5(Years). Find :

$$d = 20mm \, , length = 250mm$$

1- **Polar** moment of inertia

2- modulus of **rigidity**

$$1 - J = \frac{\pi * (0.02)^4}{32} = 1.57 * 10^{-8}$$

$$\gamma = \frac{0.003 * 0.01}{250 * 10^{-3}} = 1.2 * 10^{-4}$$

$$\tau = \frac{7.5 * 0.01}{1.57 * 10^{-8}} = 4.77MPa$$

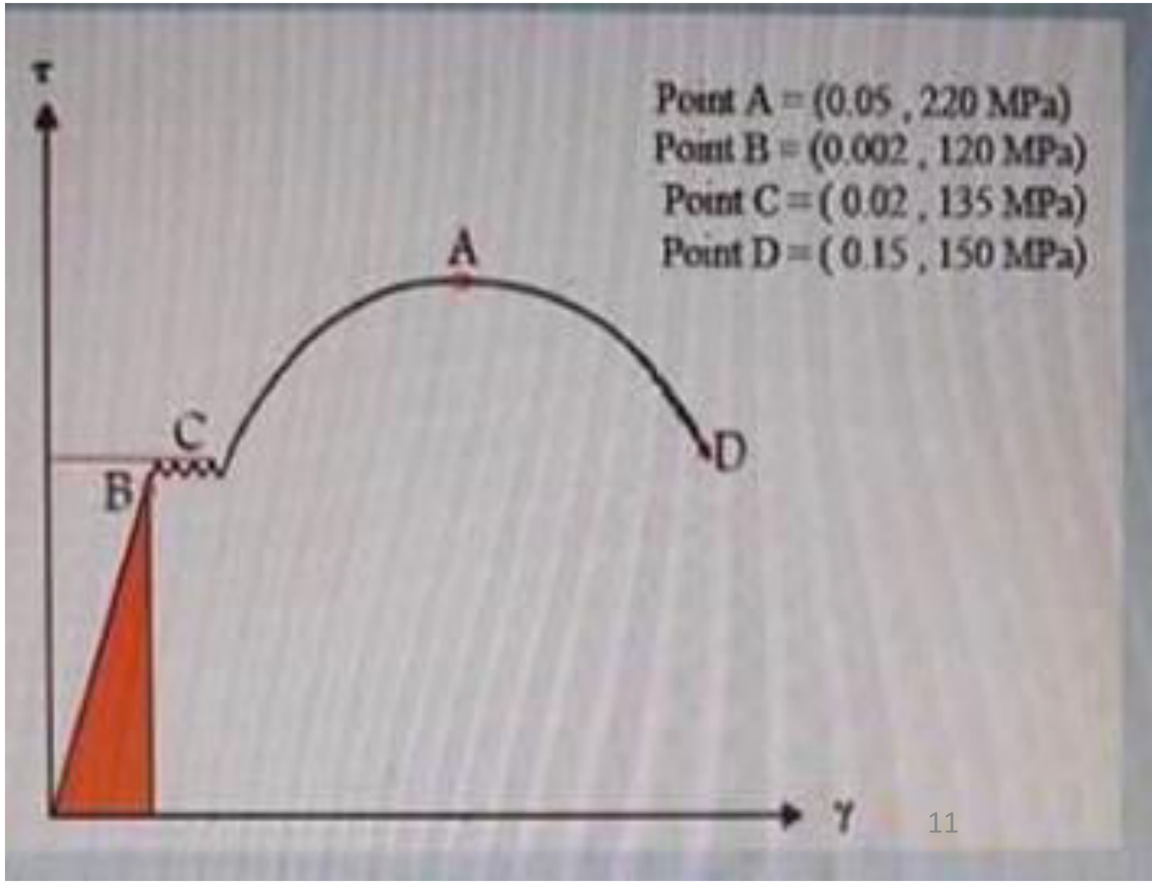
$$G = \frac{4.77 * 10^6}{1.2 * 10^{-4}} = 3.975 * 10^{10}$$

ϕ(Rad)	T(N.m)
0	0
0.003	7.5
0.006	15
0.009	22.5
0.0135	33.75
0.018	45
0.0203	50.75
0.03	62
0.046	62
0.068	62
0.123	70
0.197	75

❑**Q6(Years).** A torsion experiment is performed on the circular specimen with diameter 8 mm and gauge length of 150 mm , the resulting Shear –Strain diagram is shown below ?

- Find :

1- Applied Torque at the yield point
2- The modulus of rigidity
3- The modulus of resilience
4- Total angle of twist



Ans. 1 - $T = \frac{\tau * J}{r} = \frac{\tau * D^3 * \pi}{16} = \frac{120 * 10^6 * 3.14 * 0.008^3}{16} = 12.06$

$$2 - \ G = \frac{\tau}{\gamma} = \frac{120 * 10^6}{0.002} = 6 * 10^{10} = 60GPa$$

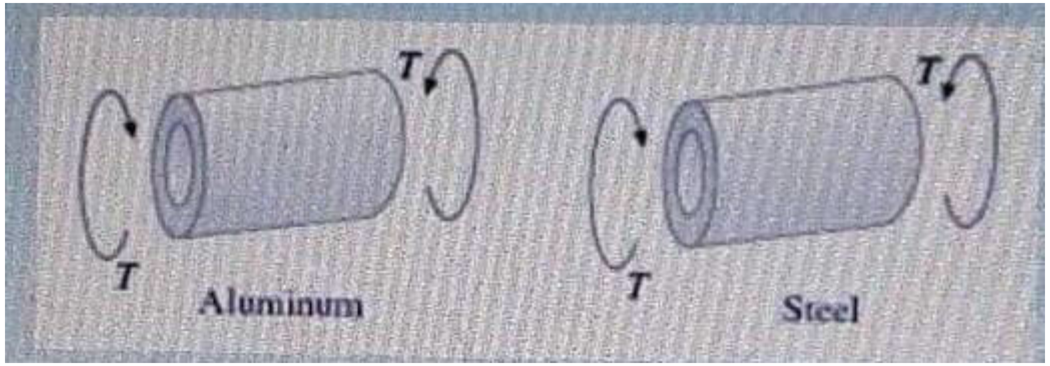
$$3 - \ \frac{1}{2} * \gamma * \tau_y = \frac{1}{2} * 120 * 10^6 * 0.002 = 0.12$$

$$4 - \ \phi = \frac{\gamma L}{r} = \frac{0.15 * 150}{4} = 5.625$$

❑**Q7(Years).** Which of the following illustrations represents brittle failure under **torsional load** ?

Ans.

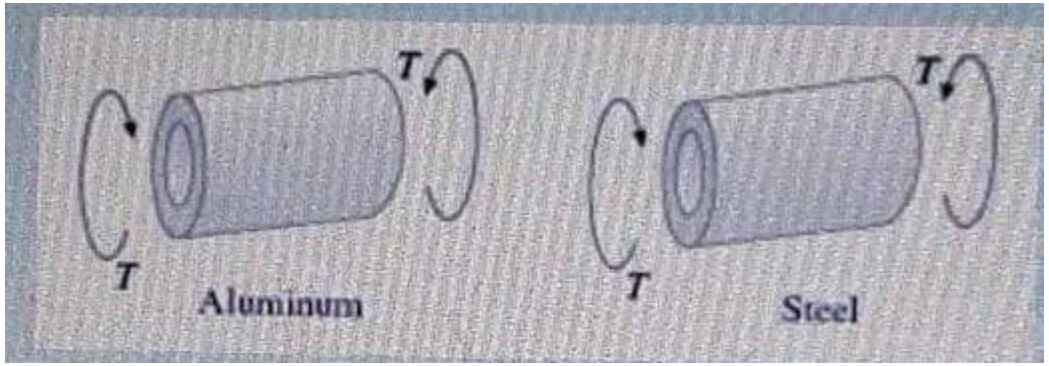
❑**Q8(Years).** The Shafts shown below differ only in regards to the material from which they were made . If the same torque is applied to each , the **maximum shear stress** is ?



Ans. Equal in both Shafts

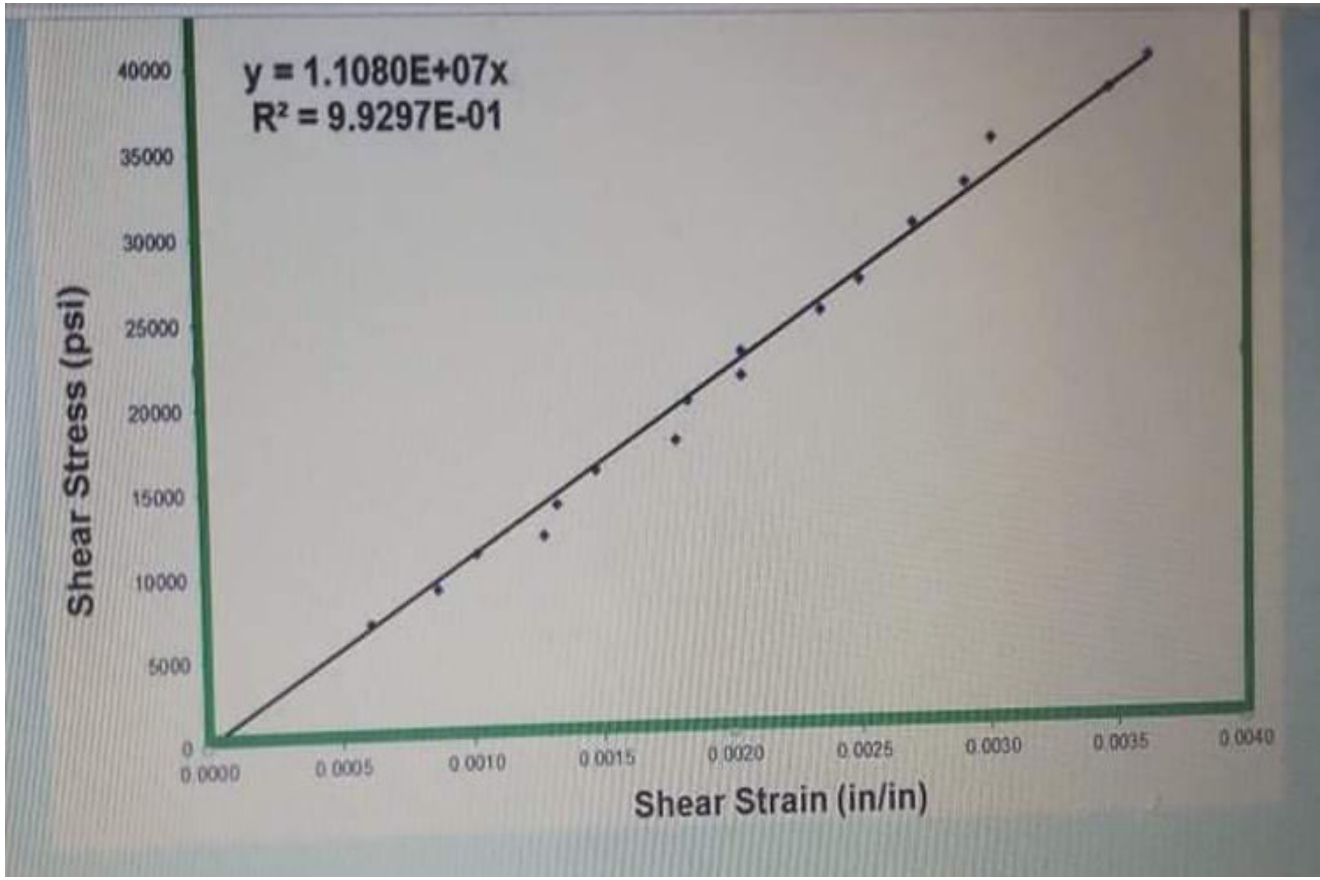
❑**Q9(Years).** The angle of twist ?

Ans. Greater in Aluminum shaft than that in steel one



❑**Q10(Years).** If the below figure shows an elastic shearing stress – strain curve for torsion test , the modulus of rigidity (Shear modulus of elasticity) is equal to ?

$$G = \frac{(20000 - 5500)}{(0.00185 - 0.0006)} = 1.11 * 10^7$$



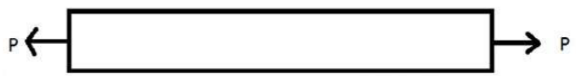
❑Exp: Strain Measurement with Strain Gauges

Give accurate measurements of **strain** .

❑**Strain Gauges:** Sensor whose **resistance** varies with applied force; It converts force, into a change in electrical resistance which can then be measured .

External forces

Axial force



$$Stress(\sigma) = \frac{P}{A}$$

$$\epsilon = \frac{\Delta L}{L}$$

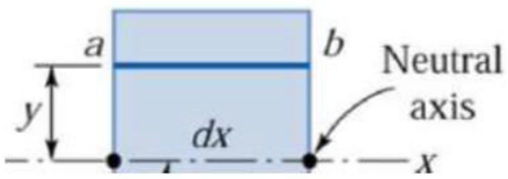
P: Load
A: Area = $r^2 * \pi$

L: Length
ΔL= Deformation

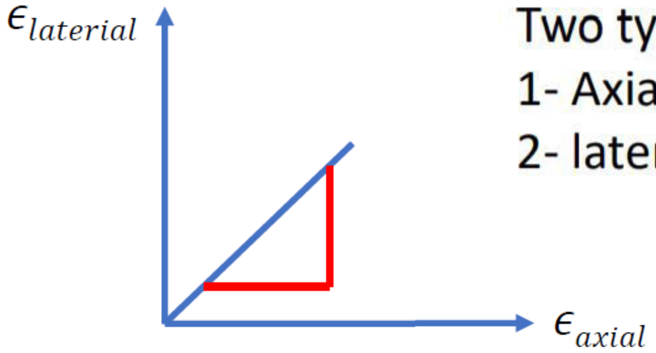
External forces

Normal force

$$\sigma = \frac{Mc}{I}$$



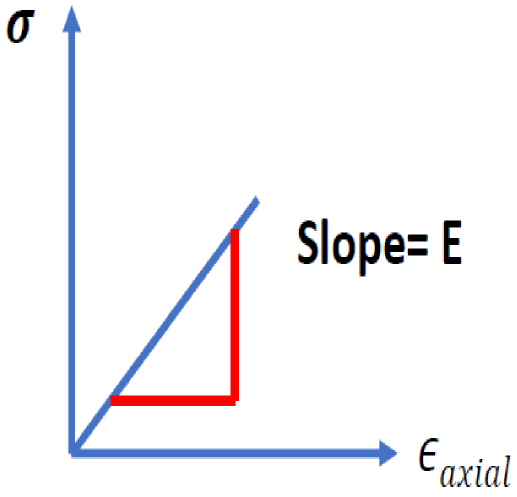
M: **Max** moment
I: Moment of inertia
Y: Distance y from the neutral axis
c = Y_{max}



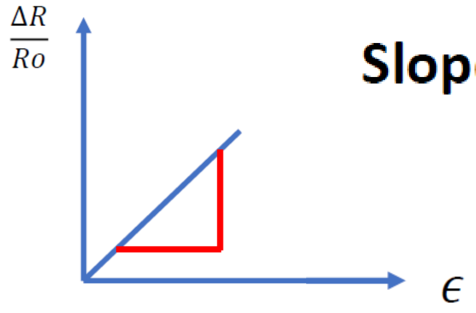
Two types of **strain** :

1- Axial : Install the strain gauge **Parallel**

2- lateral : Install the strain gauge **Perpendicular**



Slope= V= $\frac{-\epsilon_{laterial}}{\epsilon_{axial}}$



Slope= K

$$K=\frac{\frac{\Delta R}{Ro}}{\frac{\Delta L}{Lo}}=\frac{\frac{\Delta R}{Ro}}{\epsilon}$$

$R=\frac{\rho L}{A}$ ΔR and ΔL

علاقه طرديه

R: resistance

ρ : **Resistivity**

L: length

A: area

a) Quarter Bridge

$$\text{Actual Strain} = \frac{\text{القراءة}}{1}$$

b) Half Bridge

$$\text{Actual Strain} = \frac{\text{القراءة}}{2}$$

c) Diagonal Bridge

$$\text{Actual Strain} = \frac{\text{القراءة}}{2}$$

d) Full bridge.

$$\text{Actual Strain} = \frac{\text{القراءة}}{4}$$

- **Q1(Years).** A strain gauge is ?

Ans. Resistance

- **Q2(Years).** For measuring strains using the Wheatstone bridge , which of the following is directly measured from the bridge ?

Ans. Voltage

- **Q3(Years).** In strain gauge , a small change in dimensions is translated into equivalent change in ?

Ans. Resistance

- **Q4(Years).** The material type usually used for strain gauges is ?

Ans. Piezoelectric

- **Q5(Years).** For full a whetstone’s bridge , the actual strain on the beam is the reading of the bridge multiply by ?

Ans. 0.25

- **Q6(Years).** For strain gauges measurements to obtain the actual strain , the indicator reading of the **full bridge** should be ?

Ans. Divided by 4

- **Q7(Years).** Which of the following configurations is **Not used** for strain measurements using the Wheatstone bridge ?

Ans. Three quarter Bridge

- **Q8(Years).** In the strain gauge experiment both axially and laterally oriented strain gauges were attached to simply supported beam to be experimentally estimate ?

Ans. Poisson’s ratio

❑Exp: Hardness Test

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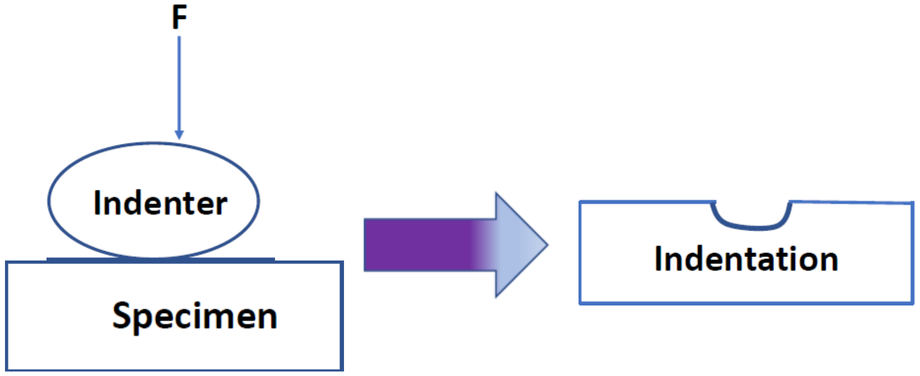
- **Hardness of any metal is** : Its **resistance** to surface indentation under standard test conditions and **its Non Destructive test** .
- **Device :** Universal Hardness Tester .



1- Specimen
العينه الذي أريد ان أخدشها

2- Indenter
الماده الذي أريد الخدش بها

Indenter diameter D

3- Indentation
الأثر الذي تتركه القوه

Indentation diameter d

We measure the diameter by **microscope**

$$d \leq D$$

- Three main test **methods** are used:

1-Brinell (HB) → Brinell harness number

$2 - \boldsymbol{Vickers(HV)}$ → Vickers Hardness number

3-Rockwell (HRC/HRB) → $\boldsymbol{type\ C}$, $\boldsymbol{type\ B}$

Brinell harness number = $\frac{P(kgf)}{\frac{1}{2}\pi D\left(D-\sqrt{D^2-d^2}\right)(mm^2)}$ → kgf=kg

P: Force applied (kg)

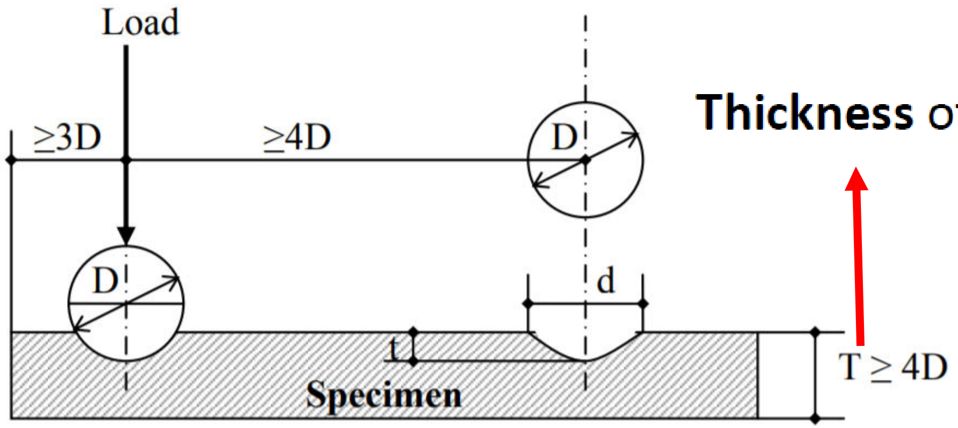
D: Diameter of indenter (mm)

d: Diameter indentation(mm)

- **Note : indenter is a ball of steel**
- Don't use Brinell tests if BHN ≥ 450 why ?

ball maybe easily deformed and this will introduce errors .

Depth of indentation **independent** with BHN .



Thickness of the test piece T

- Hardness ball ≥ 1.7 Hardness of specimen .

If several readings must be taken on the **same specimen**, they should be **spaced away** from each other and away from the edges of the work piece $\geq 4D$.

Values of $\frac{T}{t}$: For **soft** materials ≥ 15

For **hard** materials = ≥ 7

Distance from edge and specimen should be ≥3D

$$2 - Vickers(HV) = \frac{P}{\frac{D^2}{2} * \sin\frac{1}{2}(136^\circ)} = \frac{1.854P}{D^2}$$

Square based diamond pyramid **indenter**

$$D = \frac{d_1 + d_2}{2}$$

Depth of indentation **independent** with VHN

Hardness number of ≥ 300 the Brinell and Vickers Hardness values **are same**

- **Main Load = 10 for smooth material**
- **Main Load= 30 for hard material**
- Hardness scale range from very soft to very hard

3-Rockwell (HRC/HRB)

Cant be used for soft material

HRC :Rockwell test **Type C**

$$\boldsymbol{Main\ load = 150N}$$

Indenter : ***diamond cone***

HRB :Rockwell test **Type B**

$$\boldsymbol{Main\ load = 100N}$$

Indenter : ***steel ball*** (1/16")

- **Note :**

$\sigma = (3.45 - 3.5)BHN$

❑**Q1(Years).** Indicate the **name of the hardness test** ?

- 1- Pyramid indenter made of diamond **(Vickers test)**
- 2- Conical indenter made of diamond **(Rockwell C test)**
- 3- Spherical indenter of diameter D made of steel **(Brinell test)**

❑**Q2(Years).** In the **Vickers test** , which of the following is **correct ?**

Ans. The diamond produces square indentation area

❑**Q3(Years). Brinell test** is **not suitable** for testing () material .

