AS3520

Lecture 1

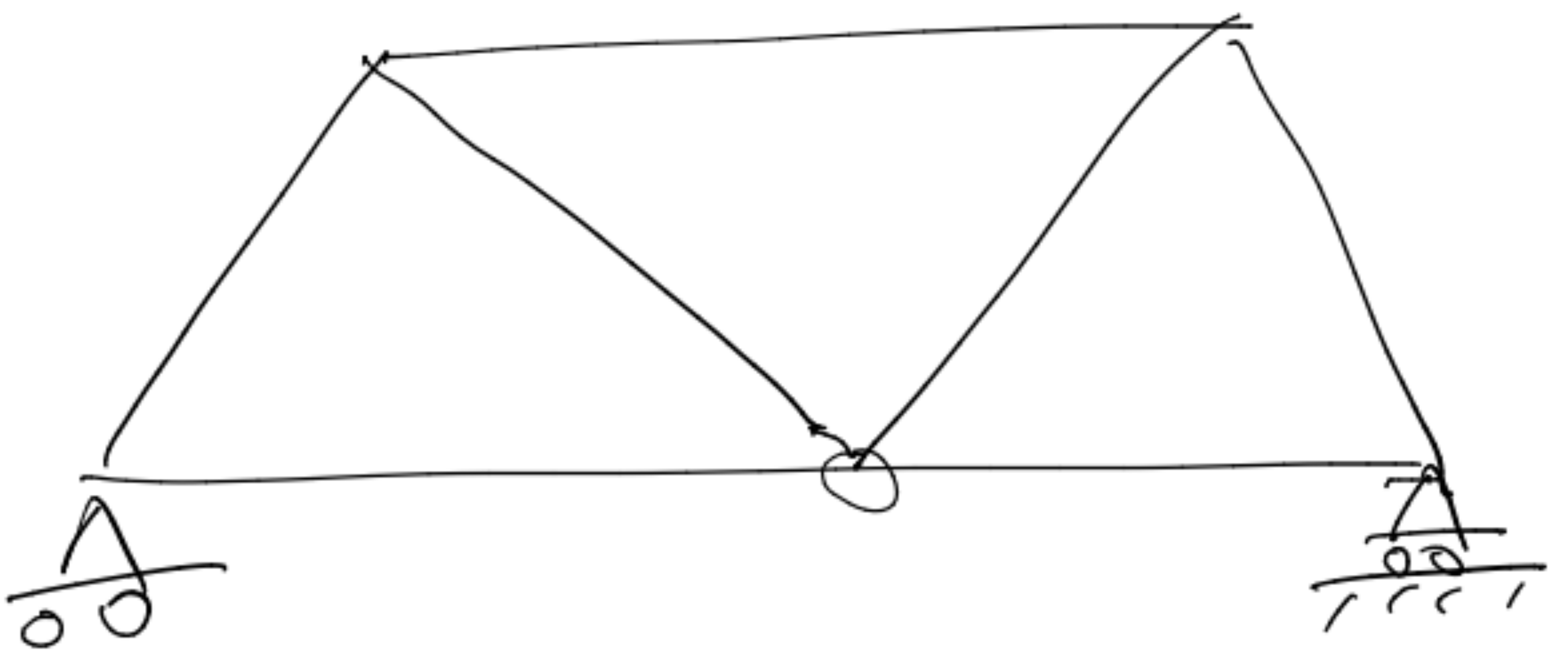
1. Strain gauges
2. Photo elasticity
3. Wave propagation

~ 10 lectures
~ 1 hour.

Book: Freddi, Olmi, Cristofolini,
Experimental stress analysis
for materials & structures.
Springer.

Chapter 2: Strain gauges
Chapter 3: Photo elasticity.

