ME133 Lecture 16 3/9/23

Last time:

> OpAmps

Today:

> Exam Structure
> Sensor Survey
> ADC converters

Special Office Hours on Monday 3/13, 2pm - 5pm

> zoom or office
> best to email first, but feel free to just drop by

Exam 2

- 4 - 5 problems (1 hr 20 mins)
- no numerical calculations
- two sheets of notes
- mix of conceptual & symbolic derivations

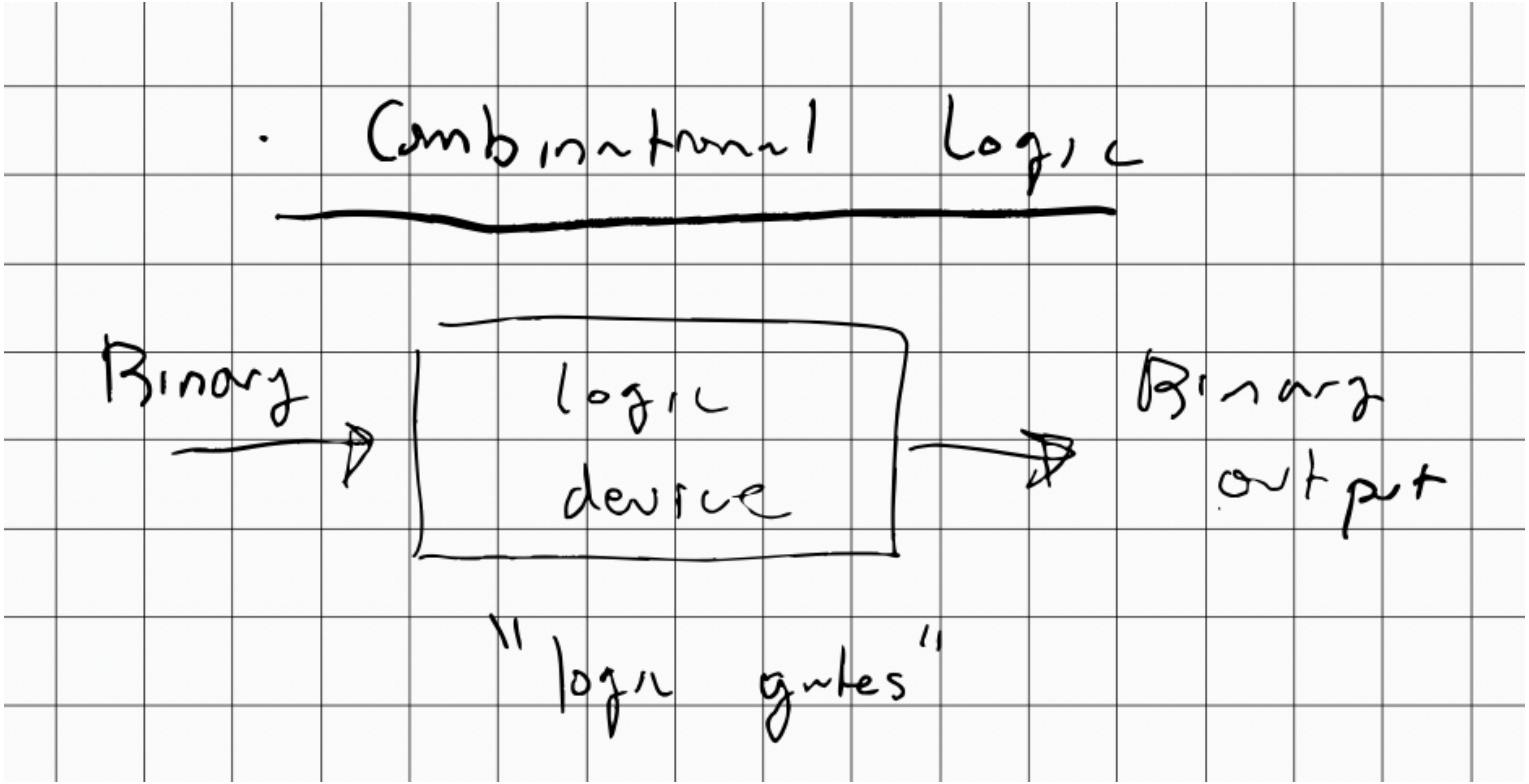
Exam 2

Ch. 6 Digital Circuits

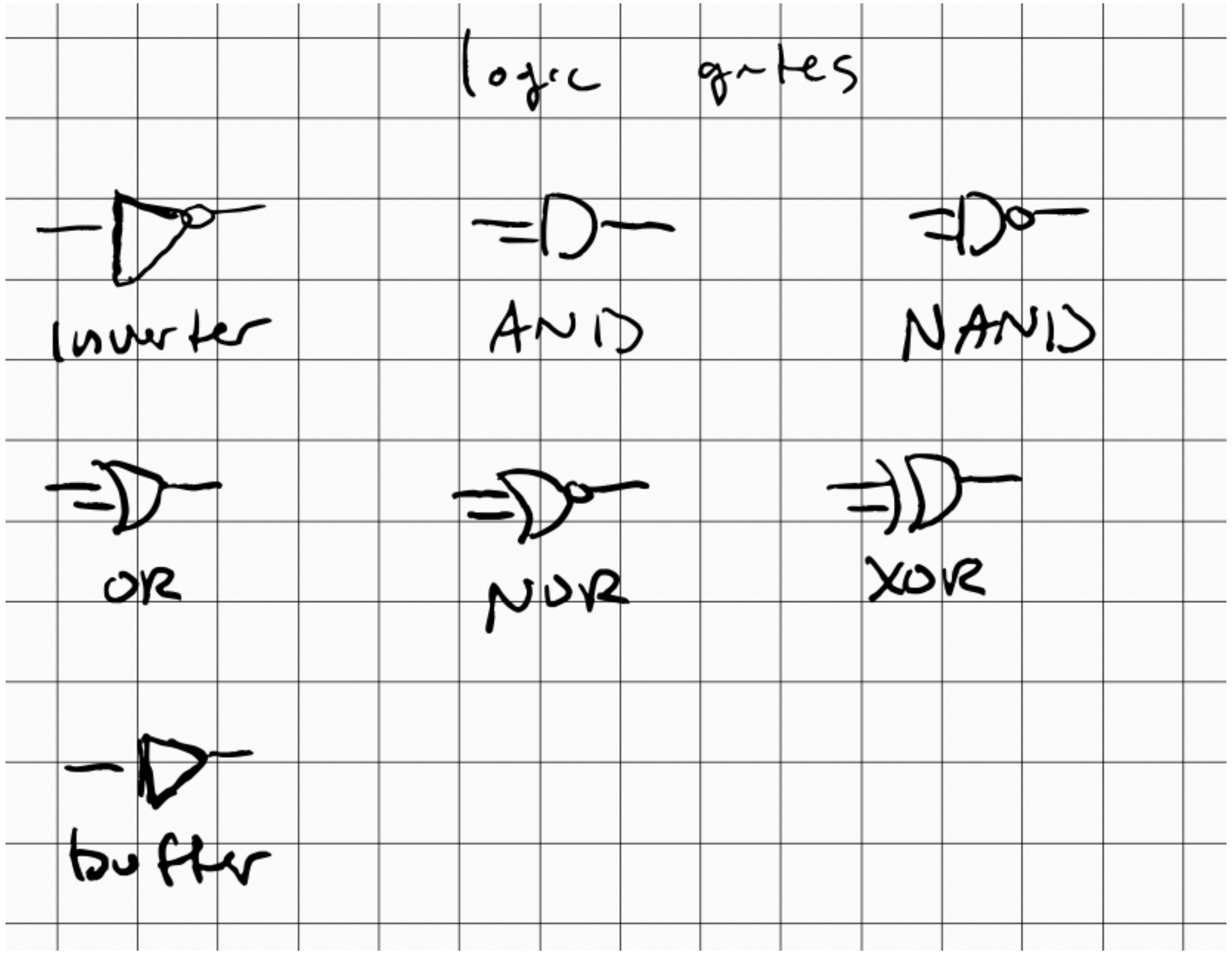
- digital vs analog signals
- Binary number
- Boolean logic