Ans. Hard or very soft material

❑**Q4(Years) .** The **Brinell hardness** number for a metal is 150 , then the **ultimate strength** in Mpa for this metal is ?

Ans. 3.5*150=525

- **Q5(Years).** Hardness is defined as the resistance of the material against plastic deformation ?

Ans. True

- **Q6(Years).** The indentation depth in the hardness test is directly indicated as hardness value in ?

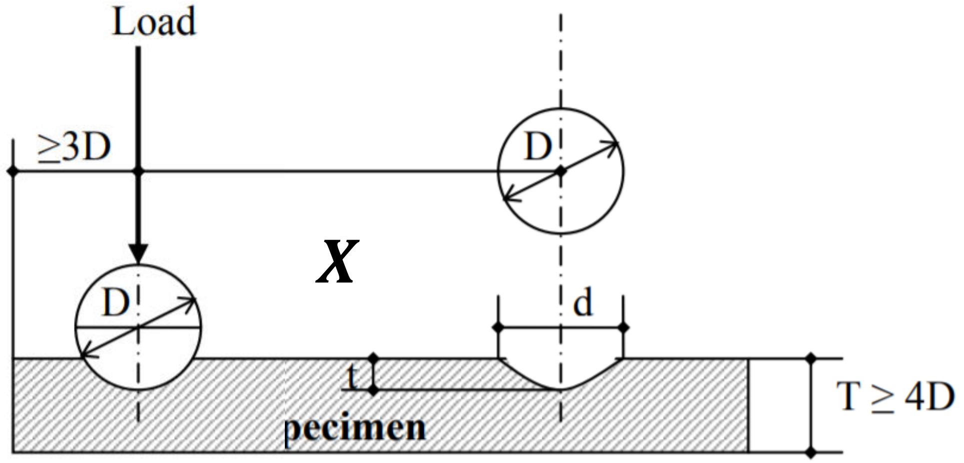
Ans. Rockwell scale

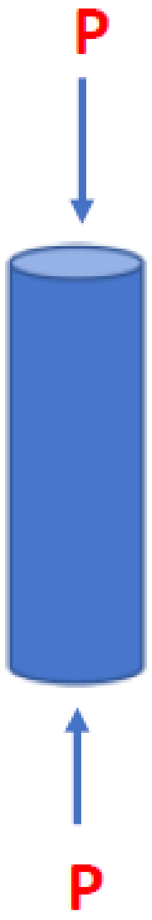
- **Q7(Years).** If material B scratches material C but not A then ?

Ans. $\boldsymbol{A > B > C}$

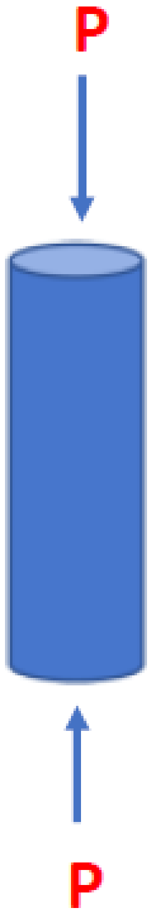
❑**Q8(Years).** For a correct hardness reading in Brinell Hardness test , the dimension marked by X on the shown figure must be ?

Ans. $\geq \boldsymbol{4D}$





❑Exp: Compression test



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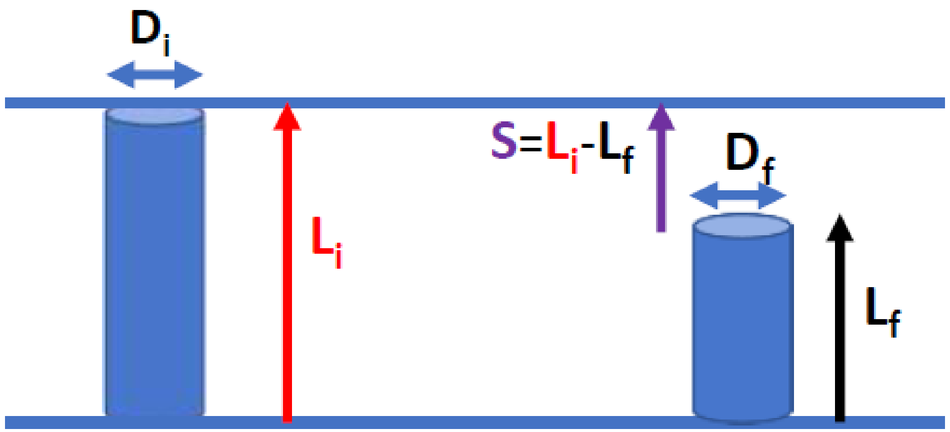


Shortening = $\frac{\Delta L}{L} * 100\%$. <u>الطول</u> الإبتدائي **أكبر** من النهائي .

Increasing in **Area**= $\frac{\Delta A}{A} * 100\%$ <u>المساحه</u> الإبتدائيه **أقل** من النهائيه

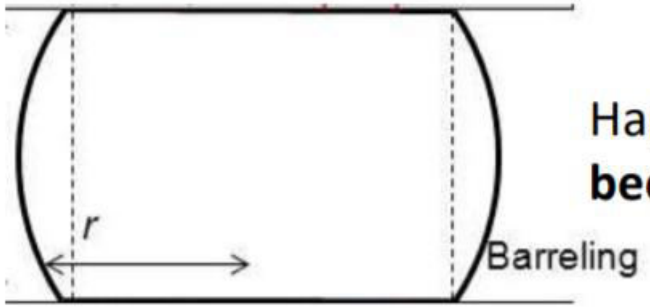
<u>حجم</u> العينه الإبتدائيه **نفس** حجم العينه النهائي .

$D > L$ *why* ?

Avoid **Buckling**

$$\frac{L}{D} < 5$$

✓**Universal Testing Machine (UTM)** :The machine is Capable doing the <u>**Compression** test .</u>



Happen **because** The **friction** between sample and the testing machine .

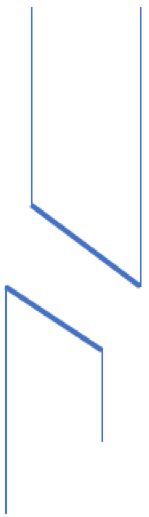
How we can **Avoid it ?**

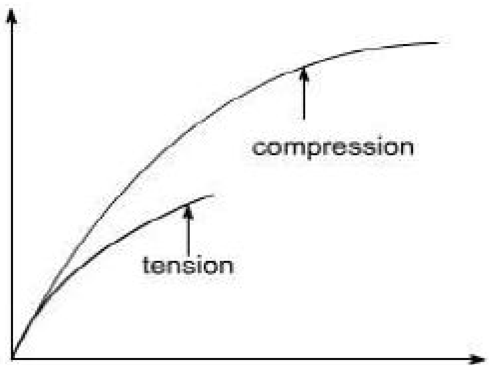
Put oil

❑ *Brittle material :*

Fracture at angle 45° سنوات

Caused by : Normal stress





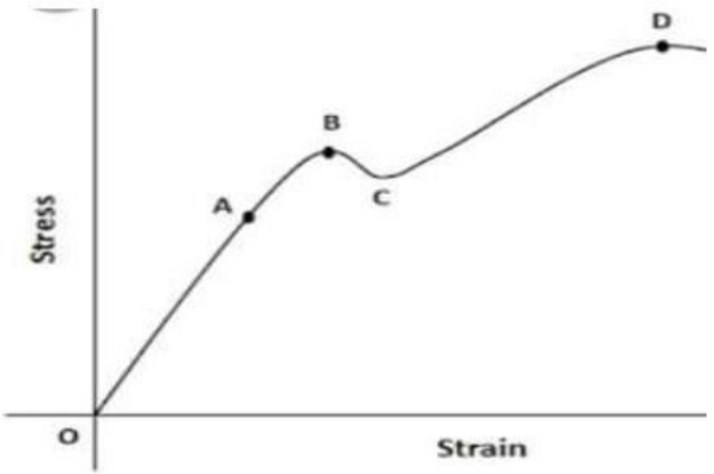
Yield=Ultimate=fracture

Compression **higher than** tension ?

Atoms and cracks will **be close** to each other

❑ *Ductile material :*

No Fracture يحدث فقط تشوهات



- **Q1(Years) .** When calculating the actual stress strain diagram , the material was assumed to have constant **(cross section) .**
- **Q2(Years).** To reduce or eliminate barreling in compression test , we must to **(decrease the friction)**
- **Q3(Years).** For a compression test of a ductile material , which of the following statements is true?

Ans. Barreling will occur .

- **Q4(Years).** Which of the following is **true** regarding ductile material ?

Ans. No fracture occurs for the material under compression .

- **Q5(Years).** For the same specimen size , compression test usually requires **(More)** energy from the test machine than tensile test .

❑**Q6(Years).** For brittle materials under compression loads ?

Ans. The modulus of toughness will be much higher than the value under tension

❑**Q7(Years).** For most brittle materials , the ultimate strength in compression in much large then the ultimate strength in tension , this is mainly due to ?

Ans . Presence of flaws and microscopies cracks or cavities

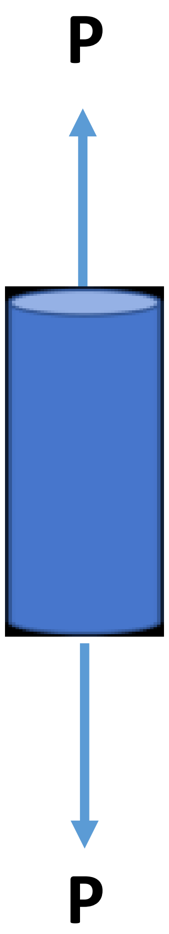
❑**Q8(Years).** In compression test to avoid buckling $\frac{L}{D}$ ratio was chosen to be ?

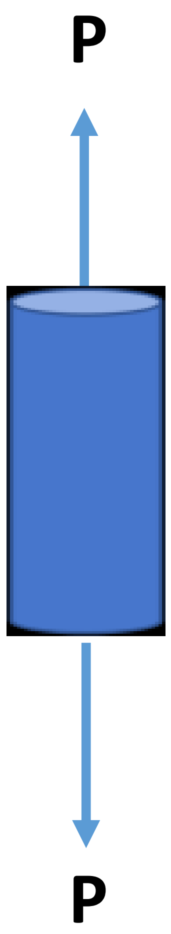
Ans. < 5

❑**Q9(Years).** For brittle materials used in compression test , the values of ultimate stress are expected to be ?

Ans. Much higher than the values obtained in the tensile test .

❑Exp: Tensile Test





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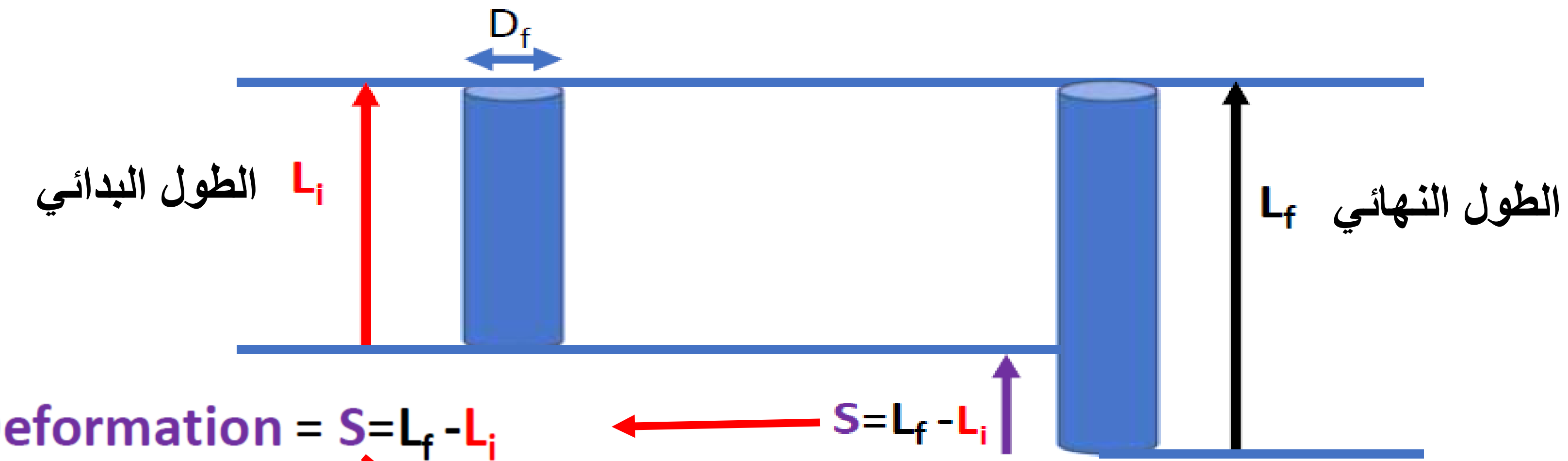
✓**Universal Testing Machine (UTM)** :The machine is Capable doing the tensile test .   سنوات مكرر



Deformation = $S = L_f - L_i$

mm

Strain

بدون وحدة

$$\varepsilon = \frac{Deformed \circ Length - Oridinal \circ length}{Original \circ Length} = \frac{L - L_o}{L_o}$$

$= Lf$

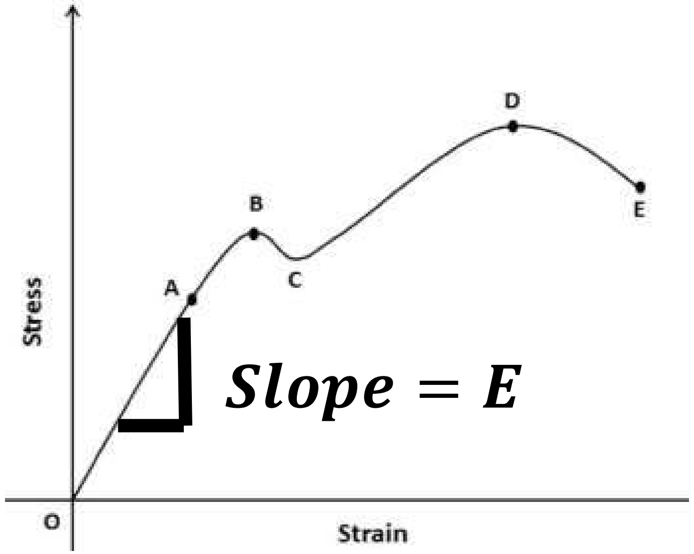
Engineering Stress

$$\sigma = \frac{Load}{Original^{\circ} Area} = \frac{P}{A_o}$$

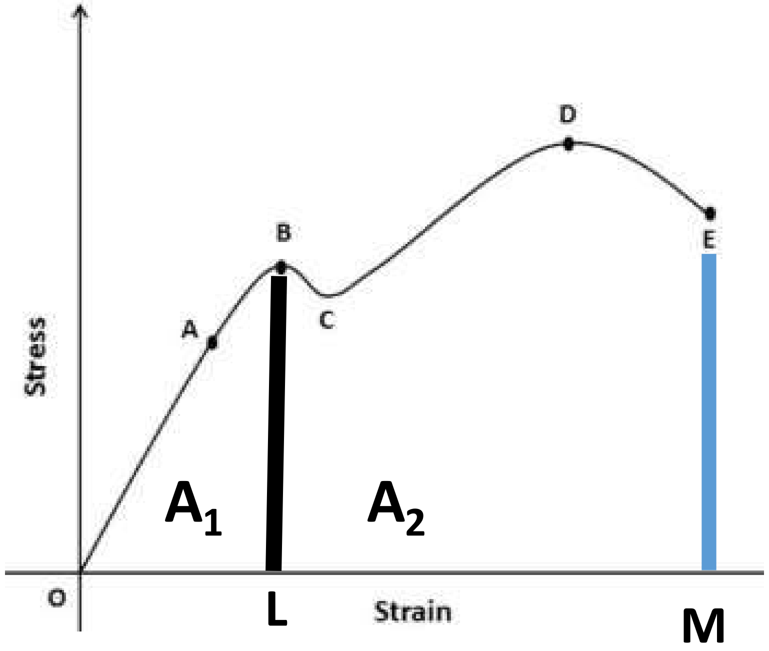
اللجنة الأكاديمية لقسم الهندسة المدنية

❑Stress-Strain Diagram for **Ductile Material** :

يحدث له إستطالة



Points (النقاط)	Definition (التعريف)	Symbol (الرمز)
Yield Stress (σ_y)	النقطة التي تفصل بين المرحلتين	B
Ultimate stress(σ_{UTS})	النقطة التي تكون في أعلى المنحنى	D
Rupture or fracture stress	اخر نقطة في المنحنى	E



Stage (المراحل)	Definition (التعريف)	Symbol (الرمز)
Proportional limit	نهاية الخط المستقيم	OA
Elastic	في حال إزلنا الحمل ترجع إلى شكلها الأصلي	OL
Plastic	في حال أزلنا الحمل لا ترجع العنية إلى شكلها الأصلي	LM
Necking	المنطقة الواقعة بين أقصى قيمة إجهاد وبين قيمة فشل العينة	Between D and E

- **Elastic limit:** Maximum load that can be applied to the specimen **without permanently deforming it.**
- **Plastic region :** The part of the stress-strain diagram after the yielding point. **the plastic deformation starts**. Plastic deformation is **permanent**.

- **The Modulus of Elasticity (E)** : Shows the **Elastic resistance** to an applied **load** that causes **deformation**. It is a measure of the **stiffness** of materials .

- E= $\frac{\sigma}{\epsilon}$ so σ= E* ϵ just in **Elastic and called Hock's Law**

- **The Modulus of Resilience (UR) :** Amount of energy stored in stressing the material to the **elastic limit .** $\boldsymbol{U_R = A_1 = \frac{1}{2} * \epsilon_y * \sigma_y}$

- This quantity is important in selecting materials for energy storage such as springs .

- **The Modulus of Toughness (UT): Total energy** absorption capabilities of the materials to failure .

$$\boldsymbol{U_T = A_1 + A_2 = \frac{2}{3} * \epsilon_U * \sigma_{Max}}$$

- This quantity is important in selecting materials for applications where high overloads are likely to occur and large amounts of energy must be absorbed .

❑**The ductility of material**: is ability of material to deform under load .

ويمكننا تحديدها عن طريق حساب الإستطالة ونقصان المساحه

➢**Elongation%**= $\frac{L_F - LO}{L_O} * 100\%$

➢**Reduction Of Area** % = $\frac{A_i - A_F}{A_F} * 100\%$

✓If the **Percentage** of elongation and reduction of cross-sectional are **large** , the material is said to be **ductile** .

✓when they are **low**, the material is said to be **brittle**.

$V_i = V_f$

$A_i * L_i = A_f * L_f$

$A_f = \frac{Ai * Li}{Lf}$

❑Shear modulus of elasticity (G) : $= \frac{E}{2(1+V)}$

❑Bulk Modulus(K) $= \frac{E}{3(1-2V)}$

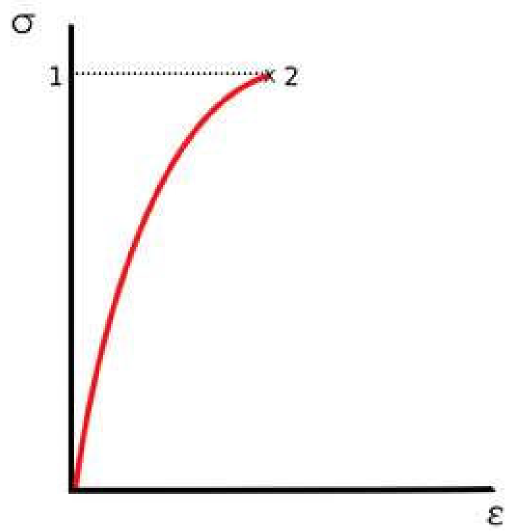
$V = \textbf{poissons ratio} = \frac{-\epsilon_{Laterial}}{\epsilon_{Axial}}$

❑ ***True Values***

$\sigma_T = \sigma(1+\epsilon)$

$\epsilon_T = Ln(1+\epsilon)$

❑Stress-Strain Diagram for **Brittle Material** :



ينكسر بسرعة

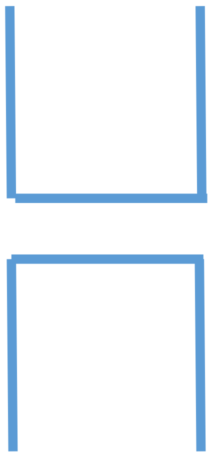
Yield=Ultimate=fracture
Only Elastic
Ductility < 5%

Happen because Normal stress

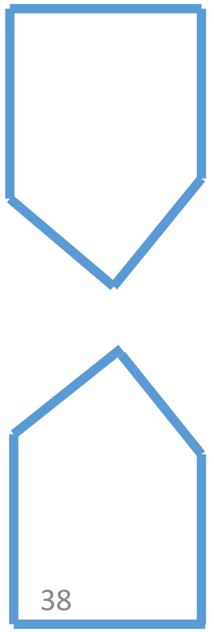
Fracture at angle 90

High carbonic steel

Shape: Flat



بعض **الخصائص** التي تكون متختصة في المواد المرنه **وهي مهمة جدا وحفظ .**



❑**Ductile Material**

Happen because **Shear stress**

Shape : Cup and Cone

Fracture at angle 45

Low carbonic steel

Ductility > 5%

❑**Q1(Years).** Consider the Stress- strain diagram for a typical structural steel in tension shown below .

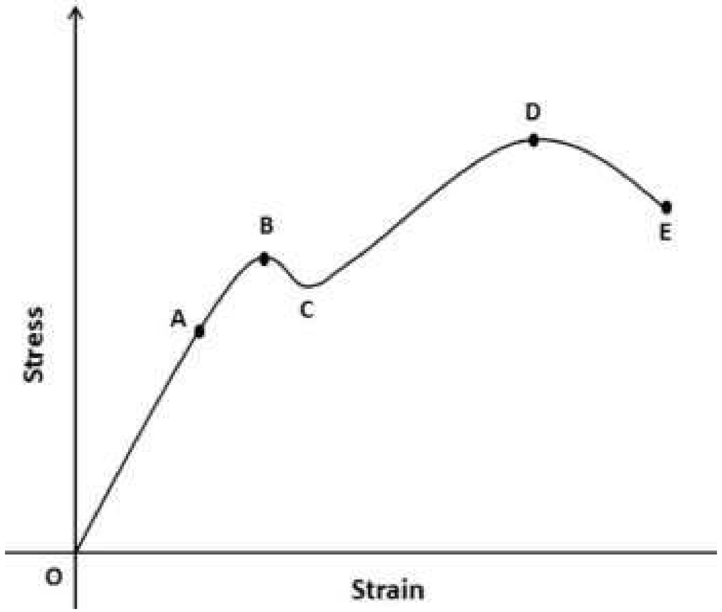
A) **Rupture** stress is at point ?