1. Strain Gauges.



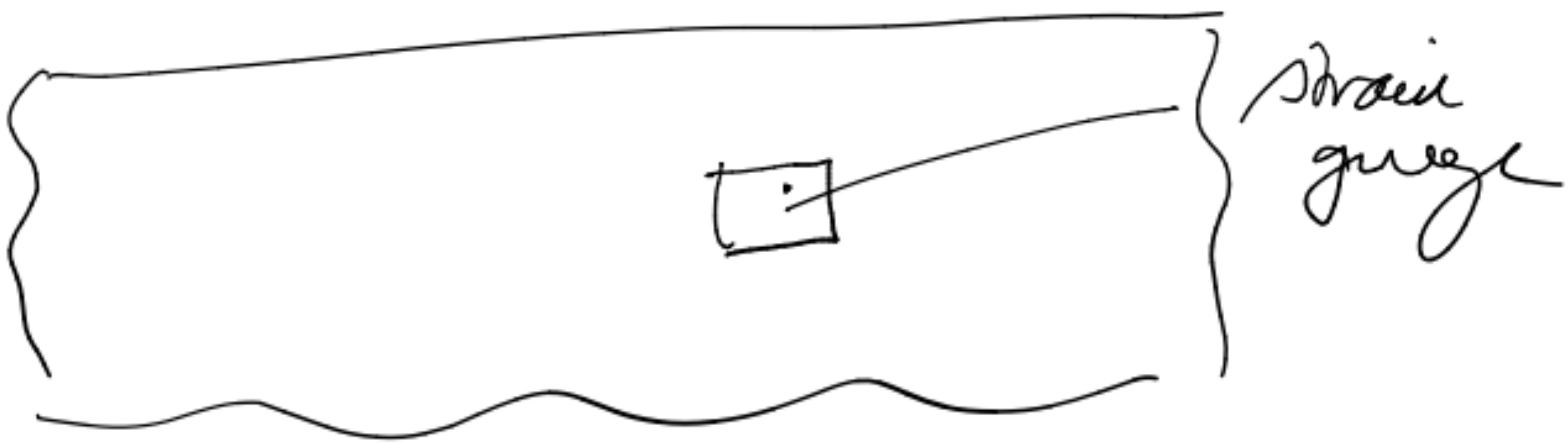
① Monitor structural health:
track the stiffness of critical components
- Embed strain gauges in various components.
- Commercial use of strain gauges.

