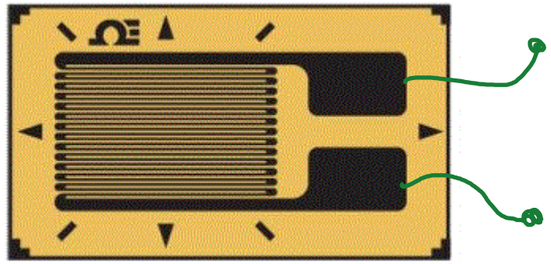
Lecture 2: Load Cells

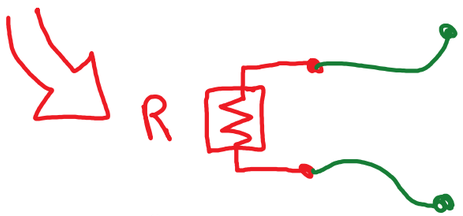
0. Review
1. Load Cells
2. ADC Basics
3. Sensitivity

- Course website: minerva.union.edu/bumat
- Reading: Load cell tutorial (pdf)
  ADC tutorial (pdf)
- PreLab 1 due at lab session (Jan 14/16)
- Hw1 due next Thu (Jan 16)
  Quiz (Jan 21)
  ↖ Hw1 material

0. Review

Strain Gauge:



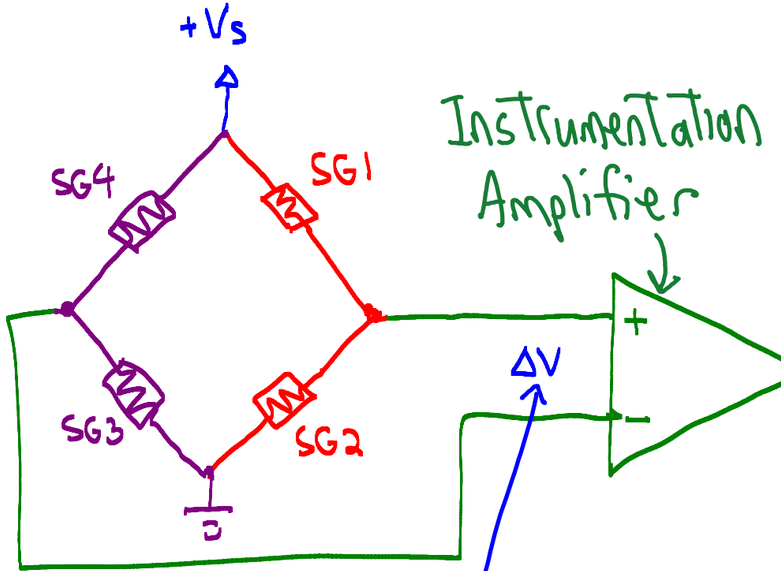


Gauge Factor ↓

$$\frac{\Delta R}{R} = G \cdot \varepsilon \quad \leftarrow \text{Strain}$$

$$= \left[1 + 2\mu + \left(\frac{\Delta\rho/\rho}{\Delta L/L}\right)\right] \times \frac{\Delta L}{L}$$

Dimensional ↑ Piezoresistive ↑



$$V_s \frac{\Delta R}{R} = V_s G\varepsilon$$

Only for full bridge!

Acquire → $V_{meas} = A_d V_s G \varepsilon$ (ΔV)

