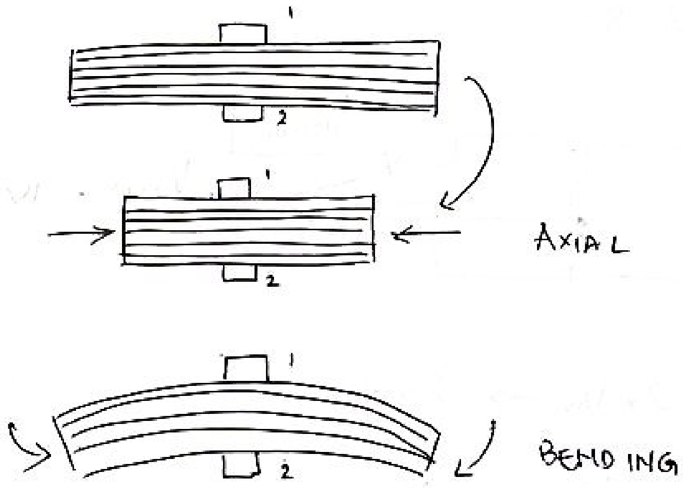
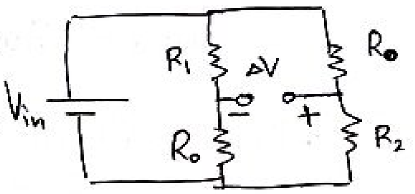
MA 2011 - Tutorial 4

1.



$S_1 = S^a + S^b + S^T$ —(1)

$S_2 = S^a - S^b + S^T$ —(2)

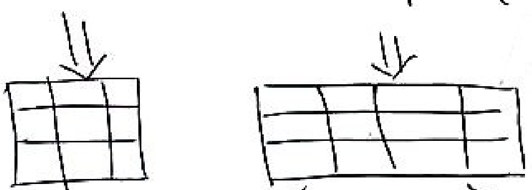


$$\frac{\Delta V}{V_{in}} = \frac{1}{4} G\left(\cdot S_2 + 0 + S_1 + 0\right) \quad \text{— (3)}$$

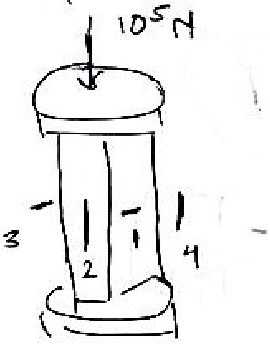
$$= \frac{1}{4} G\left(S^a - \cancel{S^b} + S^T + S^a + \cancel{S^b} + S^T\right)$$

$$= \frac{1}{4} G\left(2S^a + 2S^T\right) = \frac{1}{2} G\left(S^a + S^T\right)$$

2.



$\nu \Rightarrow$ Poisson's ratio.



$S_2 = S_4 = S^a + S^T$ —(1)

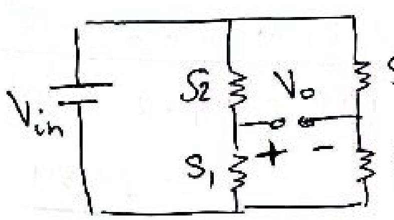
$S_1 = S_3 = \underbrace{-S^a}{} + S^T$ —(2)

$= -\nu \cdot S^a + S^T$

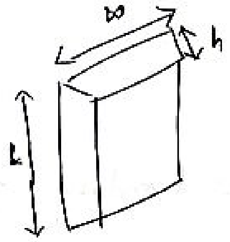
—(3)

$$\frac{V_o}{V_{in}} = \frac{1}{4} G\left(S_1 - S_2 + S_3 - S_4\right)$$

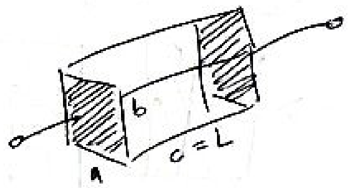
$$= \frac{1}{4} G\left(-\nu \cdot S^a + \cancel{S^T} - S^a - \cancel{S^T} - \nu \cdot S^a + \cancel{S^T} - S^a - \cancel{S^T}\right)$$

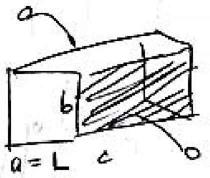


3.



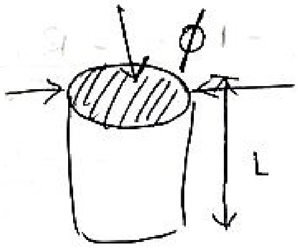
$$\frac{dR}{R} = \left(\frac{d\rho}{\rho}\cdot\frac{1}{S} + 1 + 2\nu\right)S$$





$$A = b\cdot c$$

$$A = a\cdot b$$



$$R = \rho\cdot\frac{L}{A}$$

$$dR = d\rho\cdot\frac{L}{A} + \rho\cdot\frac{dL}{A} + \rho\cdot L\, d\left(\frac{1}{A}\right)$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dL}{L} - \frac{dA}{A}$$