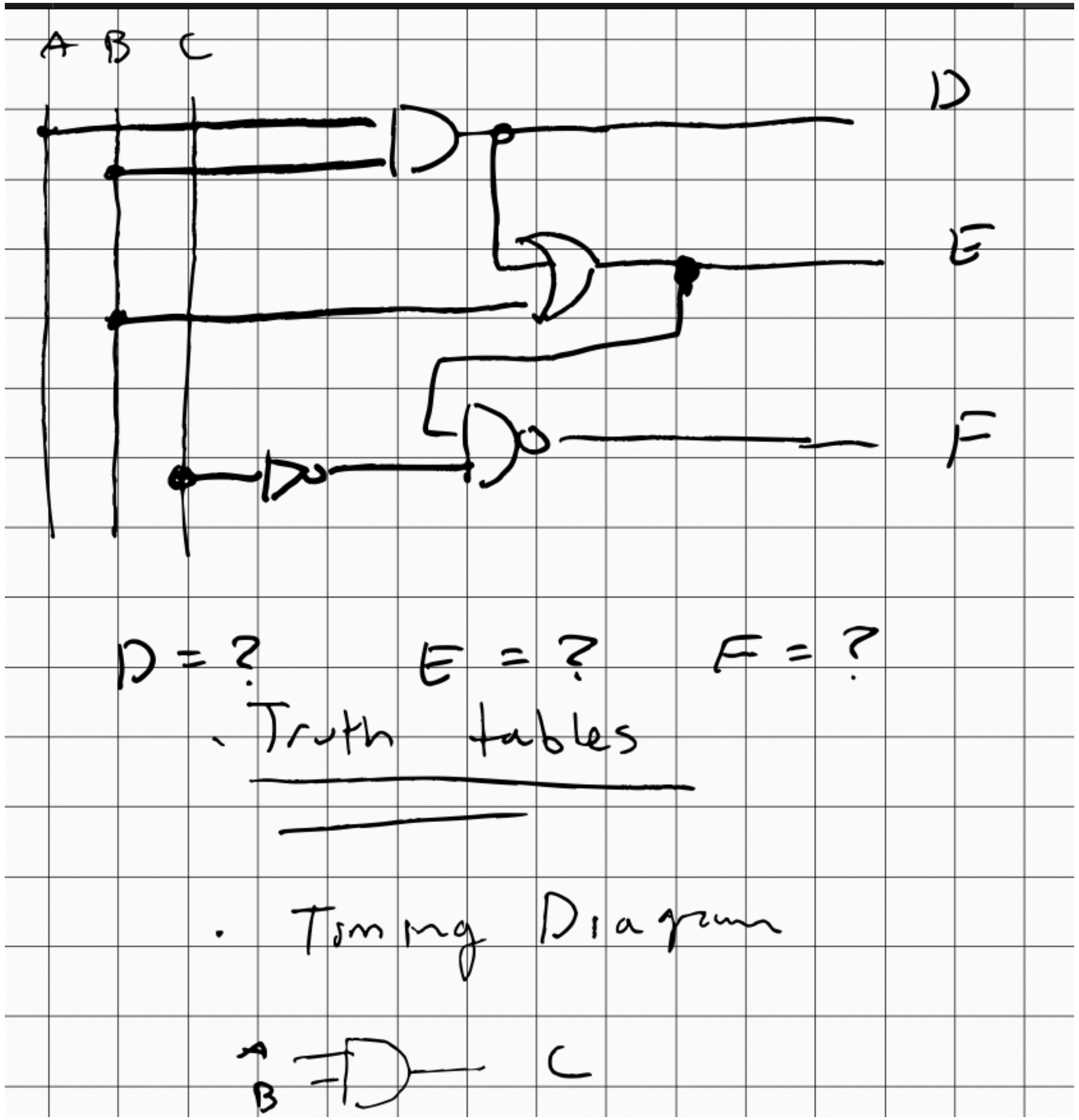
- Bits
- MSB vs LSB
- Byte
- Binary Arithmetic

Exam 2


Combinational Logic
Binary
logic
device
Binary
output
"logic gates"

Exam 2


logic gates
inverter
AND
NAND
OR
NOR
XOR
buffer


A B C
D
E
F
D = ? E = ? F = ?
Truth tables
Timing Diagram
A
B
C

Exam 2

Boolean Algebra

- Fundamental Laws
- commutative law
- Associative
- Distributive
- De Morgan's laws

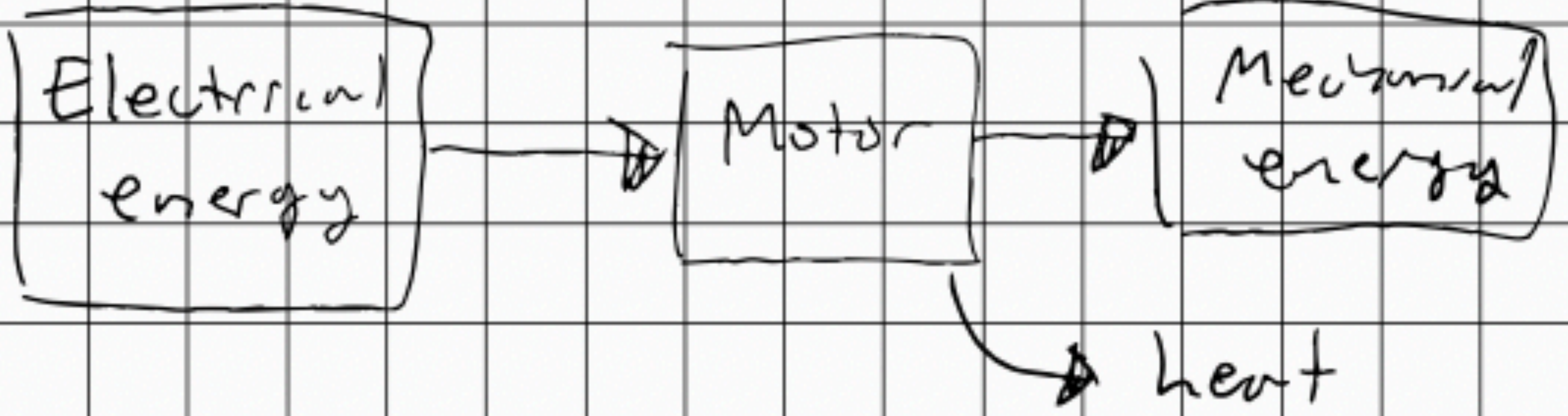
- Design logic Network
  - → like the alarm example