② 

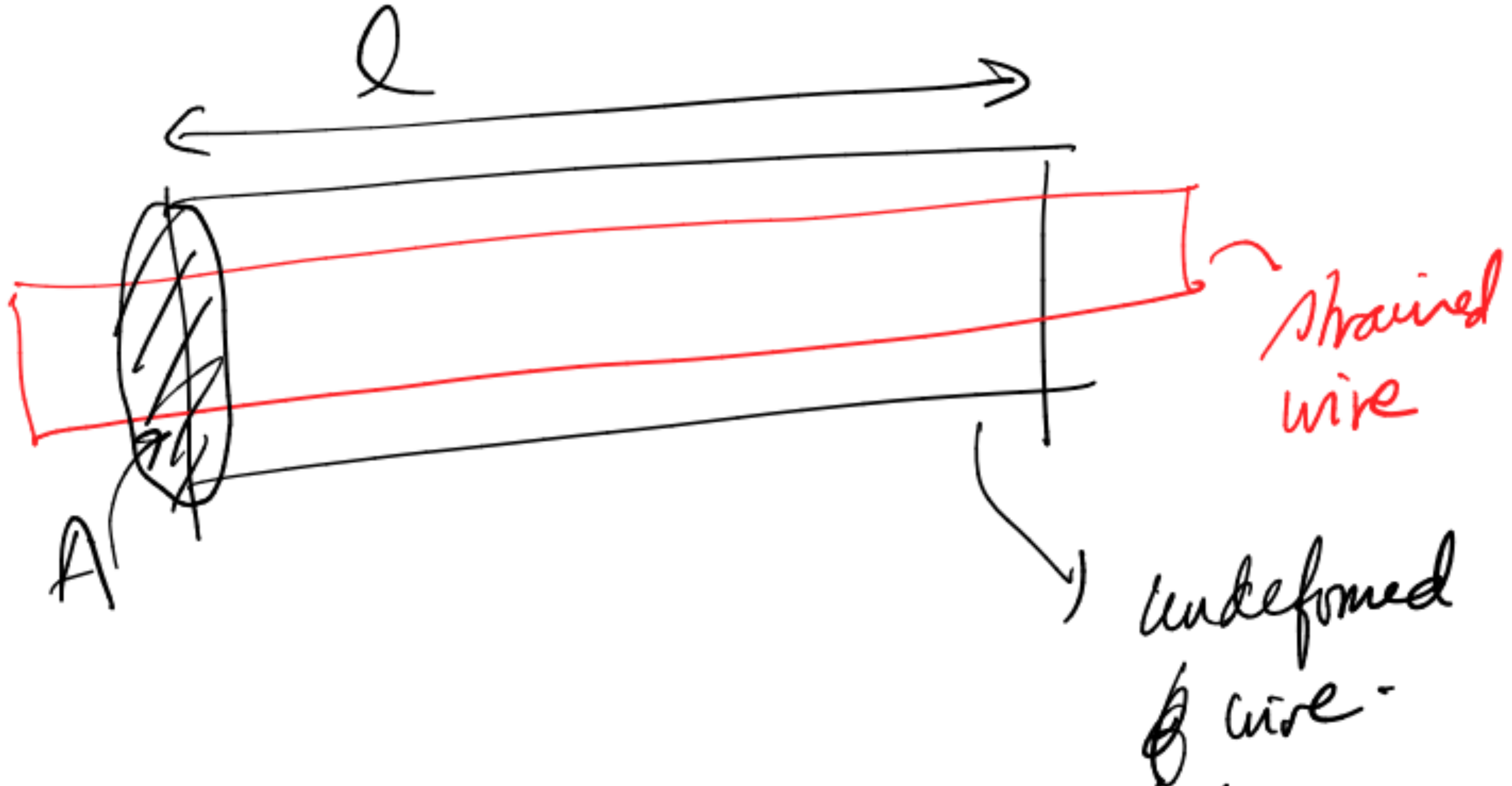
Structural mechanics theories do not apply near connections, fillets, reentrant corners etc.

- It is better to measure the stress state in a prototype.
- Strain gauges are useful for measuring the critical stress state close to connections, fillets, etc.

Principle of strain measurement.



- Resistors change their resistance when subjected to strain.
- Measure the resistance change & use it to deduce strain.

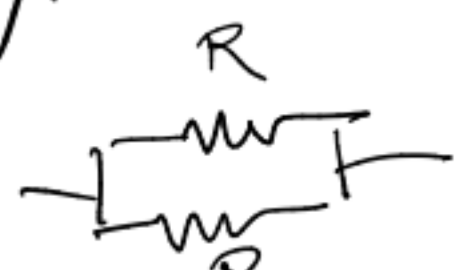


Consider a resistor (metal or alloy) l, A, ρ (resistivity)

ρ — resistivity — is a material property.

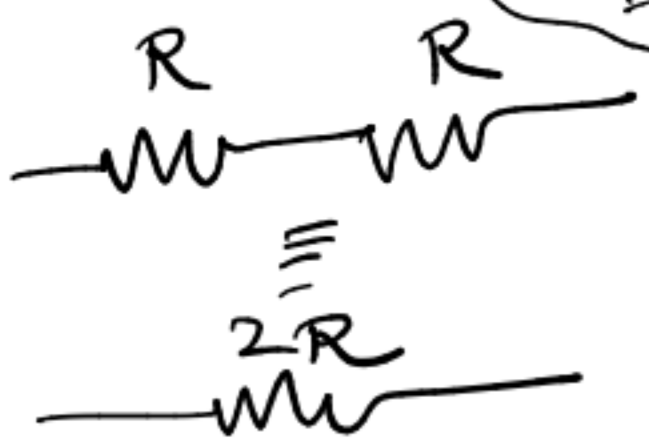
$$R = \frac{\rho l}{A}$$

↑ resistance of the wire.