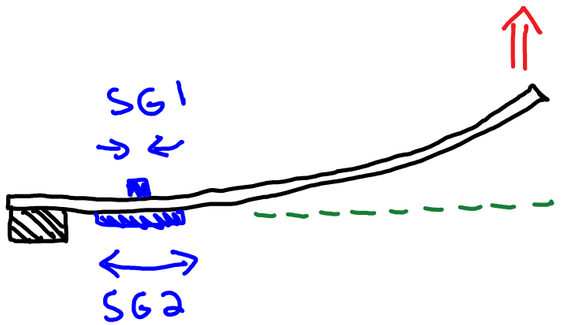
Process → Display

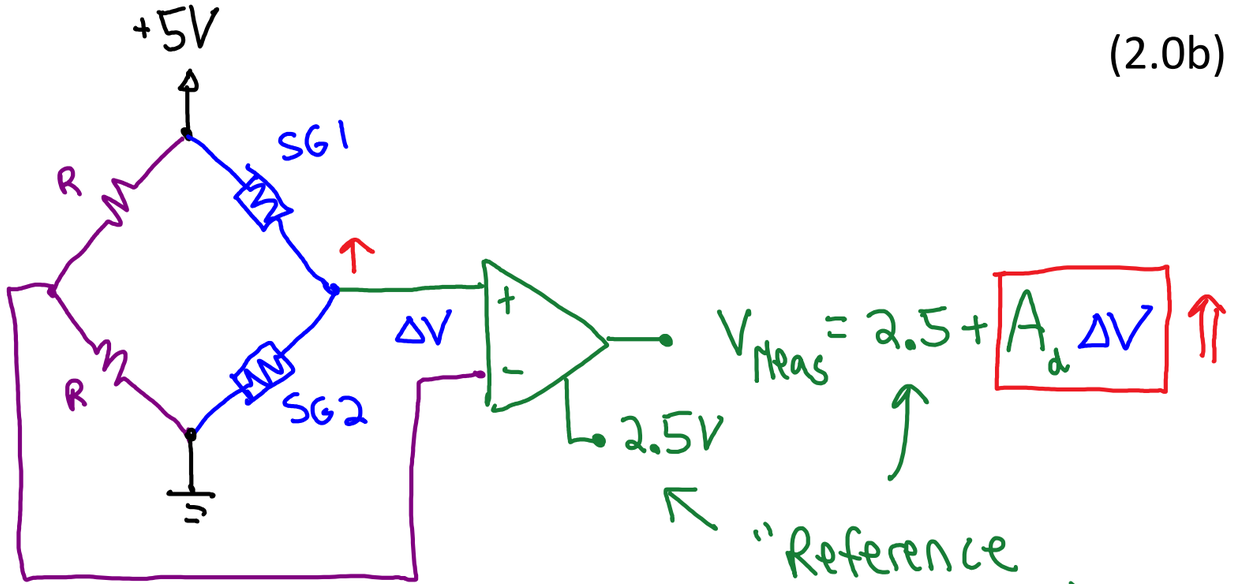
$$\varepsilon = \left[\frac{1}{A_d V_s G}\right] \cdot V_{meas}$$

★ Slightly different eqn's for $\frac{1}{2}$ and $\frac{1}{4}$ bridge!

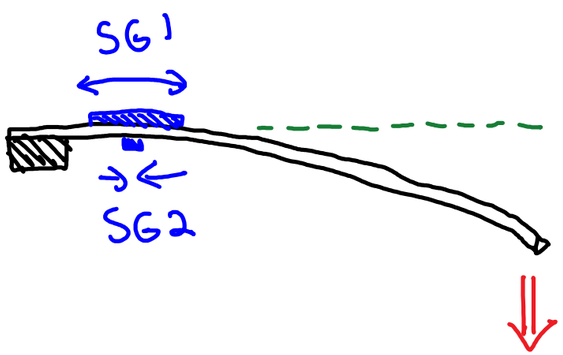
- Demo of cantilever with ½ bridge:

