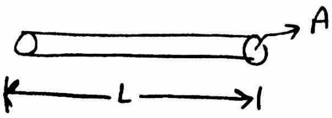
* Strain measurements with Strain Gauges

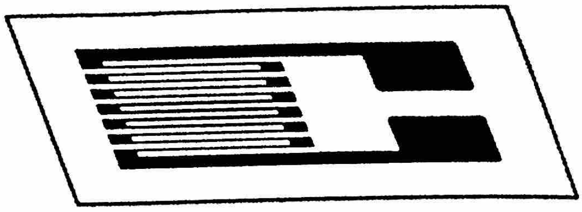
* **Strain Gauge**: It is a tool used to measure strain based on the change of Resistance

* **For a wire**



Resistance $(R) = \frac{\rho L}{A}$

ρ: resistivity
L: length
A: area



Strain gauge

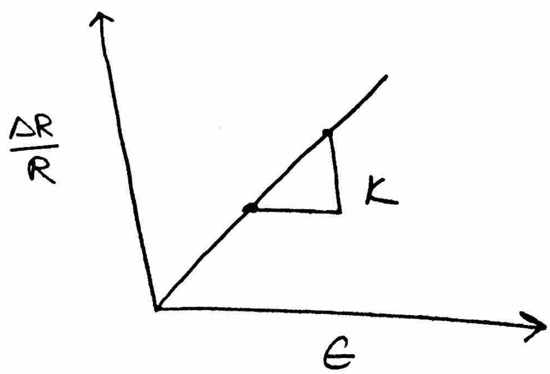
* If length (L) changes ΔL → Resistance will change ΔR

⇒ From change in Resistance we can know change in Length ⇒ Strain $\epsilon = \frac{\Delta L}{L}$

$$\frac{\Delta R / R}{\Delta L / L} = K$$

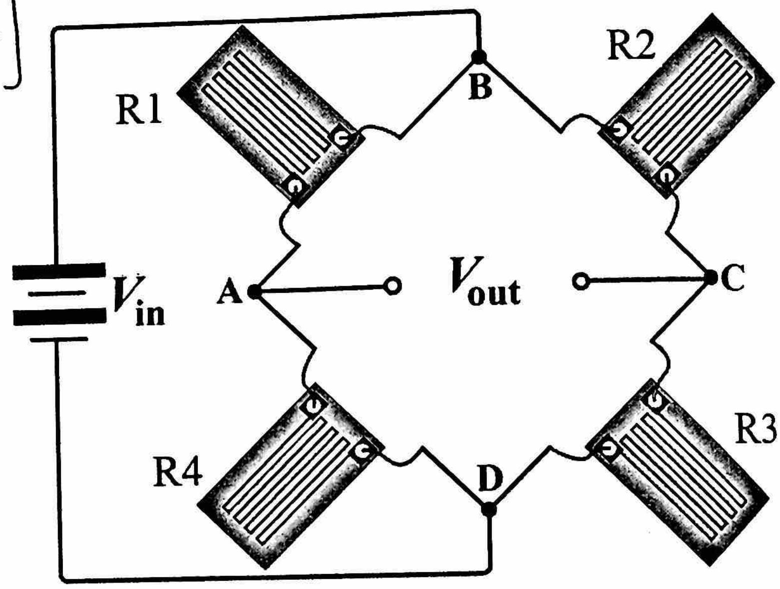
K: Gauge factor

$$\Rightarrow K = \frac{\Delta R / R}{\epsilon}$$



* Wheatstone Bridge is a common circuit used in strain measrement

$$\frac{V_{out}}{V_{in}} = \frac{1}{4}\left[\frac{\Delta R_1}{R_1} - \frac{\Delta R_2}{R_2} + \frac{\Delta R_3}{R_3} - \frac{\Delta R_4}{R_4}\right]$$



$$\frac{\Delta R/R}{\epsilon} = K \Rightarrow \Delta R/R = \epsilon K$$

$$\frac{V_{out}}{V_{in}} = \frac{K}{4}\left(\epsilon_1 - \epsilon_2 + \epsilon_3 - \epsilon_4\right)$$

Types of Wheatstone Bridges

① Full bridge - All bridges are having strain gauges

$$\frac{V_{out}}{V_{in}} = \frac{K}{4}\left(\epsilon_1 - \epsilon_2 + \epsilon_3 - \epsilon_4\right)$$

