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مختبر مقاومة المواد

إعداد : محمد عبيد

10/10

Hashemite University

Faculty of Engineering

Mechanical Engineering Department

Strength of Material Lab

Student name: **Mohammad Obead**

Student ID #: **2131715**

Experiment Title: **Tensile**

Experiment date: **15/10/2023**

Dr: **Mahdi Al Quraan**

Supervisor: **Wafa'a A. A. Murad**

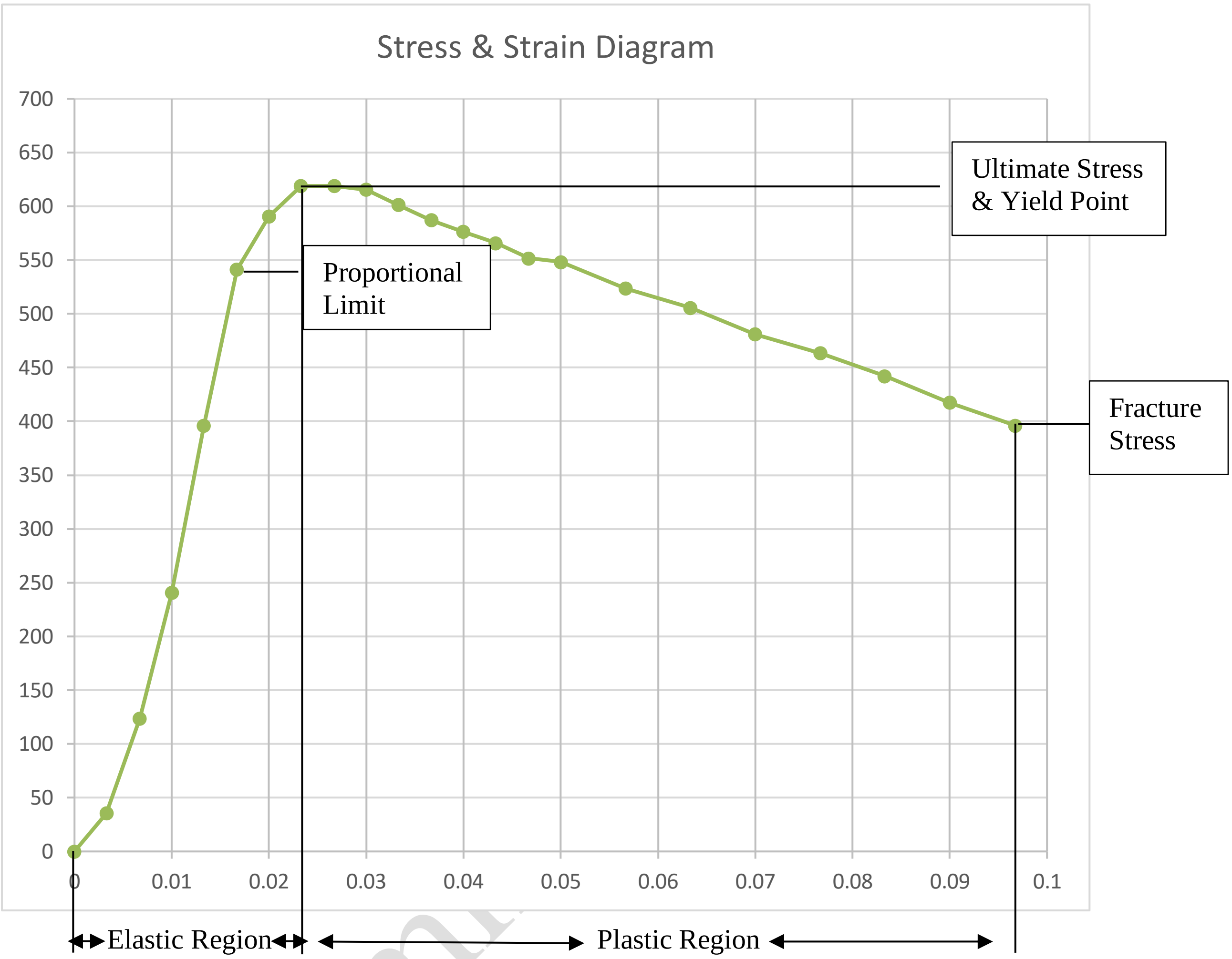
Q#1 Fill the table below by taken five reading (load vs. elongation) for each region

(Elastic & plastic) then calculate stress & strain: **(L=30mm D=6mm)**

Elongation	Load	Stress	Strain
mm	KN	MPa	mm/mm
0.1	**1**	**35.36**	**0.0033**
0.2	**3.5**	**123.78**	**0.0067**
0.3	**6.8**	**240.50**	**0.01**
0.4	**11.2**	**396.11**	**0.0133**
0.5	**15.3**	**541.12**	**0.0167**
0.6	**16.7**	**590.64**	**0.02**
0.7	**17.5**	**618.93**	**0.0233**
0.8	**17.5**	**618.93**	**0.0267**
0.9	**17.4**	**615.39**	**0.03**
1.0	**17.0**	**601.25**	**0.0333**
1.1	**16.6**	**587.10**	**0.0367**
1.2	**16.3**	**576.49**	**0.04**
1.3	**16.0**	**565.88**	**0.0433**
1.4	**15.6**	**551.73**	**0.0467**
1.5	**15.5**	**548.20**	**0.05**
1.7	**14.8**	**523.44**	**0.0567**
1.9	**14.3**	**505.75**	**0.0633**
2.1	**13.6**	**481.00**	**0.07**
2.3	**13.1**	**463.31**	**0.0767**
2.5	**12.5**	**442.09**	**0.0833**
2.7	**11.8**	**417.33**	**0.09**
2.9	**11.2**	**396.11**	**0.0967**

$$\sigma = P/A \qquad \varepsilon = \Delta L/L$$

Q2#. Plot stress strain diagram:



Note: you have to show one sample of calculation for elastic & plastic region

Q3#. Determine the following properties:

*The proportional limit

541.12 MPa

*Yield point

618.93 MPa

*Yield strength at an offset 0.1%

618.93 + [618.93*0.1%] = 619.54 MPa

*Ultimate Stress

618.93 MPa

*Fracture Stress

396.11 MPa

* Percent elongation %

$$\%\varepsilon = \Delta L/L * 100\% \Rightarrow \frac{32.9-30}{30} * 100\% = \underline{9.66\%}$$

* Percent reduction Area at fracture %

$$\%A = \Delta A/A * 100\% \Rightarrow \frac{28.27-25.78}{25.78} * 100\% = -\underline{9.66\%}$$

$A_i * L_i = A_f * L_f$

$\pi 3^2 * 30 = A_f * 32.9$

$\underline{A_f = 25.78 mm^2}$

*Modulus of Elasticity

$$E = \Delta\sigma / \Delta\varepsilon \Rightarrow \frac{123.78-35.36}{0.0067-0.0033} = \underline{26\ GPa}$$

*Modulus of resilience

$$U_r = \sigma_y/2\varepsilon \Rightarrow \frac{618.93^2}{2[26*1000]} = \underline{7.36}$$

*Modulus of Toughness

$$2/3*\sigma_{ult}*\varepsilon_{ult} \Rightarrow 2/3*618.93*0.0967 = \underline{39.90}$$

*Shear modulus of elasticity (G)

$$G = E/2(1+V) \Rightarrow \frac{26000}{2(1+0.901)} = \underline{6.838\ GPa}$$

$-\varepsilon y / \varepsilon x$

$-(-0.08711) / 0.9667$

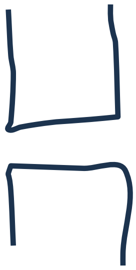
$= 0.901$

*Bulk modulus of elasticity (K)

$$K = E/3(1-2V) \Rightarrow \frac{26000}{3(1-2*0.901)} = \underline{10.806\ GPa}$$

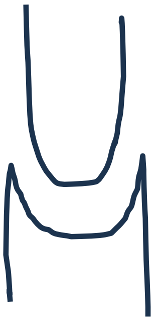
Q#4. Draw the shape of fracture and explain for the tow specimens (ductile, brittle).