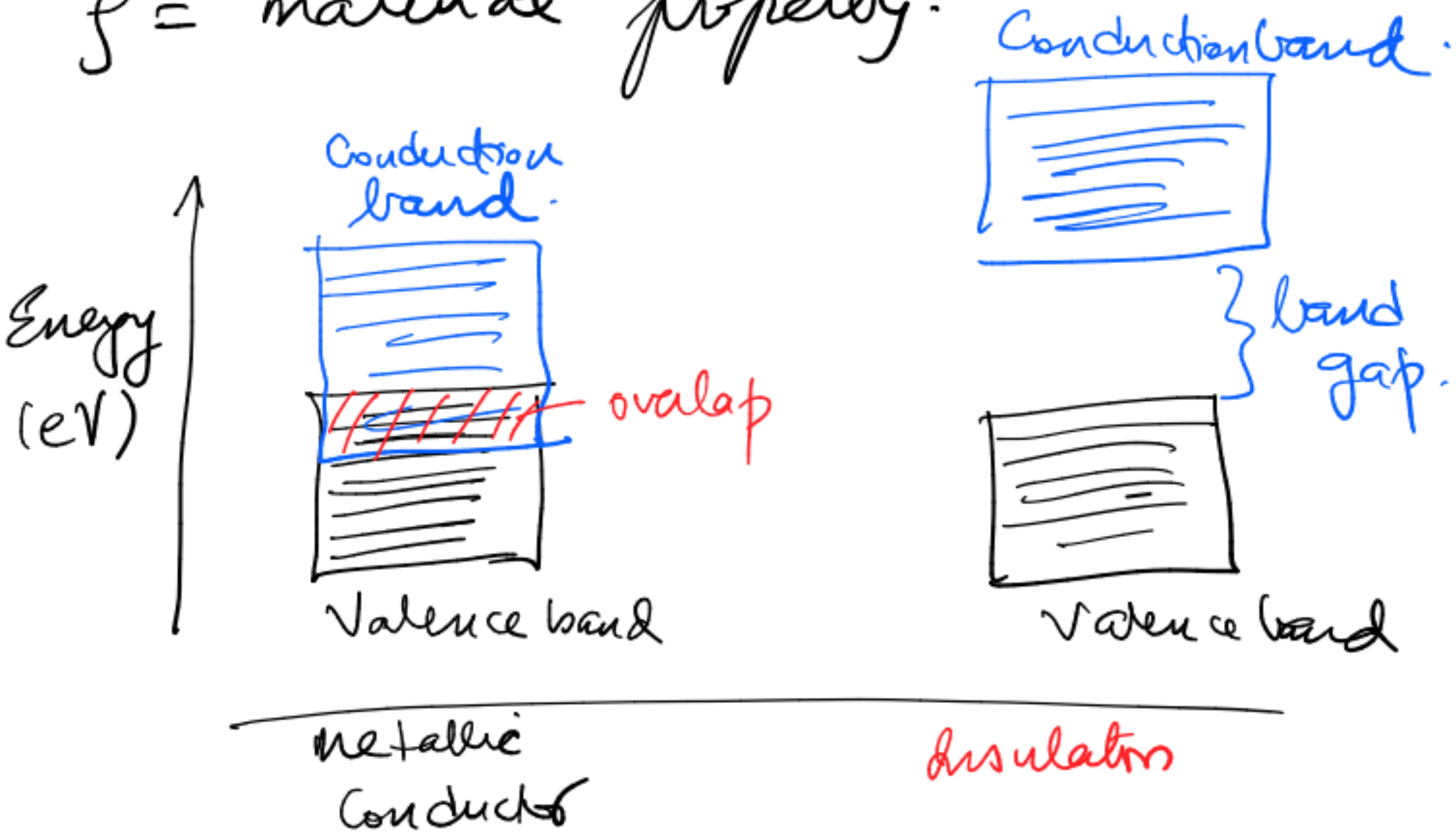


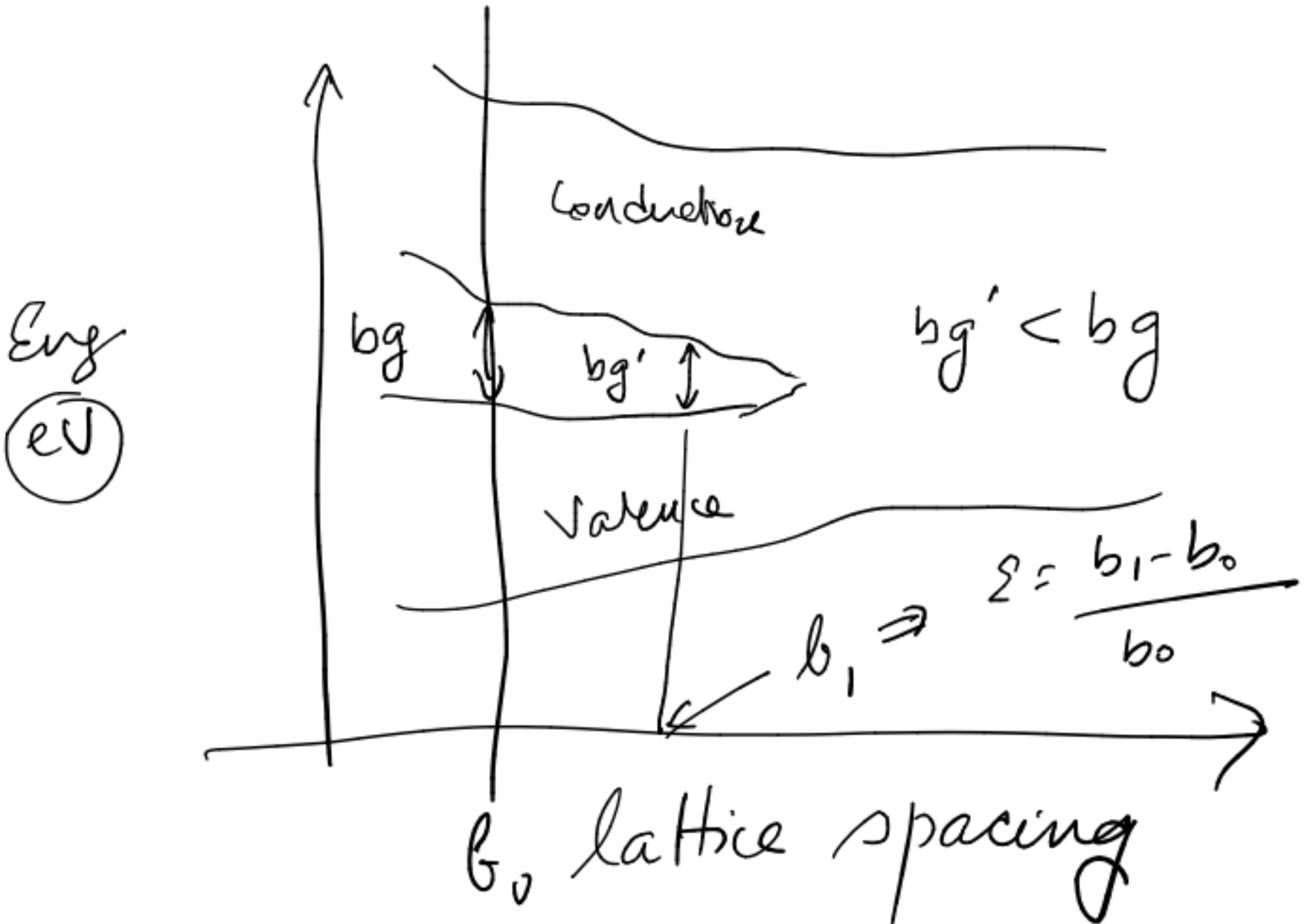
$$\frac{1}{R_e} = \frac{1}{R} + \frac{1}{R}$$

$$\Rightarrow R_e = R/2$$



ρ = material property.