Exam 2

Ch. 10 Actuators

- Identify different actuators
  - solenoids
  - electric motors

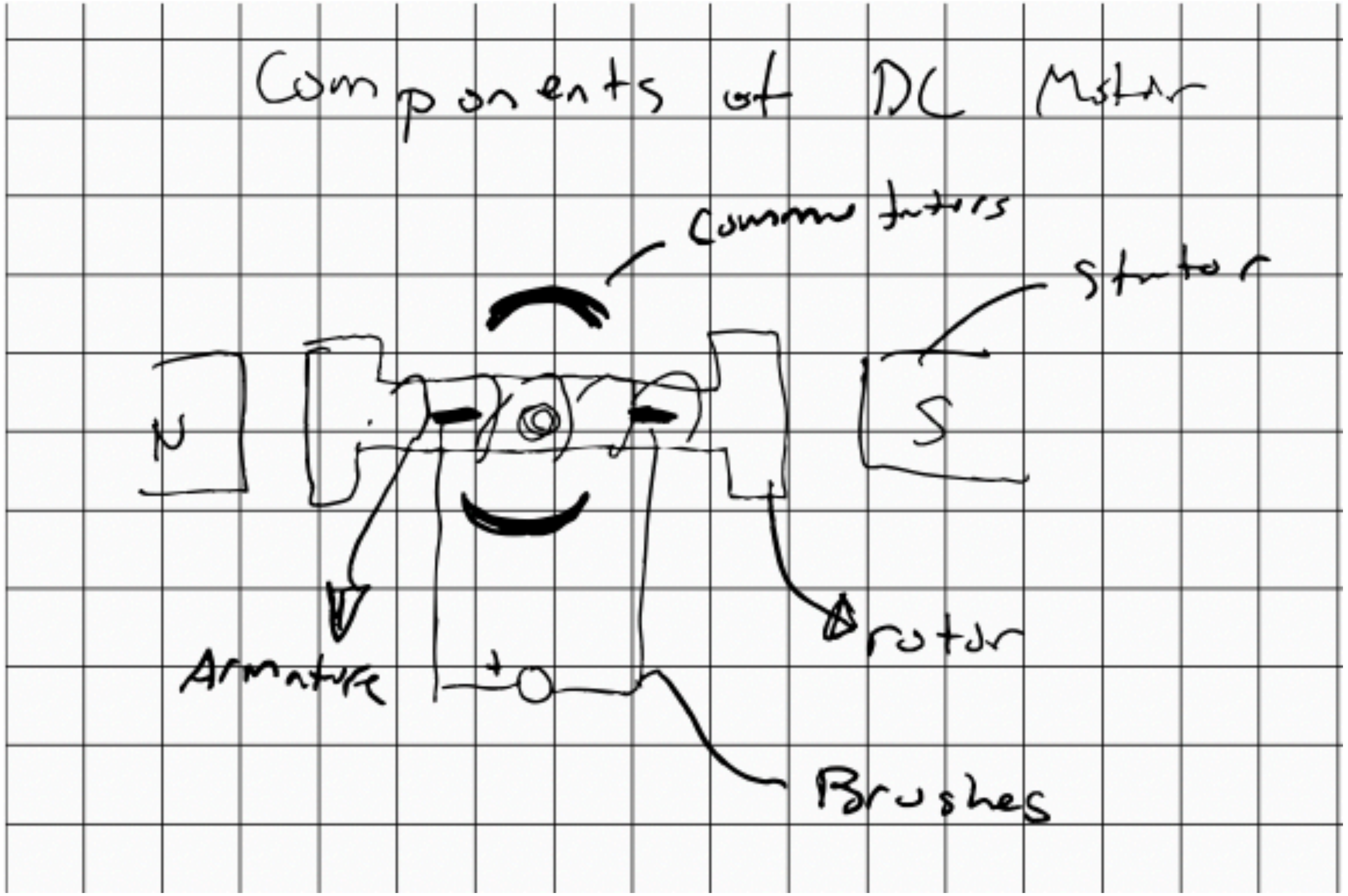
- Fundamental principle



$$P_{in} = P_{out}$$

$$\eta \, V \cdot I = \tau \cdot \omega$$

Exam 2



$$V_{in} = L\dot{I}_{in} + RI_{in} + \underline{k_e\omega}$$

Exam 2

Torque constant

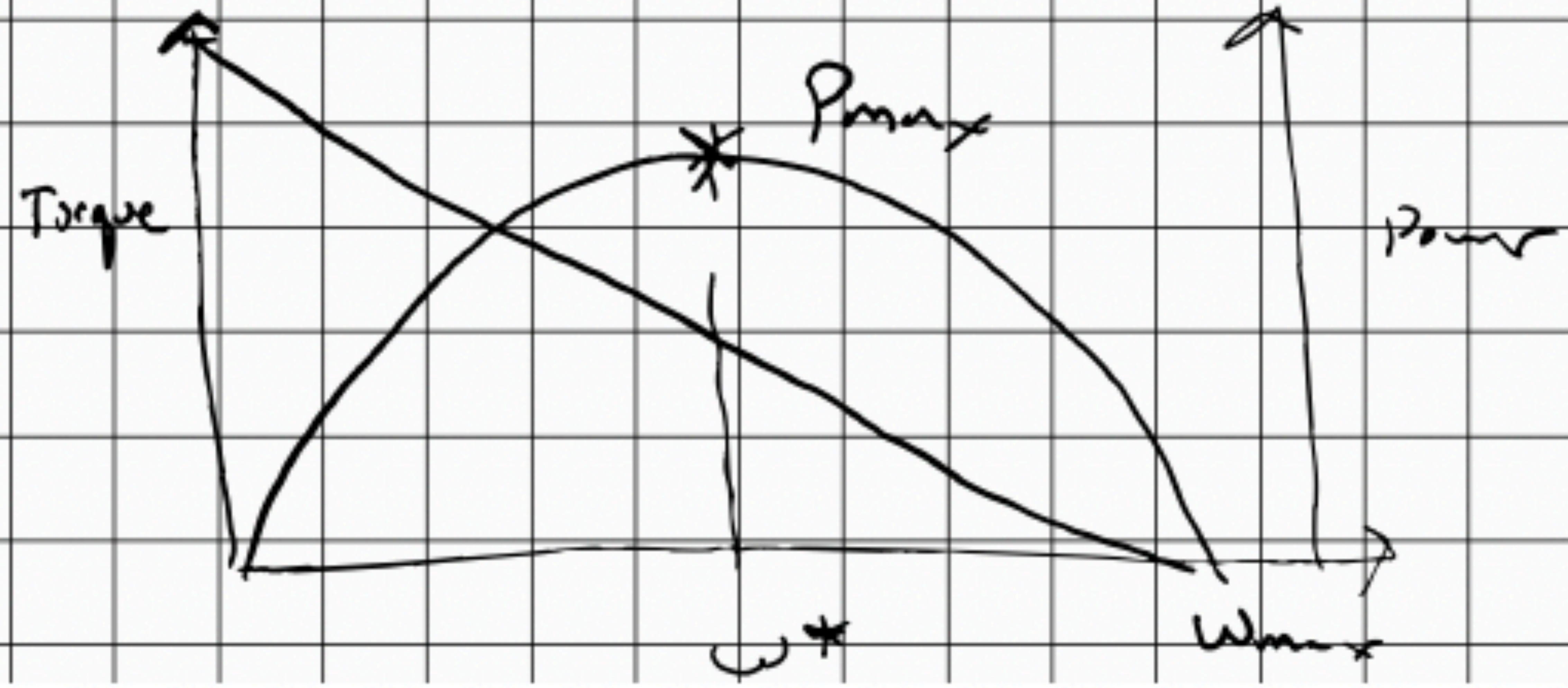
$$\tau = K_\tau I_{in}$$

Mechanical Model:

$$\tau = (\underbrace{J_m + J_L}_{\text{rotor + load inertia}}) \frac{d\omega}{dt} + \underbrace{\tau_f + \tau_L}_{\text{"losses"}}$$

Steady state behavior

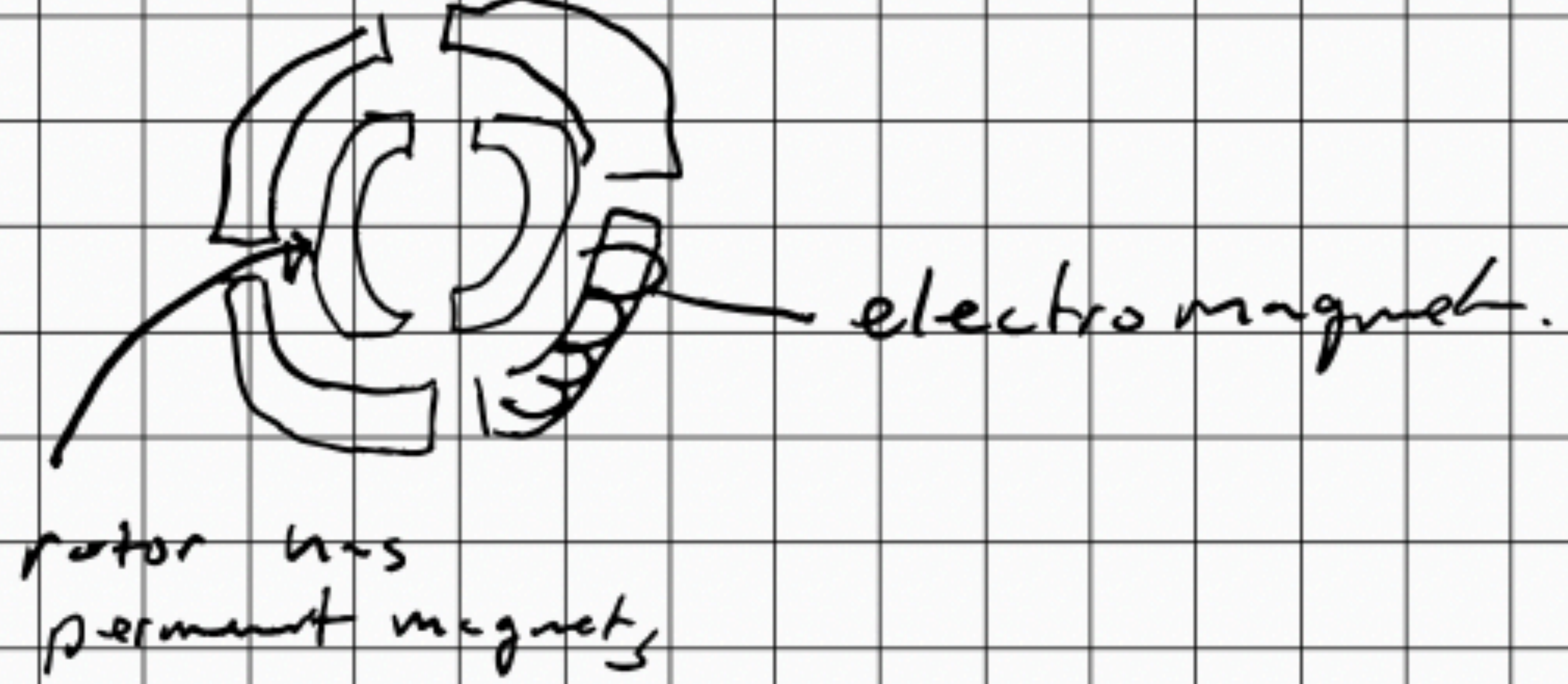
$$\tau = \left(\frac{k_\tau}{R}\right) V_{in} - \left(\frac{k_e k_\tau}{R}\right) \omega$$



$$\underbrace{\omega^* = \frac{1}{2}\omega_{max}}_{\text{Know why!!}}$$

Exam 2

Stepper Motors



locked step mode vs slewing mode

Exam 2

Ch. 5 Analog Signal Processing

→ Why?

$$V_{out} = A_{OL}\left(V^+ - V^-\right)$$

Ideal op amp Assumptions

1. Infinite input impedance
   → $I_- = I_+ = 0$
2. Infinite gain
   → $V^+ = V^-$
3. Output impedance is zero
   V_{out} is independent of I_{out}

$V = IR$
$R = \frac{V}{I}$
$Z = \frac{V}{I}$

Exam 2

[Know how to analyze op amp circuits]

- Inverting Amp
- non-inverting Amp
- Buffer
- Summer
- Intergrator
- differentiator
- comparator
- Active filter
- Sample & hold

Exam 2

- Position & Speed

conceptual
- photoemitter - detector
- switches
- potentiometer
- LVDT
- encoders

- Stress & strain

  * Wheatstone Bridge !