B) **proportional limit** is at point ?

C) **Elastic** deformation occurs between points ?

D) **Necking** occurs between points ?

E) **Strain hardening** occurs between points ?



ANS:

A) E
B) A
C) O , A
D) D , E
E) C , D

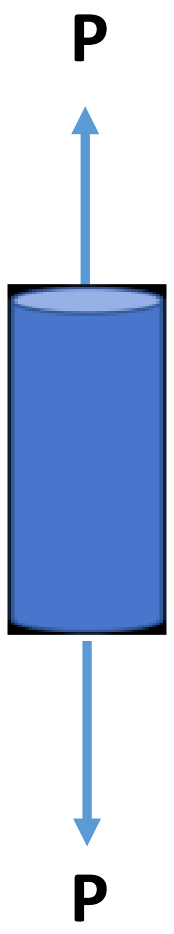
❑**Q2(Years).** A 500 mm long cylindrical bar with 10mm diameter is subjected to axial loading (P=20kN) as shown in figure , the bar is made of a material with E=90GPa and v=0.3 knowing that the stress in the bar did not reach the yield strength of the material .

➢**Find :**

1- The **stress** in the bar ?

2- the **length** of the bar under the effect of the applied load ?

3- the **diameter** of the bar under the effect of the applied load ?



$$\sigma = \frac{Load}{Original° Area} = \frac{P}{A_o} = \frac{20 * 10^3}{\frac{\pi}{4}(0.01)^2} = 254777070.1 Pa = \mathbf{254.7 MPa}$$

❑**Q3(Years).** This figure shows stress-strain diagrams , please answer questions below by writing the correct letter or number .

1- Rupture stress

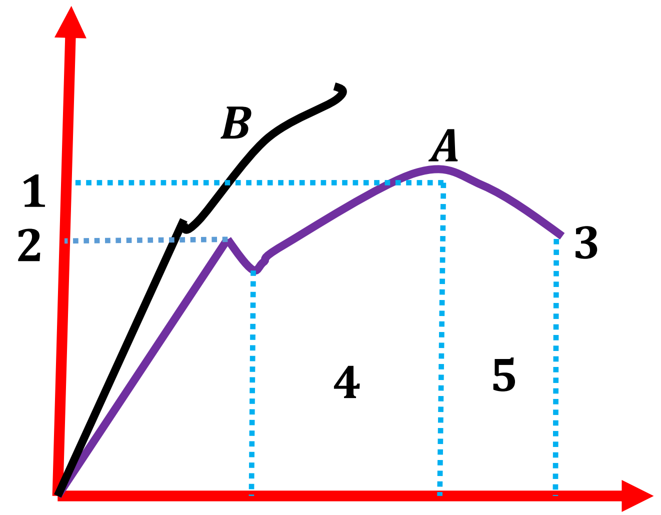
2- True stress-strain diagram

3-Engineering stress-strain diagram

4-UTS

5-Yield region

6-Necking region



❑ **Ans.**

1- 3
2- B
3- A
4- 1
5- 2
6- 5

❑**Q4(Years).** A force of 20000 N will cause 1 cm* 1cm bar of magnesium to stretch from 10 cm to 10.045 cm , calculate the modulus of elasticity in GPa ?

Ans.

$$\boldsymbol{Stress = \frac{20000}{(1 * 10^{-2})^2} = 200MPa}$$

$$\boldsymbol{Strain = \frac{10.045 - 10}{10} = 4.5 * 10^{-3}}$$

$$\boldsymbol{E = \frac{200}{4.5 * 10^{-3}} = 44444.44MPa = 44.4GPa}$$

❑**Q5(Years).** In the tension test , the property which is an indication of the **stiffness of a material** ?

Ans. **Modulus of Elasticity**

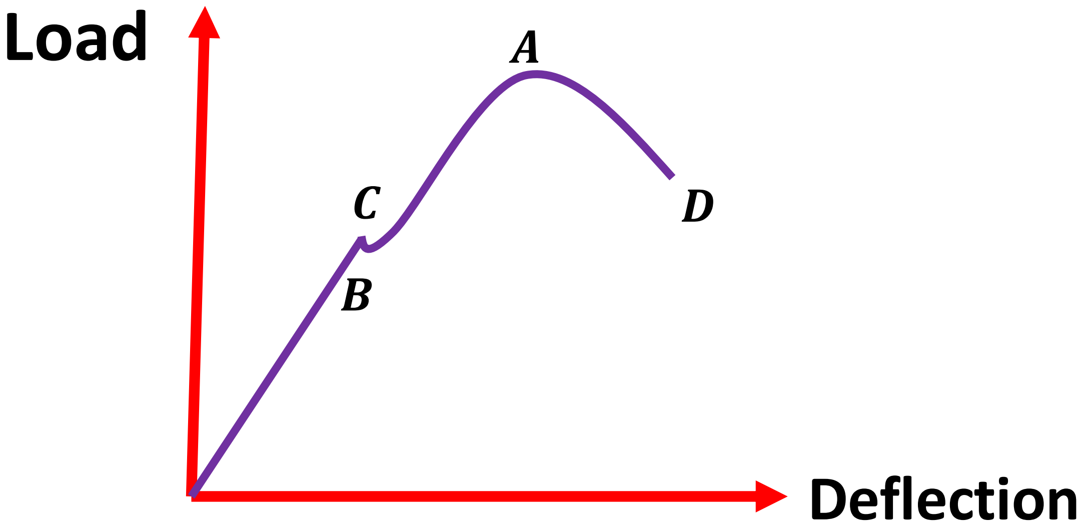
❑**Q6(Years).** In tensile test , modulus of resilience represent ?

Ans. The Amount of energy absorbed (stored) during **elastic limit .**

❑**Q7(Years).** The tensile strength –strain curve for steel shown below , the specimen **original length is 100mm** and has a **diameter** of 10mm , using the data in the table , answer the following .

1- The **modulus of elasticity**

2- **Fracture** stress



Point	Load(kN)	Deflection(mm)
B	10	0.3
C	13	0.5
A	19	6
D	15	9

$$Stress\ at\ B = \frac{10 * 10^3}{\frac{\pi}{4}(0.01)^2} = 127.38MPa$$

$$Strain\ at\ B = \frac{0.3}{100}$$

$$1 - \ E = \frac{127.38}{0.003} = 42.46GPa$$

$$2 - Stress\ at\ D = \frac{15 * 10^3}{\frac{\pi}{4}(0.01)^2} = 191.08\ MPa$$

Civiltee

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❑**Q8(Years).** The figure shown below represents a Load – Deflection curve of a tensile test .

- **Find :**

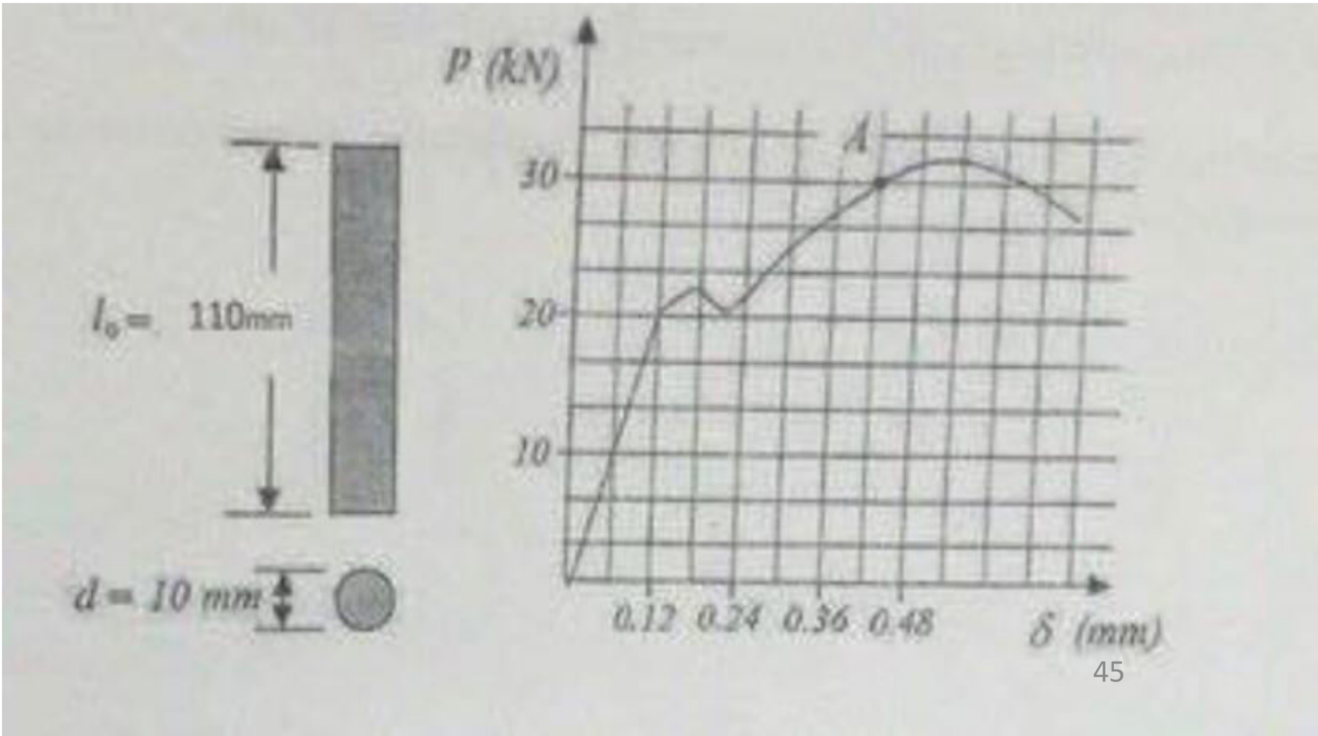
1- **Modulus of elasticity**

2- Engineering stress and strain for **point A**

3- The **ultimate** strength

4- The total length of the specimen **at fracture**

5- The modulus of **resilience**



$1 - E \; from \; Slope$

$$\mathbf{P} \; \boldsymbol{\delta} \qquad \mathbf{P} \quad \boldsymbol{\delta}$$
$$(0,0), (20,0.12)$$

$$Stress = \frac{20}{\frac{\pi}{4}(0.01)^2} = 254MPa$$

$$Strain = \frac{0.12}{110} = 1.09 * 10^{-3}$$

$$E = \frac{254.6 * 10^6}{1.09 * 10^{-3}} = 233.57GPa$$

$$\mathbf{P} \quad \boldsymbol{\delta}$$
$$2 - \; (30,0.42)$$

$$Stress = \frac{30}{\frac{\pi}{4}(0.01)^2} = 382.165MPa$$

$$Strain = \frac{0.42}{110} = 3.81 * 10^{-3}$$

$$3 - \qquad Stress = \frac{31.5 * 10^3}{\frac{\pi}{4} * (0.01)^2} = 401.07MPa$$

$$4 - \quad lf - li = \delta$$

$$l_f - 110 = 0.7$$

$$l_f = 110.7$$

$$\mathbf{5 - \mathit{UR} = \frac{1}{2} * \epsilon_y * \sigma_y}$$

$$\frac{\mathbf{1}}{\mathbf{2}} * 1.09 * 10^{-3} * 254 * 10^{6} = 138.75$$

❑**Q9(Years)** Find :

1- Total strain if loaded to point X and released

2- Proportional limit

3- Upper yield strength

4- Lower yielding strength

5- Modulus of resilience

➢ **Ans:**

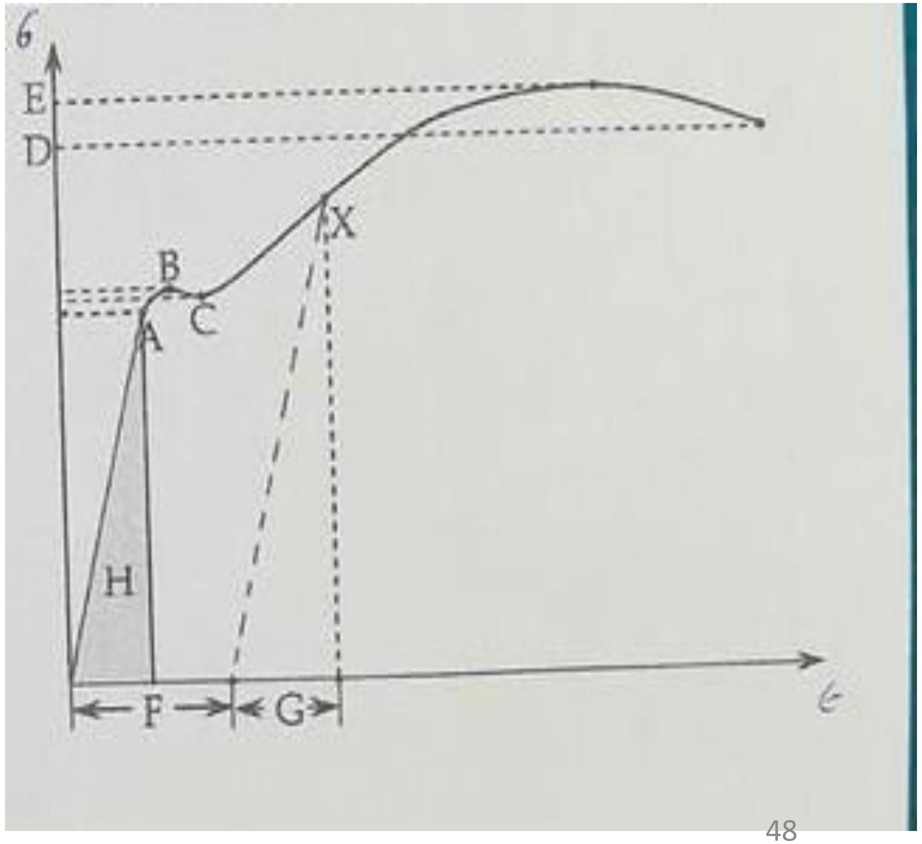
1- G

2- A

3- B

4- C

5- H



- **Q10(Years).** Which of the following is a proper sequence ?

Ans. Proportional limit **then** Elastic limit **then** yielding **then** failure .

- **Q11(Years).** The specimens used in compression tests are shorter than those used in tensile tests , this can be expected to ?

Ans. To avoid buckling (**None of the above** in the **years**)

- **Q12(Years).** During tensile- testing of a specimen using universal testing machine , the parameters actually measured include ?

Ans. Load and elongation

- **Q13(Years).** A rod of length L and diameter D is subjected to tensile Load P , which of the following is sufficient to calculate the resulting change in diameter ?

Ans. Both Young's modulus and shear modulus .

- **Q14(Years).** If fracture occurs before much plastic deformation occurs , we say that the material is brittle ?

Ans. True

❑**Q15(Years).** For the uniaxial stress- strain curve shown below , the modulus of elasticity ?

$$\boldsymbol{E = \frac{\sigma}{\varepsilon} = \frac{6.67}{0.00067} = 10000}$$

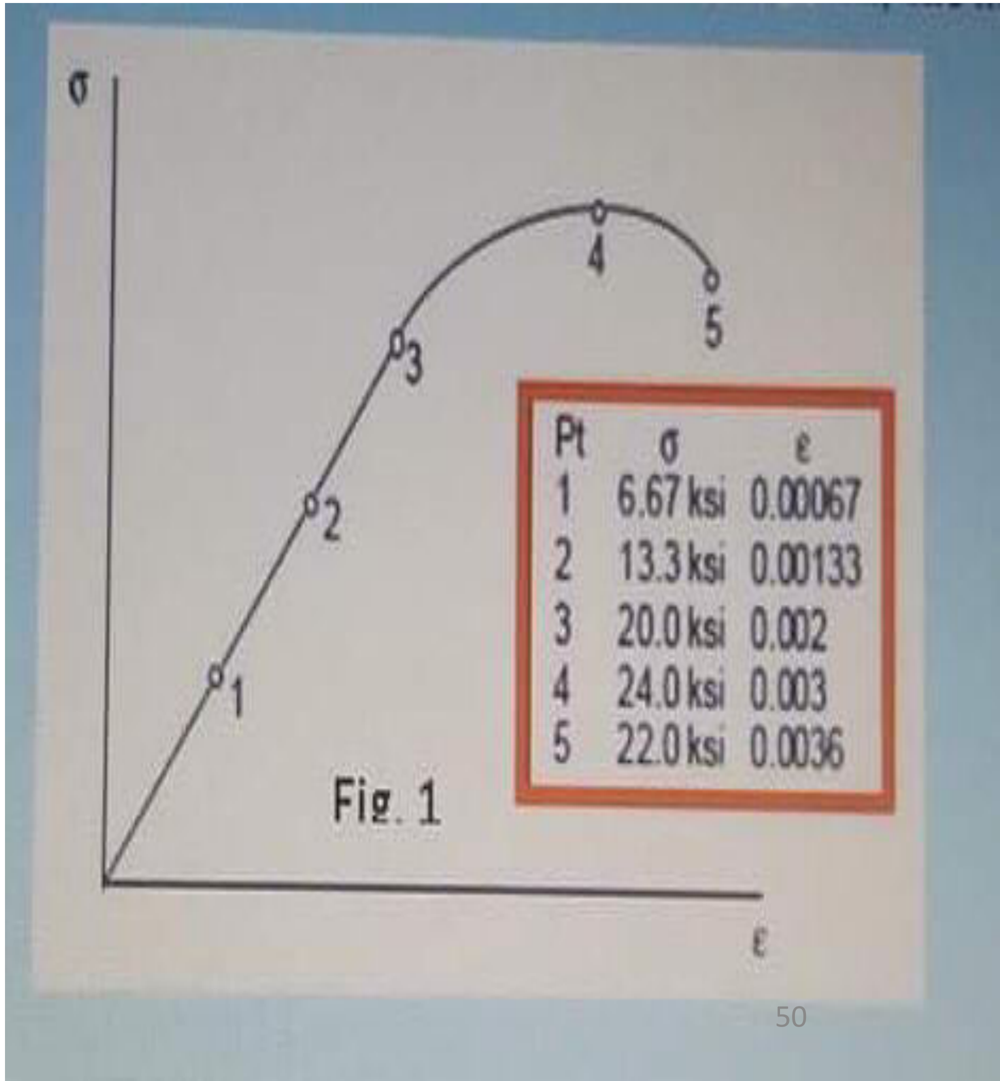
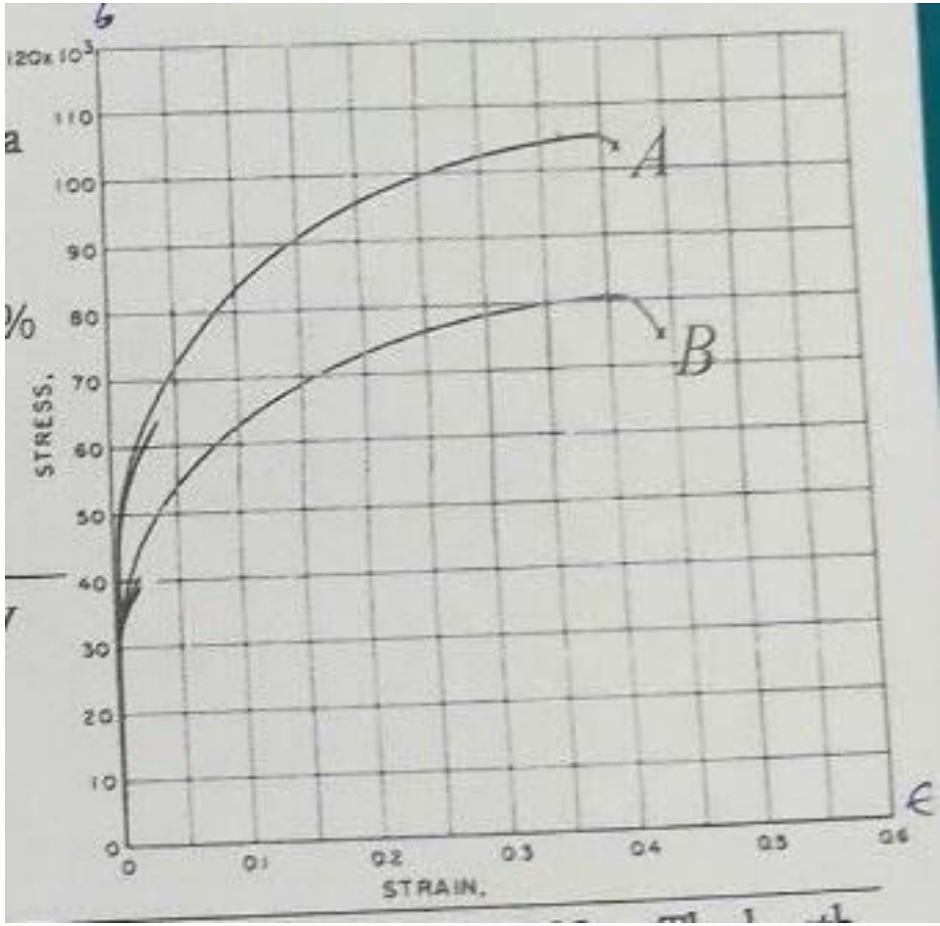


Fig. 1

❑**Q16(Years).** For the shown curve the modulus of rupture for **<u>material A</u>** approximately equals (Stress in kPa)?

Ans.



$$\frac{105 * 1000}{0.42 * 10^{-2}} = 25Mpa\ (in\ the\ years\ 27Mpa)$$

❑**Q17(Years).** A 95 mm specimen with 12 mm diameter is used in tensile test , if the specimen yielded and the test was continued till it reached a final length of 102.3 mm , calculate the actual diameter of the specimen at this point ?

Ans. $$\frac{\pi}{4} * Li * {D_O}^2 = \frac{\pi}{4} * Lf * {D_f}^2$$

$$\frac{\pi}{4} * 95 * 12^2 = \frac{\pi}{4} * 102.3 * Df^2$$

$$Df = 11.563$$

❑**Q18(Years).** When comparing engineering stress – strain curves with actual stress – strain curve , the engineering stress- strain curve will have ?

Ans. Lower values of stress after yielding point .

❑Q19(Years). Find :

1- Maximum compressive stress occurs at point ?

2- Maximum tensile stress occurs at point ?

3- Maximum Shear stress occurs at point ?

4- Zero shear stress occurs at point ?