② Half-Bridge $R_3 = R_4 = 0$ " NO (ΔR)

$$\frac{V_{out}}{V_{in}} = \frac{K}{4}\left(\epsilon_1 - \epsilon_2\right)$$

③ Diagonal-bridge $R_2 = R_4 = 0$

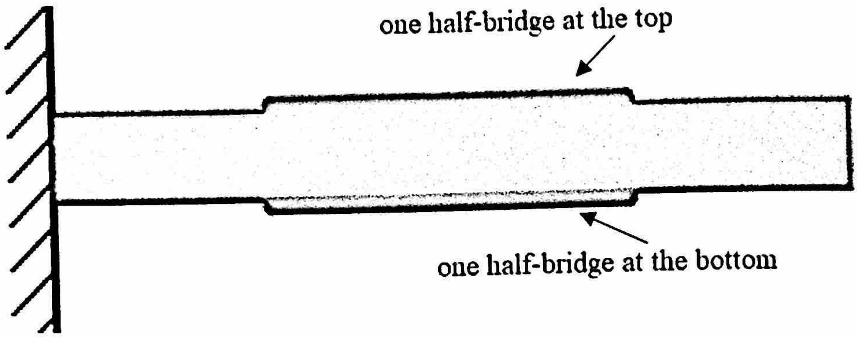
$$\frac{V_{out}}{V_{in}} = \frac{K}{4}\left(\epsilon_1 - \epsilon_4\right)$$

④ Quarter Bridge $R_2 = R_3 = R_4 = 0$

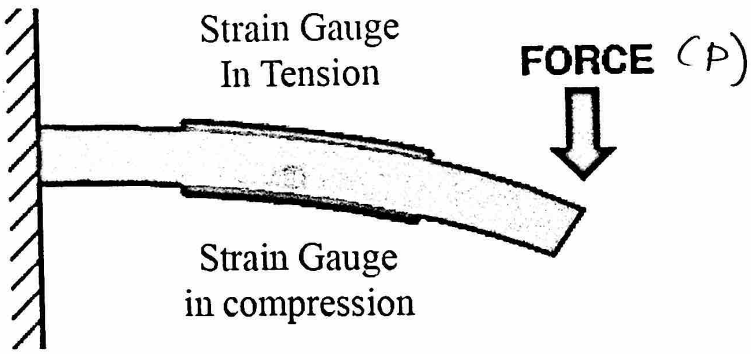
$$\frac{V_{out}}{V_{in}} = \frac{K}{4}\epsilon_1$$

* In the lab, we will attach two half-bridge circuits one at the top of the beam and one at the bottom

* One strain gauge measure axial strain ϵ_{axial} at top and one at bottom
  ⇒ Average

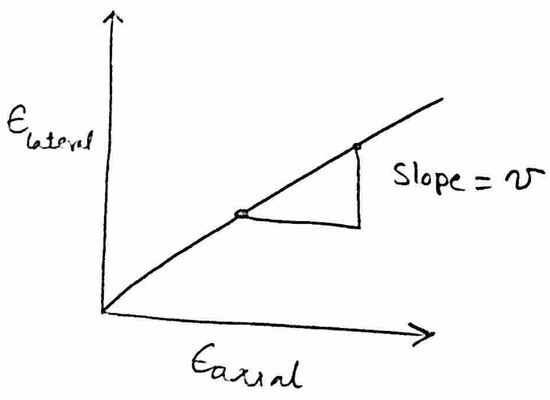


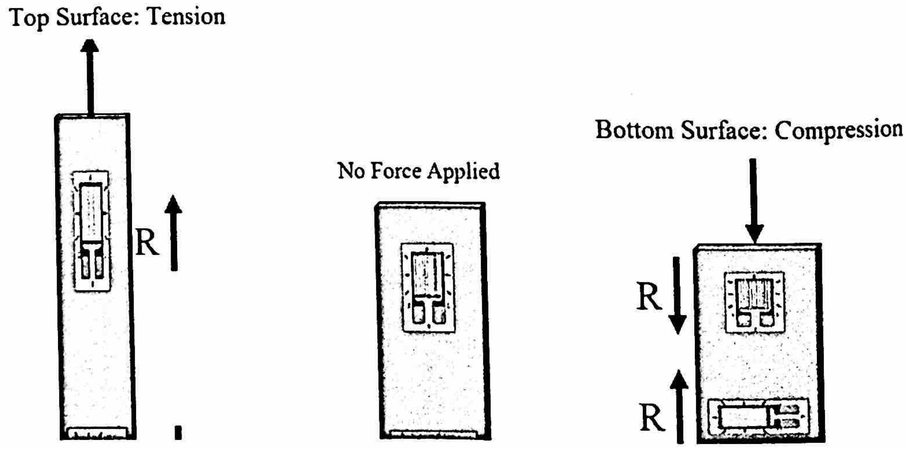
* One strain gauge measures lateral strain $\epsilon_{lateral}$ at top and at bottom
  ⇒ Average



