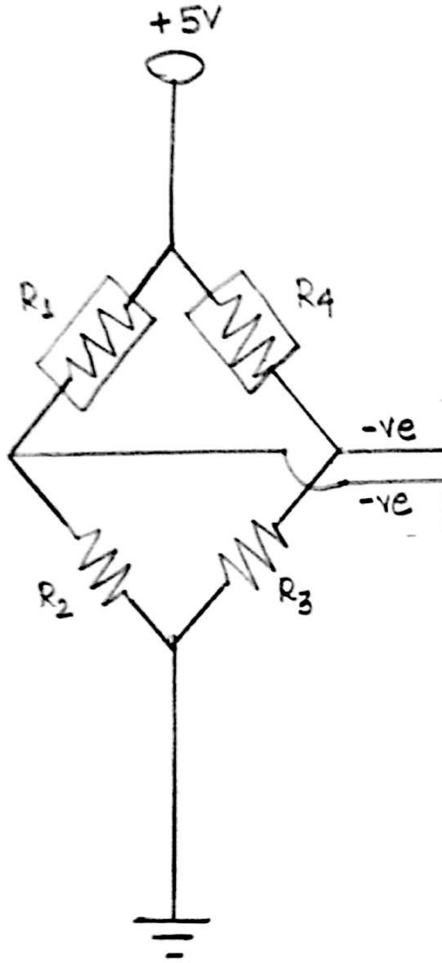
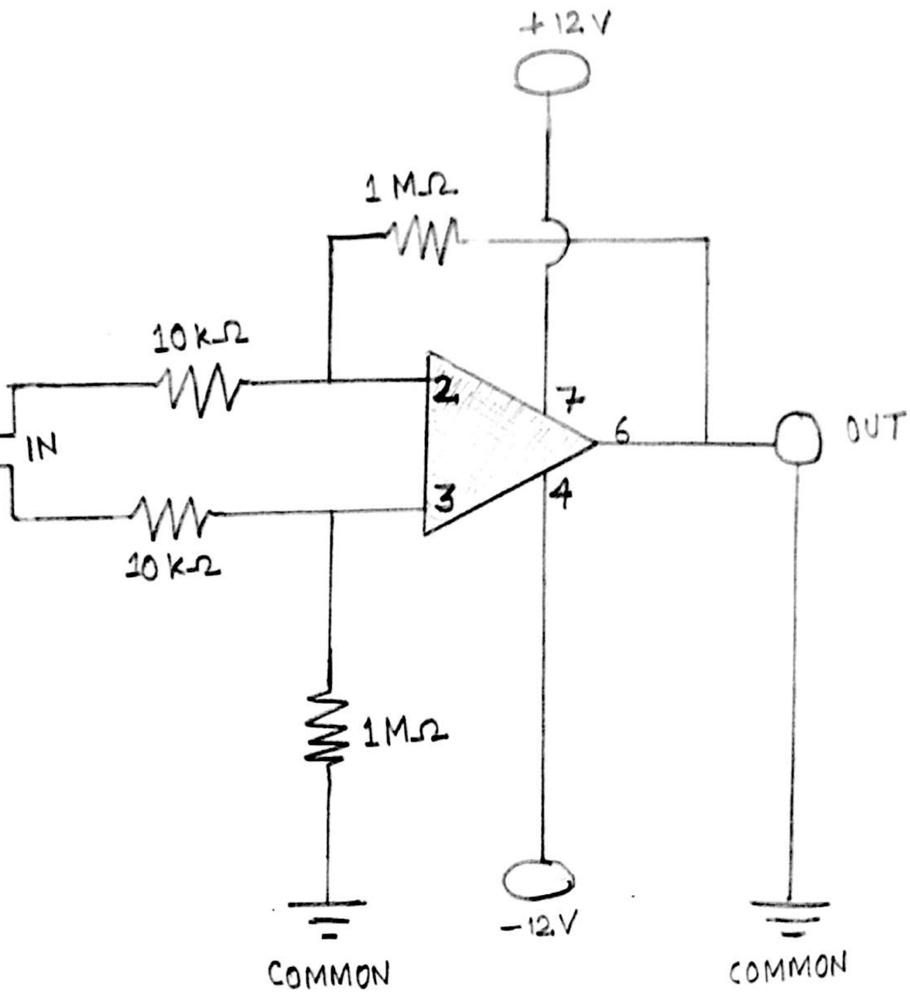
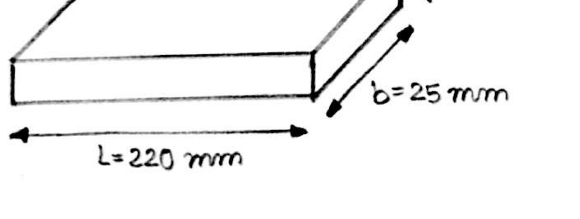


WHEATSTONE BRIDGE



VOLTAGE MAGNIFICATION CIRCUIT



DIMENSIONS OF BEAM

STRAIN GAUGE EXPERIMENT

- **Aim:** To find the Young's Modulus of aluminium using strain gauge circuit.

- **Apparatus:** Strain gauge, vernier caliper, Resistance 120 ohms, 10K, 1M, JC-OP07, Multimeter, connecting wire, Aluminium cantilever beam.