5- Zero normal stress occurs at point ?

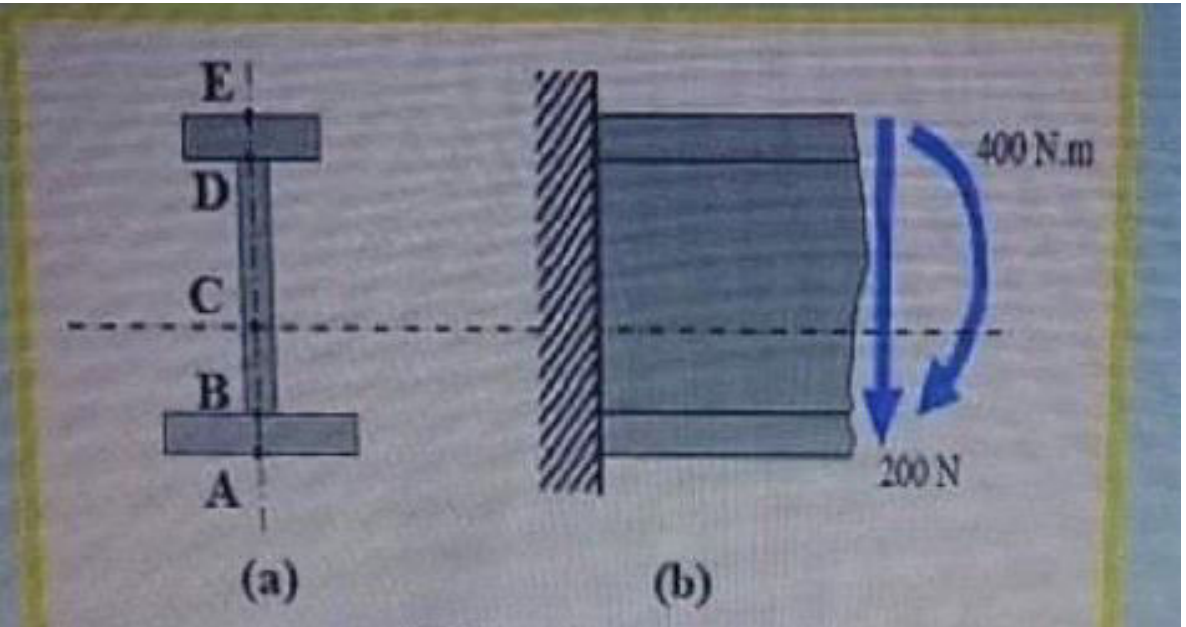
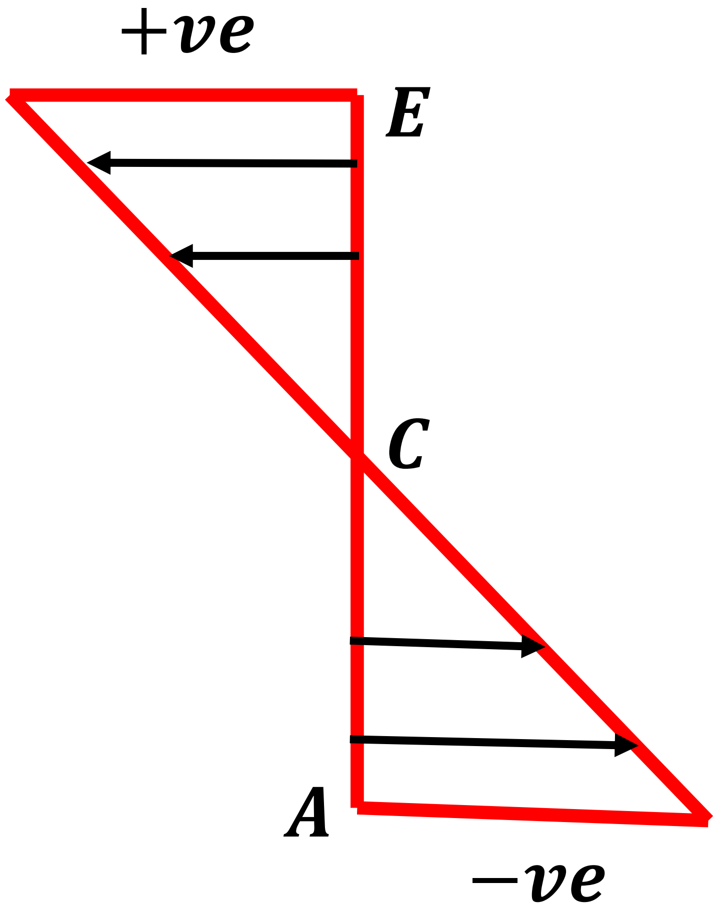
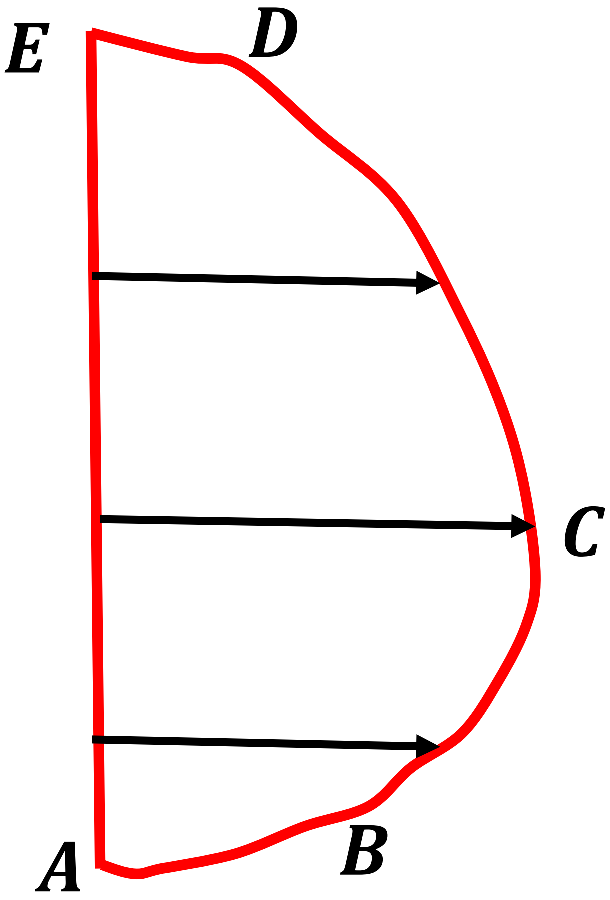


Figure 1



Normal Stress



Shear Stress

Ans.

$1 - A$

$2 - E$

$3 - C$

$4 - A$ and E

$5 - C$

❑**Q20(Years).** For a specimen under axial loading with $E = 84GPa$ and $\nu = 0.28$ if the lateral strain was measured and found to be equal to $54 * 10^{-5}$, the applied longitudinal stress is equal to ?

$$V = \boldsymbol{poissons\ ratio} = \frac{-\epsilon_{Laterial}}{\epsilon_{Axial}}$$

$$0.28 = \frac{-54 * 10^{-5}}{\epsilon_{Axial}}$$

$$\boldsymbol{\epsilon_{Axial} = -192.85 * 10^{-5}}$$

$$Longitudinal\ stress = -192.85 * 10^{-5} * 84 * 1000 = -162Mpa$$

- **Q21(Years).** The fracture surfaces will be oriented at 45° with respect to the specimen axis for the following test material combinations ?

Ans. Tensile-ductile , compression – brittle , torsion-brittle

- **Q22(Years).** Relative to the axis of the specimen , the orientation of fracture surface of a brittle material during tension , compression and torsion test will be ?

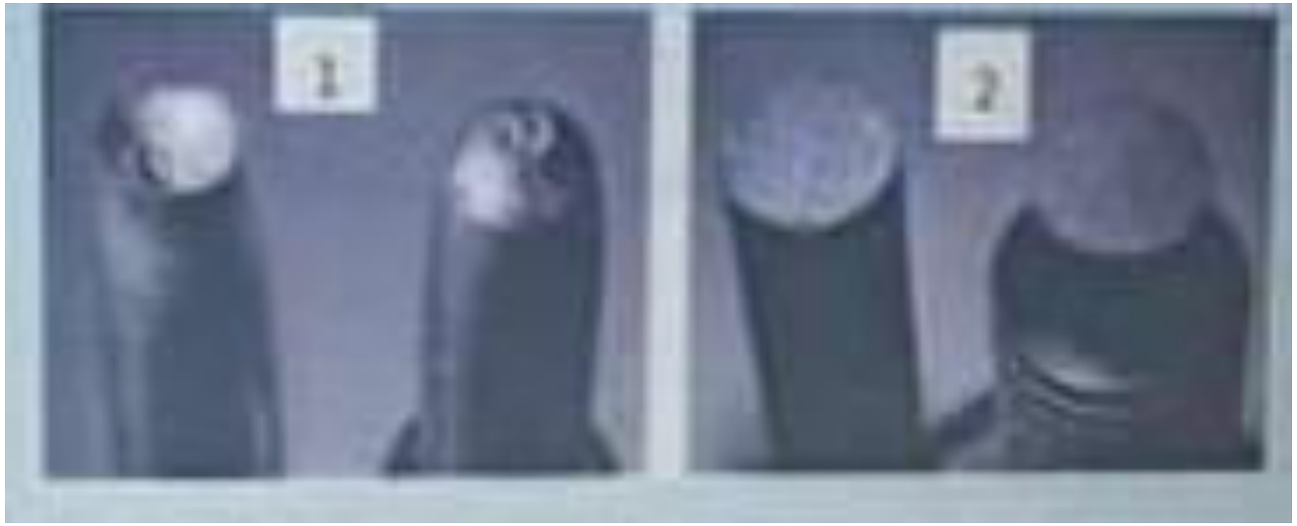
Ans. $90^{\circ}, 45^{\circ} and\ 45^{\circ}$

- **Q23(Years).** The strain energy density is equal to the area under the load deformation diagram ?

Ans. False

❑**Q24(Years).** If both material shown below are failed under tensile load , the **ductile** material ?

Ans. 1



❑ **Q25(Years).** Three identical beams with the same boundary conditions and subjected to the same loading are made of steel , brass and aluminum , the smallest stress will occur in the beam made of ?

Ans. Stress are equal in the three beams

❑Q26(Years). The figure below shows the stress-strain curves for four different material , all curves are drawn to the same scale .

Find :

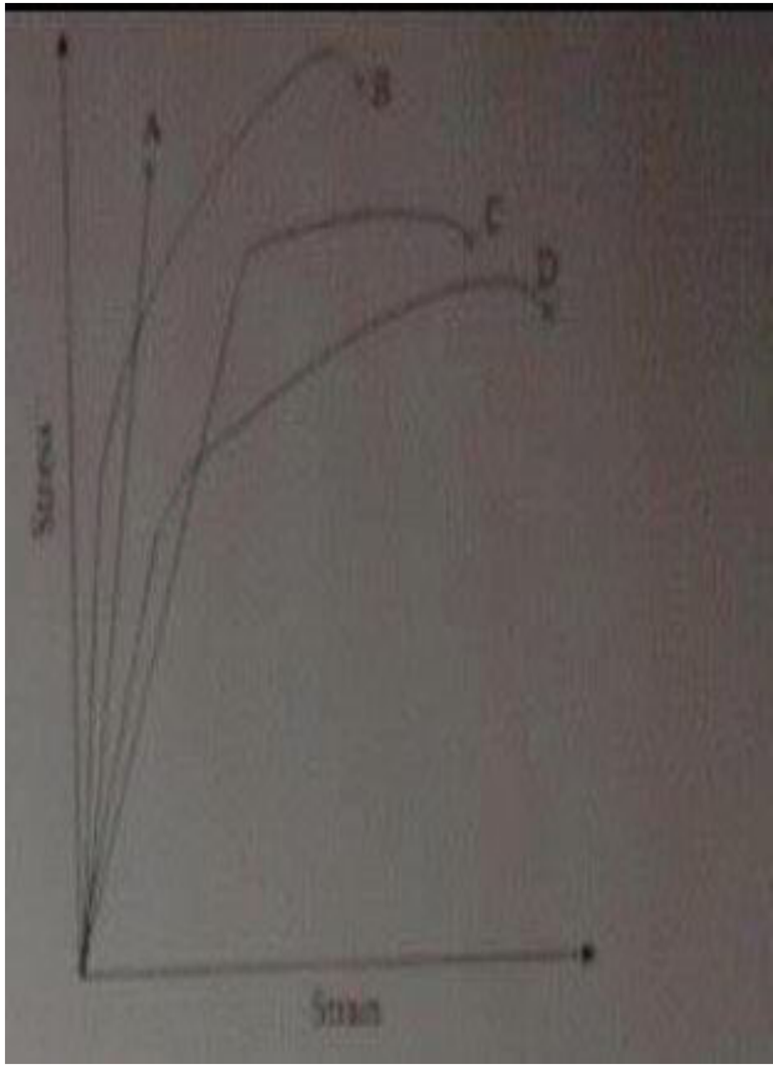
1- Material (C) has the highest yield strength .

2- Material (B) has the highest ultimate strength .

3- Material (A) did not show any necking before fracture .

4- Material (D) is the most ductile .

5- Material (A) is the most brittle .



❑Exp: THIN WALL CYLINDER

إعداد : محمد السفاريني

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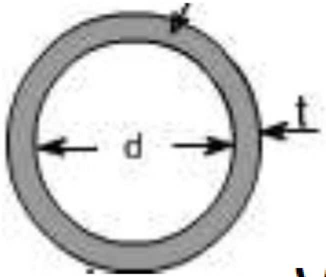


Thickness (t) Diameter (D) $\frac{t}{D} < \frac{1}{20}$ يجب تحقق هذا الشرط

We put **water , oil** in the cylinder **so** we get **stress** and **strain** .

Stress Types :

$1 - Hoop\ Stress(\sigma_H) = \frac{PD}{2t}$

$\sigma_H = 2\sigma_L$ $P = Pressure$

Pressing in the inner wall

$2 - Longitudinal\ stress(\sigma_L)$

$= \frac{PD}{4t}$ **Pressing in the ends of the cylinder**

$\sigma_L = 0\ (Spherical\ or\ open\ cylinder)$

Strain Types :

$1 - Hoop\ Strain\ (\epsilon_H) = \frac{\sigma_H}{E} - V\frac{\sigma_L}{E}$

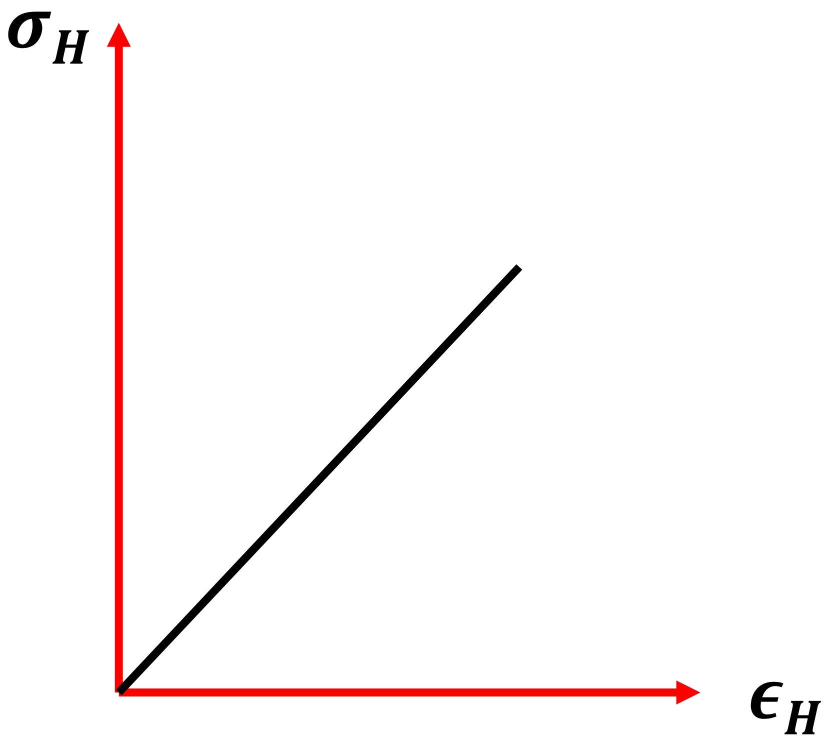
$E = Modulus\ of\ Elasticity$

$V = Poison's\ ratio$

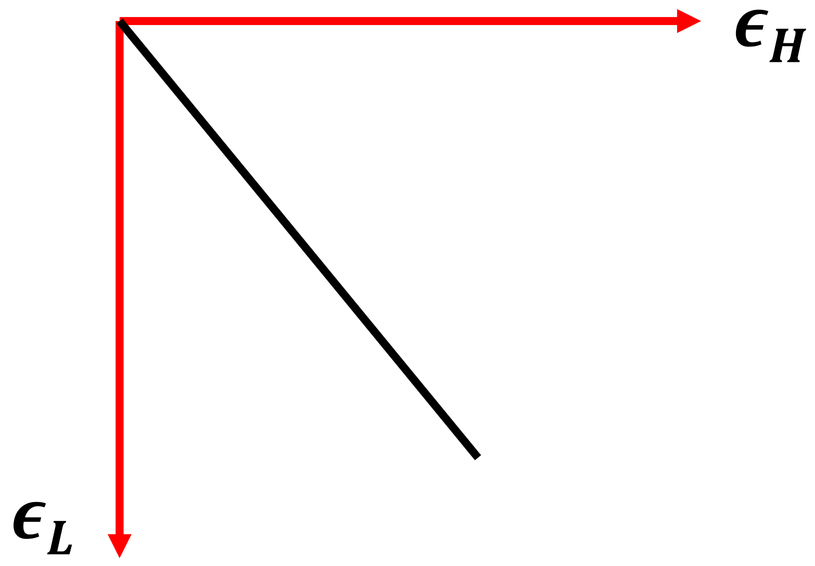
$\upsilon = \frac{-\varepsilon_L}{\varepsilon_H}$

$2 - Longitudinal\ Strain(\epsilon_L)$

$= \frac{\sigma_L}{E} - V\frac{\sigma_H}{E}$



$$Slope = E$$



$$Slope = V$$

$$\upsilon = \frac{-\varepsilon_L}{\varepsilon_H}$$

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- **Q1(Years) .** In thin wall cylinder experiment , you expect the **strain to be negative** ?

Ans. In the **axial** direction for **closed** end cylinder test .

- **Q2(Years).** If the ***Longitudinal* stress** in the thin wall cylinder is equal to 150MPa , the **hoop stress** is Mpa is ?

Ans. $\sigma_H = 2\,\sigma_L$ = 150 * 2= **300MPa**

- **Q3(Years) .** For a thin walled cylinders with **open end condition** ?

Ans. $\boldsymbol{\sigma_L = 0}$

Q4(Years). For a thin wall cylinder , if the pressure is increased above certain limit then ?

Ans. The cylinder usually cracks along the *Longitudinal* direction first .

- **Q5(Years). Poisson's ratio** is defined as ?

Ans. The ratio of lateral strain to axial strain when the material is loaded along one axis .

- **Q6(Years).** The hoop stress of spherical thin-walled pressure vessels is twice as large as the *Longitudinal* stress ?

Ans. True

- **Q7(Years).** A strain gauge placed on the **longitudinal direction** of a thin walled cylinder with **closed end** condition if the **strain gauge reported a reading of 146 $\boldsymbol{\mu}$** – strain , the value of the **pressure** inside the vessel is equal to ?

D=4m , t=1.25cm , E=70GPa , v=0.33

$$\epsilon_L = \frac{\sigma_L}{E} - V\frac{\sigma_H}{E}$$

$$146 * 10^{-6} = \frac{\sigma_L}{70 * 10^9} - 0.33 * \frac{2 * \sigma_L}{70 * 10^9}$$

$$\sigma_L = 30058823.53\ Pa$$

$$\sigma_L = \frac{PD}{4t}$$

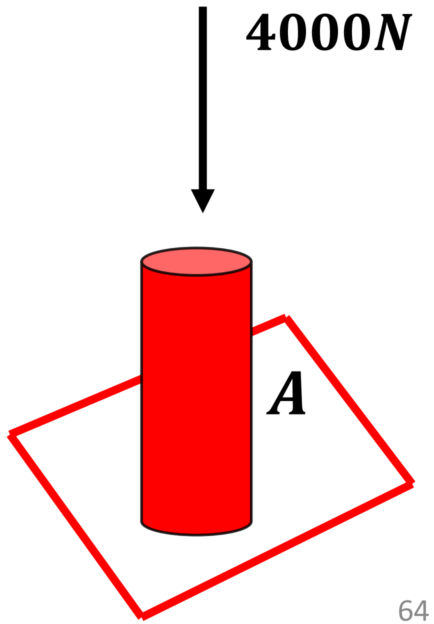
$$\mathbf{30058823.53 = \frac{P * 4}{4 * \frac{1.25}{100}}}$$

$$\boldsymbol{P = 376000Pa = 376kPa}$$

❑ **Q8(Years).** The air inside a thin walled cylinder is pressurized using a loaded piston as shown in the figure , the cylinder is made of Aluminum (E=70GPa) and it has a diameter of 60mm and wall thickness of 2mm .

