Lecture 1: Strain Gauges

0. Course Intro
1. Strain
2. Strain Gauge
3. Strain Measurement

- Course website: minerva.union.edu/bumat
- Reading: Page 1-4 of Strain Gauge Tutorial pdf
- NO LAB THIS WEEK!
- PreLab 1 due at lab session (Jan 14/16)
- HW 1 due next Thu (Jan 16)

- Office Hours: Mon 2-4 PM
  Wed 9-11 AM

  You are welcome to swing by at other times, but I may not be available!

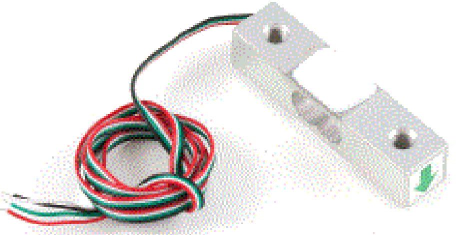
or appointment (set up by email)

bumat@union.edu

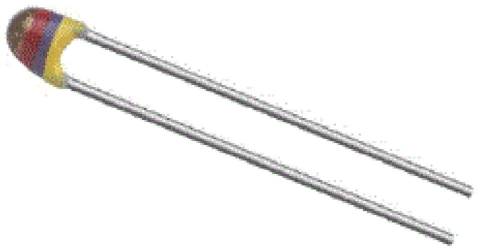
0. Course Intro

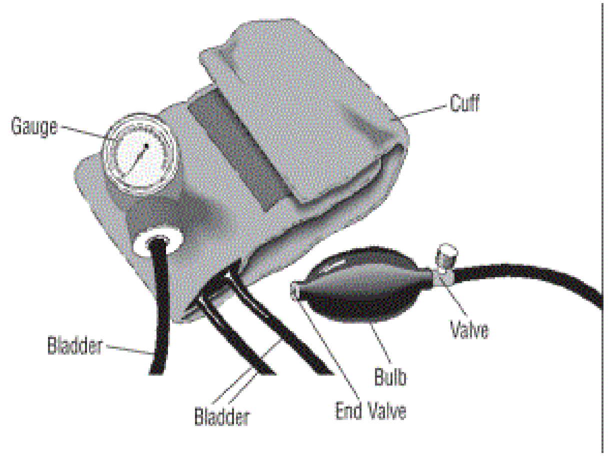
★ Course website: minerva.union.edu/bumat

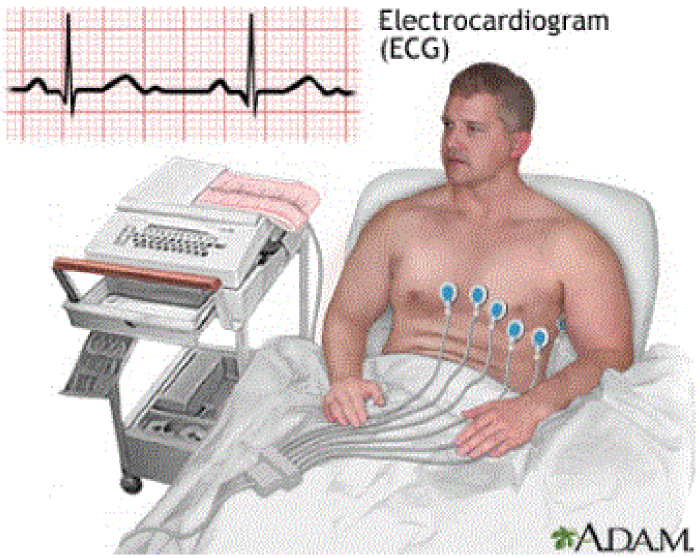
- The lectures and labs for this course will concentrate on:

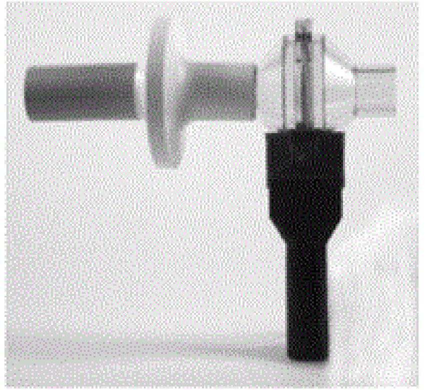
1 

4 

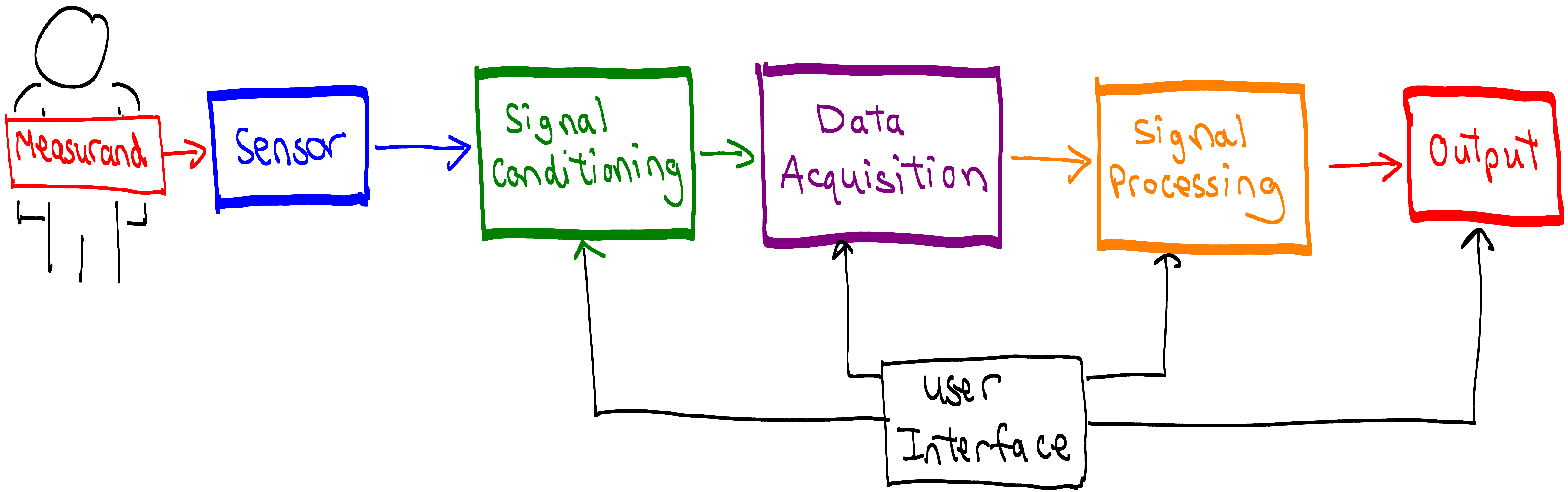
2 

5 

3 

6 

- Typical System Diagram

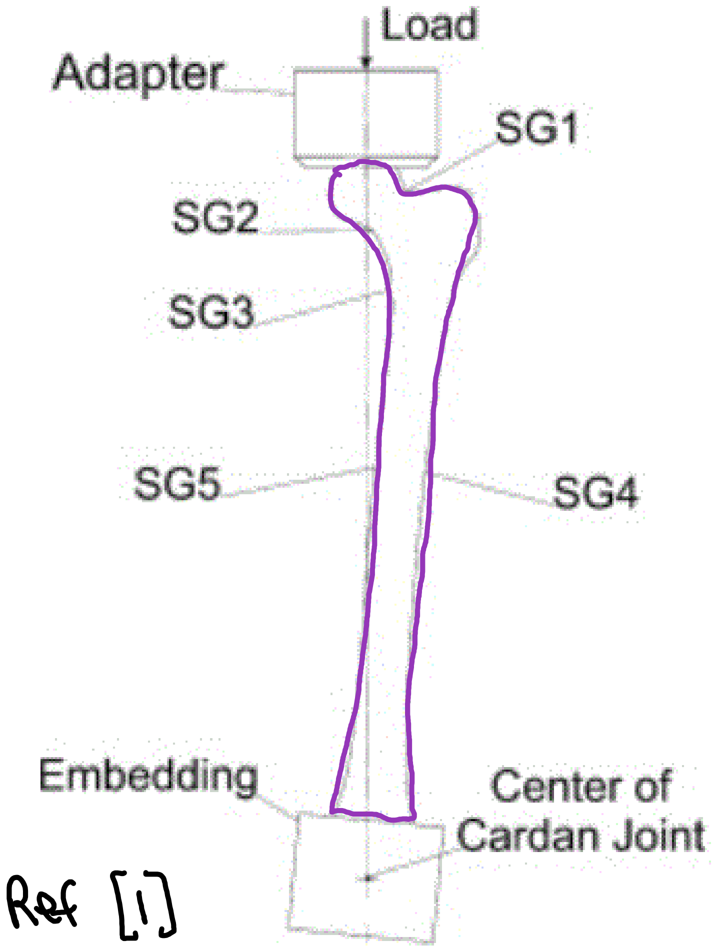


1. Strain

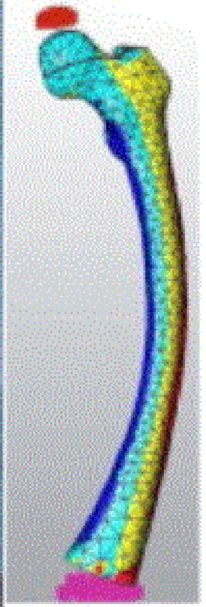
A. Why measure strain?

Strain is the ________ (e.g.   ) of a material that is under a ________ .