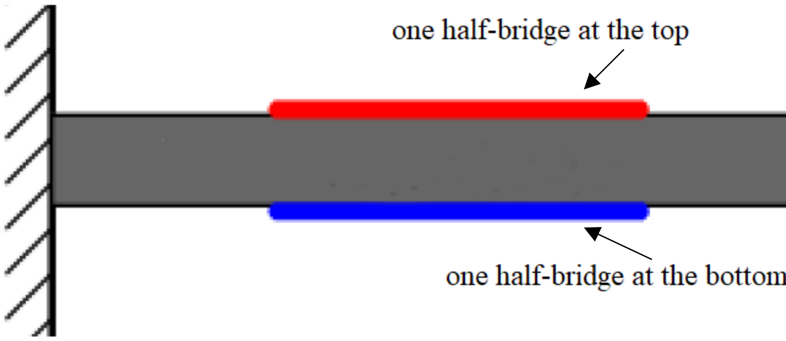
* Take many P values and measure ϵ_{axial} and $\epsilon_{lateral}$ for each run

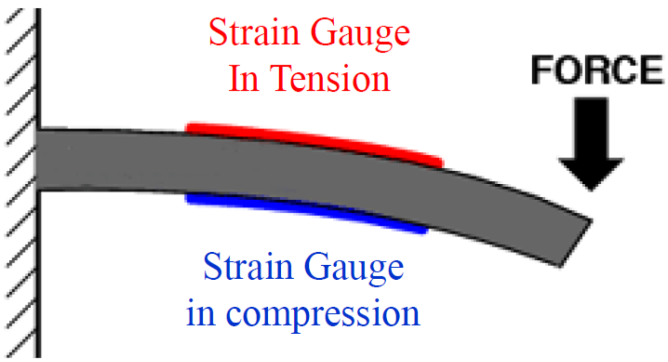
Plot

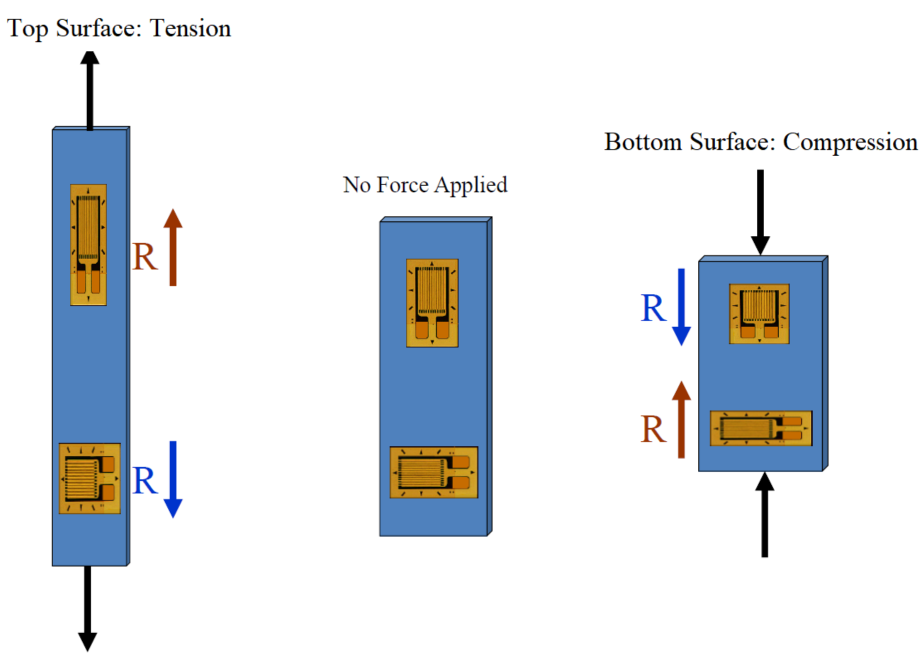




$$\text{Poisson's ratio } (\nu) = \frac{\epsilon_{lateral}}{\epsilon_{axial}}$$


one half-bridge at the top
one half-bridge at the bottom


Strain Gauge
In Tension
FORCE
Strain Gauge
in compression


Top Surface: Tension
R
R
No Force Applied
Bottom Surface: Compression
R
R