- Temperature Sensors

  → basic

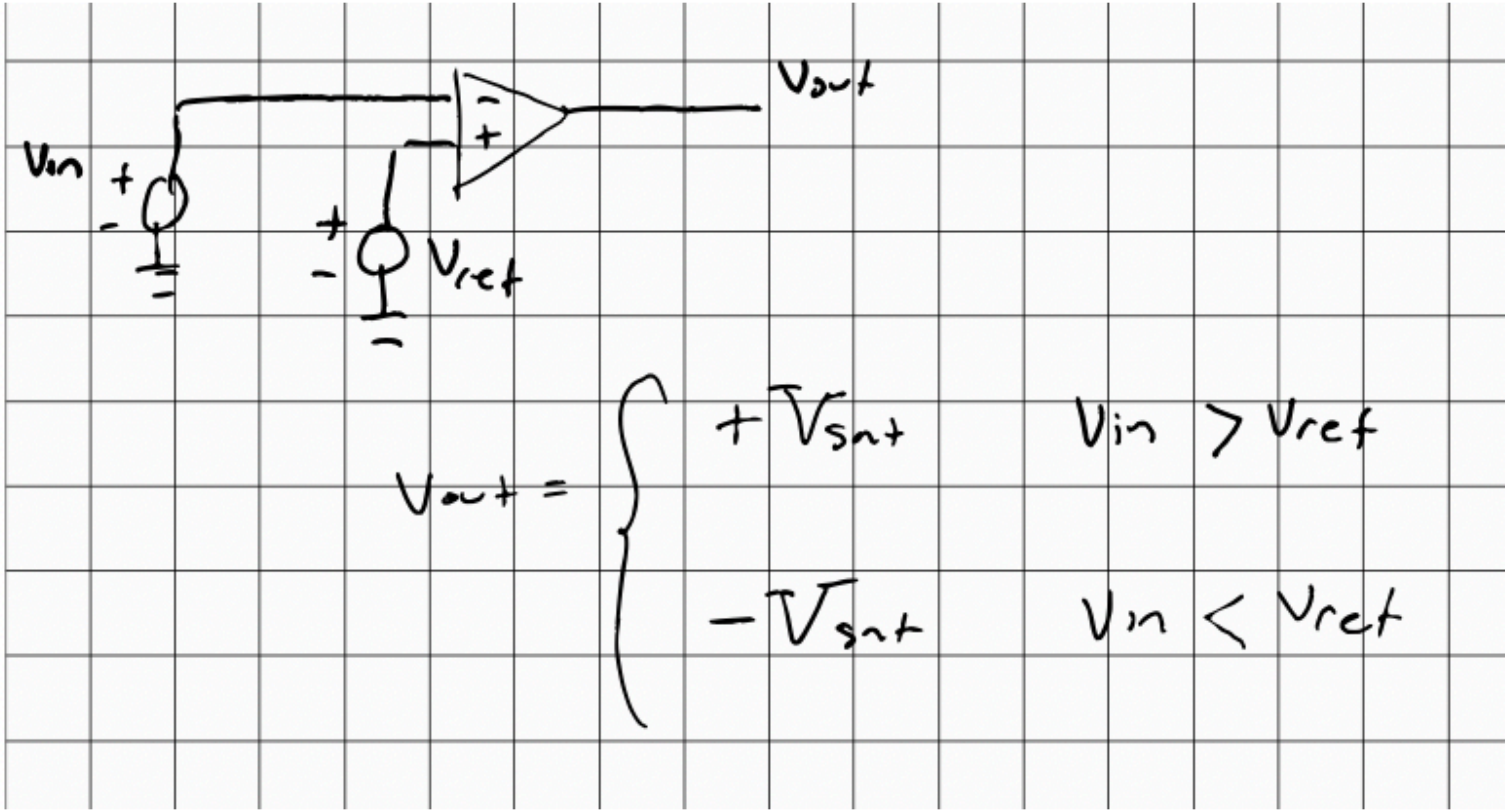
- Vibration & Accelerations

Ch. 8 Data Aquisition

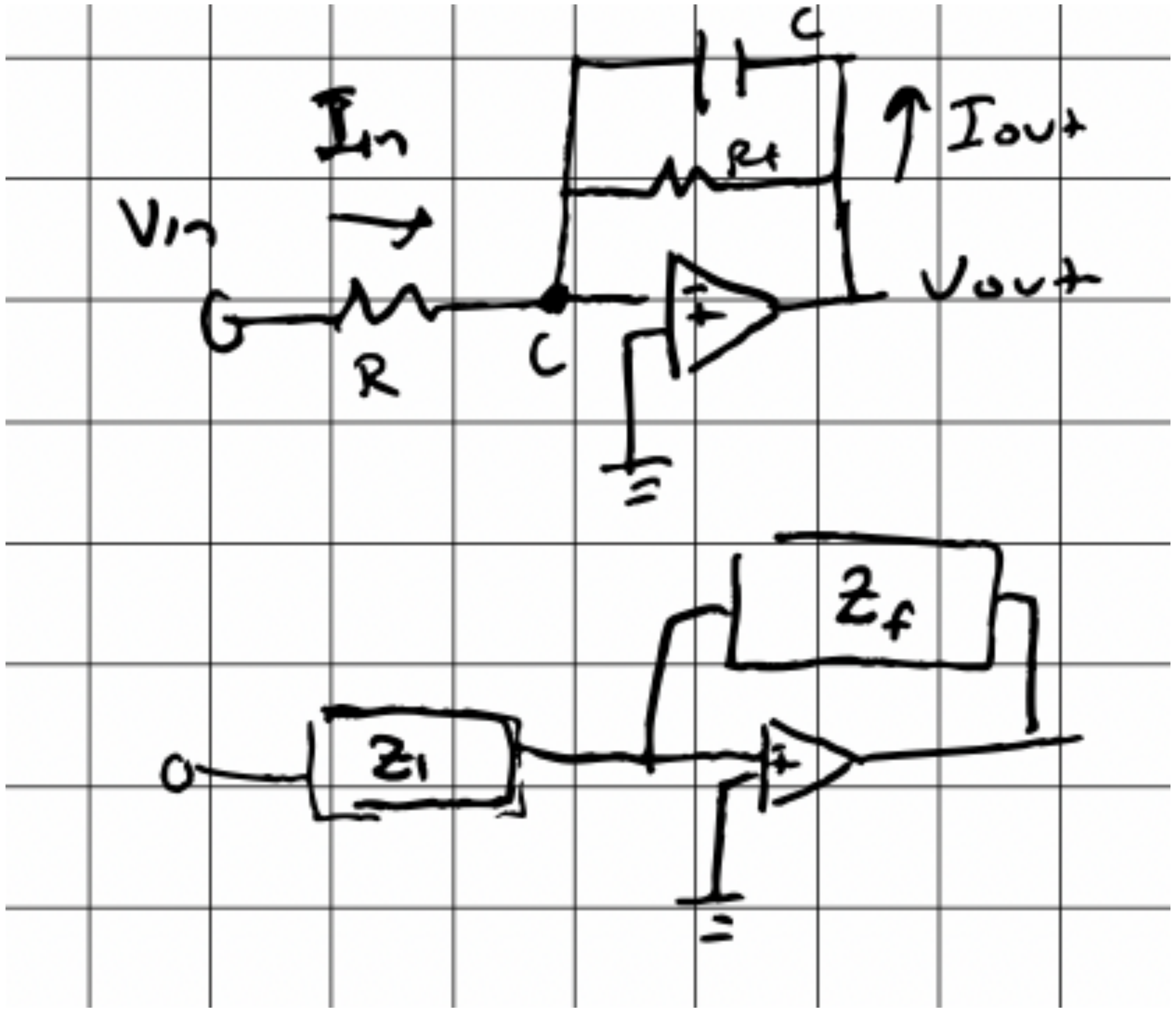
- Shannon's sampling Theorem

- ADC successive approximation

Example: Comparator



Example: Active Filters



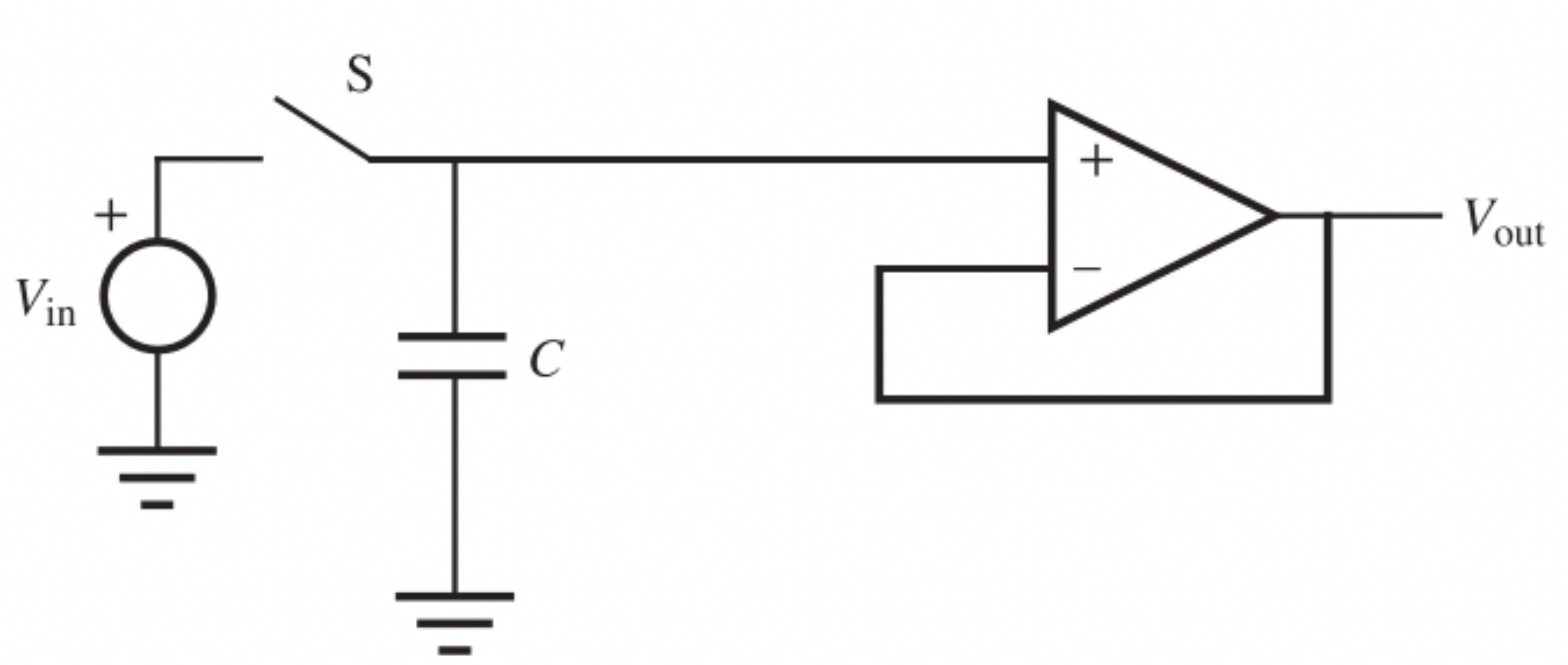
$$I_{in} = -I_{R_f} - I_C$$

$$\frac{V_{in}}{R} = -\frac{V_{out}}{R_f} - C j\omega V_0$$

$$\vdots$$

$$\frac{V_{out}}{V_{in}} = -\frac{R_f}{R}\left(\frac{1}{1 + CRj\omega}\right)$$

Example: Sample and Hold

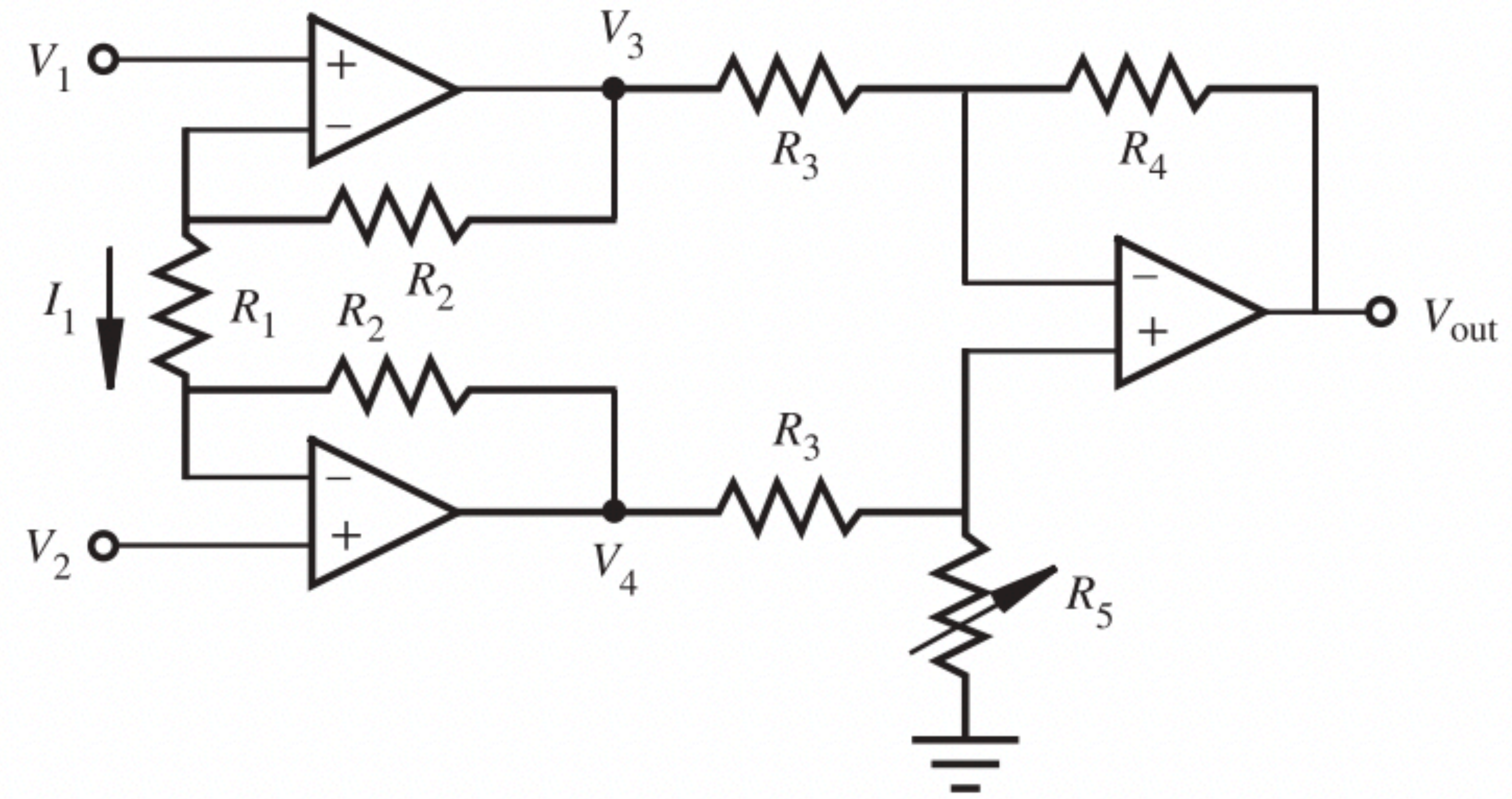


$$V_{out}(t - t_{sampled}) = V_{in}(t_{sampled})$$