Example applications include.



Ref [1]

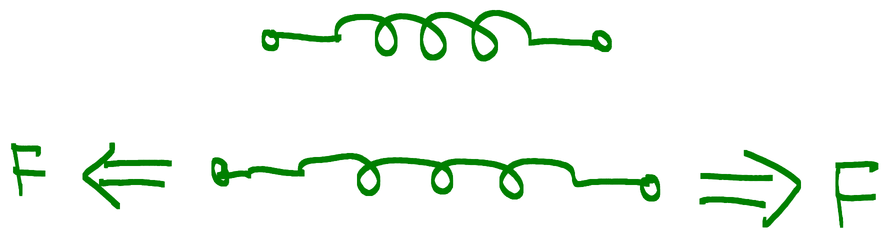


Ref [2]

B. Stress-Strain Tutorial

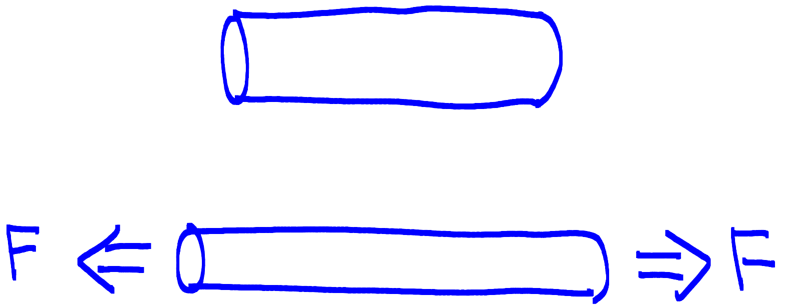
- Hooke's Law :

For a spring, $F =$



For a bulk material, $\sigma =$

Example: Tensile Strain



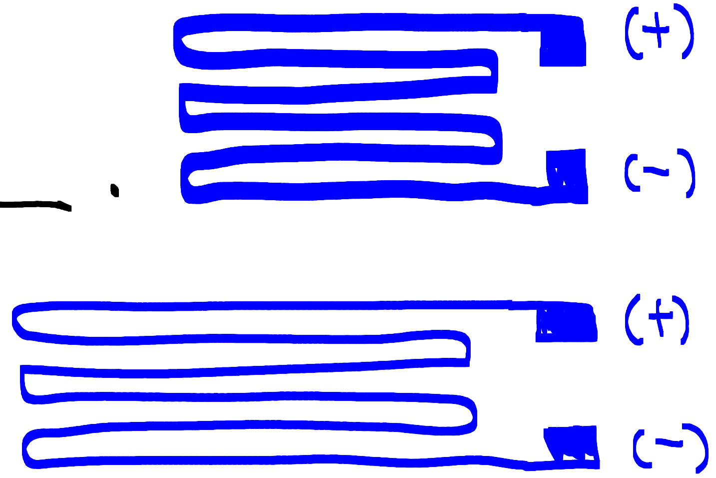
- Strain can also be

Q: How to measure strain?