- **Theory:** We know that $R = \rho \frac{l}{A}$

Any change in length l, area A or resistivity ρ would give change in resistance. Measurement of this change in resistance gives a measure of strain.

$$\frac{\Delta R}{R} = K \frac{\Delta l}{l}$$ K = constant known as gauge factor

$$K = \frac{(\Delta R/R)}{\varepsilon}$$ K = constant known as gauge factor
Its value 2-2.2

ε = strain

$$V \text{ across } R_1 = \frac{R_1}{R_1+R_2} E \qquad V \text{ across } R_4 = \frac{R_4}{R_4+R_3} E$$

$$V_0 = \frac{R_1R_4 + R_1R_3 - R_4R_2 - R_4R_1}{(R_2+R_1)(R_4+R_3)} E$$ Here, E = 5V

$$= \frac{R_1R_3 - R_4R_2}{(R_2+R_1)(R_4+R_3)} E$$

If after the initial balancing all the resistance change by $\Delta R_1, \Delta R_2, \Delta R_3$ and ΔR_4, then output voltage V_o is

$$V = \frac{(R_1 + \Delta R_1)(R_3 + \Delta R_3) - (R_4 + \Delta R_4)(R_2 + \Delta R_2)}{(R_2 + \Delta R_2 + R_1 + \Delta R_1)(R_4 + \Delta R_4 + R_3 + \Delta R_3)} E$$

$$\Delta V = E \frac{R_1 R_4}{(R_1 + R_4)^2} \left(\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4} \right)$$

ΔV = change in output voltage

$$\Delta V = E \frac{r}{(1+r)^2} \frac{\Delta R_1}{R_1} \quad \text{where } r = \frac{120\,\Omega}{120\,\Omega} = 1$$

$$\Delta V = \frac{E}{4} \frac{\Delta R}{R} \quad \text{if } R_1 = R_2 = R$$

so, $\frac{\Delta R}{R} = \frac{4 \Delta V}{E}$

Again, $K = \frac{\Delta R / R}{\varepsilon}$

$$K = \frac{4 \Delta V}{E \varepsilon} \Rightarrow \varepsilon = \frac{4 \Delta V}{E K}$$

But we used 2 strain gauge so

$$\varepsilon = \frac{1}{2} \left(\frac{4 \Delta V}{E K} \right) = \frac{2 \Delta V}{E K}$$

$\sigma = \frac{M y}{I}$ and $I = \frac{b d^3}{12}$ where, M = Bending moment

$y = \frac{d}{2}$

σ = stress

$M = WL$

so, Young's Modulus $E = \sigma / \varepsilon$

• Observation

K=2 , E = 5V , Multiplying Factor = 100

SL. No.	LOAD (N)	VOLTAGE (mV)	ΔV $(V_{i+1} - V_i)$ (mV)	STRAIN $\epsilon \times 10^{-5}$	σ (MPa)	Y (GPa)
1.	0	1901	—	—	—	—
2.	1	1859	−42	−8	5.86	73.25
3.	2	1815	−44	−8.38	5.86	69.92
4.	3	1770	−45	−8.57	5.86	68.38
5.	4	1728	−42	−8	5.86	73.25
6	5	1684	−44	−8.38	5.86	69.92

$Y_{avg} = 70.94$

• Calculations

$$I = \frac{bd^3}{12} = \frac{25 \times (3)^3}{12} mm^4 = 56.25\ mm^4$$

$$M = WL = 1 \times 220\ mmN$$

$$y = \frac{d}{2} = 1.5\ mm$$

$$\sigma = \frac{My}{I} = \frac{220 \times 1.5\ N\,mm^2}{56.25\ mm^4} = 5.86\ MPa$$

$\therefore\ I = 56.25\ mm^4$
$M = 220\ N\,mm$
$y = 1.5\ mm$
$\sigma = 5.86\ MPa$

for each reading,

$$Y = \frac{\sigma}{\epsilon} \quad \text{and} \quad \epsilon = \frac{4\Delta V}{EK}$$

1|9|16

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- **Procedure:** 1) Dimensions of cantilever beam are recorded with the help of vernier caliper.

  2) Strain gauge are attached and circuit is connected as shown in the figure.

  3) Loads are placed at the end of cantilever beam and change in voltage per newton addition of load are recorded for 5 values.

  4) Values of ε (strain), σ (stress) and Y (Young's Modulus) are calculated using ΔV.

- **Results and Conclusion:**

➤ The value of Young's Modulus found by strain gauge experiment is 70.94 GPa.

➤ This value is very close and within experimental error of the standard value (65 GPa).

- **Discussions:**

➤ Due to the application of load, the beam experiences a strain. This strain leads to a change in resistance of the beam, this change is electrically calculated using the principle of wheatstone bridge.

➤ While calculating the length of the beam, the distance between its tip (where load is applied) to the centre of the strain gauge should be taken.

➤ Since the change in the length due to applied load is very small, DATE 1/9/16

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change in potential difference observed in the wheatstone bridge will be unnoticeably small, hence an amplification factor of 100 is used.

➤ Due to heat generated by passage of current in the circuit, the resistance may change to great extent. Hence, we must pass the circuit momentarily and get the readings quickly.