Brittle :



Flat

Ductile :



Cupand Cone

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Hashemite University

Faculty of Engineering

Mechanical Engineering Department

Strength of Material Lab

Student name **Mohammad Obead**

Student ID # **2131715**

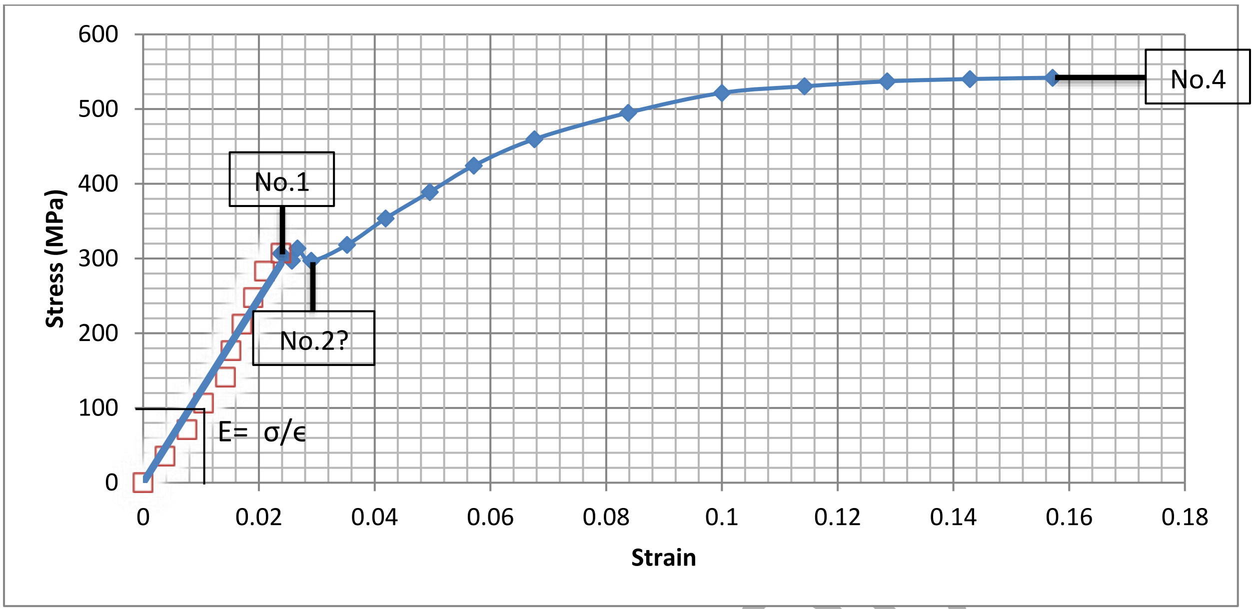
Experiment Title: Compression Test

Experiment date: **22/10/2023**

Dr.: **Mahdi Al Quraan**

Supervisor: **Wafa'a A. A. Murad**

Given that a Compression Test is applied on **Brass** specimen initially has ***9mm* Diameter** and ***10 mm* Height**, the result was **the Stress-Strain curve** below:



Q1: According to this result, fill the table below with units (show your calculations in details in the provided space):

No.	Item	Answer	No.	Item	Answer
1	*Proportional Limit*	**306.81 MPa**	2	*Yield Strength*	**297.08 MPa**
3	*Yield Strength for an offset of 0.2%*	297.08+(297.08*0.002) = **297.67 MPa**	4	*Ultimate and fracture stress*	**542.01 MPa**
5	*Percentage of shortening*	$\frac{10-8.43}{10}*100$ = **%15.7**	6	*Final Length*	$0.157=\frac{10-L_f}{10}$ ***L_f = 8.43 mm***
No.	**Item**	**Answer**	**No.**	**Item**	**Answer**
7	*Final Area*	$A_o L_o = A_f L_f$ $63.61*10=A_f*8.43$ $\mathbf{A_f=75.45\ mm^2}$	8	*Percentage of increasing in Area*	$\frac{75.45-63.61}{63.61}*100$ = **%18.61**
9	*Modulus of Elasticity*	$E=\frac{\sigma}{\epsilon}\rightarrow\frac{106.10}{0.0104}$ = **10.19 GPa**	10	*Modulus of Resilience*	$Ur=\frac{1}{2}*\sigma_y*\epsilon_y$ $\frac{1}{2}*297.08*0.0290$ = **4.30 MPa**

11	*Modulus of Toughness*	$U_T = \frac{2}{3}\sigma_{frac} * \epsilon_{frac}$ $\frac{2}{3} * 542.01 * 0.1571$ = **56.76 MPa**	**12**	*Shear Modulus of Elasticity**	$G = \frac{E}{2(1+V)}$ $\frac{10.19 * 1000}{2(1+0.24)}$ = **4.108 GPa**
13	*Bulk Modulus of Elasticity**	$K = \frac{E}{3(1-2V)}$ $\frac{10.19 * 1000}{3(1-2*0.24)}$ = **6.532 GPa**			

Use the Poisson's Ratio as **0.24*

Q2: State the **differences** between **compression and tensile test**.

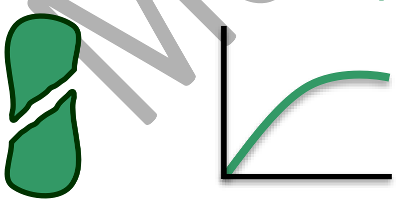
	Tensile Test	Compression Test
Load Direction	**Outward**	**Inward**
The change in length	$L_f > L_i$	$L_f < L_i$
The change in cross section area	$L_f < L_i$	$L_f > L_i$
Ultimate Strength	**Higher**	**Lower**

Q3: State the **differences** between the **brittle material** and the **ductile material** with respect to each test (Tensile & Compression Tests).

Brittle

Compressive

Fracture at 45º caused by normal stress

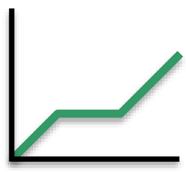


Ductile

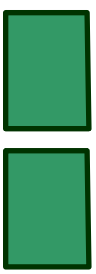
Compressive

No Fracture

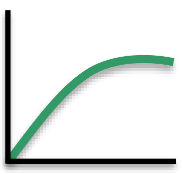
Yield = Ultimate = Fracture



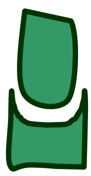
Tension (Brittle)



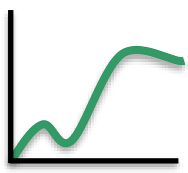
Flat



Tension (Ductile)



Cup & Cone



Q5: Why we need to **lubricate** the surfaces of the specimen?

1- **To reduce Friction**
2- **To Avoid Barrel Shape**

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Fatigue test

Student Name: Mohammad Obead ID # : 2131715

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Results and Analysis:

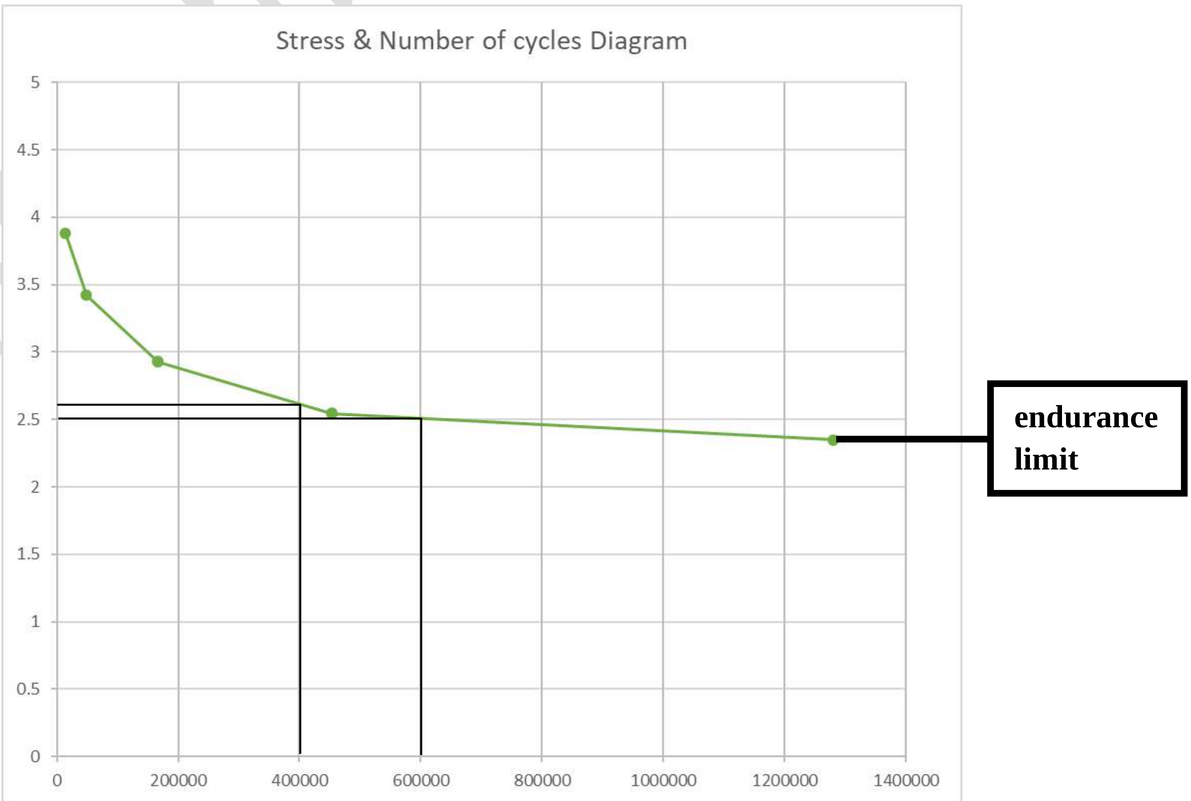
	# of load cycles for test bar under different loads		
Trial No.	Load F_a (N)	Endurance N (cycles)	Stress σ_a (N/mm^2)
1	195	14030	3.879 MPa
2	172	48800	3.421 MPa
3	147	167000	2.924 MPa
4	128	455000	2.546 MPa
5	118	1280800	2.347 MPa
L = 100. 5 mm d = 8 mm			