where tsampled is the time when the switch was last opened.

Example: Instrumentation Amplifier

* most important amplifier for differential measurement



$$V_{out} = \left[\frac{R_4}{R_3}\left(1 + 2\frac{R_2}{R_1}\right)\right](V_2 - V_1)$$

really good @ common mode rejection

What is a sensor?

- element in a mechatronic system that detects the **magnitude** of a physical quantity & changes it into a signal that can be processed

→ sometimes called **transducer**

→ energy converter

Sensor Survey

Position & Speed

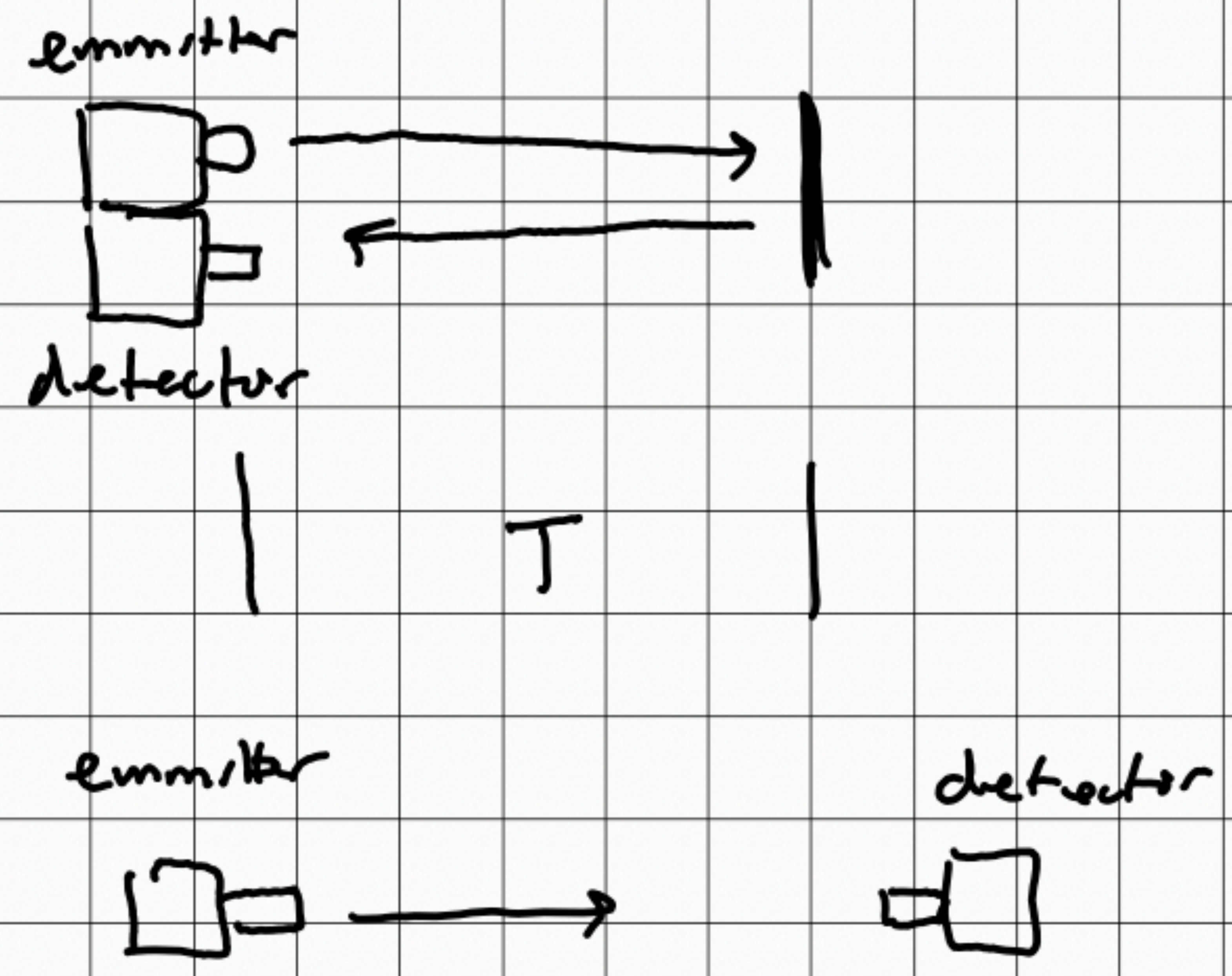
(maybe)