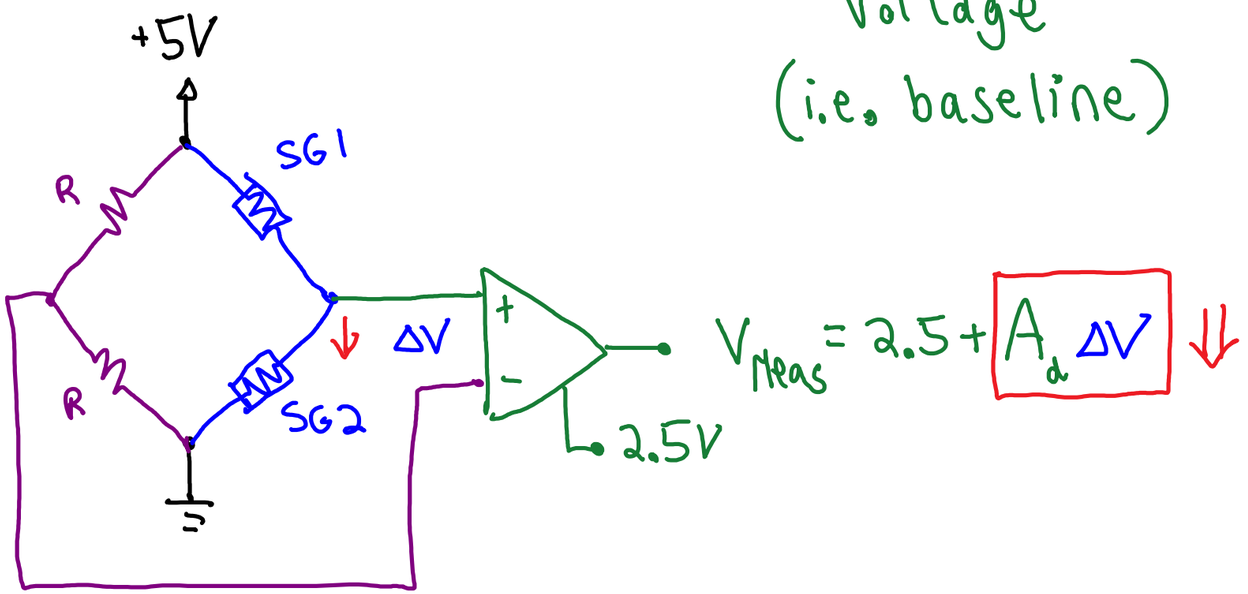
(+) Deflection





(−) Deflection

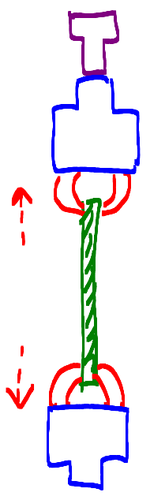




1. Load Cells

- In many applications, you want to measure ____ or ____ rather than strain.

Ex: "Instron" mechanical testing system.



www.instron.com

Ex: Digital weighing scale

www.ohaus.com

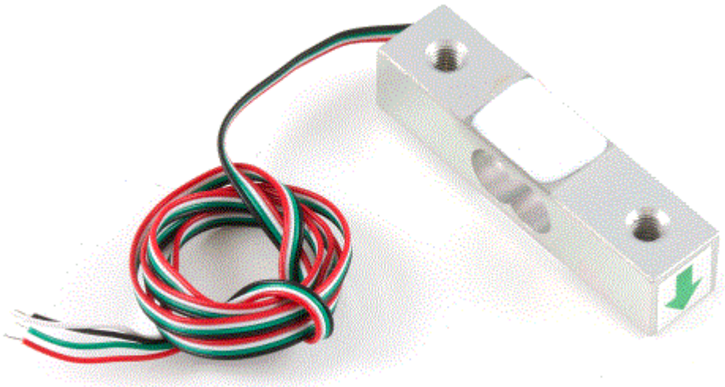
A load cell is basically a metal structure with strain gauges

① Load

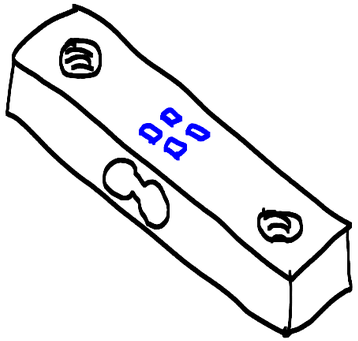
② Structure

③ Output

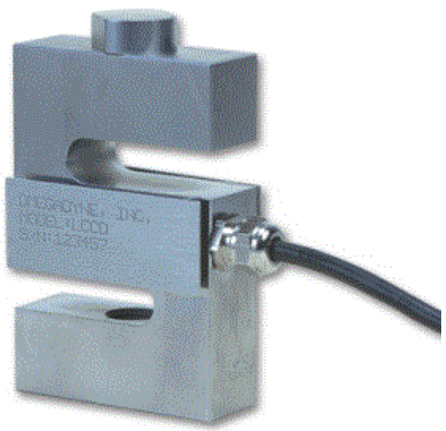
Many different shapes + sizes...