1. calculate the bending stress

Polar MOI $I = (\pi \times r^4) / 2 =$ **402.12 mm^4** , $M = F \times d$ >> 195×100.5 = **19597.5 N.mm**

$\sigma = (M \times y) / I$ >> [19597.5×(8/2)] / 402.12 = **194.94 MPa**

2. plot stress against number of cycles .



3. find the endurance limit

   2.347 MPa

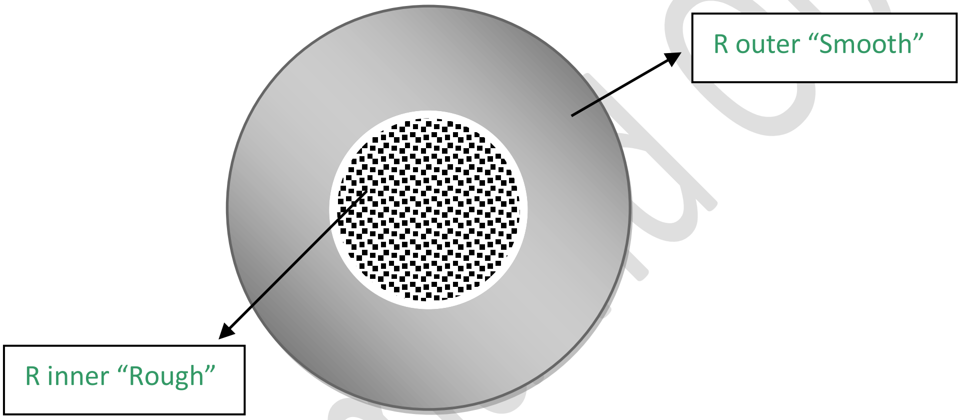
4. Estimate the fatigue strength corresponding to $4*10^5$ cycles.

   2.6 MPa

5. estimate the expected fatigue life corresponding to a bending stress of 250 Mpa

   $6*10^5$ Cycle

6. Comment on the shape of fracture for tested specimens.



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Deflection of Beams

Student Name: Mohamamd Obead ID # : 2131715

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9p,Result and calculations:

Rod material	Steel	**Modulus of Elasticity**	210 GPa
Length	1000 mm	**Cross section dimension**	(20 x 6) mm
Cross section type	Rectangle	**Ends condition**	Simply supported

Experiment parameters

Part (1): Measurement of the reaction forces: The load = 20N

$$\left|\frac{Theoretical - Experimental}{Theoretical}\right| * 100$$

Distance X from support A (mm)	Experimental		Theoretical		Percentage Error (%)	
	Reaction force A (N)	Reaction force B (N)	Reaction force A (N)	Reaction force B (N)	Reaction force A	Reaction force B
100	19	3	18	2	5.55%	50%
200	17	4	16	4	6.25%	0%
300	15	7	14	6	7.14%	16.66%
400	13	9	12	8	8.33%	12.50%
500	10	11	10	10	0%	10%

Experiment data and result

Sample of calculation:

$\sum Fy = 0 \rightarrow R_A + R_B - F = 0 \rightarrow R_A = F - \frac{F * X}{L} \rightarrow R_A = F\left(1 - \frac{X}{L}\right)$ $At\ X = 100 \rightarrow R_A = 20\left(1 - \frac{100}{1000}\right) = 18N$

$\sum M_A = 0 \rightarrow F * X = R_B * L \rightarrow R_B = F * \frac{X}{L}$ $At\ X = 300 \rightarrow R_A = 20\left(\frac{300}{1000}\right) = 18N$

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$$\%Error = \left|\frac{Theoretical - Experimental}{Theoretical}\right| * 100\% \qquad At\ X = 100 \rightarrow R_A = \left|\frac{18-19}{18}\right| * 100 = 5.55\%$$

Part (2): Deflection of simply supported beam: The load = 20N

Distance X from support A (mm)	Deflection W (Experimental) mm	Deflection W (Theoretical) mm	Percentage Error (%)
100	1.60	1.63139	1.92%
200	3.00	3.13051	4.16%
300	4.10	4.36507	6.07%
400	4.80	5.20282	7.74%
500	5.10	5.51146	7.46%

Experiment data and result

$$I = \frac{bh^3}{12} \rightarrow \frac{20 * 6^3}{12} = 360mm$$

Sample of calculation:

$$w(x) = \frac{FL^3}{48EI}\left[\frac{3X}{L} - \frac{4X^3}{L^3}\right] \qquad at\ X = 100 \rightarrow \frac{20 * 1000^3}{48 * 210000 * 360}\left[\frac{3 * 100}{1000} - \frac{4 * 100^3}{1000^3}\right]$$

$$\underline{= 1.63139mm}$$

Part (3): Cantilever beam Deflection: The load = 15N

Length L from clamp (mm)	Deflection W (Experimental) mm	Deflection W (Theoretical) mm	Percentage Error (%)
200	0.80	0.529	51.22%
300	2.00	1.785	12.04%
400	4.40	4.232	3.96%

Experiment data and result

$$w(x) = \frac{FL^3}{3EI} \qquad at\ X = 200 \rightarrow \frac{15*200^3}{3*210000*360} = 0.529mm$$

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State the sources of error?

1- **Personal Error in reding the dynamometer (difference in the angle of view causes the error)**
2- **The Beam is not Fully straight**
3- **Beam is already in plastic deformation before the experiment**

Comment on your results in each case:

Part (1):

Less distance X to support, Higher reaction value

Part (2):

Higher distance X, Higher Deflection .. until it reaches the middle of the beam

***Max deflection at X/2**

Part (3):

Higher distance X, Higher Deflection

***Max deflection at free-end**

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Strain Measurement with Strain Gauges

Student Name: ID # :

Mohammad Obead 2131715

Result and calculations:

Rod material	Steel	Cross section dimension	(20 x 4) mm
Length	800 mm	Distance of W from center	200 mm
Cross section type	Rectangle	Ends condition	Simply supported

Experiment parameters

#	W1 (N)	W2 (N)	Channel 1 Reading µ	Channel 2 reading µ	Є lateral	Є axial	Reaction (R)	Bending moment (M)	Stress (σ) Mpa
1	0	2.5	14	8	7	4	0.625	250	4.6875
2	2.5	2.5	27	14	13.5	7	2.5	500	9.375
3	2.5	5	48	21	24	10.5	3.125	750	14.0625
4	5	5	--------	--------	--------	--------	--------	--------	--------
5	5	7.5	87	31	43.5	15.5	5.625	1250	23.4375
6	7.5	7.5	110	37	55	18.5	7.5	1500	28.125

Experiment data and result

Sample of calculation:

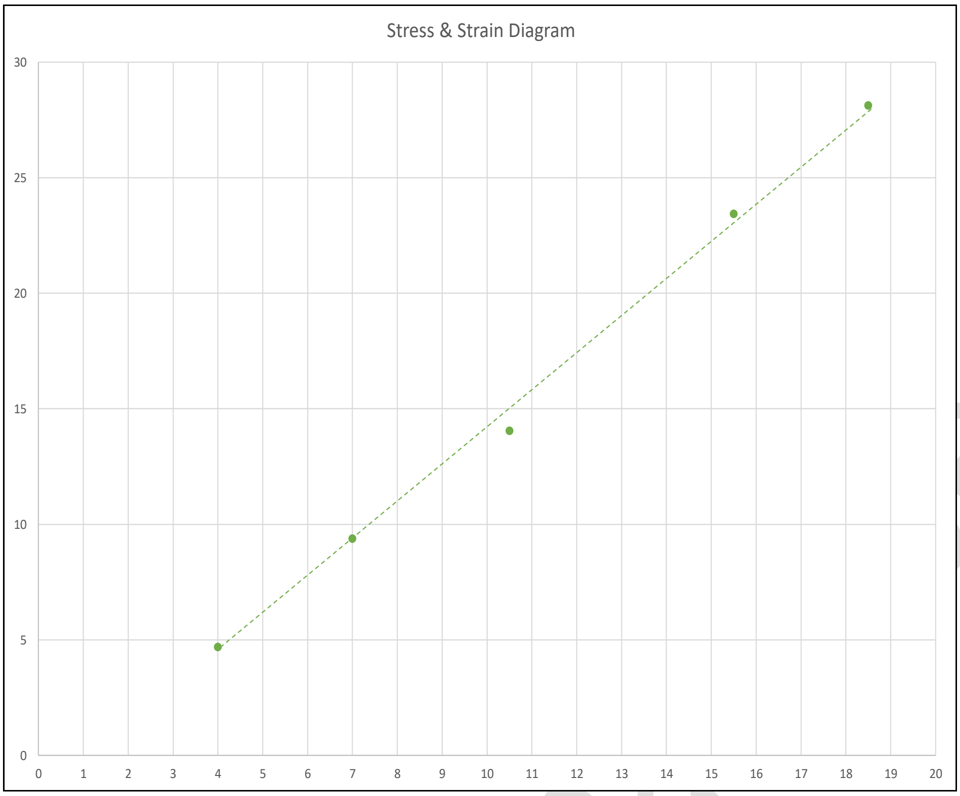
$\sum M_B = 0$ → $W_2*200 + W_1*600 - R_A*800 = 0$ → RA = $(W_2*200 + W_1*600) / 800$

Ex, Take #3 → (5*200 + 2.5*600) / 800 = 3.125N

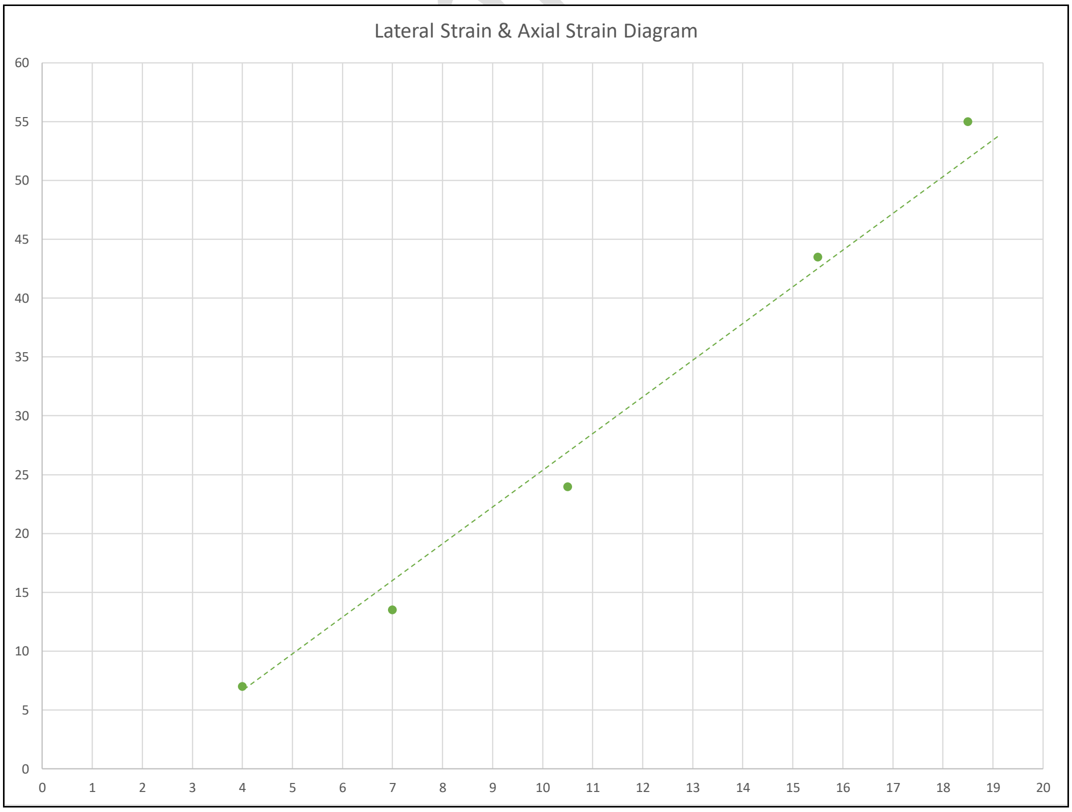
M = W1*200 – RA*400 → 2.5*200 – 3.125*400 = -750N.mm

σ = My/I → $[(750*2)] / [(20*4^3)/12]$ = 14.0625MPa

Plot **σ** versus ϵ_{axial} then find E and compare with theoretical values



Plot ϵ_{axial} versus $\epsilon_{lateral}$ then find **V** and compare with theoretical values



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stability of columns

Student Name: ID # :

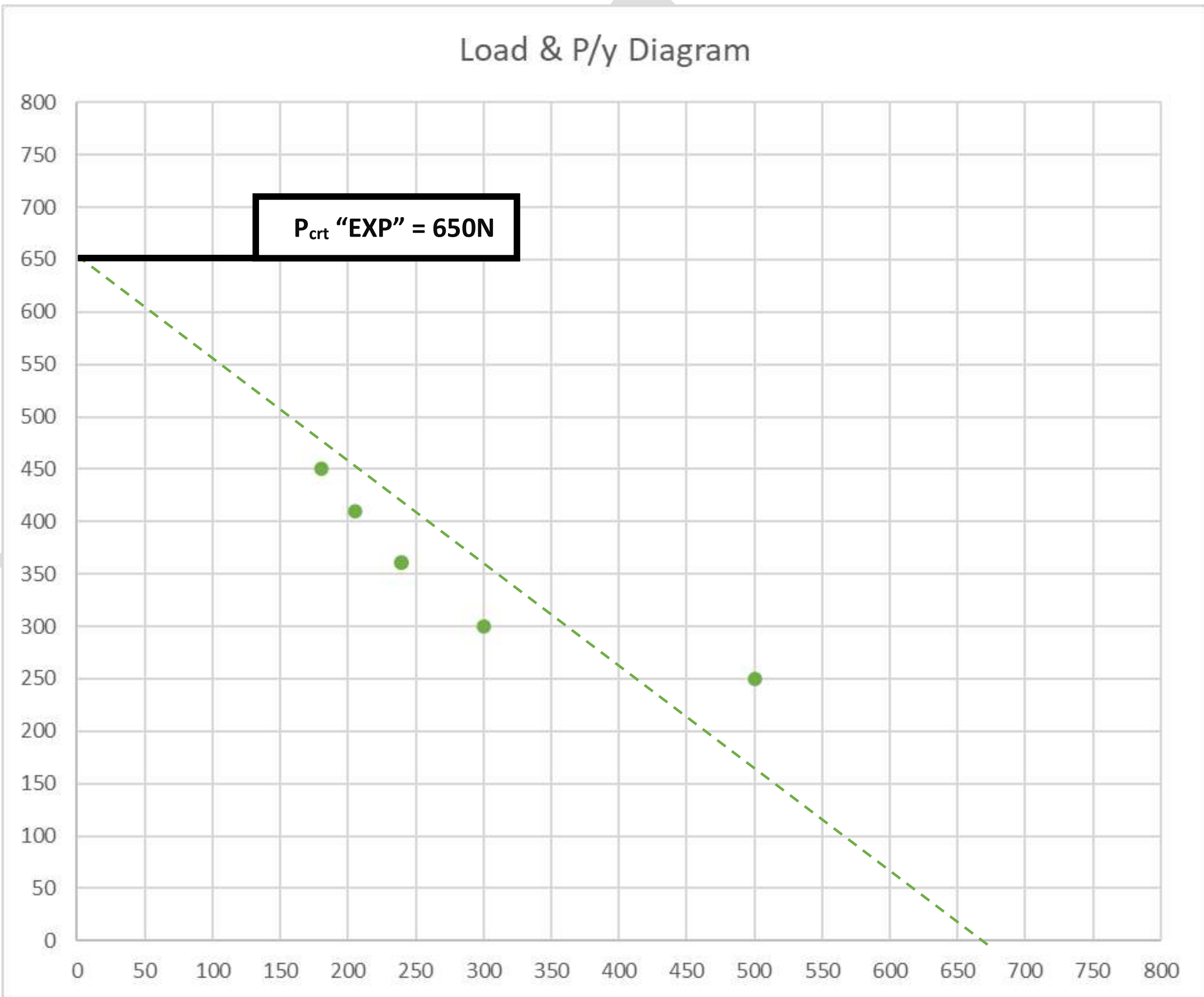
Mohammad Obead 2131715

Result and calculations:

Rod material	Steel	**Cross section dimension**	(20 x 4) mm^2
Length	700 mm	**Modulus of elasticity**	210 Gpa
Cross section type	Rectangle	**Ends condition**	Pin –pin (K=1)

Experiment parameters

Deflection y [mm]	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**
Load (P) N	*250*	*300*	*360*	*410*	*450*
P/y (N/mm)	**500**	**300**	**240**	**205**	**180**



Calculation:

$$I = \frac{20 * 4^3}{12} = \boxed{106.66mm^4}$$

$$P_{crt} = \frac{\pi^2 * E * I}{(L * K)^2} \rightarrow \frac{\pi^2 * 210000 * 106.66}{(700 * 1)^2} = \boxed{451.18N}$$

$$\%e = \left|\frac{451.18 - 650}{451.18}\right| * 100 = \boxed{\%44.06}$$

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Creep Test

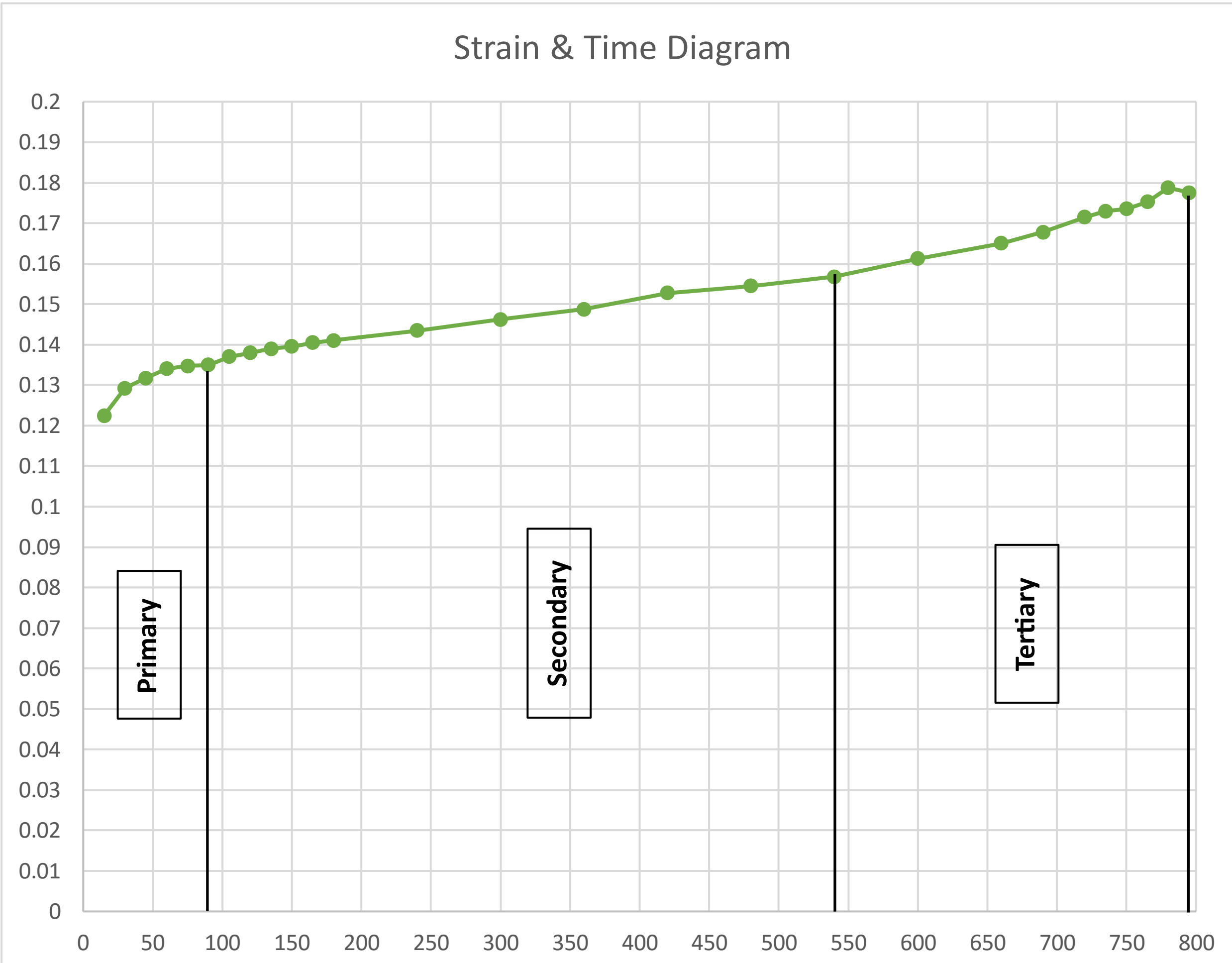
Specimen specifications: - made of Lead. - Dimensions: (2*5mm –Section), 20mm Length.
- Applied mass: 1.5 Kg. - Ambient temperature: 14°C.

Time (Sec.)	Dial Gauge Extension mm (Ext.1)
15	4.90
30	5.17
45	5.27
60	5.36
75	5.39
90	5.40
105	5.48
120	5.52
135	5.56
150	5.58
165	5.62
180	5.64
240	5.74
300	5.85
360	5.95
420	6.11
480	6.18
540	6.27
600	6.45
660	6.60
690	6.71
720	6.86
735	6.92
750	6.94
765	7.01
780	7.15
795	7.10

- Plot Strain against Time(s), the slope of the curve at the secondary region is the creep rate **έ.**
- Find the time required for each stage.
- Calculate the constant B.
- State 2 applications where the creep test is essential in elements and members design.

Q1 : Plot Strain against Time(s), the slope of the curve at the secondary region is the creep rate έ.

Ans.



Q2 : Find the time required for each stage.

Ans.

1. Time required for Primary Stage : [15 – 90]s

2. Time required for Secondary Stage : [90 – 540]s

3. Time required for Tertiary Stage : [540 – 795]s

Q3 : Calculate the constant B.

Ans.

$$Tensile\ force\ F = (2.84 + 8 * m) * g \ \rightarrow \ (2.84 + 8 * 1.5) * 9.81 = \boxed{145.58N}$$

$$\sigma = \frac{P}{A} \rightarrow \frac{145.58}{5 * 2} = \boxed{14.558MPa}$$

$$\varepsilon = B\, e^{\alpha\sigma} e^{-\frac{E}{RT}} \rightarrow 4.31 * 10^{-5} = B * e^{0.85*(14.558*10^6)} * e^{-\frac{120*10^3}{8.31*285}}$$

Can’t Calculate B .. MA Error

Q4 : State 2 applications where the creep test is essential in elements and members design.

Ans.

1- Solar Panel Structures.
2- Elevators and Lifts
3- Railway Tracks

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Impact Test

Student Name: **ID#:**

Mohammad Obead **2131715**

Apply the ***impact test*** on the following ***Specimens:***

Material	Notch Type	Total Absorbed Energy (N.m)		Absorbed Energy by specimen only (N.m)	
Mild Steel	V,U	**45**	**52**	**41.5**	**48.5**
Brass	V,U	**24**	**30**	**20.5**	**26.5**
Aluminum	V,U	**300**	**300**	**296.5**	**296.5**

Absorbed Energy by friction only is _____3.5 N.m__.

Q1: State the main ***Material Property*** obtained from this test.

Relative Toughness

Q2: According to the above table, answer the following questions:

A. Why we use ***notched specimens***?

1-To Decrease the Energy needed to break specimens

2-To Facilitate the breakage

B. Which specimens from the ***same material*** absorb ***higher*** amount of energy and why?
Material with "U notch" absorb higher energy because it gives less Stress Concentration than "V notch"

C. Which specimen absorbed higher energy (Mild Steel , Brass or aluminum), and why?
Mild Steel, Because it's a ductile material ! "ductility of mild steel is higher than ductility of brass"

Q3: If we apply ***the same impact load*** on ***the same specimens*** but at ***different temperature***, what you think will happen? Explain.

