ELL 301

01.03.2019

Sensor → Strain Gauge

↳ $\frac{\Delta L}{L}$

→ underlying principle

→ typical usage

Underlying principle

Strain causes a change in resistance. Change in resistance is measured to measure the strain

x - independent variable

y - dependent variable

	$\Delta y / \Delta x$	$\frac{\Delta y}{y} / \frac{\Delta x}{x}$
$y = x$	1	1
$y = x^2$	$2x$	2
$y = x^n$	$n x^{n-1}$	n
	$\frac{dy}{dx}$ ↑ absolute change	$\frac{d \ln y}{d \ln x}$ ↑ relative change

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

F ↑ gauge factor

$\Delta L / L$ → strain

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

ρ → resistivity (material dependent)

L → length

A → area of cross-section

$$\ln R = \ln \rho + \ln L - \ln A$$

$$\frac{\Delta R}{R} = \frac{\Delta \rho}{\rho} + \frac{\Delta L}{L} - \frac{\Delta A}{A}$$

$$= \frac{\Delta \rho}{\rho}_{\text{material}} + \frac{\Delta L}{L} - 2 \cdot \frac{\Delta r}{r}, \quad \left[\text{assuming } A = \pi r^2\right]$$

$$= \frac{\Delta\rho}{\rho} + (1+2\nu)\frac{\Delta L}{L}$$

Poisson factor $\nu = \dfrac{-\Delta r/r}{\Delta L/L}$

$$\frac{\Delta R}{R} = \frac{\Delta\rho}{\rho} + (1+2\nu)\frac{\Delta L}{L}$$

$$\Rightarrow F = \frac{\Delta R/R}{\Delta L/L} = \frac{\Delta\rho/\rho}{\Delta L/L} + (1+2\nu)$$

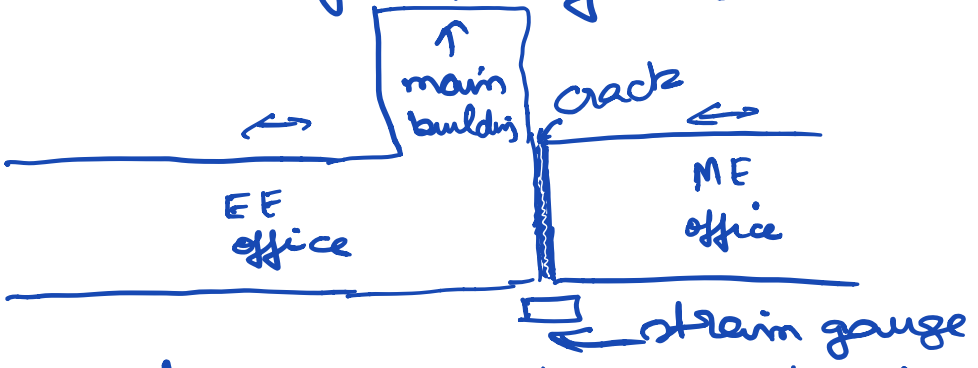
$\frac{\Delta\rho/\rho}{\Delta L/L}$: small for metals, large for semiconductors

$(1+2\nu)$: 2-3 for metals

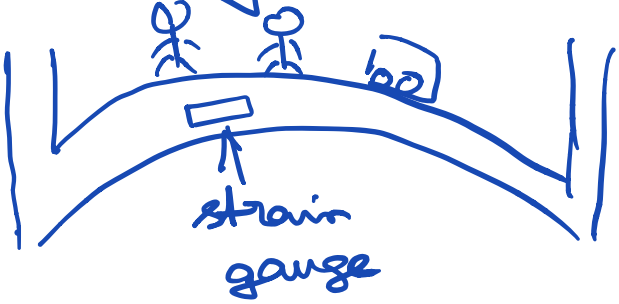
For metals, $F \cong 1+2\nu$

Strain Gauges

Where might they be used?



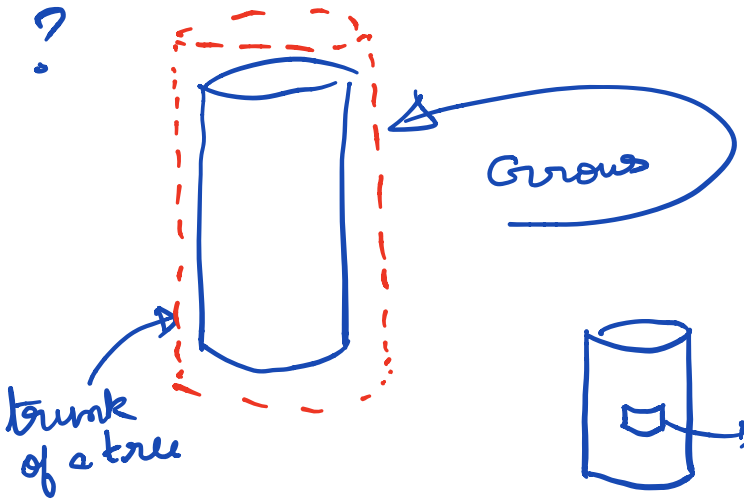
Building and other vibrations



Bridge

winds
people
vehicles

- ?

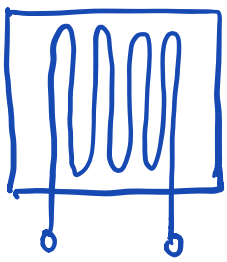


Can strain gauges be used to measure this growth?

→ measuring strain or increase in length in radial direction

One classification

Type 1: Bonded strain gauges



Bonded because this is attached to the surface under measurement.

strain in this direction measured

→ Resistance changes add up in series

→ this measures strain in up-down direction

→ $\frac{\Delta R}{R}$ should be the same

so what is reason for multiple conductors?

→ average strain across length

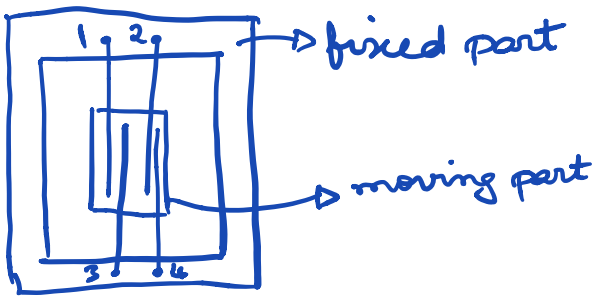
→ will check ...

→ average strain by taking long length.

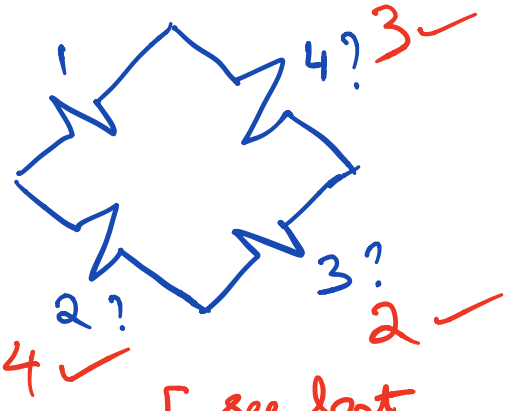
- these are available in configurations that measure strains in different directions - rosettes

Type 2: Unbonded strain gauges (not attached)

What arrangement of 1, 3, 4 on a Wheatstone bridge maximises sensitivity?



1, 2, 3, 4 → conductors under strain



relative motion between the parts cause strain in the conductors 1, 2, 3, 4, which are converted into resistance change.

[see last lecture on which resistance changes add up?