➢ **Find :**

- 1- The $\boldsymbol{Longitudinal}$ **stress** at point A on the cylinder wall .
- 2- The **hoop stress** at Point A on the cylinder wall .
- 3- If two strain gauges were placed side by side at point A **along the hoop direction** , what will be the **strain reading** if the strain gauges were connected using **double quarter bridge** .



$$1 - \sigma_L = 0\ (Spherical\ or\ open\ cylinder)$$

$$2 - Hoop\ Stress(\sigma_H) = \frac{PD}{2t} = \frac{\frac{4000}{\frac{\pi}{4} * (\frac{60}{1000})^2} * 60}{2 * 2} = 21.2MPa$$

$$3 - Hoop\ Strain\ (\epsilon_H) = \frac{\sigma_H}{E} - V\frac{\sigma_L}{E}$$

$$\epsilon_H = \frac{\sigma_H}{E} = \frac{21.2 * 10^6}{70 * 10^9} = 3.02 * 10^{-4}$$

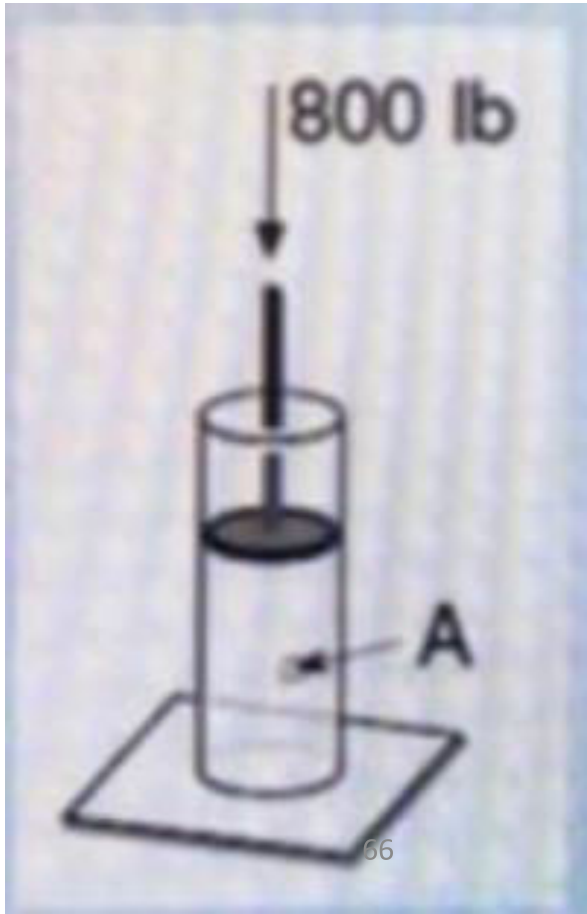
$$\mathbf{2} * 3.02 * 10^{-4} = 6.057 * 10^{-4}$$

❑**Q9(Years).** The air pressure in a cylinder is increased by a loaded piston as shown below , the cross sectional area of the piston face is $18.1 in^2$, the thickness of the cylinder wall is 0.125 inches and the radius of the cylinder is 2.4 inches , the stress in the cylinder wall at point A are ?

$$\boldsymbol{P = \frac{F}{A} = \frac{800}{18.1} = 44.19}$$

$$Hoop\ Stress(\sigma_H) = \frac{PD}{2t} = \frac{44.19 * 2.4 * 2}{2 * 0.125} = 848.448$$

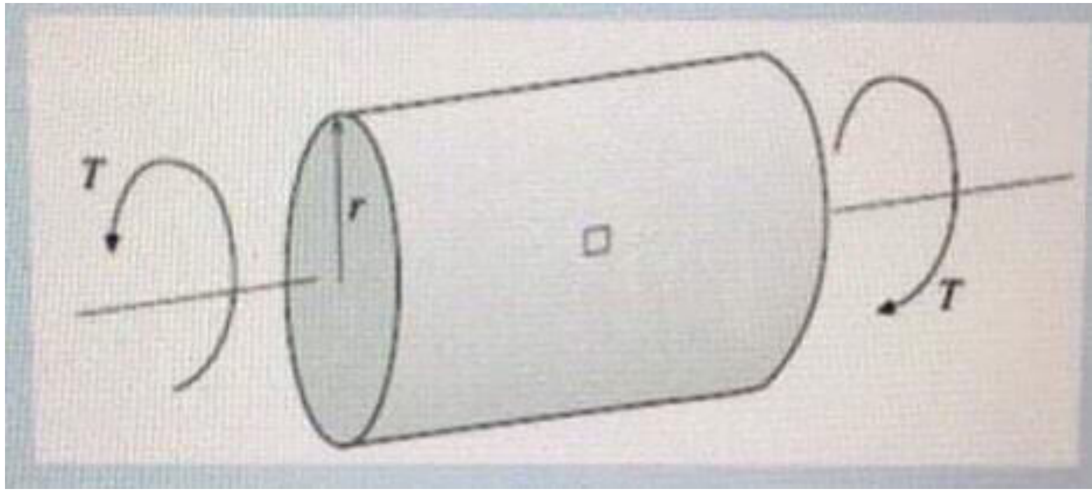
$$Longitudinal\ stress(\sigma_L) = \frac{PD}{4t} = \frac{44.19 * 2.4 * 2}{4 * 0.125} = 424.224$$



❑**Q10(Years).** The thin walled cylinder shown is loaded both by an internal pressure p=20 psi and an applied torque T=4000 , the radius of the cylinder is r =4 inch and the wall thickness is t =0.125 inch , the tangential and longitudinal stress ?

$$Hoop\ Stress(\sigma_H) = \frac{PD}{2t} = \frac{20 * 8}{2 * 0.125} = 640$$

$$Longitudinal\ stress(\sigma_L) = \frac{PD}{4t} = \frac{20 * 8}{4 * 0.125} = 320$$



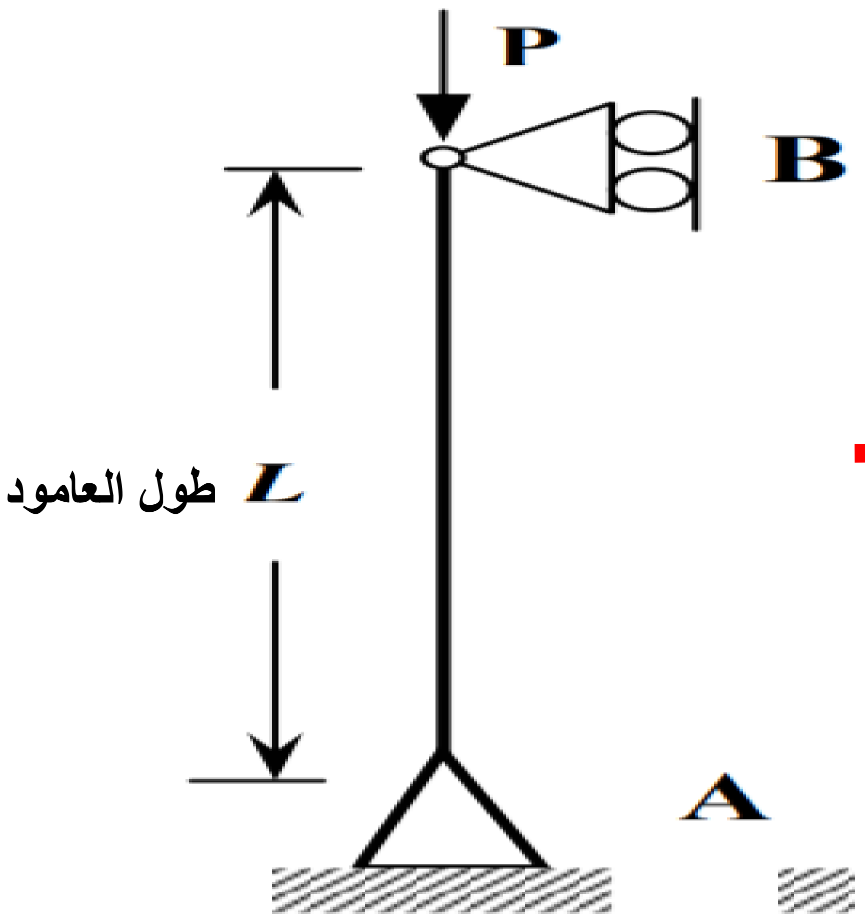
❑Exp: Stability Of Columns

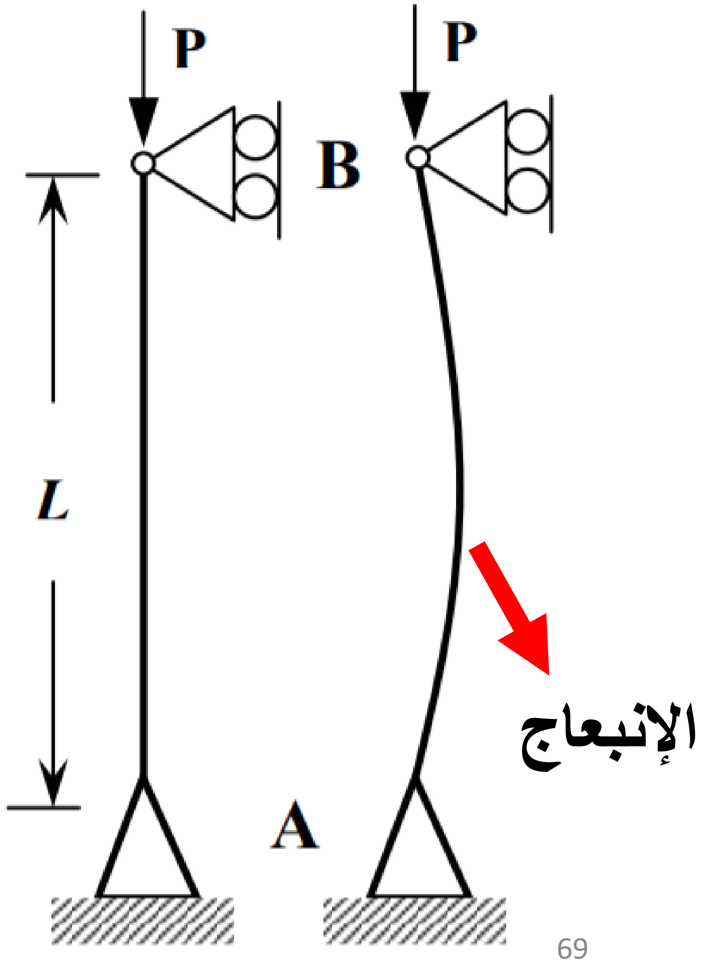
إعداد : محمد السفاريني

اللجنة الأكاديمية لقسم الهندسة المدنية

لدينا عامود مثبت وطوله معروف وتم تسليط **حمل محوري** عليه وقمنا ب زيادة هذا الحمل إلى أن وصلنا إلى الحمل الحرج وبالتالي العمود سوف يحدث له إنبعاج وهذا هو الشرح المختصر ل التجربة

Buckling



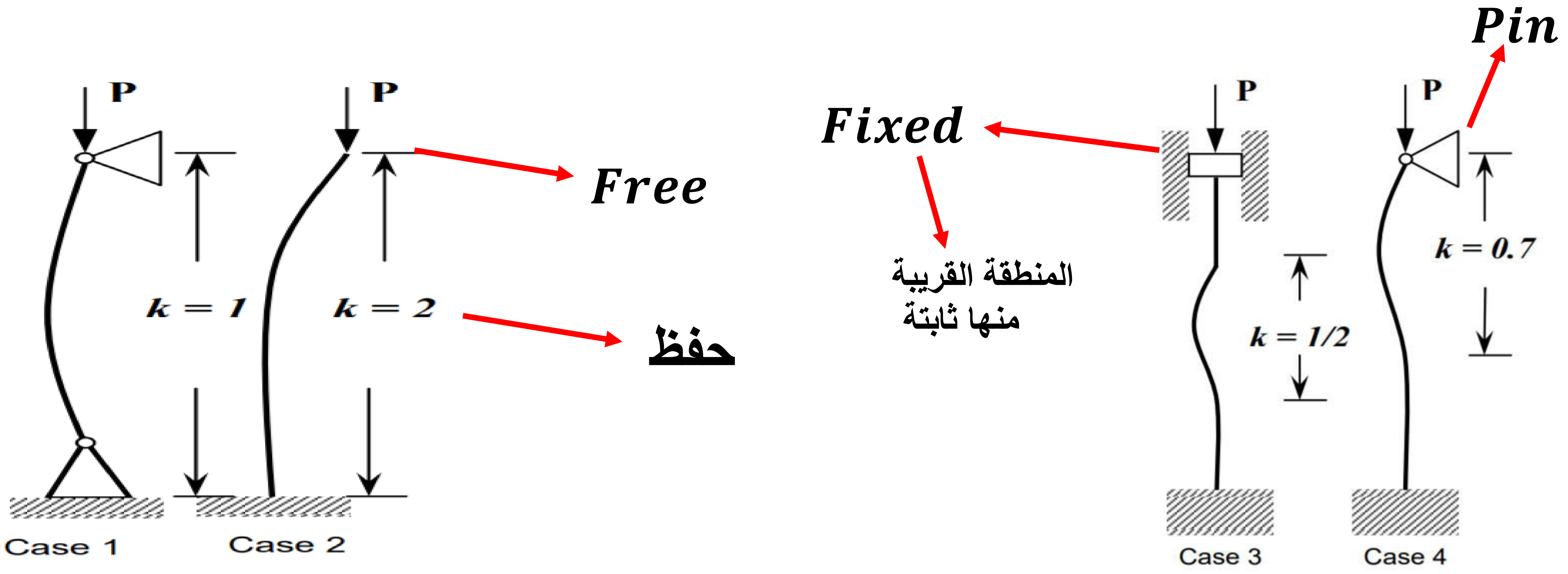


Buckling of a column due to an axial compressive load P

= ***Axial Load***

❑End condition of columns(K values) :

- ➢**Case 1** : (Pin - Pin) : **Max Deflection** in the **middle** of column .
- ➢**Case 2** : (Fixed Free) : **Max Deflection** in the **top** of column .
- ➢**Case 3** : (Fixed Fixed): **Max Deflection** in the **middle** of column .
- ➢**Case 4** : (Fixed-Pined)



هذا هو الحمل الذي تحدثنا عنه في البداية والذي تسبب ب حدوث الإنبعاج

- P_{cr} = **Critical** Load "**Theoretical** value " : The Load at which the **buckling**(lateral deflection) **will occur** .

$$P_{cr} = \frac{n^2 * \pi^2 * E * I}{(Leff)^2}$$

$$\boldsymbol{n = 1}$$

$Leff \rightarrow KL$

$$P_{cr} = \frac{\pi^2 * E * I}{(KL)^2}$$

$$P \geq Pcr$$

Failure , Unstable , Buckling happened

$$P \leq Pcr$$

No failure , Stable

Symbol	Mean
E	Modulus of Elasticity
I	Moment of inertia
K	Depends on type End condition
L	Length
L_{eff}	Length of column affected by axial load

$$I = \frac{1}{12} bh^3$$

b: الرقم الأكبر

❑**Q1(Years) .** A 500mm long column has a **square** cross section (6mm*6mm) , the column has fixed- free ends and is made of steel (E=210GPa) , Find the **critical buckling load** ?

يوجد فرع تابع لهذا السؤال

$$\boldsymbol{I = \frac{b^4}{12} = \frac{(0.006)^4}{12} = 1.08 * 10^{-10}}$$

$$P_{cr} = \frac{\pi^2 * 210 * 10^9 * 1.08 * 10^{-10}}{(2 * 0.5)^2} = 223.84\ N$$

❑**Q2(Years).** if the column is to be **replaced** by another column having a rectangular cross-section (4mm*10mm) , what should **be the length** of the column such that it will have the **same critical buckling load** ?

$$\boldsymbol{I = \frac{1}{12} * 0.01 * 0.004^3 = 5.33 * 10^{-11}}$$

$$223.84 = \frac{\pi^2 * 210 * 10^9 * \boldsymbol{5.33 * 10^{-11}}}{(2 * L)^2}$$

$$L = 0.351m = 351.5mm$$

اللجنة الأكاديمية لقسم الهندسة المدنية

- **Q3(Years).** To find the critical force experimentally in the stability of columns experiment , the relationship between $\frac{P}{Y}$ and P is drawn and the intersection of the line with P-axis is taken as the critical force because that point represents the ?

Ans . **Load value at which deflection is very high .**

- **Q4(Years).** **Buckling** always occurs in the direction with the **(minimum)** second moment of Area .

- **Q5(Years).** Buckling is **affected by** ?

Ans. Elasticity of the material

- **Q6(Years).** A beam with **fixed- pinned** end condition loaded in the middle is expected to have the **maximum deflection** at a point ?

Ans. Closer to the pinned end

- **Q7(Years).** A beam with **pinned- pinned** end condition loaded in the middle is expected to have the **maximum deflection** at a point ?

Ans. Loaded directly below the applied load .

❑**Q8(Years).** For a column of length L is subjected to a compressive load and having a critical load P_{cr} , if the **length** of the column was changed to $\frac{L}{2}$ then the critical buckling load will be ?

$$P_{cr} = \frac{\pi^2 * E * I}{(KL)^2}$$

قبل التغير

$$P_{cr} = \frac{\pi^2 * E * I}{(K * \frac{L}{2})^2}$$

بعد التغير

كل شئ ثابت ما عدا الطول لأنه هو الذي تغير

$$P_{cr} = \frac{4 * \pi^2 * E * I}{K^2 L^2} \div P_{cr} = \frac{\pi^2 * E * I}{K^2 L^2}$$

$$\boldsymbol{Ans. Increase\ 4\ times}$$

❑**Q9(Years).** In stability of columns test the rod , if rod material is steel (E=210GPa) , The **cross section** with dimensions of 0.5*2 cm and length 90 cm , if the data given in **table** are for **pinned-pinned end condition**

Find :

1- **Experimental** critical load .

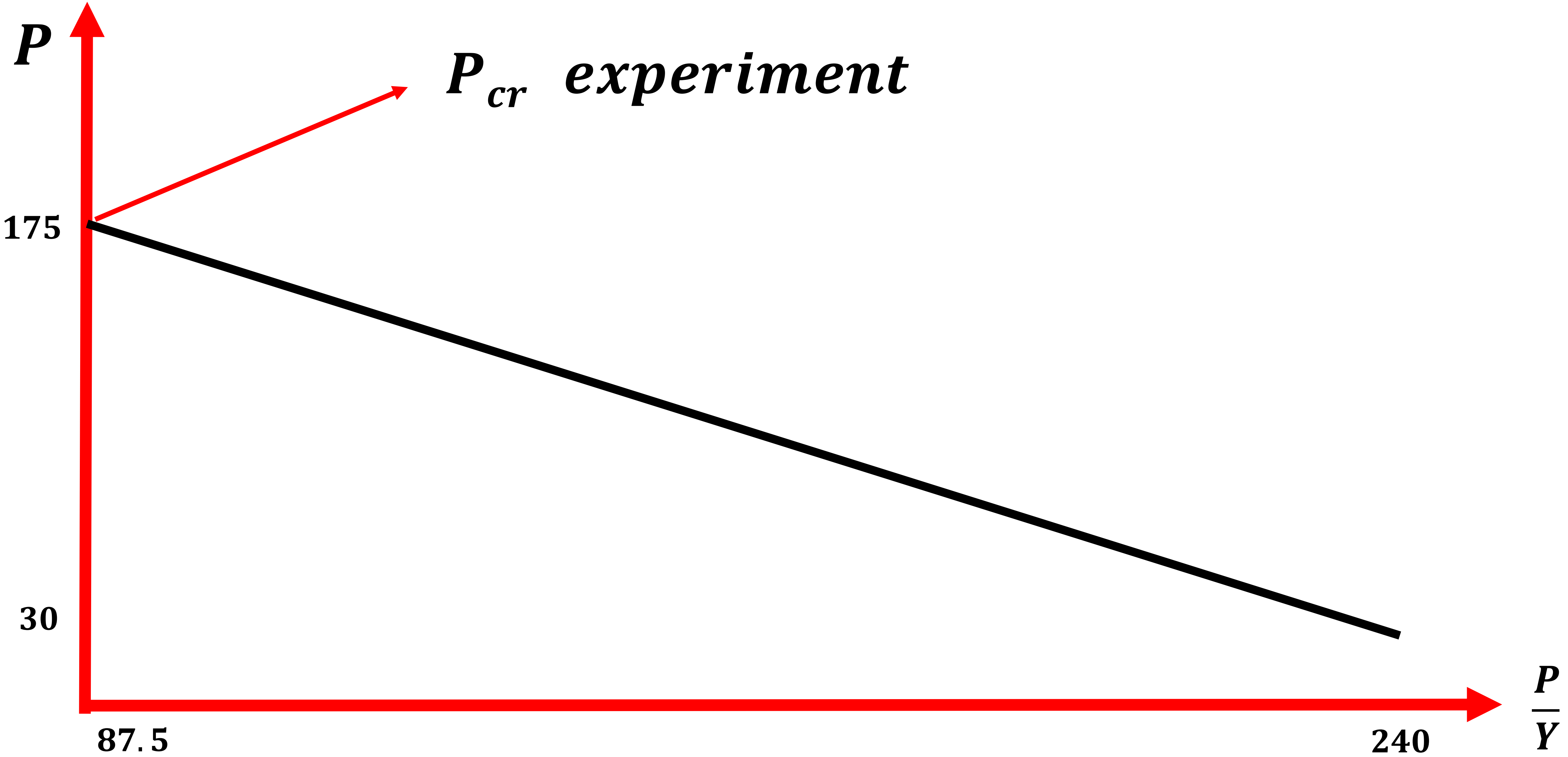
2- **Theoretical** critical load .

3- Percentage error .

P	Y(mm)
30	0.125
50	0.250
75	0.500
100	0.750
125	1
137.5	1.25
150	1.50
162.5	1.75
175	2

Ans: نجدها لكي نرسم الرسمة ومن ثم إيجاد الحمل الحرج

P	Y(mm)	$\frac{P}{Y}$
30	0.125	**240**
50	0.250	**200**
75	0.500	**150**
100	0.750	**133.33**
125	1	**125**
137.5	1.25	**110**
150	1.50	**100**
162.5	1.75	**92.85**
175	2	**87.5**



P
P_{cr} experiment
175
30
87.5
240
$\frac{P}{Y}$

$$P_{cr} = \frac{\pi^2 * E * I}{(KL)^2}$$

$$\boldsymbol{I = \frac{1}{12} * 0.02 * 0.005^3 = 2.08 * 10^{-10}}$$

$$P_{cr} = \frac{\pi^2 * 210 * 10^9 * \mathbf{2.08 * 10^{-10}}}{(1 * 0.9)^2} = 531.68\ N$$

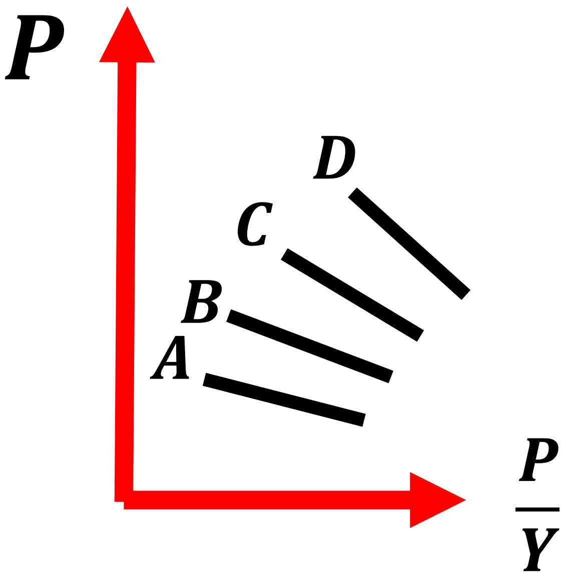
$$Error\% = \left(\frac{P_{cr} - P}{P_{cr}}\right) * 100\%$$

$$Error\% = \left(\frac{531.68 - 175}{531.68}\right) * 100\% = 67\%$$

❑**Q10(Years).** Four specimens (A,B,C,D) of the **same** material length and cross section but with **different** end conditions are tested for buckling , the load P is plotted against $\frac{P}{Y}$ where y is the lateral deflection as shown .