When Temperature Increase, Ductility & Toughness Increase.

Material with higher temperature will absorb more energy than other material

Q4: Compare between impact test and tensile test.

	Impact Test	**Tensile Test**
Type of Load	**Shock**	**Static**
Strain Rate	**High Strain**	**Low Strain**
Specimen's Notch	**V , U**	**No Notch**

Q5: state two differences between **Charpy** and **Izod** test ?

Charpy Test	**Izod Test**
Simply Supported **Notch opposes the hummer**	**Cantilever Supported** **Notch opposes the hummer**

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Hardness Test

Student Name: Mohammad Obead

ID # : 2131715

Results and Analysis:

Test / Setting	Brinell Hardness Test (HB)	Vickers Hardness Test (HV) 10	Vickers Hardness Test (HV) 30	Rockwell Hardness Test (HRC)	Rockwell Hardness Test (HRB)
Indenter	Steel ball 2.5 mm.	Diamond pyramid	Diamond pyramid	Diamond cone	Steel ball (1/16'')
Preload	3	3	3	10	10
Main load	187.5	10	30	150	100

Experiment parameters

Test / Materials	Brinell Hardness Test (HB)	Vickers Hardness Test (HV) 10	Vickers Hardness Test (HV) 30	Rockwell Hardness Test (HRC)	Rockwell Hardness Test (HRB)
Mild steel	173	208	X	X	85.9
High speed steel	X	X	619	64.2	X
Aluminum	100	105	X	X	50.6
Brass	102	97	X	X	56.2

Experiment data and results

1-What is the reason or for using a minor load in the case of Rockwell hardness test method?

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2-A 10 mm diameter Brinell hardness indenter produced an indentation 2.5 mm in diameter in a steel alloy when a load of 100 kg was used. Compute the HBN of this material؟

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3- Find the Ultimate tensile strength for the mild steel based on the hardness test?

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1- What is the reason or for using a minor load in the case of Rockwell hardness test method?

The test piece is placed to make full contact with the surface

2-A 10 mm diameter Brinell hardness indenter produced an indentation 2.5 mm in diameter in a steel alloy when a load of 100 kg was used. Compute the HBN of this material?

$$HBN = \frac{P}{\frac{\pi}{2}D(D-\sqrt{D^2-d^2})} \rightarrow \frac{100}{\frac{\pi}{2}10(10-\sqrt{10^2-2.5^2})} = \boxed{20.048}$$

D → indenter , d → indentation

3- Find the Ultimate tensile strength for the mild steel based on the hardness test?

$$\sigma = 3.4 * HB \rightarrow 3.4 * 173 = \boxed{588.2MPa}$$

The Hashemite University
Faculty Of Engineering
Mechanical Engineering Department

Strength Of Materials Lab

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Thin Wall Cylinder

Student Name: Mohammad Obead

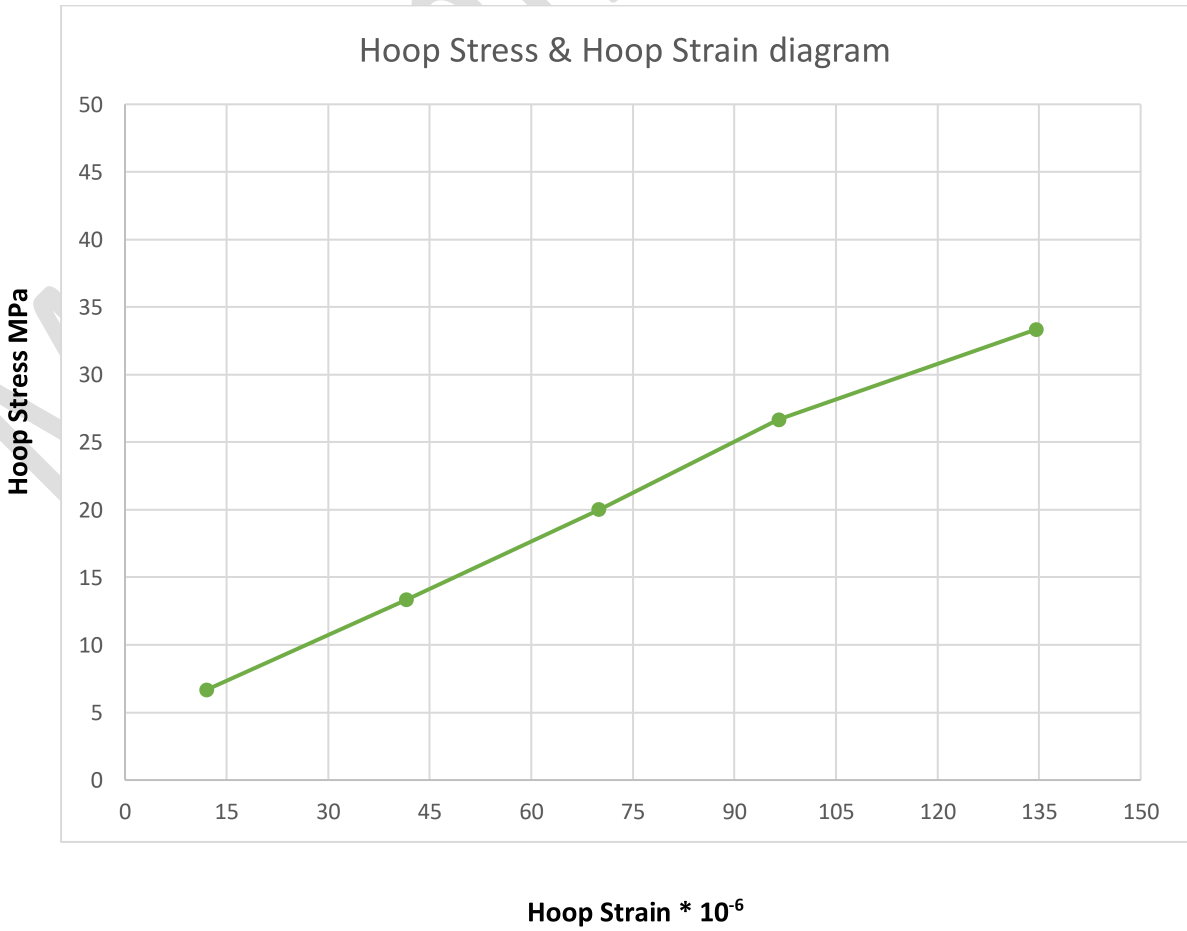
ID # : 2131715

Results and Analysis:

- Fill the experiment results for all parts and compare with theoretical value:

Trial No. #	Cylinder Pressure P (Mpa)	Hoop Strain ε_H Gauge 1	Hoop Strain ε_H Gauge 6	Average Hoop Strain ε_H	Hoop stress σ_H (Mpa)
1	0.5	$11 * 10^{-6}$	$13 * 10^{-6}$	$12 * 10^{-6}$	6.667
2	1	$42 * 10^{-6}$	$41 * 10^{-6}$	$41.5 * 10^{-6}$	13.33
3	1.5	$68 * 10^{-6}$	$72 * 10^{-6}$	$70 * 10^{-6}$	20
4	2	$97 * 10^{-6}$	$96 * 10^{-6}$	$96.5 * 10^{-6}$	26.667
5	2.5	$132 * 10^{-6}$	$137 * 10^{-6}$	$134.5 * 10^{-6}$	33.33
d = 80 mm t = 3.00 mm L = 358mm Theoretical modulus of elasticity (E) =69 Gpa					

- Plot σ_{Hoop} versus ϵ_{Hoop} then find E and compare with theoretical values.