2. Strain Gauge

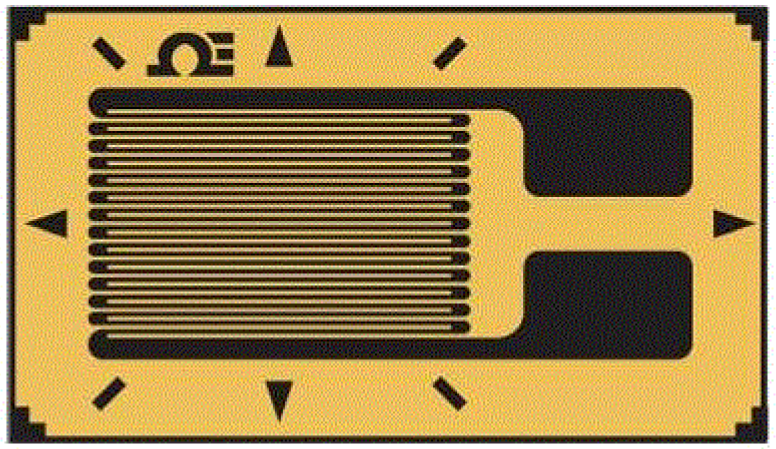
(1.3)

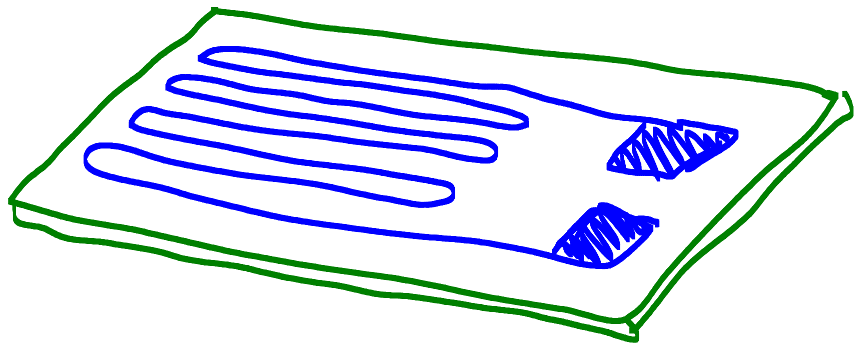
When a thin wire is ______,
its electrical resistance ______.

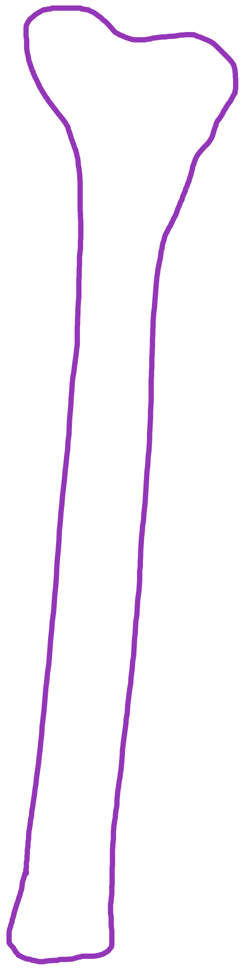


www.omega.com

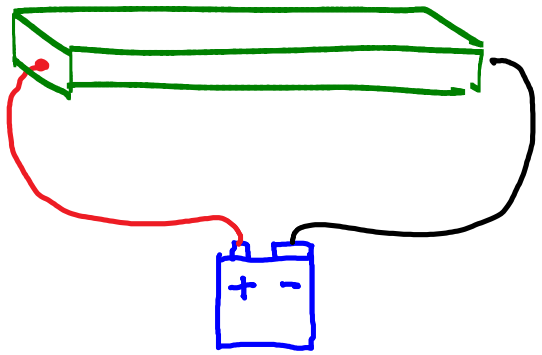
Ref [3]