1- The specimen with **Fixed-Free** end conditions is ?

2- The specimen with **Pinned-Fixed** end conditions is ?



1- Fixed –free : K=2

So P_{cr} is lowest so the Ans (A)

2- Pinned –fixed : K=0.7

So P_{cr} is higher so the Ans (C) not (D) because (D) k=0.5 so its has the highest P_{cr} .

❑**Q11(Years).** One of the following is an example for buckling of column ?

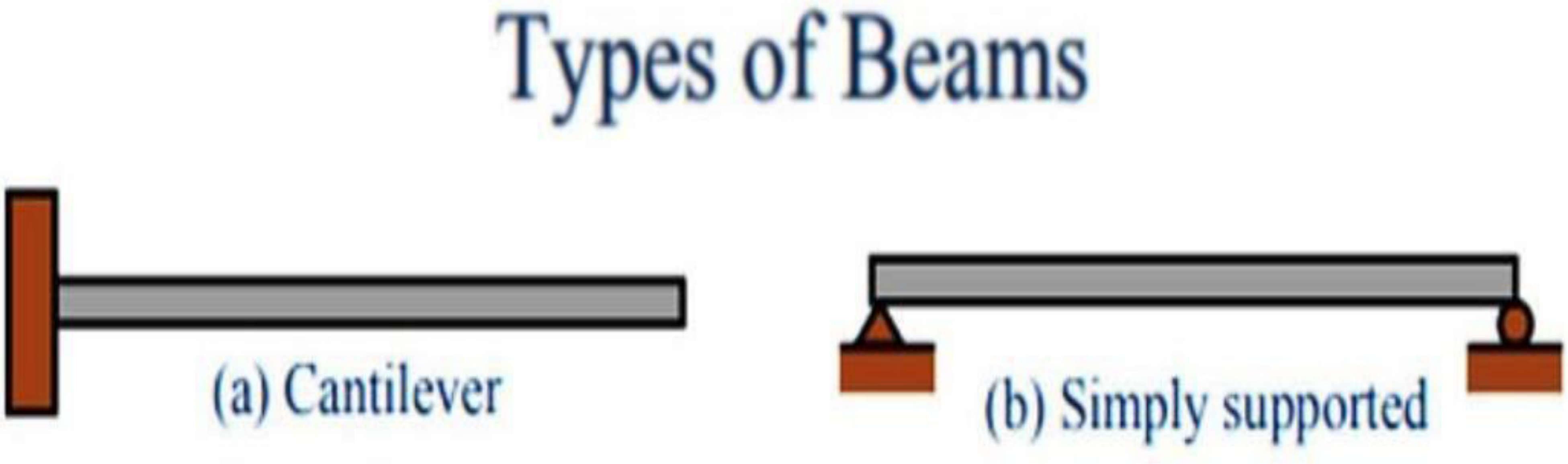
A- Column in a building

B- a beam loaded by an axial compressive force only

C- Walking stick

D- All of the above

❑ Exp: Deflection of Beams



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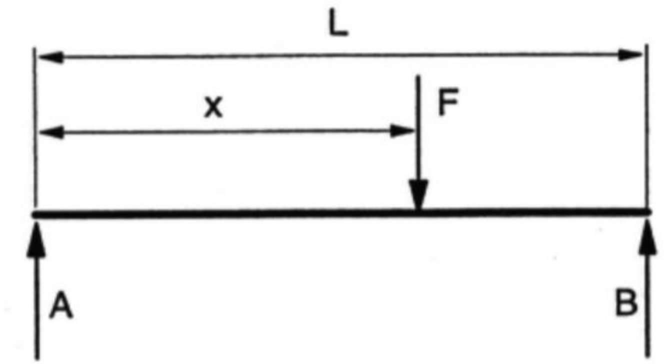
Simply supported beam

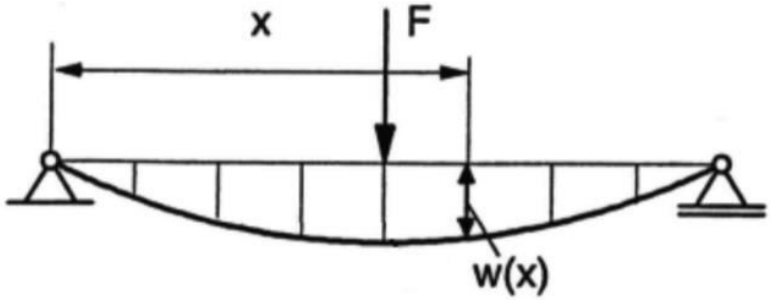


$$A_x = F(1 - \frac{x}{L})$$

Reaction

$$B_x = F * \frac{x}{L}$$

Reaction



$$w(x) = \frac{FL^3}{48EI}\left[3\frac{x}{L} - 4\frac{x^3}{L^3}\right]$$

Deflection

$$\mathbf{0 \le x \le \frac{L}{2}}$$

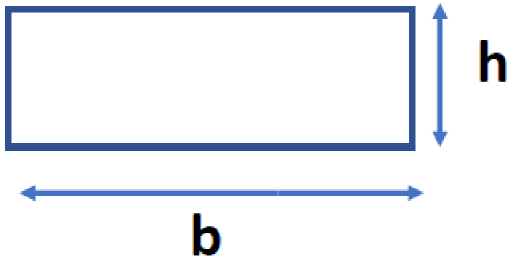
$$w_{L/2} = \frac{FL^3}{48EI}$$

Max Deflection

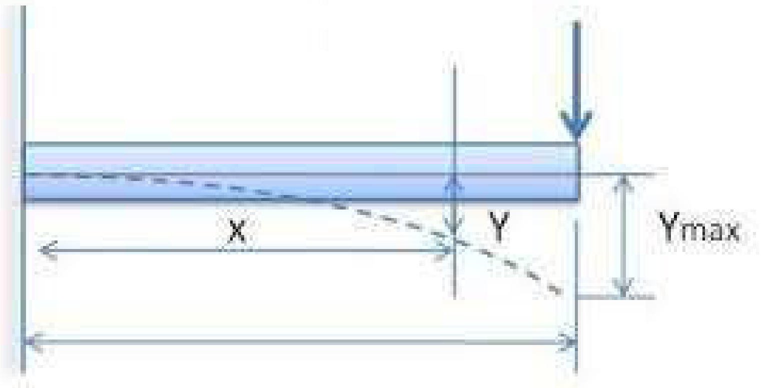
$$\mathbf{when\ x = \frac{L}{2}}$$

$$\mathbf{I = \frac{1}{12} bh^3}$$

b: الرقم الأكبر



➢ Cantilever beam



$$Deflection\,(y) = \frac{FL^3}{3EI}$$

$$I = \frac{1}{12}bh^3$$

b: الرقم الأكبر

موقع القوة

سنوات مكرر

Deflection **Proportional** to F and L^3

Deflection **Inversely** to E and I

S or **Deformation** at point **A** = Zero

S or **Deformation** at point **B** = Max

سنوات مكرر

Measurement of the **Deflection** : By **Dial gauge** and the units in (mm) .

Measurement of the **Reaction** : By **Dynamometer** and the units in (N) .

Reading → **1 Round= 360° = 1mm**

1 Round = 100 part

$$E = \left| \frac{Theoretical - Experiment}{Theoretical} \right| * 100\%$$

Experiment → الناتج العملي

Theoretical → الناتج النظري

❑**Q1(Years).** For a **simply supported** beam with loading shown , if it has **cross section** of (20mm*4mm) :

- **Find :**

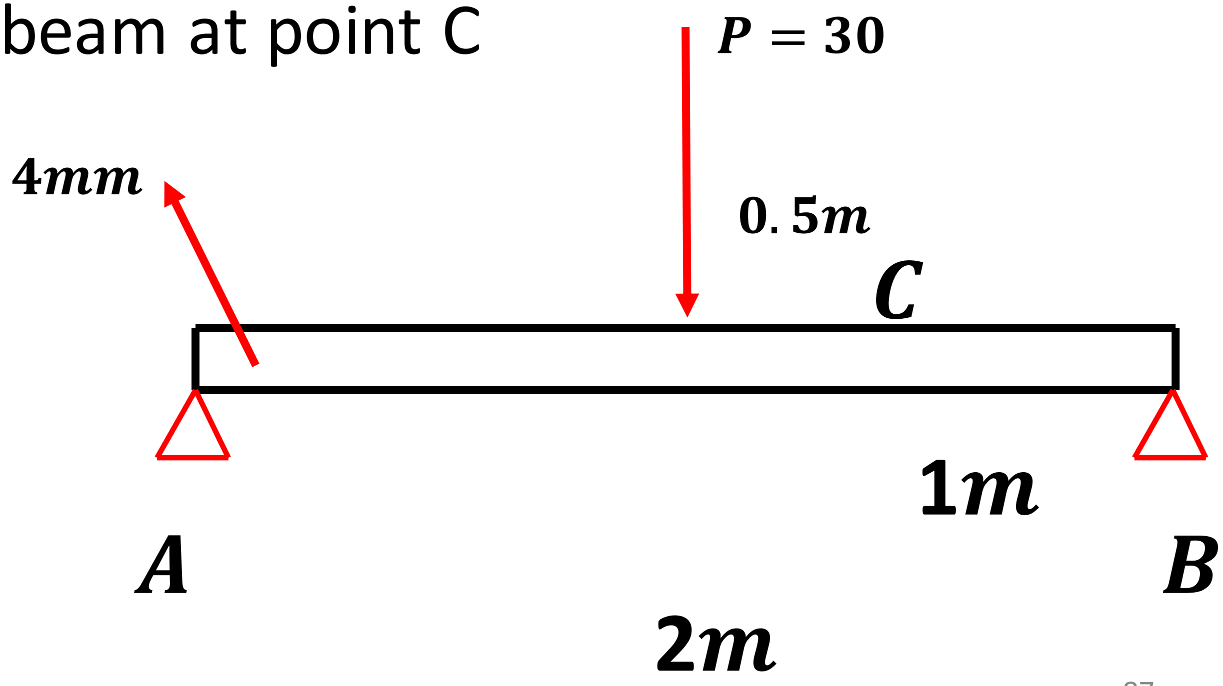
سؤال مهم ومكرر

1- **Reaction** at A and B

2- **Maximum** deflection occurs at ?

3- **Moment** at point C

4- The Maximum **tensile stress** in the beam at point C



$$1- \ Ax = 30\left(1-\frac{1}{2}\right) = 15N$$

$$B_x = 30 * \frac{1}{2} = 15N$$

$$\boldsymbol{2 - \ Max\ at\ the\ centre\ of\ the\ beam}$$

$$\boldsymbol{3 - \ \Sigma M_C = 15 * 0.5 = 7.5}$$

إعمل سكشن

$$\boldsymbol{4 - \ \frac{Mc}{I} = \frac{7.5 * 2 * 10^{-3}}{\frac{1}{12} * 0.02 * 0.004^3} = 140.63Mpa}$$

❑**Q2(Years).** If the beam is **replaced** by another one of same material , same length and same loading but with **circular sectional area** of diameter 10 mm then ?

$$w(x) = \frac{FL^3}{48EI}\left[3\frac{x}{L} - 4\frac{x^3}{L^3}\right]$$

$$I = \frac{\pi d^4}{64} = \frac{\pi(0.01)^4}{64} = 4.90 * 10^{-10}$$

$$I = \frac{1}{12}bh^3 = \frac{1}{12} * 0.02 * 0.004^3 = 1.06 * 10^{-10}$$

Ans. Beam of rectangular cross section will deflect more than circular one because moment of inertia is higher than circular cross section

- **Q3(Years).** A cantilever beam of rectangular cross-section is subjected to a load W at its free end , if the **depth** of the beam is doubled and the **load** is halved , the deflection of the free end as compared to original deflection will be ?

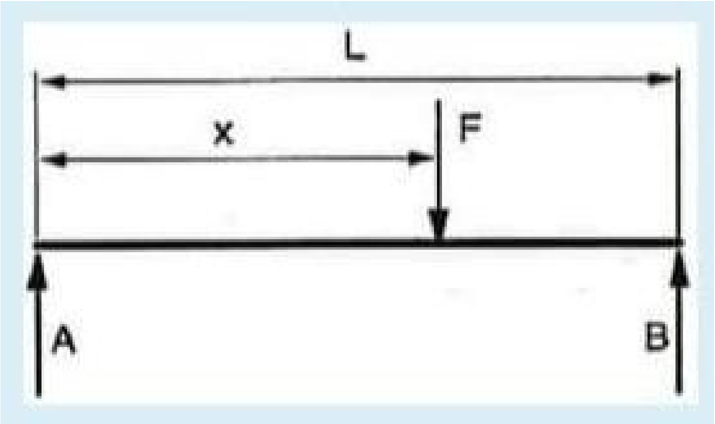
$$Deflection\,(y) = \frac{FL^3}{3EI}$$

$$S_1 = \frac{4F_1{L_1}^3}{Eb_1{h_1}^3} \qquad S_2 = \frac{F_2{L_2}^3}{4Eb_2{h_2}^3} \qquad \boldsymbol{S_2 \div S_1} = \frac{\mathbf{1}}{\mathbf{16}}$$

$$F_2 = \frac{1}{2}F_1$$

$$h_2 = 2h_1$$

❑**Q4(Years).** A 1.75 m beam subjected to a load at point x if the **reactions** found at A and B are 1245N and 1975N respectively , the load F and its location are ?



$$A_x = F(1 - \frac{x}{L}) \qquad 1245 = F(1 - \frac{x}{1.75})$$

$$B_x = F * \frac{x}{L} \qquad 1975 = F * \frac{x}{1.75} \qquad 3456.25 = F * x$$

$$1245 = (F - \frac{F * x}{1.75}) \qquad 1245 = (F - \frac{3456.25}{1.75}) \qquad 3220 = F$$

$$1245 = 3220(1 - \frac{x}{1.75}) \qquad 1.07 = X$$

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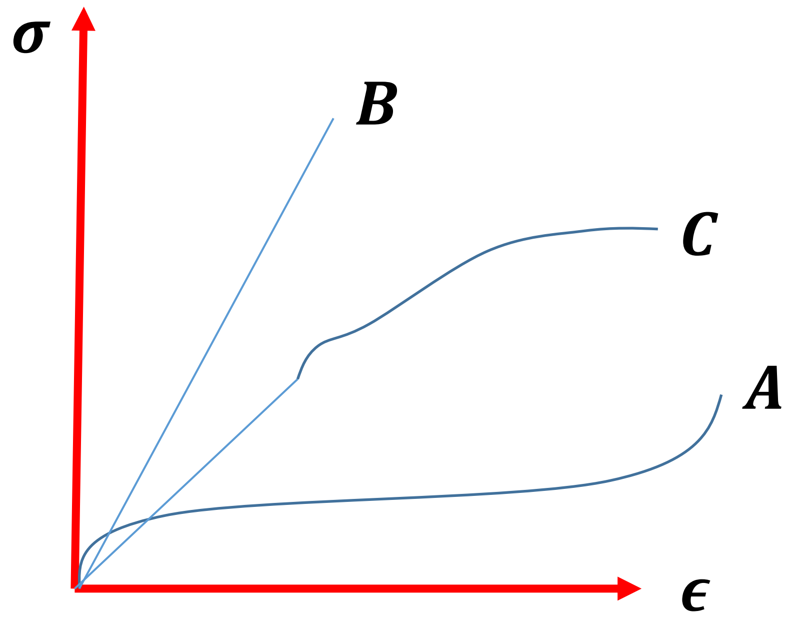
❑ $Q5(Years)$.



1- The material that has the <u>highest</u> ductility ?

Ans. A

2- The material that has the <u>largest</u> elastic modulus ?

Ans. C

3- The material that has the <u>highest</u> toughness ?

Ans. C

❑Q6(Years).

1- The shear strain in a rod is the deformation per unit length ?

Ans. F

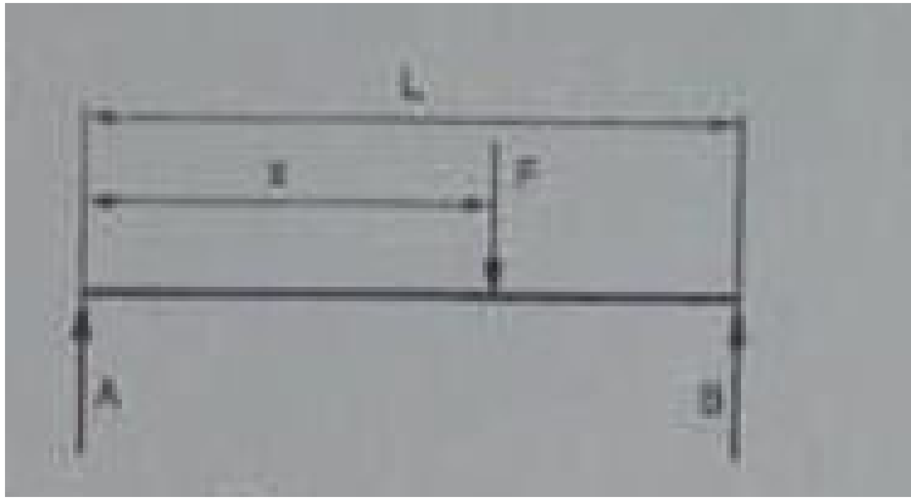
2- Buckling is a mode of failure that does not depend on stress or strength but rather than on structural stiffness ?

Ans. T

3- Horizontal equilibrium is used to determine that the neutral axis of an elastically deforming beam is located at the centroid of the cross – section

Ans. T

- **Q7(Years).** A 800mm beam is used in deflection of beams test , if the load of 4 kg is applied at point 650 mm from A , the reaction at B will be equal to ? If you know $E = 190GPa\ and\ A = 18 * 6\ mm^2$



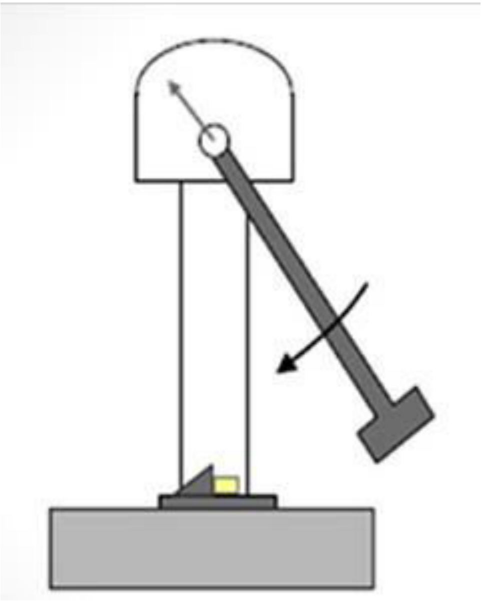
$$B_x = F * \frac{x}{L}$$

$$B_x = 4 * 9.807 * 10^{-3} * \frac{650}{800} = 0.0318kN = 31.872N$$

❑**Q8(Years).** For the **<u>same data in previous question</u>** , if the load is applied at the center of the beam , the expected deflection at x=650mm from A equal to ?

$$I = \frac{1}{12} * 18 * 6^3 = 324mm^4$$

$$S = \frac{4 * 9.807 * 10^{-3} * 800^3}{48 * 324 * 190 * 1000000}\left[\frac{3 * 150}{800} - \frac{4 * 150^3}{800^3}\right] = 3.64$$



❑Exp: Impact test

إعداد : محمد السفاريني

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- **Toughness :** The energy required to fracture a material and it depends on geometry (strength) and ductility or Total strain energy per unit volume of a metal .
- Impact is a shock load which is applied for a very short time **under consideration .**

Consideration : $t < \frac{1}{3} W_n$

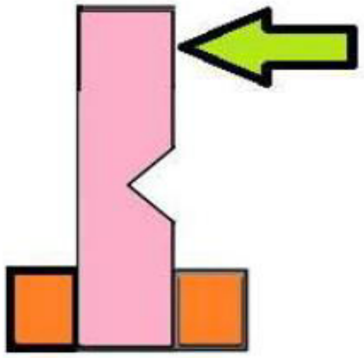
t: time of application of load on specimen
W_n : natural period of vibration of structure(natural frequency)

Toughness and ductility
Toughness and Temperature
علاقة طردية

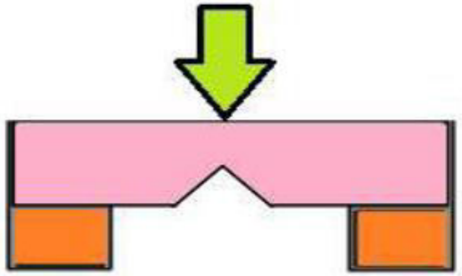
Types of Notch : 1- V 2- U

Type	V	U
Toughness	Low	Hight
Stress concentration	Hight	Low

Types of impact tests
1. Charpy test 2. Izod test



(a) Izod Test



(b) Charpy Test

Charpy test

1-Notch **opposes** the hammer

2-Specimen is **simply supported**

3-Simple and fast

4- **Low** Toughness

(Brittle example : steel)

5- **Two** shearing Area

6- E **Charpy** =2 E **Izod**

7- التدريج الخارجي

Izod test

1-Notch **faces** the hammer

2-**Cantilever** type specimen (clamped)

3-More complicated and slower

4- **Hight** Toughness

(Ductile example : Aluminum)

5- **One** shear Area

6- E **Izod** $=\frac{1}{2}$ E **Charpy**

7- التدريج الداخلي

$$U = mg(h_1 - h_2) - \text{friction}$$

$$U = mgL(\cos\theta_1 - \cos\theta_2) - \text{friction}$$

Max velocity so h1= zero then $h_2 = \frac{v^2}{2g}$

- **Q1(Years).** Four different samples were used in impact test for the same material , the order of samples based on the amount of energy absorbed from Low to high ?

Ans.

(V notch charpy) – (U notch charpy) – (V notch Izod) – (U notch Izod)

- **Q2(Years).** In the impact test , the pendulum load was released before installing the test specimen to ?

Ans. Measure the friction energy loss

- **Q3(Years).** Impact test use the principle of () the material ?

Ans. Conservation of energy to find the toughness

- **Q4(Years).** In Izod test , the specimen is kept as ?

Ans. Cantilever Beam

- **Q5(Years).** In Charpy test , the specimen is kept as ?