- Sample of calculation:

$$AVG\ Hoop\ Strain \rightarrow \epsilon_H = \frac{Gage\ 1 + Gage\ 6}{2} \rightarrow \frac{11 + 13}{2} = \boxed{12}$$

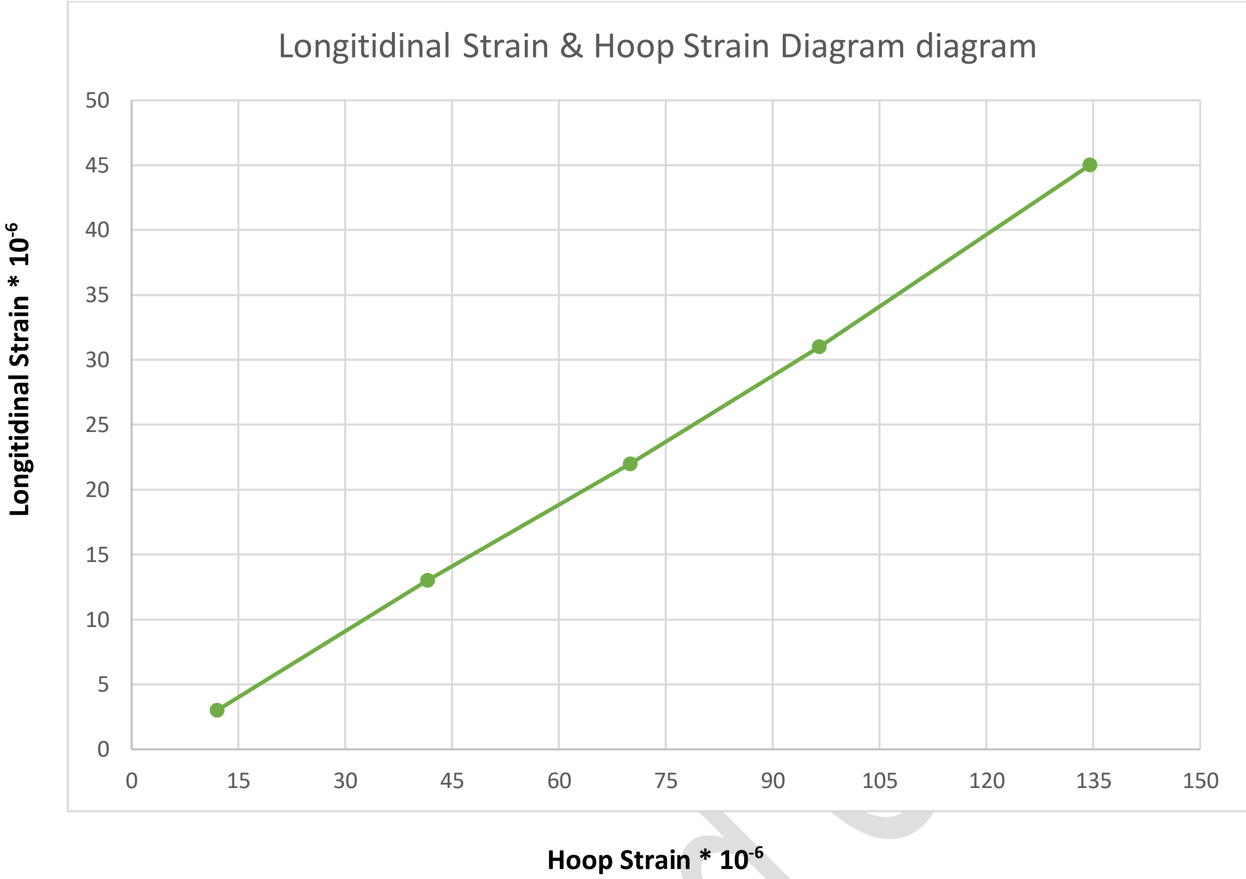
$$Hoop\ Stess \rightarrow \sigma_H = \frac{P * d}{2t} \rightarrow \frac{1 * 80}{2(3)} = \boxed{13.33\ MPa}$$

$$Slope \rightarrow E = \frac{\Delta\sigma}{\Delta\epsilon} \rightarrow \frac{(26.67 - 6.67)}{(96.5 - 12) * 10^{-6}} = \boxed{236.686\ GPa}$$

- Fill table below and find the Poisson's ratio (v):

Trial No. #	Hoop Strain ε_H Gauge 1	Hoop Strain ε_H Gauge 6	Longitudinal strain ε_L Gauge 2	Average Hoop Strain ε_H
1	$11 * 10^{-6}$	$13 * 10^{-6}$	$3 * 10^{-6}$	$12 * 10^{-6}$
2	$42 * 10^{-6}$	$41 * 10^{-6}$	$13 * 10^{-6}$	$41.5 * 10^{-6}$
3	$68 * 10^{-6}$	$72 * 10^{-6}$	$22 * 10^{-6}$	$70 * 10^{-6}$
4	$97 * 10^{-6}$	$96 * 10^{-6}$	$31 * 10^{-6}$	$96.5 * 10^{-6}$
5	$132 * 10^{-6}$	$137 * 10^{-6}$	$45 * 10^{-6}$	$134.5 * 10^{-6}$
Theoretical Poisson's ratio (v) =0.33				

- Plot ϵ_{Hoop} versus $\epsilon_{Longitudinal}$, then find Poisson's ratio (v) and compare with theoretical value.



- Calculate the theoretical longitudinal stress ?

Zero, Because it's an open gage

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Hashemite University

Faculty of Engineering

Mechanical Engineering Department

Strength of Material Lab

Group #:......

	Student name	Student ID #	Section
1	**Mohammad Obead**	**2131715**	**1**

Experiment Title: Torsion Test

Experiment date: **24/12/2023**

Dr.: **Mahdi Al Quraan**

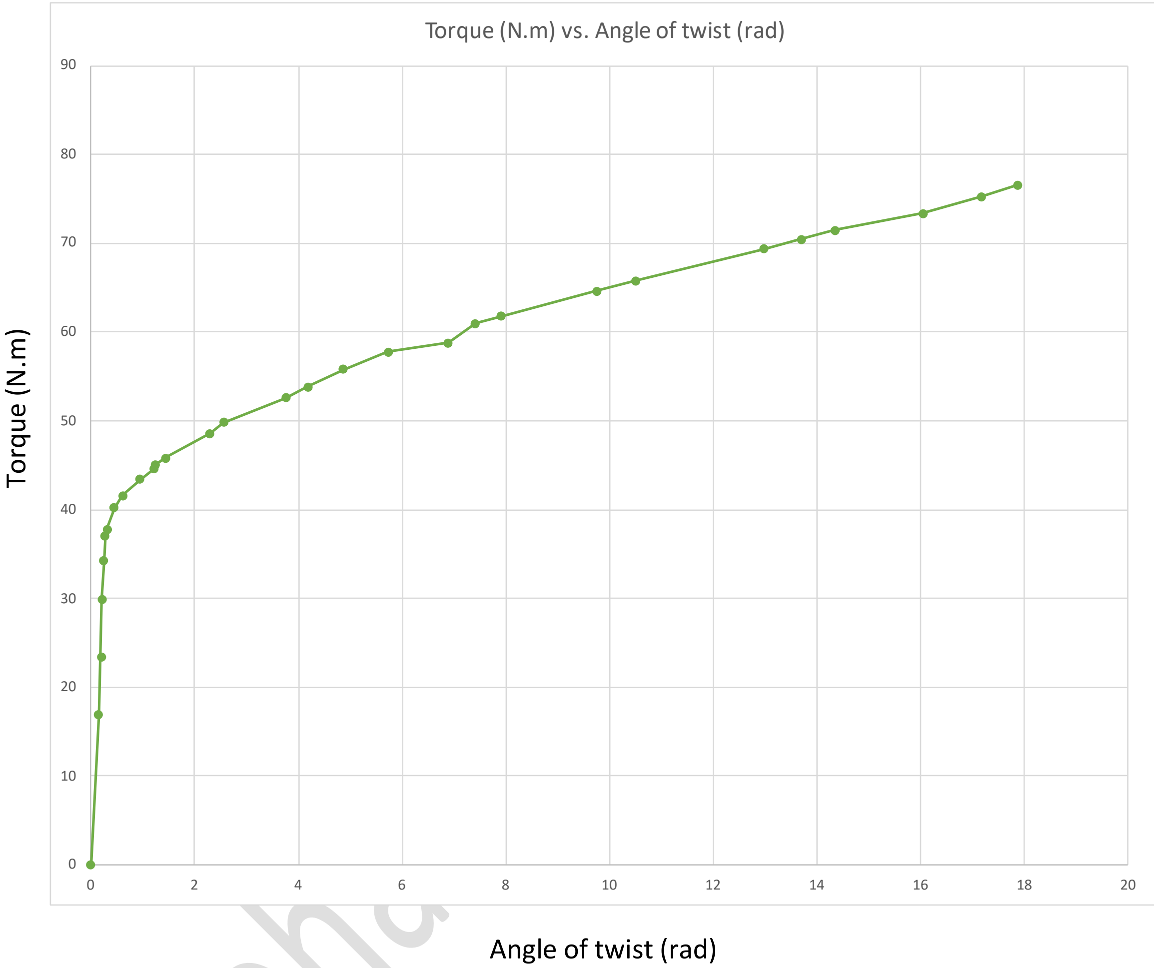
Supervisor: **Wafa'a Murad**

Q#1 from the table below plot torque vs. angle of twist then take five reading for each Region (Elastic & plastic) from the figure then calculate stress & strain:

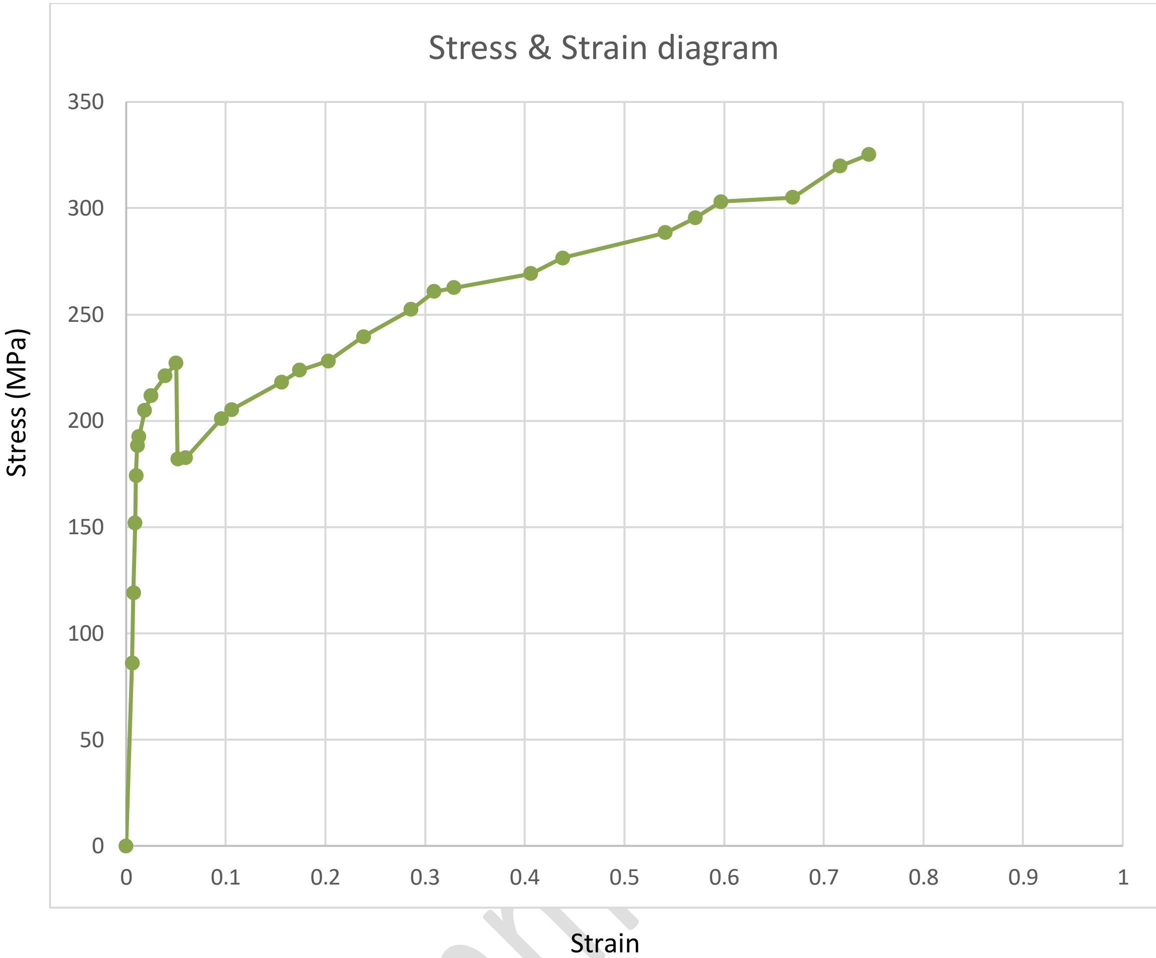
Dimensions : diameter= 10mm length = 120mm

Torque N.m	Φ deg	Φ rad	stress (Map) τ	strain γ
0	0	0	0	0
16.9	8.5	0.148	86.07	0.00617
23.4	10.3	0.179	119.175	0.00745
29.8	12.1	0.211	151.77	0.00879
34.2	13.7	0.239	174.179	0.00996
37	15.6	0.272	188.43	0.0113
37.8	17.6	0.307	192.514	0.0127
40.2	25.3	0.442	204.737	0.0184
41.6	34.6	0.604	211.867	0.0251
43.4	53.8	0.939	221.034	0.0391
44.6	68.8	1.201	227.146	0.05
45	70.8	1.236	182.073	0.0515
45.8	82.2	1.435	182.582	0.0597
48.6	131.5	2.295	201.044	0.0956
49.8	146.8	2.562	205.246	0.106
52.6	214.9	3.751	218.233	0.156
53.8	239.6	4.182	223.708	0.174
55.8	279.2	4.873	228.164	0.203
57.8	328.3	5.729	239.623	0.238
58.8	394.6	6.887	252.356	0.286
61	424.9	7.416	260.759	0.309
61.8	453.2	7.909	262.541	0.329
64.6	558.9	9.755	269.163	0.406
65.8	602.3	10.512	276.547	0.438
69.4	743.3	12.973	288.516	0.541
70.5	784.9	13.699	295.391	0.571
71.5	822	14.347	303.031	0.597
73.4	920	16.057	305.068	0.669
75.3	985	17.191	319.837	0.716
76.6	1025	17.889	325.185	0.745

Q2#. Plot Torque (N.m) vs. Angle of twist (rad)



Q3#. Plot stress strain diagram



Note: you have to show me one sample of calculation for elastic & plastic region

Calculations :

D = 10mm , L = 120mm

$$Polar\ MOI \rightarrow J = \frac{\pi * r^4}{2} \rightarrow \frac{\pi * 5^4}{2} = \boxed{981.747mm^4}$$

$$\emptyset rad = \frac{\emptyset deg * \pi}{180} \rightarrow \frac{131.5 * \pi}{180} = \boxed{2.295rad}$$

Elastic

$$\tau = \frac{T * r}{J} \rightarrow \frac{(16.9 * 10^3) * 5}{981.747} = \boxed{86.07MPa}$$

$$\gamma = \frac{r * \theta}{L} \rightarrow \frac{5 * 0.148}{120} = \boxed{0.00617}$$

16.9	8.5	0.148	86.07	0.00617

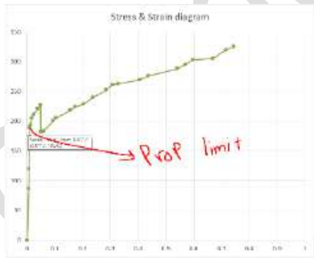
Plastic

$$\tau = \frac{PC * 3AP}{2\pi r^3} \rightarrow \frac{25.6 * (3 * 76.6)}{2 * \pi * (5 * 10^{-3})^3} = \boxed{325.185\text{MPa}}$$

$$\gamma = \frac{r * \theta}{L} \rightarrow \frac{5 * 17.889}{120} = \boxed{0.745}$$

76.6	1025	17.889	325.185	0.745

Q4#.Determine the following properties:



The proportional limit

Point (0.0113, 188.43)

Yield strength at an offset 0.1%

$$\gamma_{max} * 0.001 \rightarrow 0.745 * 0.001 = \boxed{0.000745}$$

$$\tau' = \frac{227.146 * (0.05 + 0.000745)}{0.05} \rightarrow \tau' = \boxed{230.53MPa}$$

Modulus of rigidity

$$G = Slope \rightarrow \frac{188.43 - 0}{0.0113 - 0} = \boxed{16.675GPa}$$

Modulus of resilience

$$Area\ Under\ Elastic\ Region = \frac{1}{2}\tau_y\gamma_y \rightarrow \frac{1}{2} * 230.53 * 0.051 = \boxed{5.878}$$

Modulus of rupture

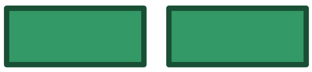
$$\frac{2}{3}\tau_{max}\gamma_{max} \rightarrow \frac{2}{3} * 325.185 * 0.745 = \boxed{161.5}$$

The total angle of twist

$$1025° = 17.889rad$$

Q5#. Draw the shape of fracture and explain for the tow specimens (ductile, brittle).

<u>Ductile</u>



90 degree facture

Specimens is not pure

<u>Brittle</u>

45 degree facture

Specimens is pure (normal state)