- Derivation of $\frac{\Delta R}{R} = G\varepsilon$: $R =$



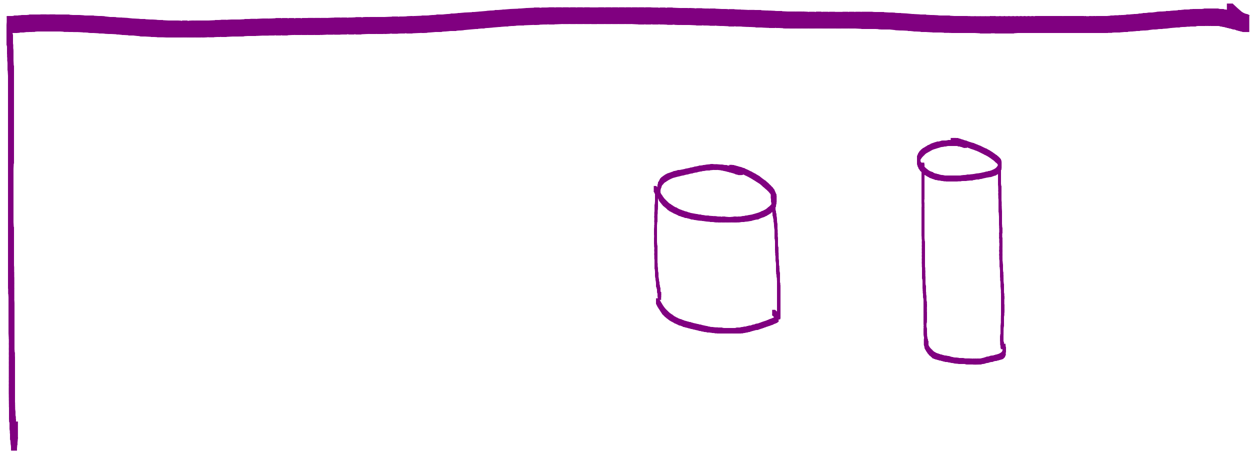
$\Delta R =$

$=$

$=$

$\frac{\Delta R}{R} =$

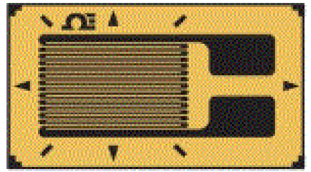
$=$

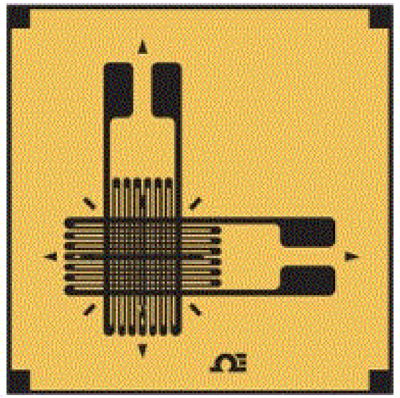


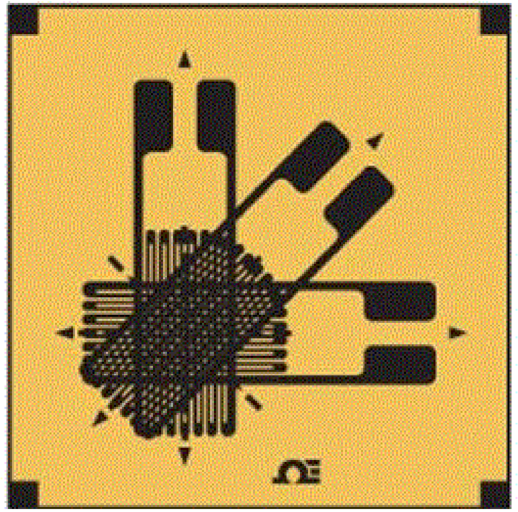
(1.5)

Table 2.1 Properties of Strain-Gage Materials

Material	Composition (%)	Gage Factor	Temperature Coefficient of Resistivity ($°C^{-1}$–10^{-5})
Constantan (advance)	Ni_{45}, Cu_{55}	2.1	±2
Isoelastic	Ni_{36}, Cr_8 $(Mn, Si, Mo)_4$ Fe_{52}	3.52 to 3.6	+17
Karma	Ni_{74}, Cr_{20}, Fe_3 Cu_3	2.1	+2
Manganin	Cu_{84}, Mn_{12}, Ni_4	0.3 to 0.47	±2
Alloy 479	Pt_{92}, W_8	3.6 to 4.4	+24
Nickel	Pure	−12 to −20	670
Nichrome V	Ni_{80}, Cr_{20}	2.1 to 2.63	10
Silicon	(*p* type)	100 to 170	70 to 700
Silicon	(*n* type)	−100 to −140	70 to 700
Germanium	(*p* type)	102	
Germanium	(*n* type)	−150	