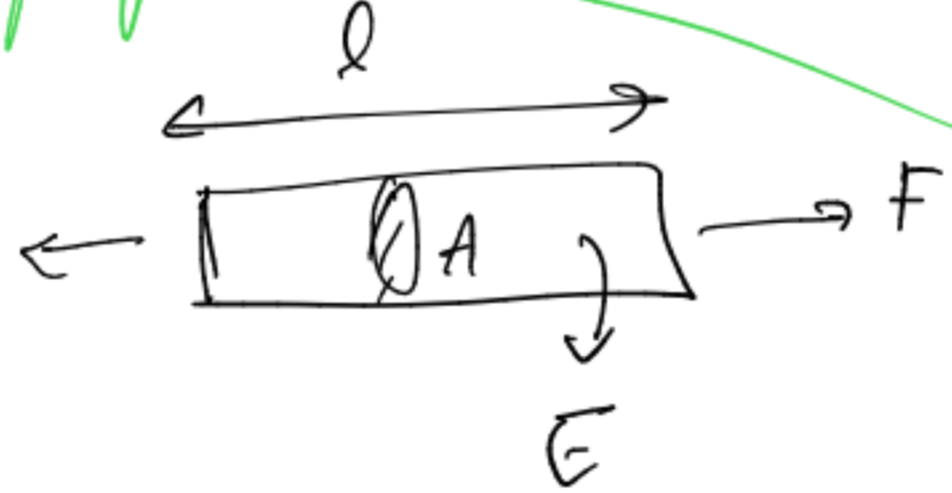
ρ = resistivity = material property =

ρ can change with strain.

Component properties

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

material — geometric



$$k = \frac{EA}{l}$$

material — geometric

$$\delta = \frac{Fl}{AE}$$

Change of $R \rightarrow \Delta R$.

$$R = \frac{\rho l}{A}.$$

$$d(\log R = \log \rho + \log l - \log A)$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \frac{dl}{l} - \frac{dA}{A}.$$

circular cross section: $A = \frac{\pi r^2}{2}$.

$$A = \pi r^2$$

$$dA = \pi\, 2r\, dr$$

$$\frac{dA}{A} = \frac{2\pi r\, dr}{\pi r^2}$$

$$= \frac{2\, dr}{r}$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \underbrace{\frac{dl}{l}}_{\varepsilon} - \underbrace{\frac{2\, dr}{r}}_{-\nu\varepsilon}$$

$$= \frac{d\rho}{\rho} + \varepsilon + 2\nu\varepsilon$$

$$\frac{dR}{R} = \frac{d\rho}{\rho} + \varepsilon(1+2\nu)$$

$$= \left[\underbrace{\frac{d\rho}{\rho}\Big/\varepsilon}_{\text{const}} + 1+2\nu\right]\varepsilon .$$

We will have $\frac{d\rho}{\rho} / \frac{dl}{l}$ being a constant

for many materials.

We define "guage factor", "sensitivity".

$$S = \left\{ 1 + 2\nu + \frac{d\rho/\rho}{dl/l} \right\}.$$

$$\frac{dR}{R} = S\,\varepsilon$$

ε → calculate.

S → pre-set.

$\frac{dR}{R}$ → measuring

Typical values:

$R = 120\,\Omega$ || $350\,\Omega$, $600\,\Omega$, $1000\,\Omega$

$\varepsilon \simeq 10^{-4}$ to 10^{-2}.

$$\frac{dR}{120} = (2)\left\{10^{-4} \text{ to } 10^{-2}\right\}$$

$dR = 0.024\,\Omega$ to $2.4\,\Omega$

"range of changes in resistance that must be measured by the electrical circuitry".

Strain gauge wire materials:

Constantan — 45Ni55Cu

— $S = 2.1$.

— Room temperature.

" In built temperature correction".