$$A = \pi r^2 = \frac{\pi}{4}\cdot\phi^2$$

$$dA = \frac{\pi}{4}\cdot 2\cdot\phi\cdot d\phi$$

$$\frac{dA}{A} = \frac{\pi/4\cdot 2\cdot\phi\cdot d\phi}{\pi/4\cdot\phi^2} = \frac{2\cdot d\phi}{\phi}$$

$$\frac{d\phi}{\phi} = \frac{dL}{L}(-\nu)$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dL}{L} - \left(-\nu\cdot 2\cdot\frac{dL}{L}\right)$$

$$= \frac{d\rho}{\rho} + \frac{dL}{L} + \frac{2\nu\, dL}{L}$$

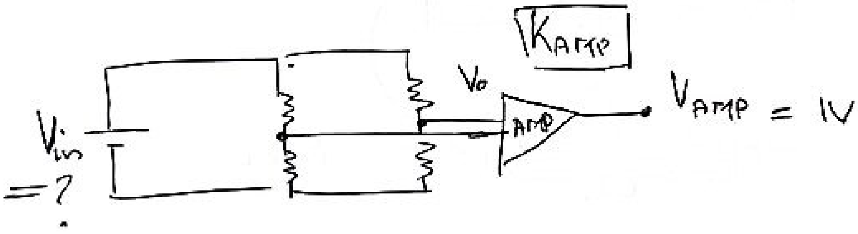
$$= \frac{d\rho}{\rho} + S + 2\nu\cdot S$$

$$= \left(\frac{d\rho}{\rho}\cdot\frac{1}{S} + 1 + 2\nu\right)\cdot S$$

$$= -\frac{1}{4} G \left(2 + 2\nu\right) \varepsilon^{a}$$

$$= -\frac{1+\nu}{2} \cdot G \cdot \varepsilon^{a}$$

$$\frac{V_o}{V_{in.}}$$



$$2 \times V_{in} \rightarrow 2 \times V_o$$

$$V_{MAX} = ?$$

$$I_{MAX} = 30mA$$

Nominal resistance, R_o

$$\boxed{V_{MAX} = 2R_o \cdot I_{MAX}}$$

$$= 2 \cdot 100\Omega \cdot 30mA$$

$$= 6V$$

$$\boxed{V_{MAX} \leq 6V}$$

$$\boxed{V_{AMP} = K_{AMP} \cdot V_o}$$

$$V_o = \frac{V_{AMP}}{K_{AMP}}$$

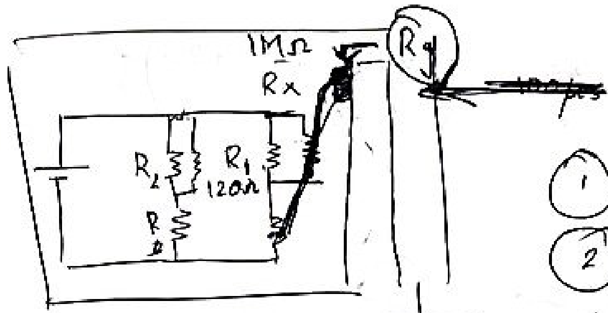
$$\frac{V_o}{V_{in}} = \frac{V_{AMP}}{K_{AMP} \cdot V_{MAX}} = \frac{-1+\nu}{2} \cdot G \cdot \varepsilon^{a}$$

$$= \frac{-1+\nu}{2} \cdot G \cdot \left(\frac{-F_o}{A \cdot E}\right)$$

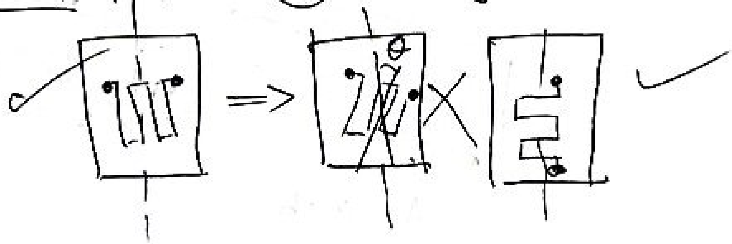
$$K_{AMP} = \frac{2 \cdot V_{AMP} \cdot A \cdot E}{(1+\nu) \cdot G \cdot F_o \cdot V_{MAX}} = \frac{2 \cdot 1 \times 10^{-2} m^2 \cdot 210 \cdot 10^9 Pa}{(1+0.29) \cdot 2 \cdot 1 \times 10^5 N \cdot 6V}$$

$$= \underline{2584}$$

4.



① Poor bonding
② Misalignment



$$\frac{dR_g}{R_g} = G^* \cdot S$$

$G^* = ?$

$$\frac{dR_1}{R_1} = \frac{R_1 // R_x}{R_1} - \frac{R_1}{R_1} = \frac{R_x}{\cancel{R_1} + R_x} - 1 \approx -\frac{R_1}{R_x}$$

$$= \frac{-120\ \Omega}{1M\Omega}$$

$$= -120 \cdot 10^{-6}$$

$$\frac{dR_g}{R_g} + \frac{dR_1}{R_1} = 0$$

$$\frac{dR_g}{R_g} = -\frac{dR_1}{R_1} = +120 \cdot 10^{-6}$$

$G^* \cdot 100\,\mu s = G^* = 1.2$