Ans. Simply supported Beam

- **Q6(Years).** A loads acts on a structure for period of time , this izod can be considered impact if ?

Ans. Its application time is less than one third of the first natural frequency of the structure .

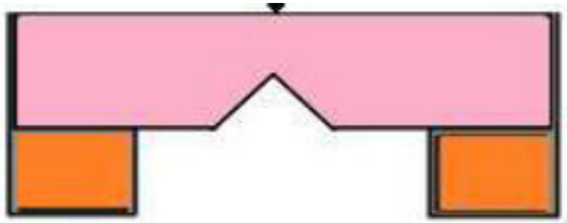
- **Q7(Years).** Charpy testing determines the yield strength as a function of temperature ?

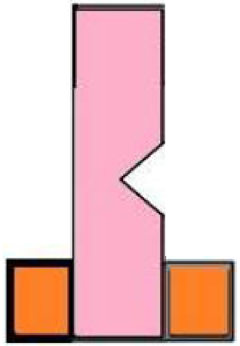
Ans. False

- **Q8(Years).** The energy per unit volume required to cause fracture in the charpy specimens is called ?

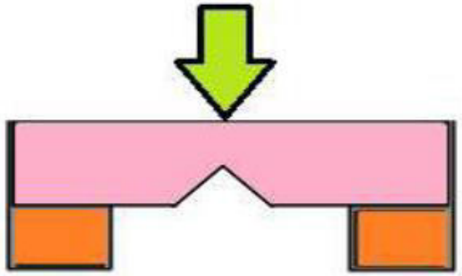
- **Ans.** Modulus of toughness

❑Q9(Years). Write Down the name of each test in the provided box and draw an arrow showing the direction and location where the hammer hits the specimen ?

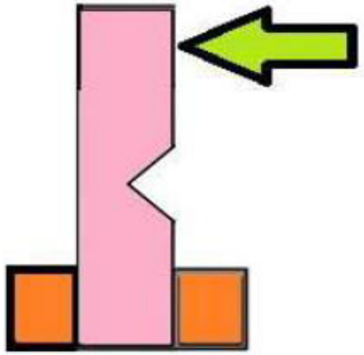




***Ans*.**

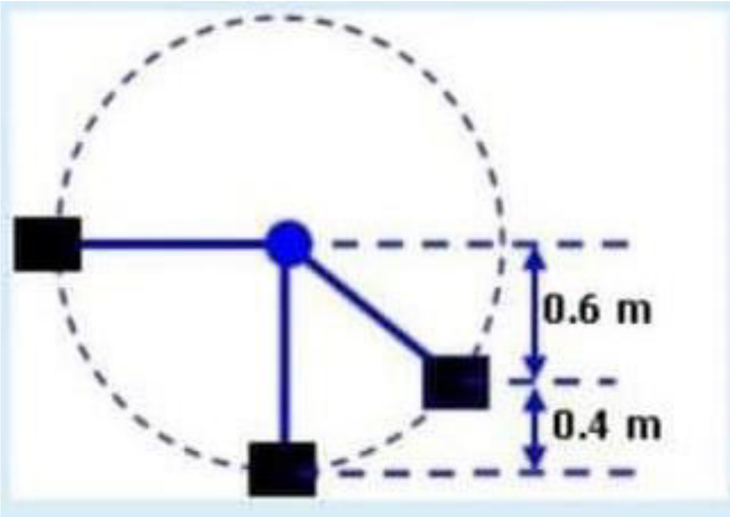


(b) Charpy Test



(a) Izod Test

❑**Q10(Years) .** Using the figure shown , the energy absorbed through the impact test is ? If you know the mass is 1 kg and g = $9.81\,\frac{m}{s^2}$



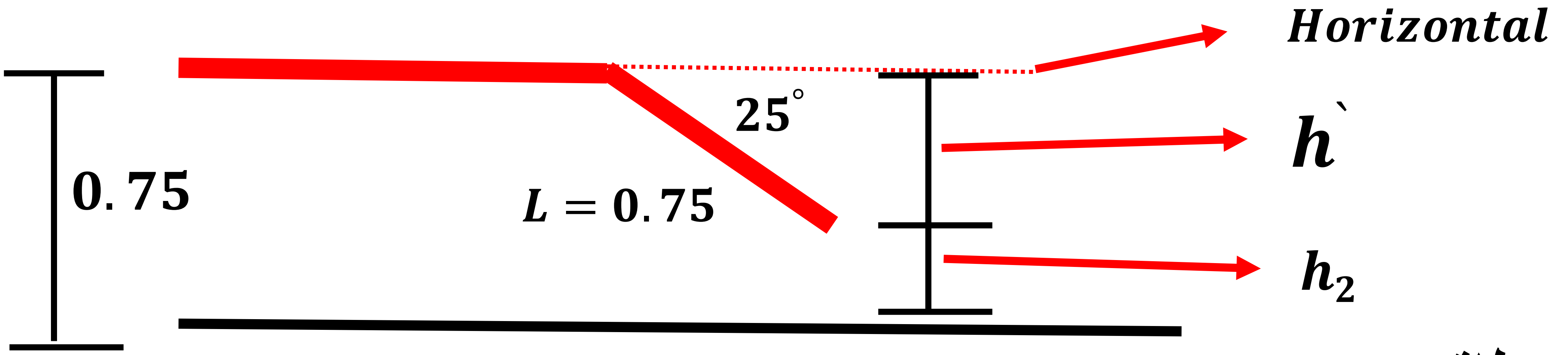
U= $mg(h_1-h_2)$

$$\mathbf{9.81 * (1 - 0.4) = 5.9\,N.m}$$

❑**Q11(Years).** A specimen is used in charpy test absorbed 45 joule to fracture , if the same specimen is used in Izod test will most likely absorb ?

Ans. $\frac{1}{2} * 45 = 22.5\,joule$

❑**Q12(Years).** A 4 kg hammer is used to construct a pendulum for impact test with L=0.75m , the pendulum was initially held at 0° angle with the horizontal line and used in charpy impact test , if the final pendulum position was at angle 25° with the horizon , what the expected value of the energy absorbed by the specimen ?



الرسمة غير معطاة

$$h^{`} = 0.75 * \sin 25^\circ = 0.43$$

$$4 * 9.81 * (0.75 - 0.43) = 12.44$$

U= mg(h_1-h_2)

❑**Q13(Years).** In impact test experiment , a hammer with mass 50 kg is released from rest . The maximum velocity was measured to be 5 $\frac{m}{s}$, the resistance energy loss coming from air just before impact is 5 joule , after hammer had strike the specimen , the maximum elevation of the hummer on the opposite side is 0.4 m , estimate the energy absorbed by the specimen ?

Ans.

$$\Delta u = \left[\frac{1}{2} m * v^2 - (mgh)\right] - 5$$

$$\Delta u = \left[\frac{1}{2} 50 * 5^2 - (50 * 9.81 * 0.4)\right] - 5 = 423.8$$

❑Exp: Fatigue Test

إعداد : محمد السفاريني

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So , Fracture **happen** at a stress **less than** yield stress or Ultimate stress $\sigma < \sigma_{ult}$

Or

$\sigma < \sigma_y$

Form of Fracture at angle 90°

Appearance of the fracture surface of a sample

Fatigue Life: It is the **number of cycles** to cause failure at a specific stress taken from S-N curve

S: stress

N: # of cycles

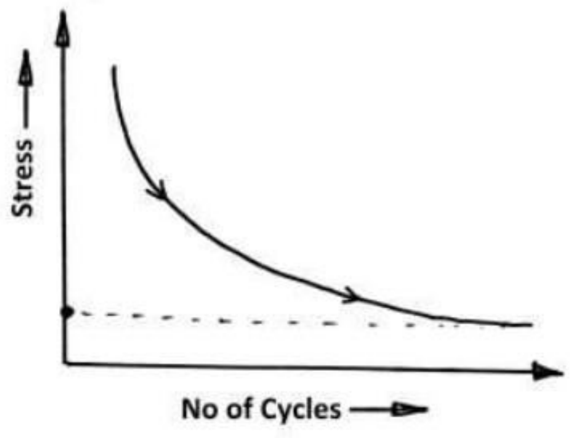
Fatigue strength: It is the **stress** at which failure will occur for a specified number of cycles.

$\sigma = \frac{Mc}{I}$

M: Bending Moment = F*L

$$c = centroud = \frac{d}{2}$$

I: Moment of Inertia= $\frac{\pi d^4}{64}$



Endurance : the number N of load cycles until rupture at a certain load.

#of cycles = ∞ then No failure

#of cycles = Zero then $\sigma = \sigma_{ult}$

Relation between Stress and #of cycles is **inverse**

Fatigue Endurance Limit: It is the stress level at which fatigue will **never occur**, that is the **largest** value of fluctuating stress that will not cause failure for **infinite** number of cycles.

- **Q1(Years).** In fatigue testing , a material with no clear endurance limit is typically ?

Ans. Non ferrous

- **Q2(Years).** The stress level below the material can withstand an infinite number of Load cycles ?

Ans. Endurance Limit

- **Q3(Years).** The laboratory instrument used to test the fatigue life of material has ?

Ans. A rotating element with an applied bending Load .

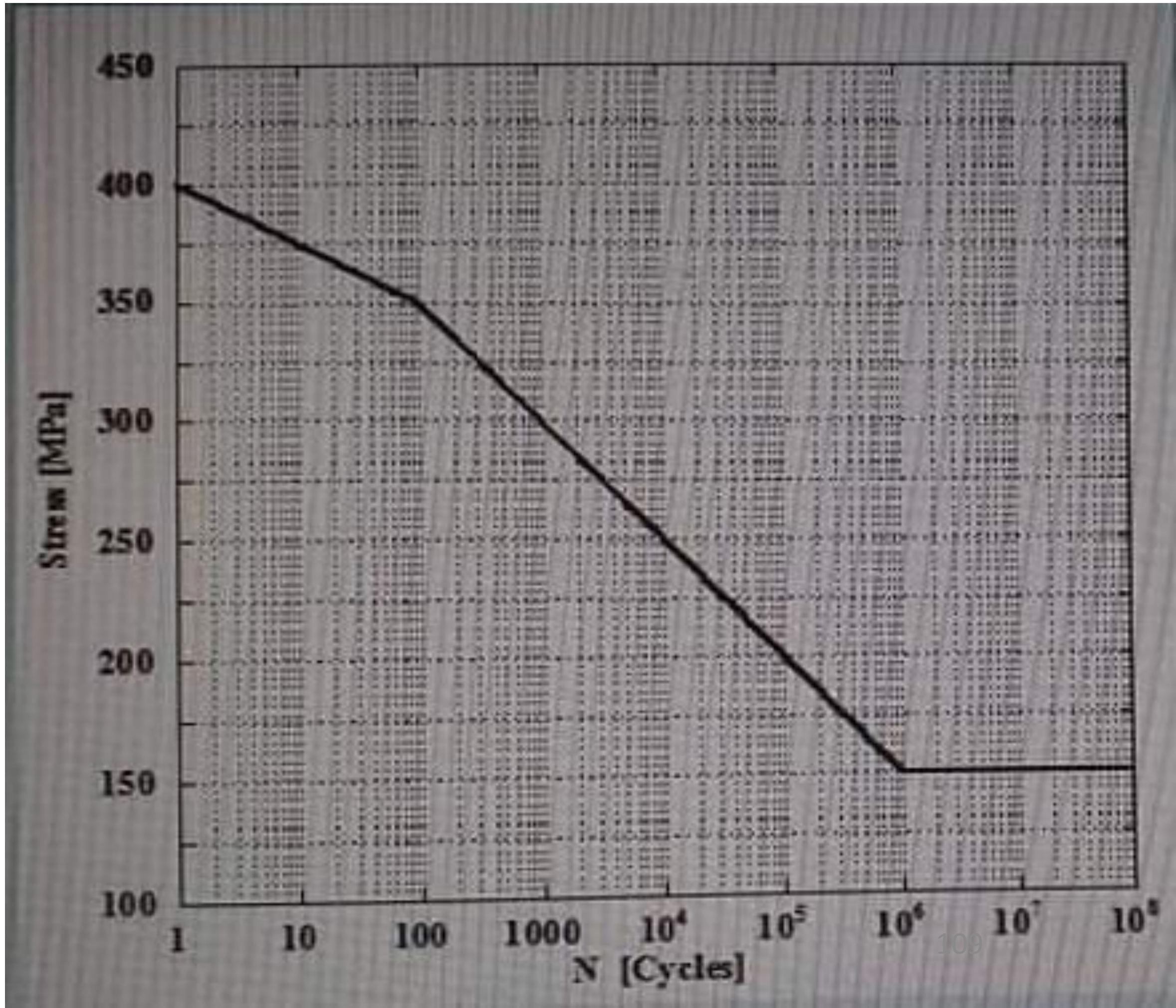
- **Q4(Years).** In fatigue test an alternating Load can be defined as a load that ?

Ans. Changes periodically between tension and compression cycles

❑**Q5(Years).** The figure below shows the results of the fatigue experiment , in this experiment a beam rotates with the motor and is subjected to a load F at the free hand . The beam is 100.5 mm long , 8mm diameter and the moment of inertia is $201mm^4$

- Find :

1- the ultimate strength for this material
2- The life at the ultimate strength
3- The life at a stress of 200 Mpa in cycles
4- the endurance limit
5- the fatigue strength that cause failure of this metal at 1000 cycles
6- the maximum load F that will cause failure in the previous question



Ans. 1- 400 MPa when the number of cycles (N) is 1

2- One cycle

3- when the stress 200 MPa , the cycles is 10^5

4- 150 MPa

5- 1000 cycle so the stress 300 MPa

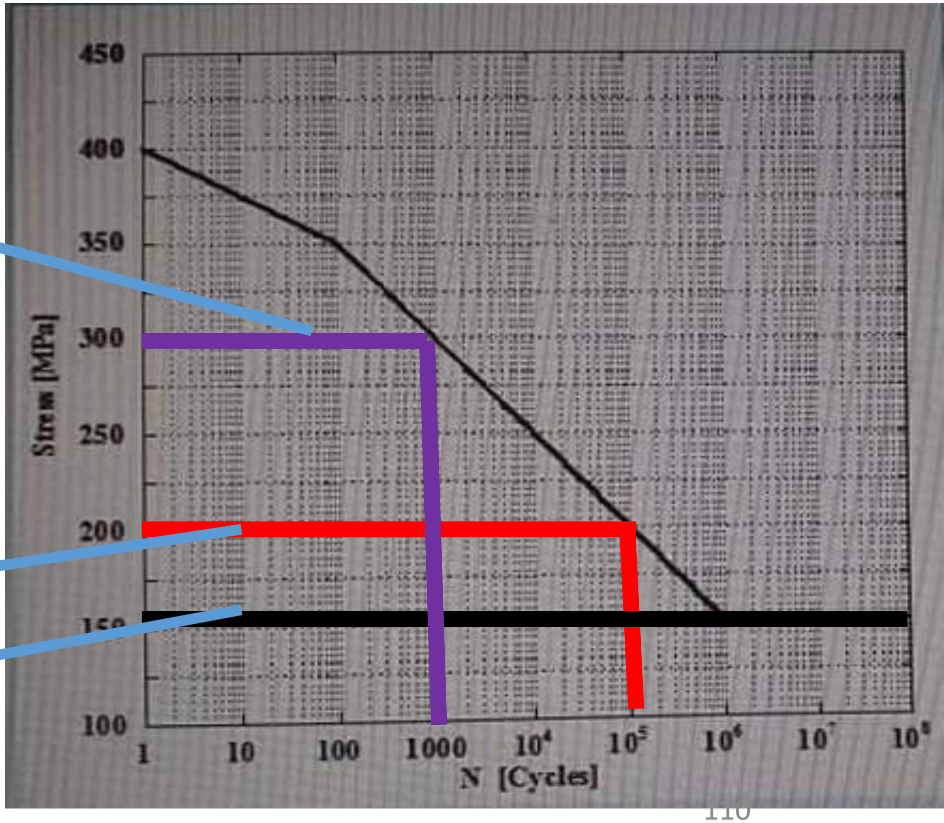
6- $Load = Stress * Area$

$$300 * \frac{\pi}{4} * 8^2 = 15072N = 15.072kN$$

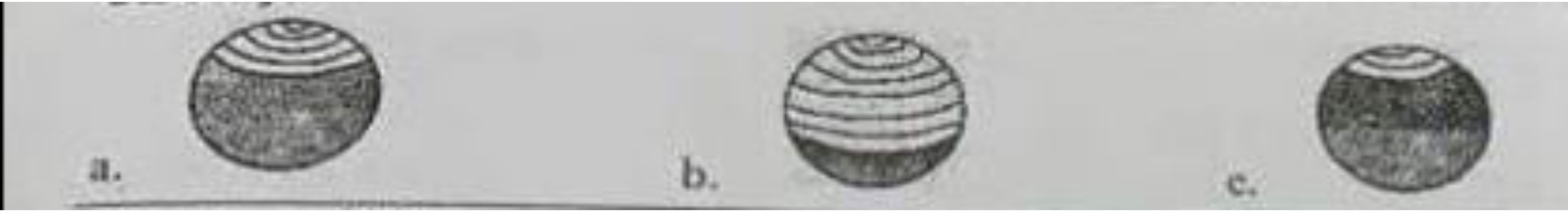
الفرع الخامس

الفرع الثالث

الفرع الرابع



Q6(Years). Three different specimens of the same material were subjected to fatigue loads , the following illustrations represents the broken specimens , which one of them represents the one that had the least load (Lowest stress) ?



Ans. C

- **Q7(Years).** In fatigue test if we reduce the magnitude of the cycle stress ?

Ans. The part would serve more cycles before breaking

- **Q8(Years).** Fracture usually occurs as soon as critical stress has been reached , however repeated applications of somewhat lower stress my cause fracture , this is called fatigue ?

Ans. True

- **Q9(Years).** What is the relation between stress at the tension side and the diameter of the fatigue test specimen ?

Ans. Stress is proportional to $(diameter)^{-3}$

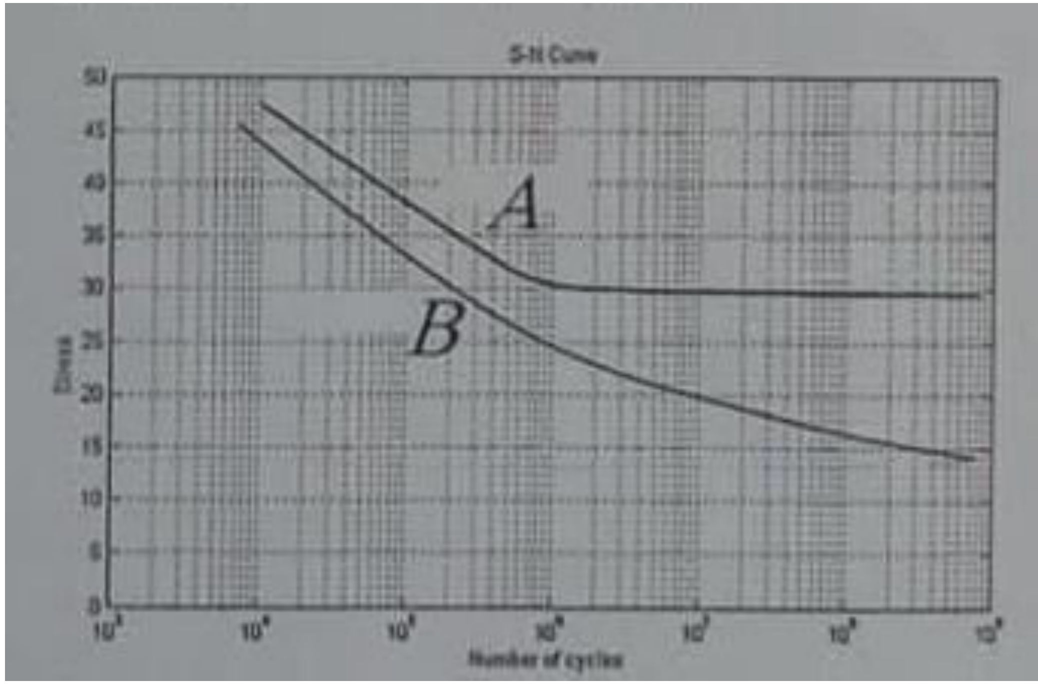
- **Q10(Years).** In fatigue test if we increase the magnitude of the cycle stress ?

Ans. The part would survive less cycles before breaking

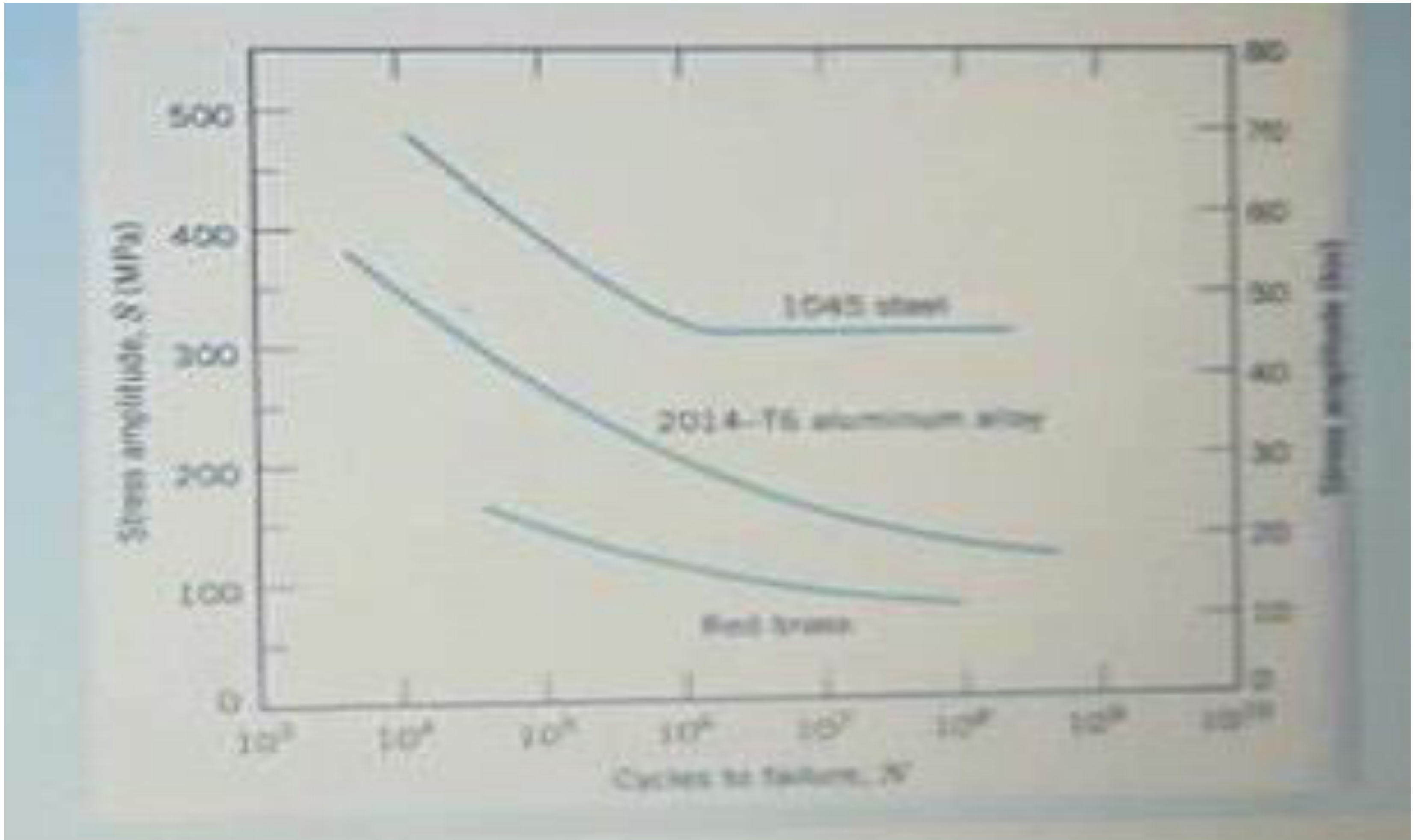
❑**Q11(Years).** The Shown curve represents fatigue test , results for aluminum and steel , refer to it answer . The endurance limit for Material B and represents what ?