Ref [3] www.omega.com

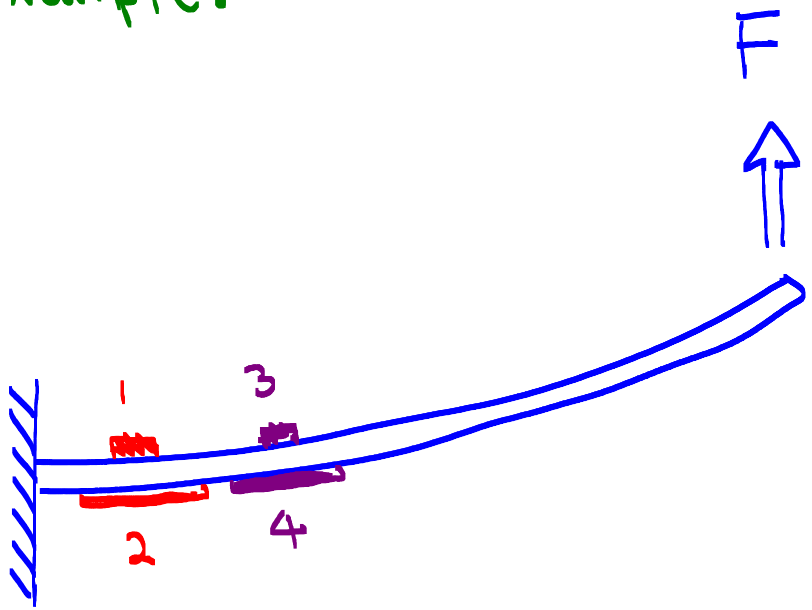
3. Signal Conditioning

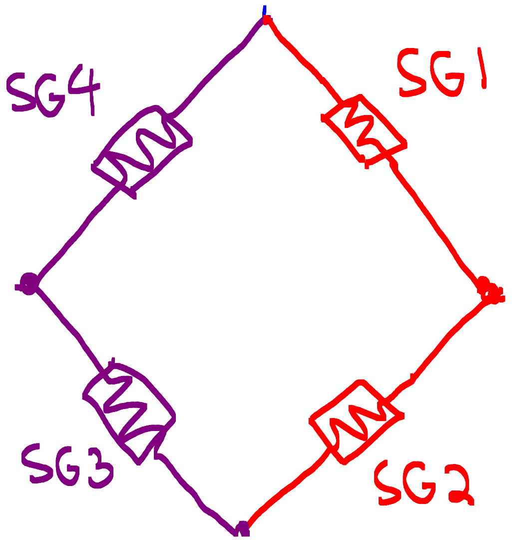
Example

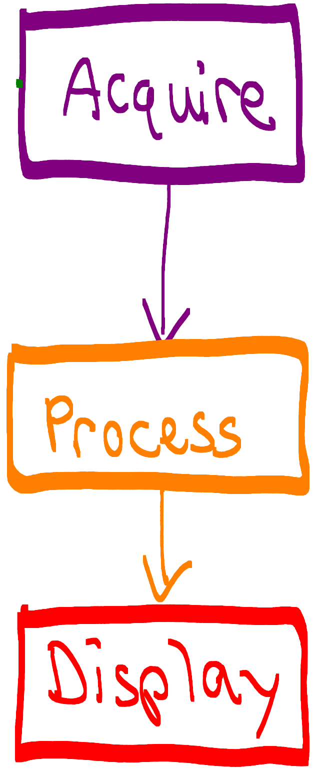
A. How to make a recording?

- To be useful, a strain gauge must be part of a circuit!

Example:

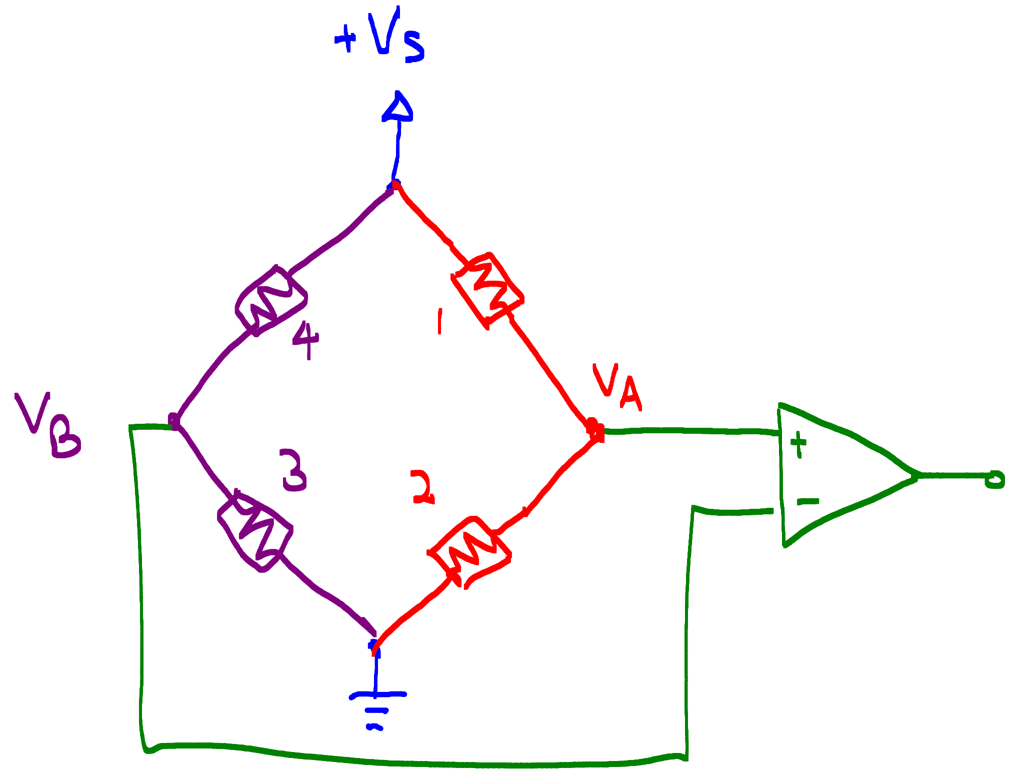






B. Resistor Bridge

- Classic method to detect tiny ΔR (e.g. 0.01Ω)



- $V_A =$

- $V_B =$

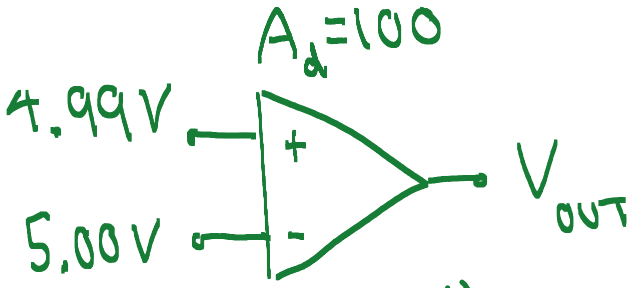
C. Instrumentation Amplifier ← Discuss details later...

Ref [4]

- Used in many biomedical measurement systems
- Amplifies the ______ between two inputs

$V_{OUT} =$

Ex:

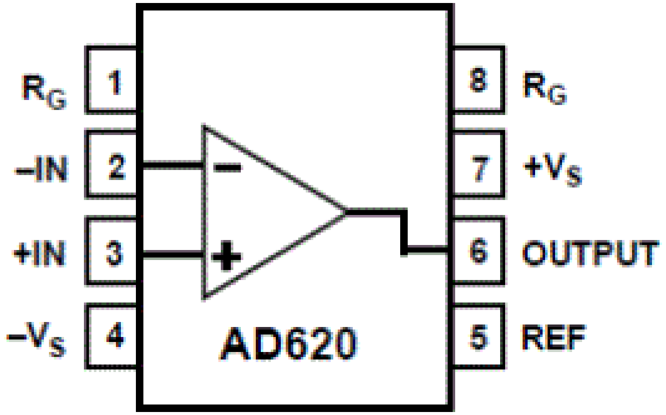


"In Amp"

ANALOG DEVICES

Low Cost Low Power Instrumentation Amplifier

AD620



APPLICATIONS

Weigh scales
ECG and medical instrumentation
Transducer interface
Data acquisition systems
Industrial process controls
Battery-powered and portable equipment

We are using this kind, but there are lots of others...

D. Processing

Q: once we measure $A_d \Delta V$, how do we get strain?