* most common measurement

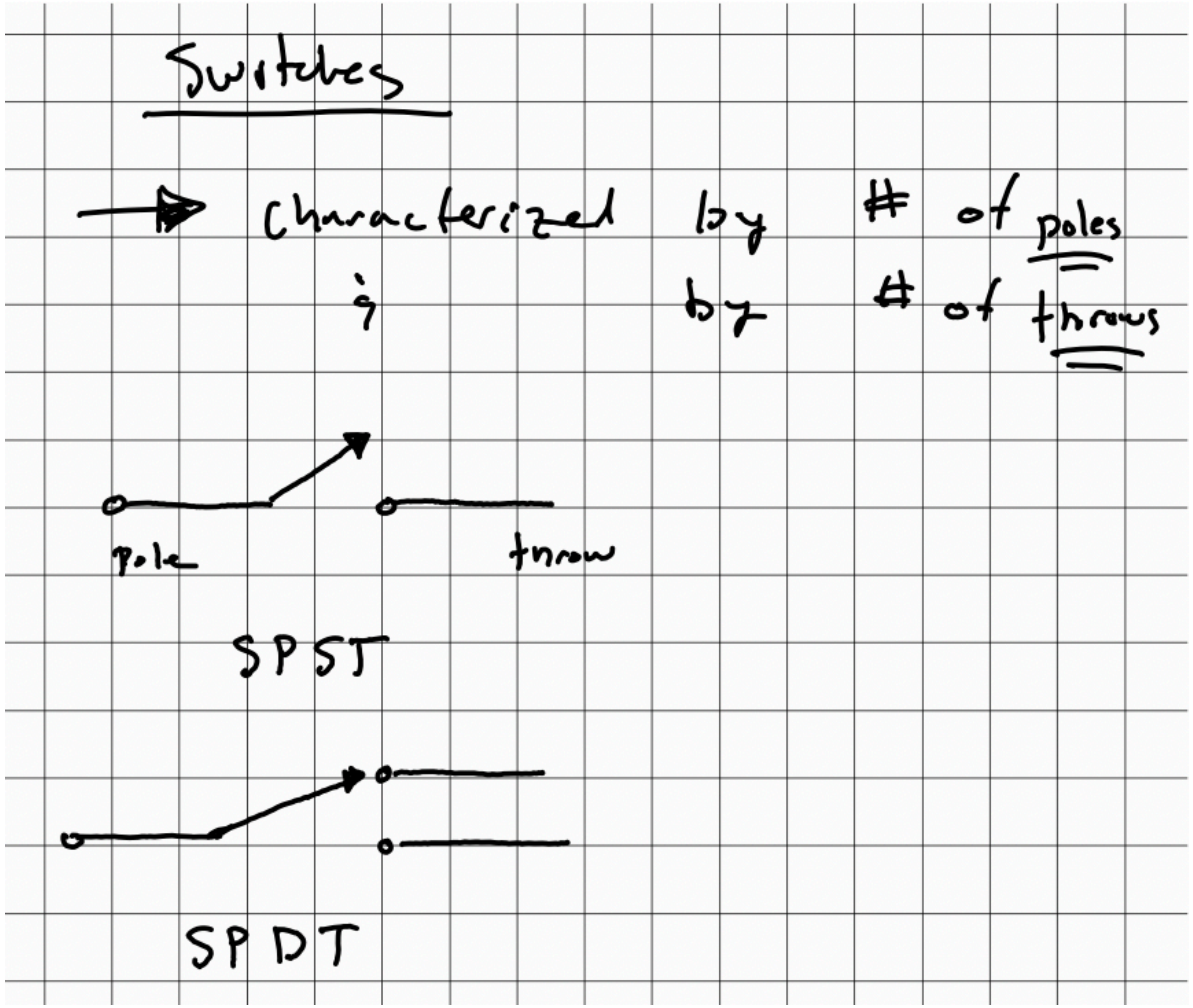
→ rotary position sensors

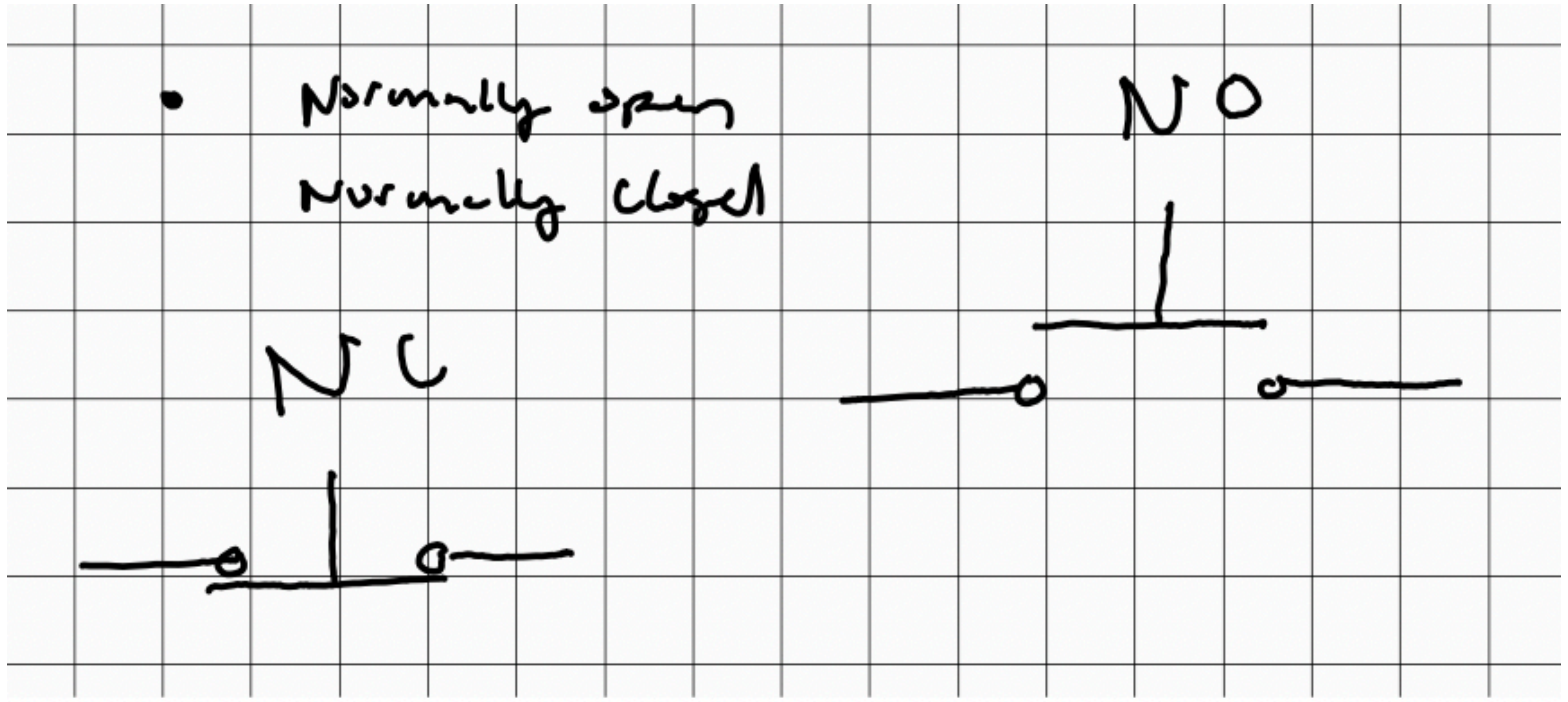
Proximity Sensors & Switches

* photoemitter - detector pair

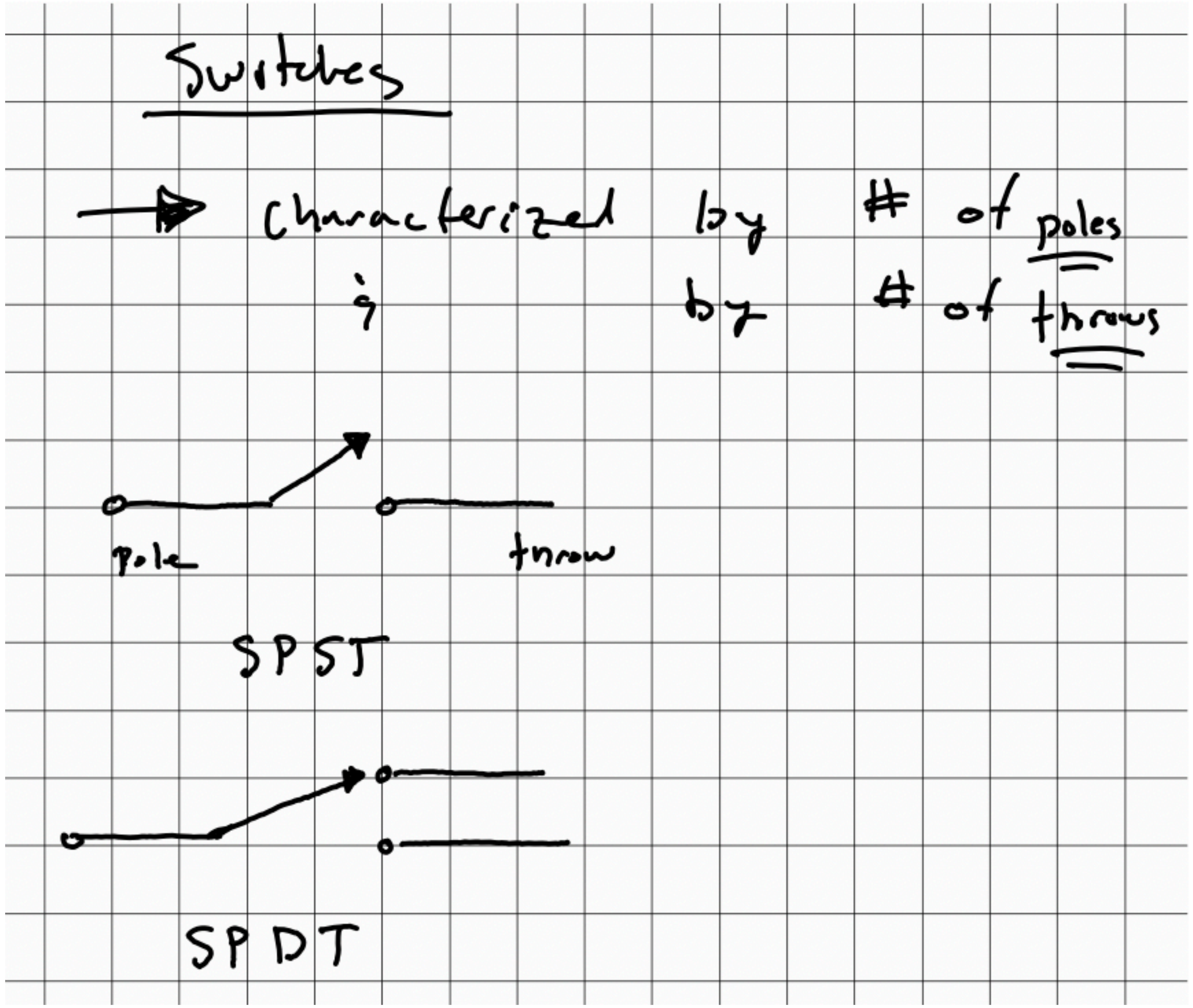