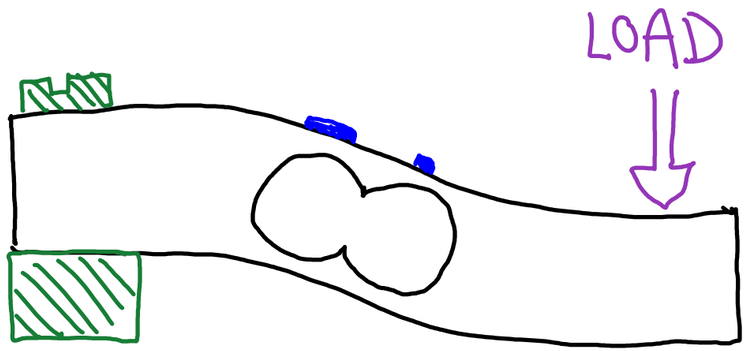
Phidgets.com



Instron



www.omega.com



- Output voltage of load cell:

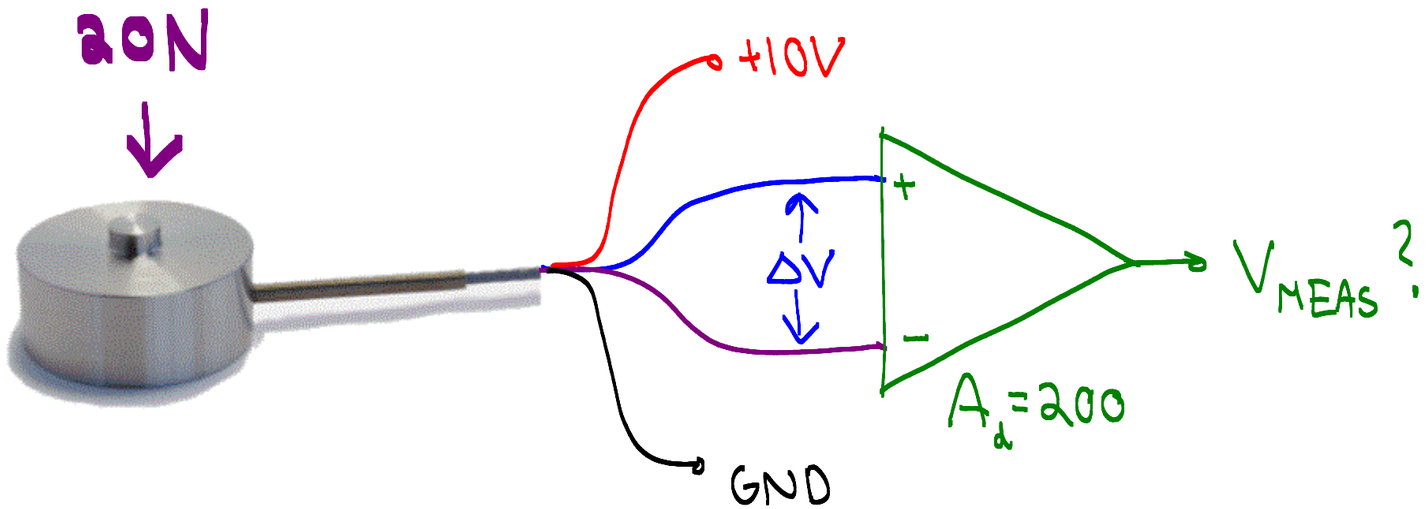
ΔV is linearly proportional to load.

$\Delta V =$

Example:

Rated output = 2 mV/V

Rated load = 100N



Start with:

V_{MEAS} =

2. ADC Basics

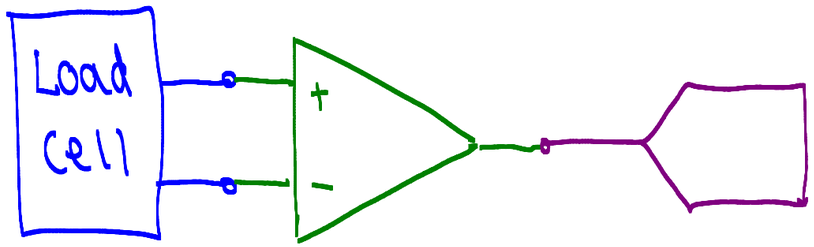
- Most measurement systems rely on <u>digital</u> data acquisition