Ans. Endurance limit **cant be determined**

and it represents **Aluminum** .



❑**Q12(Years).** A cylinder of 2014 T6 aluminum is subjected to full reverse load cycle with a maximum load of 125000 N , using the fatigue data in the figure , the diameter of the cylinder of giving a lifetime to failure of 100 million cycles ?



$$\boldsymbol{\sigma = \frac{P}{\frac{\pi}{4} * D^2}}$$

$\boldsymbol{P = 125000N}$ **(معطى)**

$$\boldsymbol{\#of\ cycles = 10^8}$$

$$\sigma = 20ksi\ (From\ diagram\ ) = 18 * 6.895 = 124.11\ MPa$$

$$\boldsymbol{124.11 = \frac{125000}{\frac{\pi}{4} * D^2}}$$

$$\boldsymbol{D = 35.8}$$

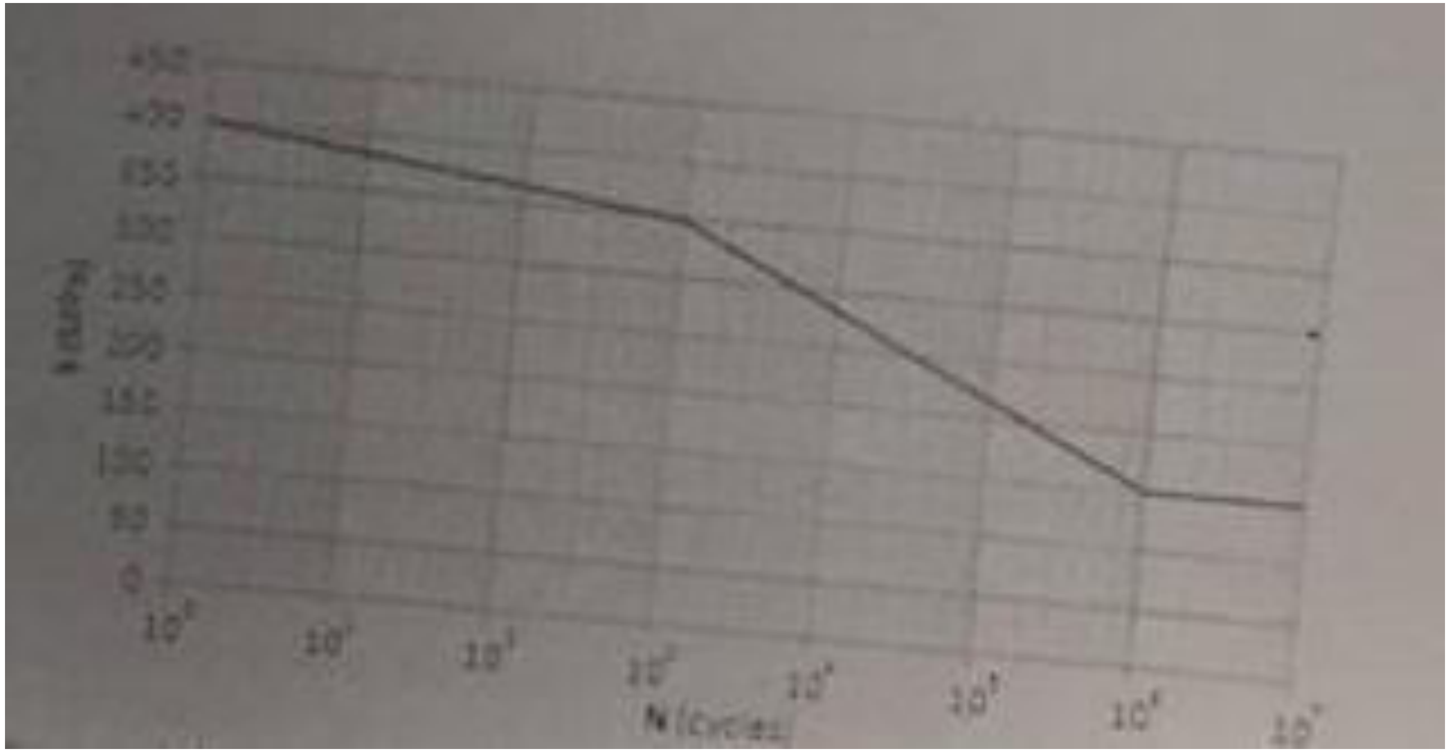
❑**Q13(Years).** The S-N diagram from some steel alloy is shown , find :

1- The **endurance limit** of the material ?

2- The fatigue life corresponding to a **stress level of 350MPa** ?

3- The **ultimate strength** of the material ?

4- The fatigue strength corresponding to **30000 load cycle** is ?



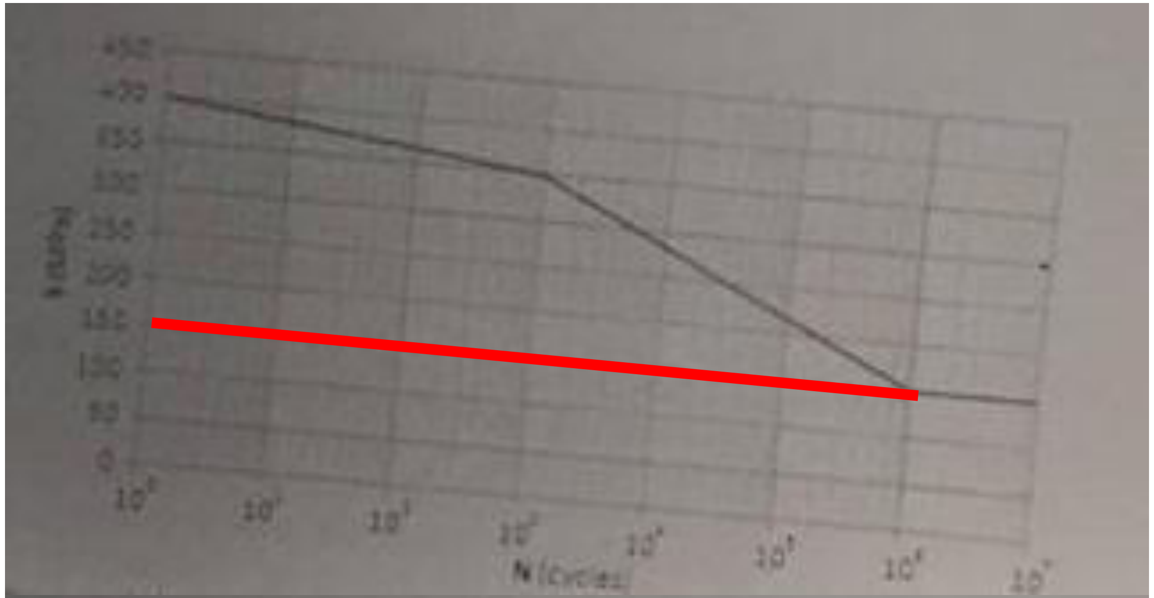
Ans.

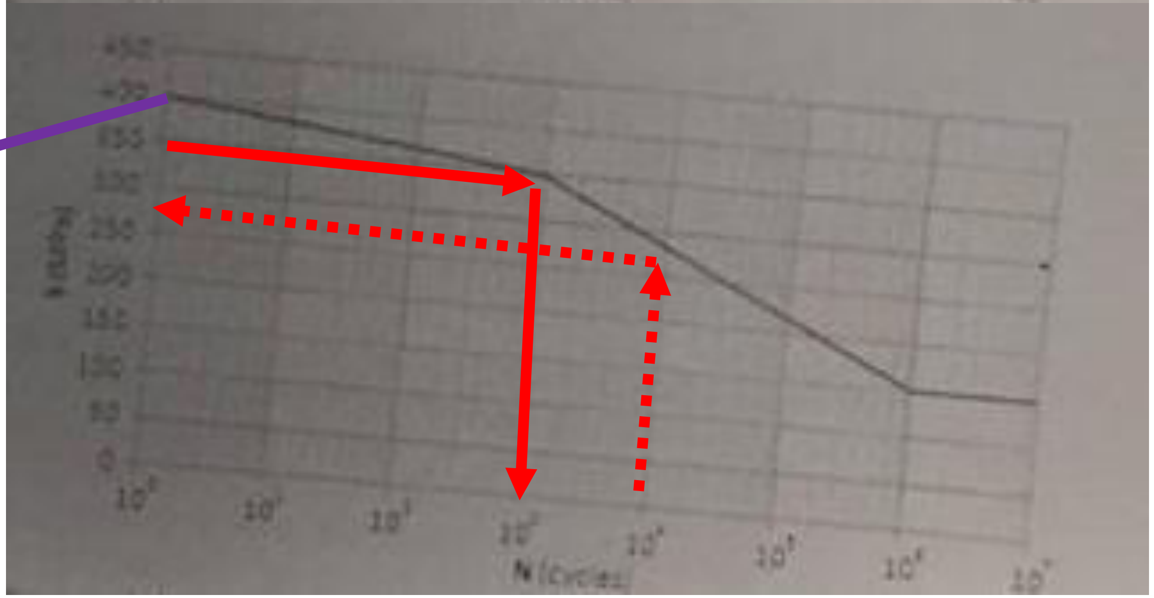
1- 150MPa

2- 1000

3-400

4- 270





Ultimate strength

❑Exp: Creep Test of Metallic Materials

إعداد : محمد السفاريني

اللجنة الأكاديمية لقسم الهندسة المدنية

Creep : A **consequence** of this is that steel under a **constant stress** at an elevated **temperature** will continuously **deform** with time .

Slope= Rate of strain

Unit : $\frac{1}{sec}$

- Rate of Strain (Creep) **depends** on :

1- Temperature 2- Stress

Creep **occurs** if :

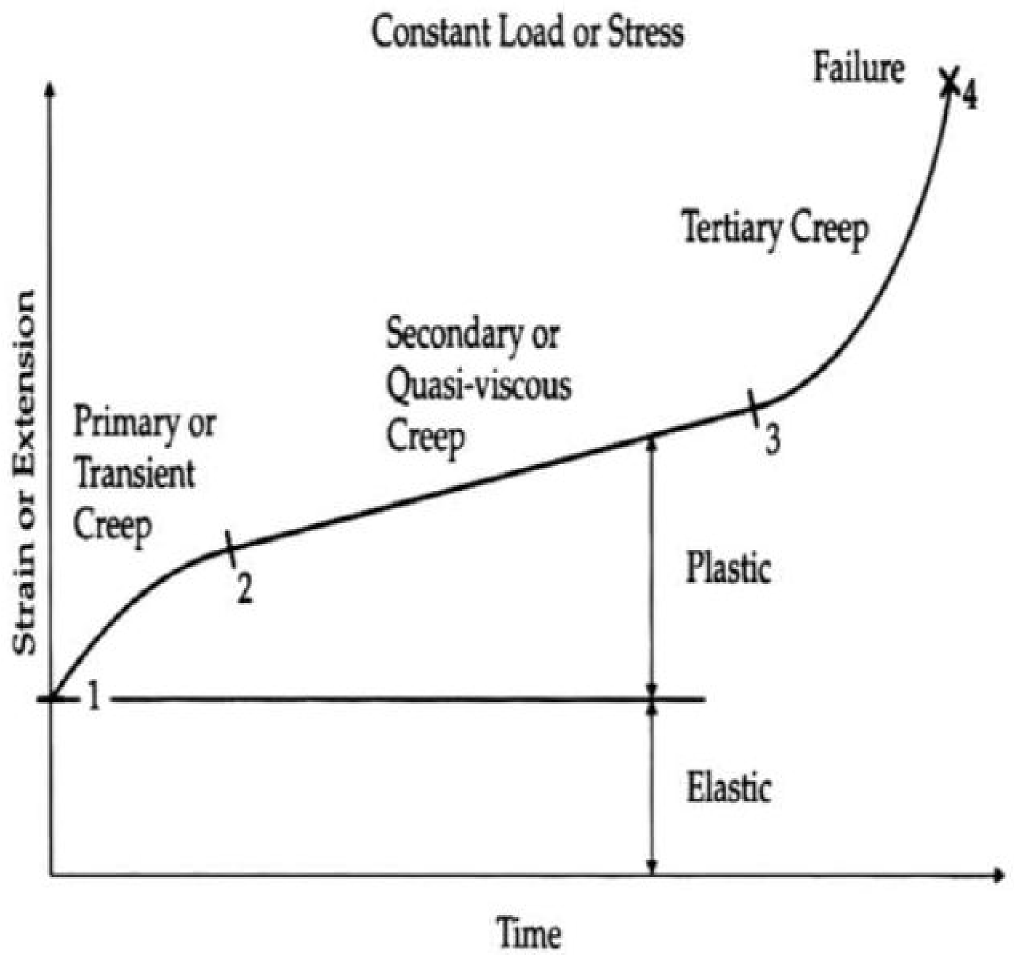
- $T_s \geq 0.4\ T_m$
- $\boldsymbol{\sigma \geq \sigma_y}$

T_m: **Absolute** melting Temperatu

T_s : **Surrounding** Temperature

1 to 2 **Primary** (Transient) Creep :
Diminishing rate due to work hardening of the metal
Work hardening > Annealing
Rate of strain **decreases**

2 to 3 **Secondary Creep**(Quasi-viscous) :
Constant rate because a balance is achieved between the work Hardening and annealing (thermal softening) processes.
Work hardening = Annealing
Rate of strain **constant**
Determines the **life of a given component**
Needs **more time** , Most important stage
Prime importance as a **design criterion**



3 to 4 **Tertiary Creep** :
The creep rate increases due to **necking** of the specimen and the associated increase in local stress.
Failure occurs at point 4.
Work hardening < annealing
Rate of strain **increases**

❑**Q1(Years).** The creep rate is ?

Ans. Directly proportional to the metal temperature and applied Load

❑**Q2(Years).** Of the three stages of creep it is the second stage that shows a constant strain rate ?

Ans. True

❑**Q3(Years).** An elements which are subjected to creep spend most of their live in ?

Ans. Secondary Creep

❑**Q4(Year).** Plastic deformation and eventual failure at elevated temperature under static mechanical stress is called creep ?

Ans . True

❑**Q5(Years).** A good example of a material which has creep under loading at room temperature ?

Ans. Lead

❑**Q6(Years).** As the working temperature () the creep strain rate () ?

Ans. Increased , Increased .

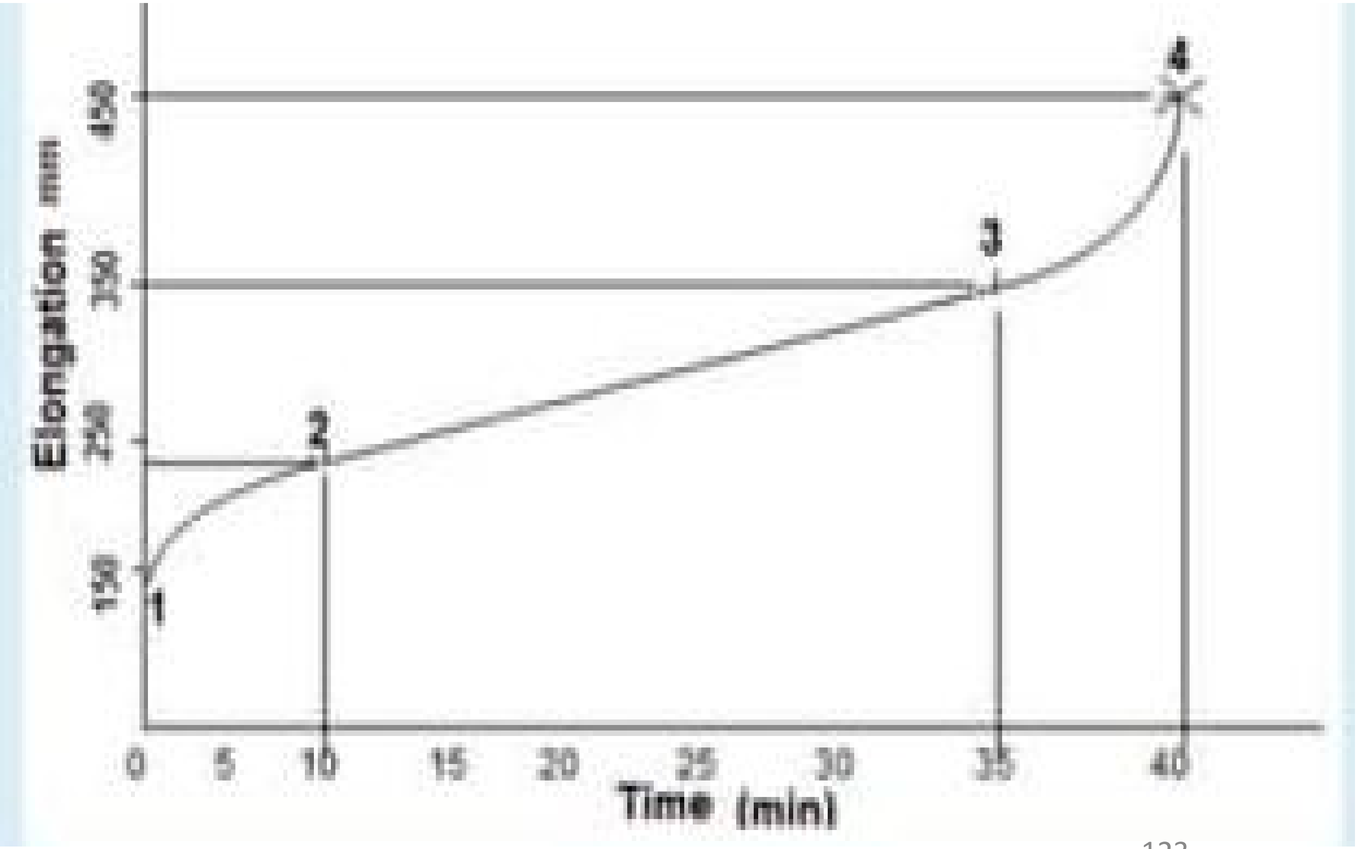
❑**Q7(Years).** Creep in metals occurs at significant rate when ?

Ans. The stress **is higher than** the yield strength and the temperature is **higher than 40%** of the melting temperature .

- **Q8(Years).** In the creep experiment , a typical extension – time curve is shown below .
- Dimension of the specimen : Thickness 2mm , width 5 mm and gauge length 90 mm

- Find :

1- Design creep rate
2- Elastic region
3- Plastic region
4- Fracture strain

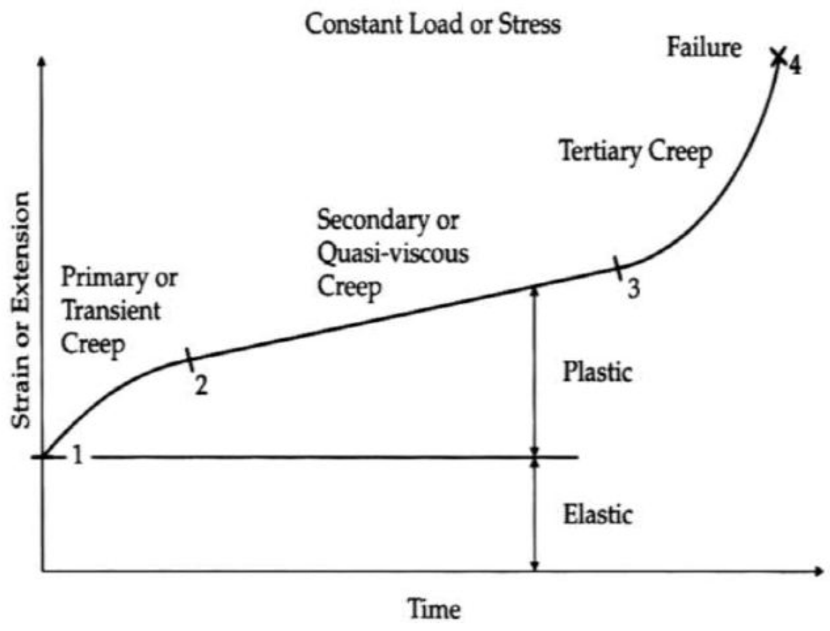


Ans. 1- Creep rate for stage (2-3) = $\frac{Elongation}{Time} = \frac{350-250}{35-10} = 4\ \frac{mm}{min}$

2- from 0 to 150

3- From 150 to 450

4- $\frac{Elongation}{Length} = \frac{450}{90} = 5$



❑**Q9(Years).** A material with **melting point** = $755C^{\circ}$ is subjected to stress at elevated temperature , the maximum temperature for this material to be used so it wont shown creep behavior is ?

Ans. $Ts \geq 0.4 * (755 + 273.15)$

$Ts \geq 411.2C^{\circ}$

$Ts \geq 411.2 - 273.15 = 138C^{\circ}$

❑**Q10(Years).** The figure bellow shows an actual results obtained from creep test for 4 different conditions of the same material , the longest time for rapture is for ?

Ans. Curve 2