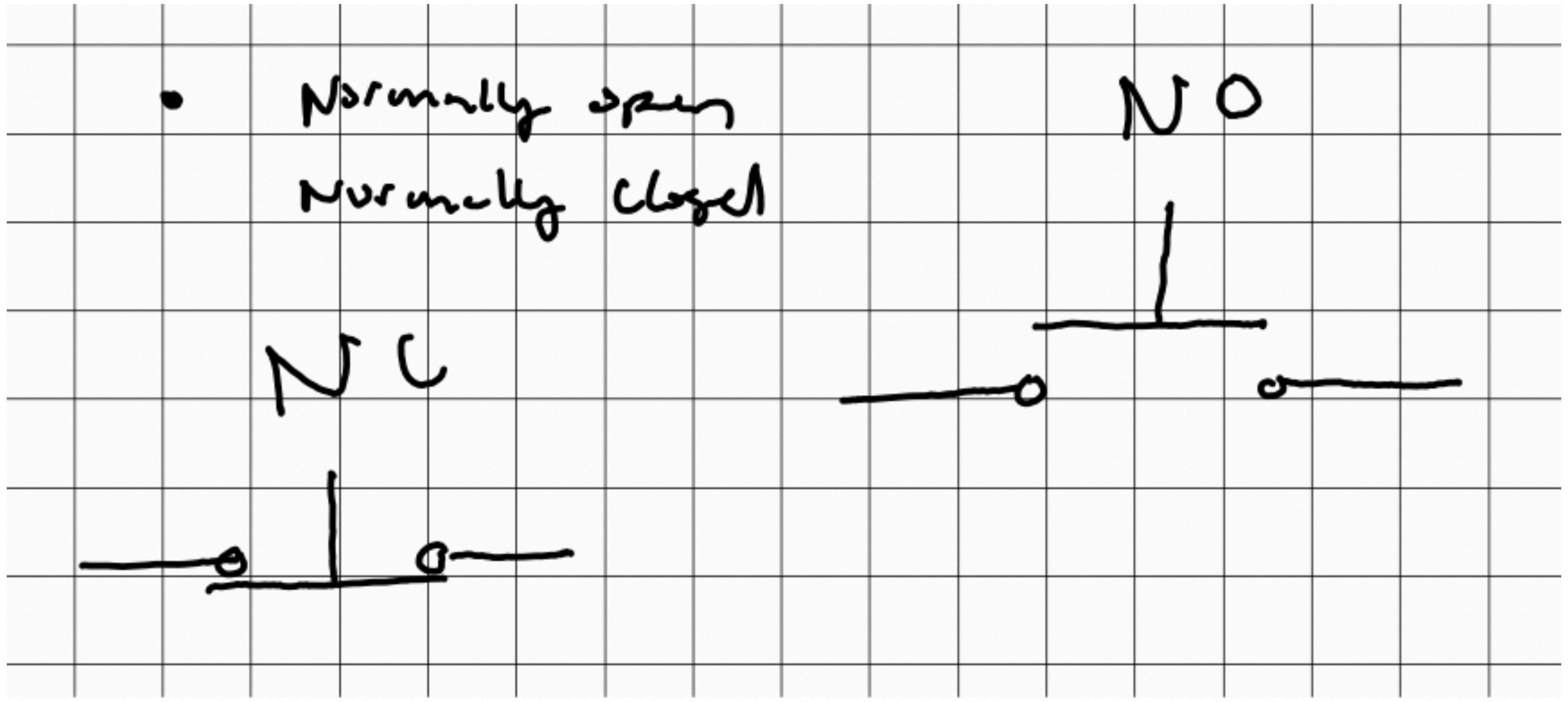
Sensor Survey



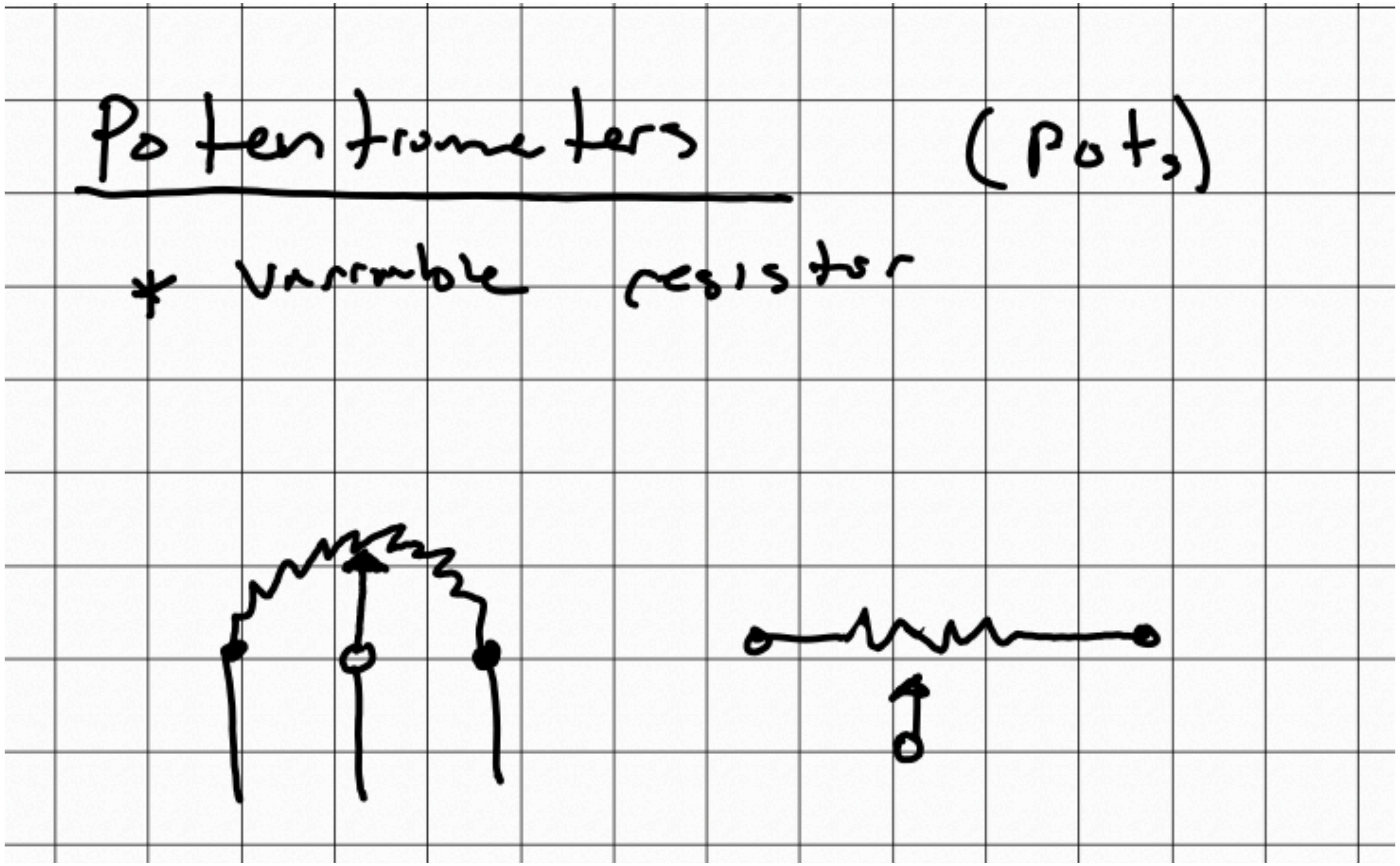


Sensor Survey





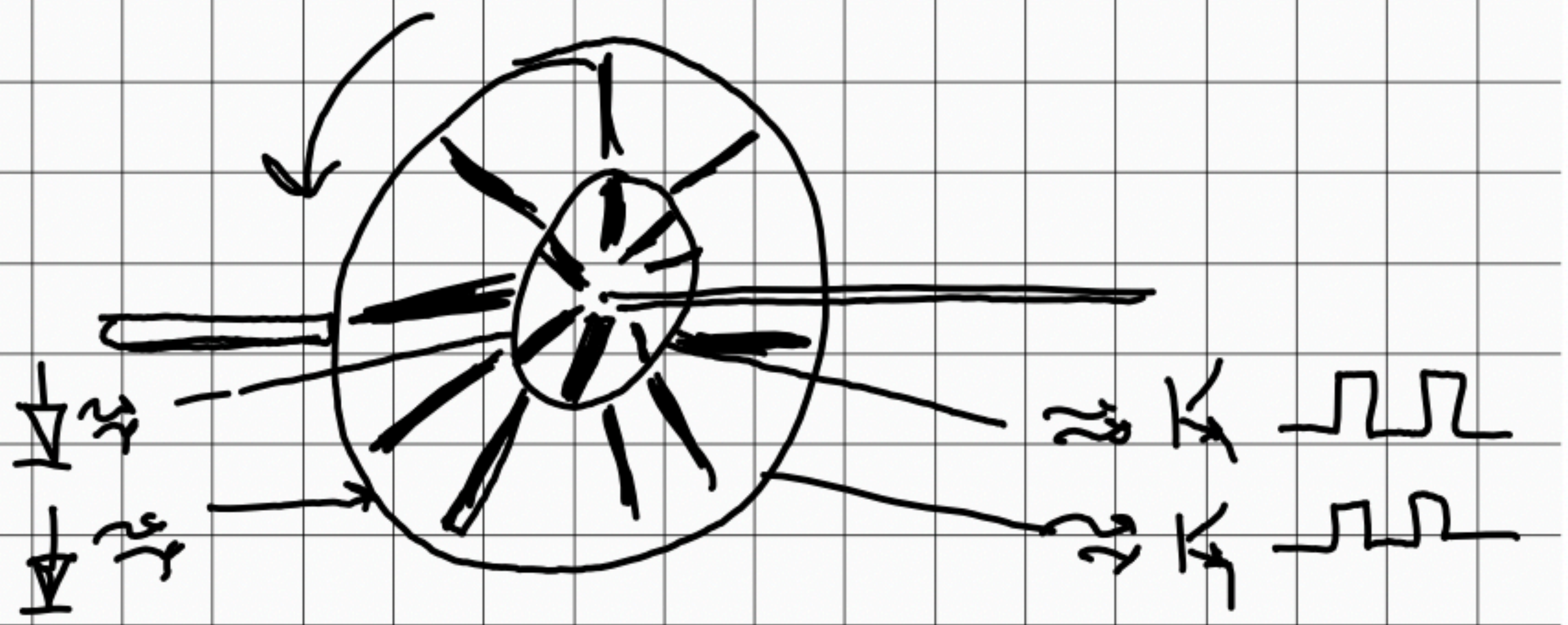
Sensor Survey



Sensor Survey

Digital Encoder

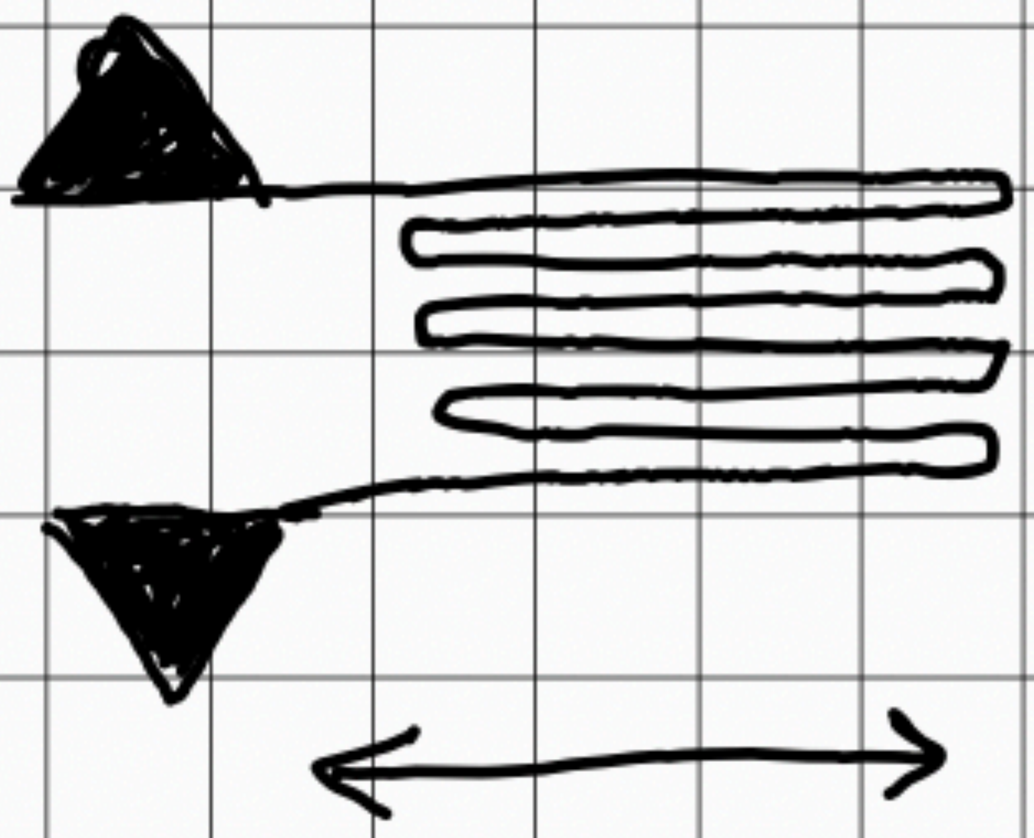