Example: For full bridge:

$V_{measure} =$

Example: $V_{measure} = .5V$

$A_d = 500$

$G = 2.1$

$V_s = 5V$

For full bridge:

$\rightarrow \varepsilon =$

- Bridge Types

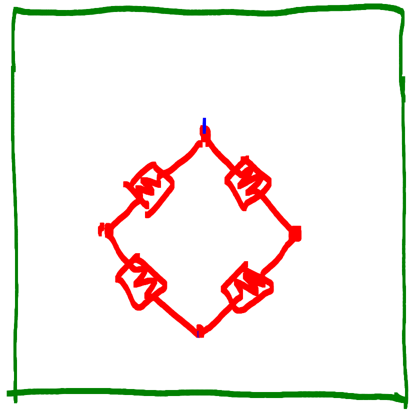
Sample

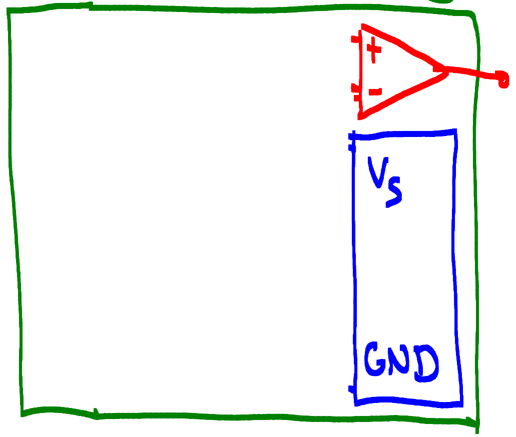
Signal Conditioning

FULL BRIDGE

4 active bridge legs on the sample

$\Delta V =$



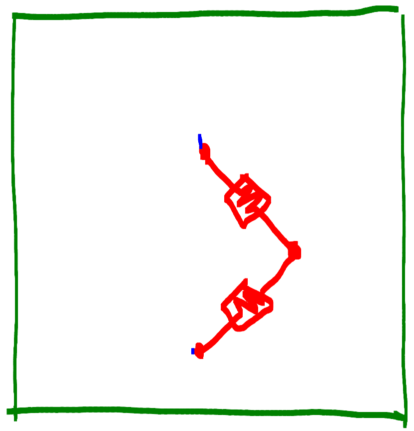


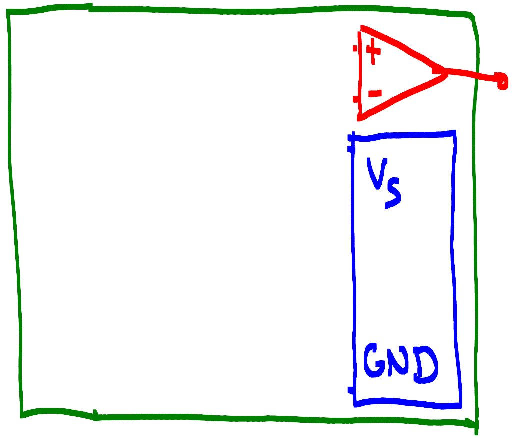
OUT =

HALF BRIDGE

2 active bridge legs on the sample

$\Delta V =$



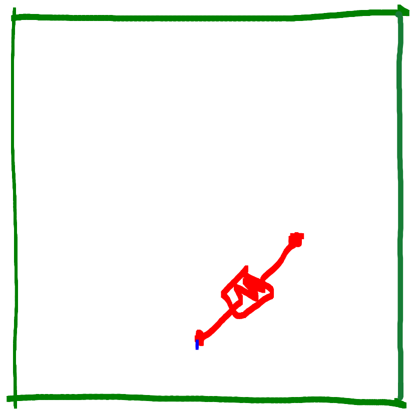


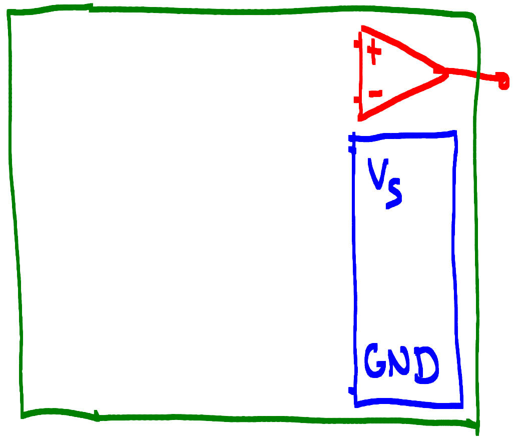
OUT =

QUARTER BRIDGE

1 active bridge leg on the sample

$\Delta V =$





OUT =

- References

[1] Z. Yoshibash, "p-FEMs in biomechanics: Bones and Arteries", Computer Methods in Applied Mechanics and Engineering, v249-252, pp169-184 (2012)

[2] Instron (www.instron.us)

[3] Omega Engineering, Inc (omega.com)

[4] Analog Devices, Inc (analog.com)