Session 8, Electrical, Thermal, Magnetic, Optical

1. $l = 100\,m$ $\quad V = 1.5\,V$ $\quad \sigma = 6.0 \times 10^7\,(\Omega m)^{-1}$

$d = ?$ $\quad I = 2.5\,A$

$$R = \frac{V}{I} = \frac{1.5}{2.5} = 0.6 \qquad \rho = \frac{1}{\sigma} = \frac{RA}{l}$$

$$\frac{1}{6 \times 10^7} = \frac{0.6A}{100} = \frac{0.6\,\frac{\pi}{4}d^2}{100} \longrightarrow d = 0.00188\,m = \underline{1.88\,mm}$$

2. $\mathcal{E} = 1000\,V/m$ $\qquad V_d = \mu_e \mathcal{E}$ $\qquad$ for Ge, $\mu_e = 0.38\,m^2/Vs$ (from table)

a) $V_d = 0.38(1000) = \underline{380\,m/s}$

b) $t = \frac{l}{V} = \frac{0.025}{380} = \underline{6.58 \times 10^{-5}}\,s$

3. $\sigma = 500\,(\Omega m)^{-1}$ $\qquad \mu_e = 0.16\,m^2/Vs$

$\mu_h = 0.075\,m^2/Vs$

$$\sigma = ne\mu_e + pe\mu_h$$

$$500 = 1.6 \times 10^{-19}(0.16)n + 1.6 \times 10^{-19}(0.075)p$$

if intrinsic, $n = p$

$$500 = (1.6 \times 10^{-19})(0.16 + 0.075)n \longrightarrow n = 1.329 \times 10^{22}\,m^{-3} = p$$

$$n + p = 2n = \underline{2.659 \times 10^{22}}\,m^{-3}$$

ENGR 244 (Mechanics of Materials)

Lab No. 5: DEFLECTION OF BEAMS

DATA SHEET

Student Name: Bahram [illegible] Student ID: 5809541 Lab Group: AP

Dimensions	BRASS	STEEL	ALUMINUM
Span Length, L (mm)	455	455	455
Width, w (mm)	19.03	19.03	19.43
Height, h (mm)	12.71	12.66	12.82

DEFLECTION OF BEAM, δ (mm)						
Applied Load	**BRASS**		**STEEL**		**ALUMINUM**	
	at x = L/2	at x = L/4	at x = L/2	at x = L/4	at x = L/2	at x = L/4
200 N	-1.36	-1.08	-0.70	-0.47	-1.96	-1.28
400 N	-2.91	-2.18	-1.35	-0.98	-3.73	-2.50
600 N	-4.51	-3.29	-1.98	-1.38	-5.51	-3.75
800 N	-6.16	-4.44	-2.61	-1.83	-7.33	-5.01
1000 N	-78.5	-5.60	-3.25	-2.28	-9.12	-6.27

PART 2

Beam Material: Brass, Beam width = 19.06 mm, height h=3.19 mm

DEFLECTION OF BEAM, δ (mm)			
Applied Load		B) Cantilever Beam, L = 250 mm	
		at x = L	at x = L/2
100 gm		-1.37	-0.47
200 gm		-2.60	-0.90
300 gm		-3.87	-1.31
400 gm		-5.11	-1.75
500 gm		-6.42	-2.19

Analysis & Discussion: Follow the instructions given on page # 21 of your lab manual.

4.11

Sb has 1 more valence electron

thus n-type (donor)

for extrinsic n-type $n \gg p$ and $\sigma \approx n e \mu_e$

if each Sb provides 1 electron, then $n = 5 * 10^{22}\ m^{-3}$

$$\sigma = 5*10^{22}(1.6*10^{-19})(0.1) = \underline{800}\ (\Omega m)^{-1}$$

5.11 W $d_{o_w} = 10\ mm$ $d_{o_s} = 9.988\ mm$ $\varepsilon = \alpha \Delta T$ must have same final diameter and same temp. change

$$\frac{d_f - d_{o_w}}{d_{o_w}} = \alpha_w \Delta T \qquad \frac{d_f - d_{o_s}}{d_{o_s}} = \alpha_s \Delta T$$

$$d_f = (\alpha_w \Delta T + 1) d_{o_w} \quad = \quad d_f = (\alpha_s \Delta T + 1) d_{o_s}$$

$$(\alpha_w \Delta T + 1) d_{o_w} = (\alpha_s \Delta T + 1) d_{o_s}$$

$$[4.5*10^{-6}(T_f - 25) + 1]0.01 = [16*10^{-6}(T_f - 25) + 1]0.00988$$

$$\longrightarrow T_f = \underline{129.5\ ^\circ C}$$

3.924	26.123915	32.588073
4.905	26.497898	32.665027

6.) $l_0 = 0.5\,m$ 1025 steel, $\alpha = 12.0 * 10^{-6}\,K^{-1}$

$T_0 = 20°C$ $T_f = 80°C$

a) $\varepsilon = \alpha(T_f - T_0) = \frac{\sigma}{E}$

$\sigma = E\alpha(T_f - T_0) = 200*10^9(12*10^{-6})(80-20) = 1.5 * 10^8\,Pa$

$= \underline{150\,MPa}$ compression

b) same

c) $\sigma = 207*10^9(12*10^{-6})(-10-20) = -7.45*10^7\,Pa = \underline{-74.5\,MPa}$

tension

7.)