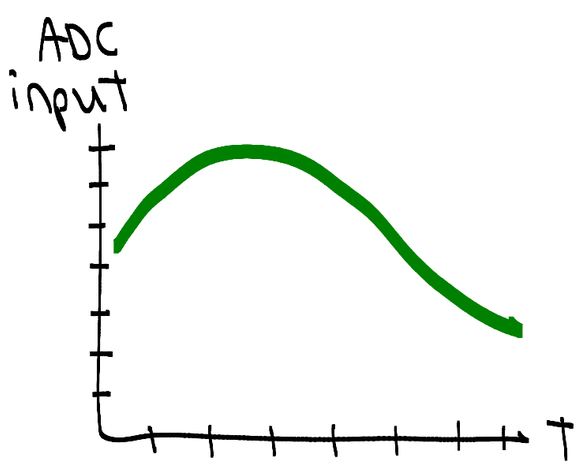
- ADC

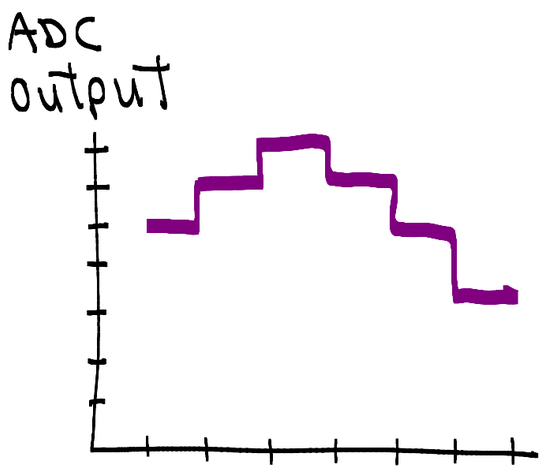
Ⓐ Vertical

Ⓑ Horizontal

Ex:







A. Vertical Resolution

- The _____ of an ADC determines the number of _____.

- The smallest voltage difference that can be recorded is:

$\Delta V_{ADC} =$

Example:

4-bit ADC operates from -5 to +5 V

n	2^n
8	
10	
12	
14	
16	

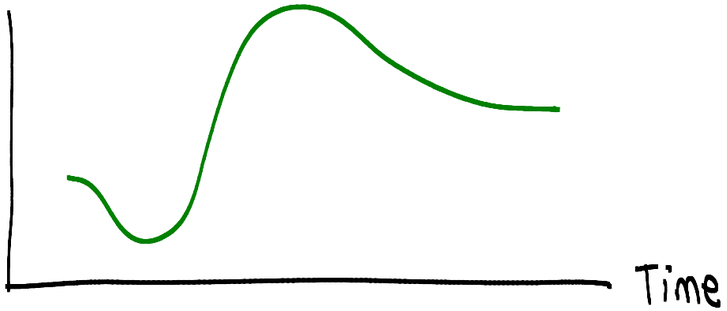
B. Sampling Rate

- Sampling Rate =

Ex: $f_s = 44\ kS/sec$

- Sampling Interval =

Ex: If $f_s = 44\ kHz$,



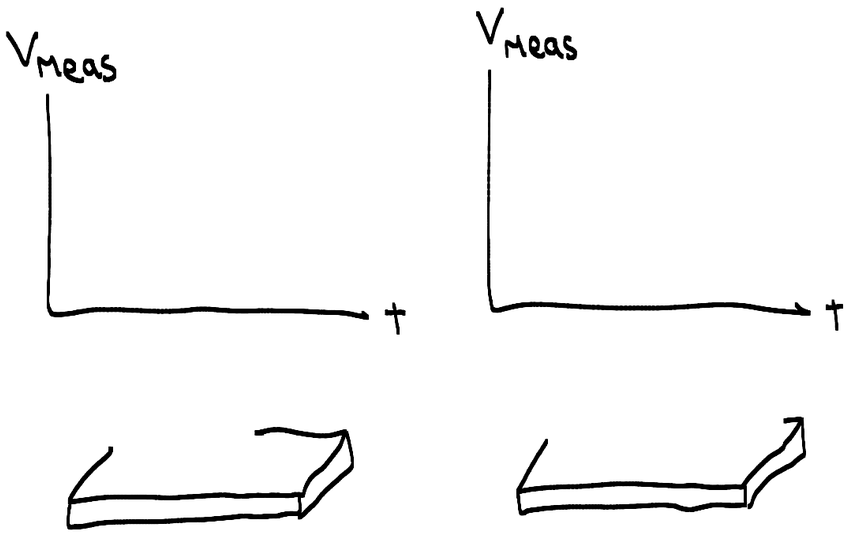
NOTE: Usually, there is a trade off between resolution ( ) and max speed ( )

# bits	Typical f_s
8	
10	
12	
14	

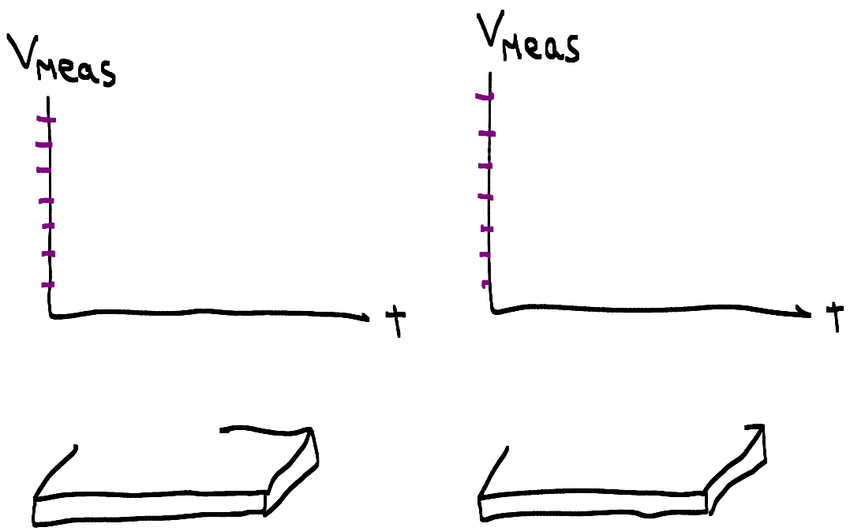
3. Sensitivity

Q: what is the smallest measurable change in load ΔL_{MIN}?

① Measurement noise



② Vertical Resolution



- Let ΔV_{MIN} be the minimum detectable voltage change

- We can detect a signal change if $\Delta V_{Meas} =$

Example Load Cell: $RO = 1.5\ mV/V\ @\ 5\ kg$, $V_s = 10V$

$A_d = 500$, $V_{N,rms} = 10\ mV$, $\Delta V_{ADC} = 5\ mV$

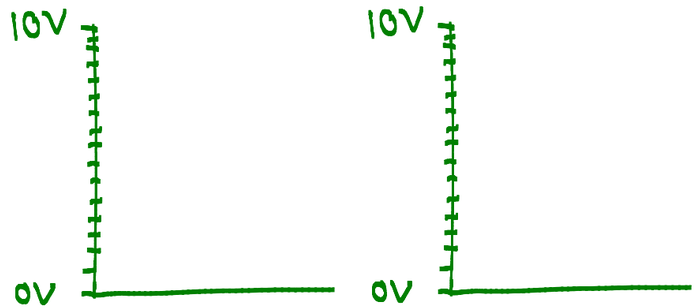
- Start with: $V_{Meas} =$

- Compute derivative: $\frac{\partial V_{Meas}}{\partial L} =$

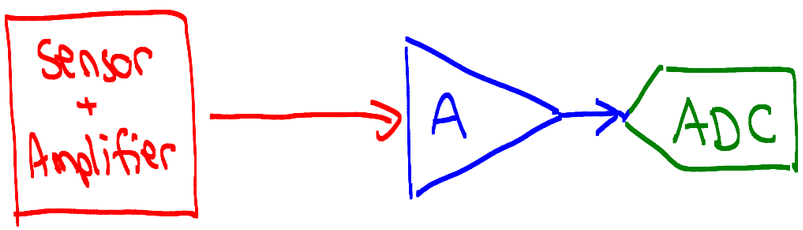
D. Proper amplifier gain

- Naturally, we want to measure a signal with the finest possible resolution.

Ex:



Ex:



⇒ If adjustable gain is not possible, then we must wisely choose the proper gain!

①

②