$N = 200$

$l = 2m$ $I = 10A$

a) $H = \frac{NI}{l} = \frac{200(10)}{0.2} = \underline{10000}\,A/m$

b) $B_0 = \mu_0 H = (1.257*10^{-6})(10000) = \underline{0.01257}\,T$

c) $B = \mu_0 H + \mu_0 M = \mu_0 H + \mu_0 \chi_m H = \mu_0 H(1+\chi_m)$

$= (1.257*10^{-6})(10000)(1 + 1.81*10^{-4}) = 0.\underline{012572}\,T$

Discussion

4/5

1)

	Error percentage in deflection					
Applied Load N	Brass		Steel		Aluminium	
	x=L/2	x=L/4	x=L/2	x=L/4	x=L/2	x=L/4
200	18.46853	37.08734	14.857923	12.37515	4.8381745	0.794587593
400	26.7439	38.35667	10.755854	11.17967	0.7851523	1.567785554
600	30.95418	39.20289	8.2946132	9.984193	0.7459894	1.567785554
800	34.14819	40.89533	7.0639926	9.386453	0.9711573	1.370921125
1000	36.76146	42.16465	6.6537858	9.027809	1.4304998	1.252802468

	Error % in deflection	
Applied Load N	x=L	x=L/2
0.981	31.111899	37.249536
1.962	27.40254	34.460626
2.943	26.839769	32.459424
3.924	26.123915	32.588073
4.905	26.497898	32.665027

Yes accuracy does depend on material, load machine,…, however it mostly depend on its human factor. As humans' errors cause corruption in data by not setting up the experiment correctly or mistaking while gathering data. Thus, accuracy of or experiment lowers.

2)

	Error percentage in E					
Applied Load N	Brass		Steel		Aluminium	
	x=L/2	x=L/4	x=L/2	x=L/4	x=L/2	x=L/4
200	15.5894	27.05381	12.935915	11.01236	4.6148977	0.788323671
400	21.10074	27.72304	9.7113191	10.0555	0.7790357	1.592756561
600	23.63741	28.16241	7.6593036	9.077844	0.7515963	1.592756561
800	25.45557	29.02532	6.5979163	8.581001	0.9806813	1.389976608
1000	26.87999	29.65903	6.2386775	8.280281	1.4512601	1.268696732

	Error % in E	
Applied Load N	x=L	x=L/2
0.981	31.111899	37.249536
1.962	27.40254	34.460626
2.943	26.839769	32.459424

8.// $B = 0.435\ T \qquad H = 3.44 * 10^5\ A/m$

$$B = \mu H \qquad \mu = \frac{B}{H} = \frac{0.435}{3.44*10^5} = \underline{1.264*10^{-6}}\ \frac{Wb}{Am}$$

$$\mu_r = \frac{\mu}{\mu_0} = \frac{1.264*10^{-6}}{1.257*10^{-6}} = \underline{1.006}$$

$$\chi_m = \mu_r - 1 = 1.006 - 1 = \underline{0.006}$$

Since χ_m is positive and on the order of 10^{-3} —> paramagnetic

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9.// No. $\quad n = \frac{c}{v}$ and c is always greater than v

$$v = \frac{1}{\sqrt{\epsilon\mu}} \qquad c = \frac{1}{\sqrt{\epsilon_0\mu_0}}$$

$$n = \frac{\sqrt{\epsilon\mu}}{\sqrt{\epsilon_0\mu_0}}$$

10.// $\epsilon_r = 2.056 \qquad \chi_m = -1.43*10^{-5}\ T$

$$v = \frac{1}{\sqrt{\epsilon\mu}} \qquad \epsilon_r = \frac{\epsilon}{\epsilon_0} \qquad \epsilon = \epsilon_r\epsilon_0 = (2.056)(8.85*10^{-12})$$

$$= 1.82*10^{-11}\ \frac{F}{m}$$

$$\chi_m = \mu_r - 1$$

$$\mu = \mu_r\mu_0 = (\chi + 1)\mu_0 = (-1.43*10^{-5} + 1)(1.257*10^{-6})$$

$$= 1.257*10^{-6}$$

$$v = \frac{1}{\sqrt{(1.82*10^{-11})(1.257*10^{-6})}} = \underline{2.09*10^8\ m/s}$$

1.962	-0.0018875	-0.00059
2.943	-0.0028313	-0.000885
3.924	-0.0037751	-0.00118
4.905	-0.0047188	-0.001475

2)

Beam deflection m	theoretical		exprimental	
Applied Load N	x=L	x=L/2	x=L	x=L/2
0.981	-0.0009438	-0.000295	-0.00137	-0.00047
1.962	-0.0018875	-0.00059	-0.0026	-0.0009
2.943	-0.0028313	-0.000885	-0.00387	-0.00131
3.924	-0.0037751	-0.00118	-0.00511	-0.00175
4.905	-0.0047188	-0.001475	-0.00642	-0.00219

3)

$$E = \frac{P}{6yI}(x^3 - 3Lx^2) = \frac{0.981}{6(0.00137)(5.156 * 10^{-11})}(0.25^3 - 3(0.25)(0.25^2)) = 72.33\ GPa$$

E Pa		
Applied Load N	x=L	x=L/2
0.981	7.233E+10	6.589E+10
1.962	7.623E+10	6.882E+10
2.943	7.682E+10	7.092E+10
3.924	7.757E+10	7.078E+10
4.905	7.718E+10	7.07E+10

4)