* converts motion into a series of digital pulses
* count pulses to get positions



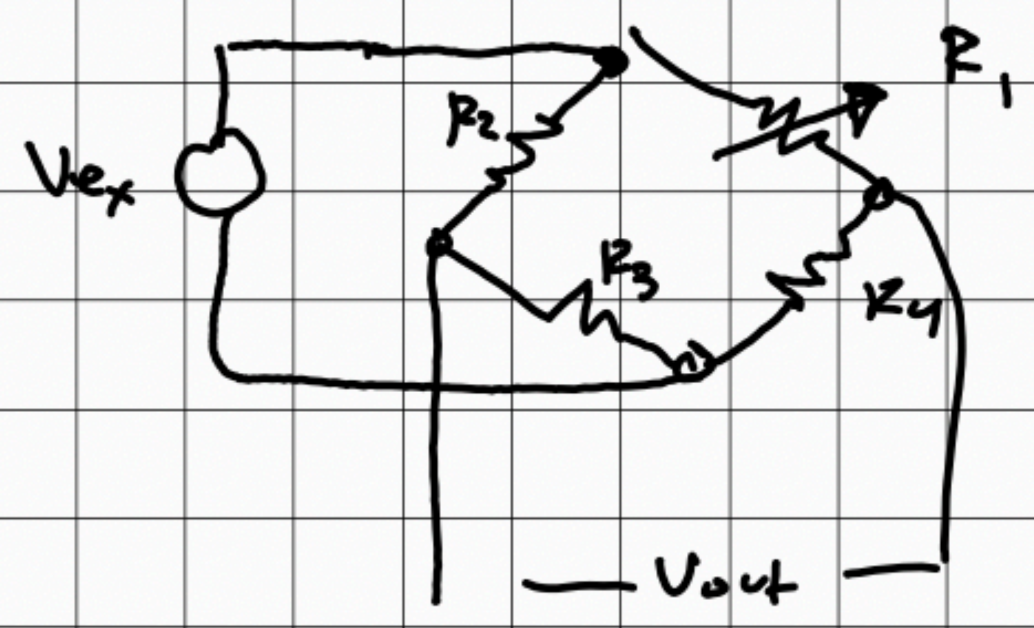
Sensor Survey

Stress & Strain

* Strain gage is a thin foil conductor which can change length depending on loading → change in resistance

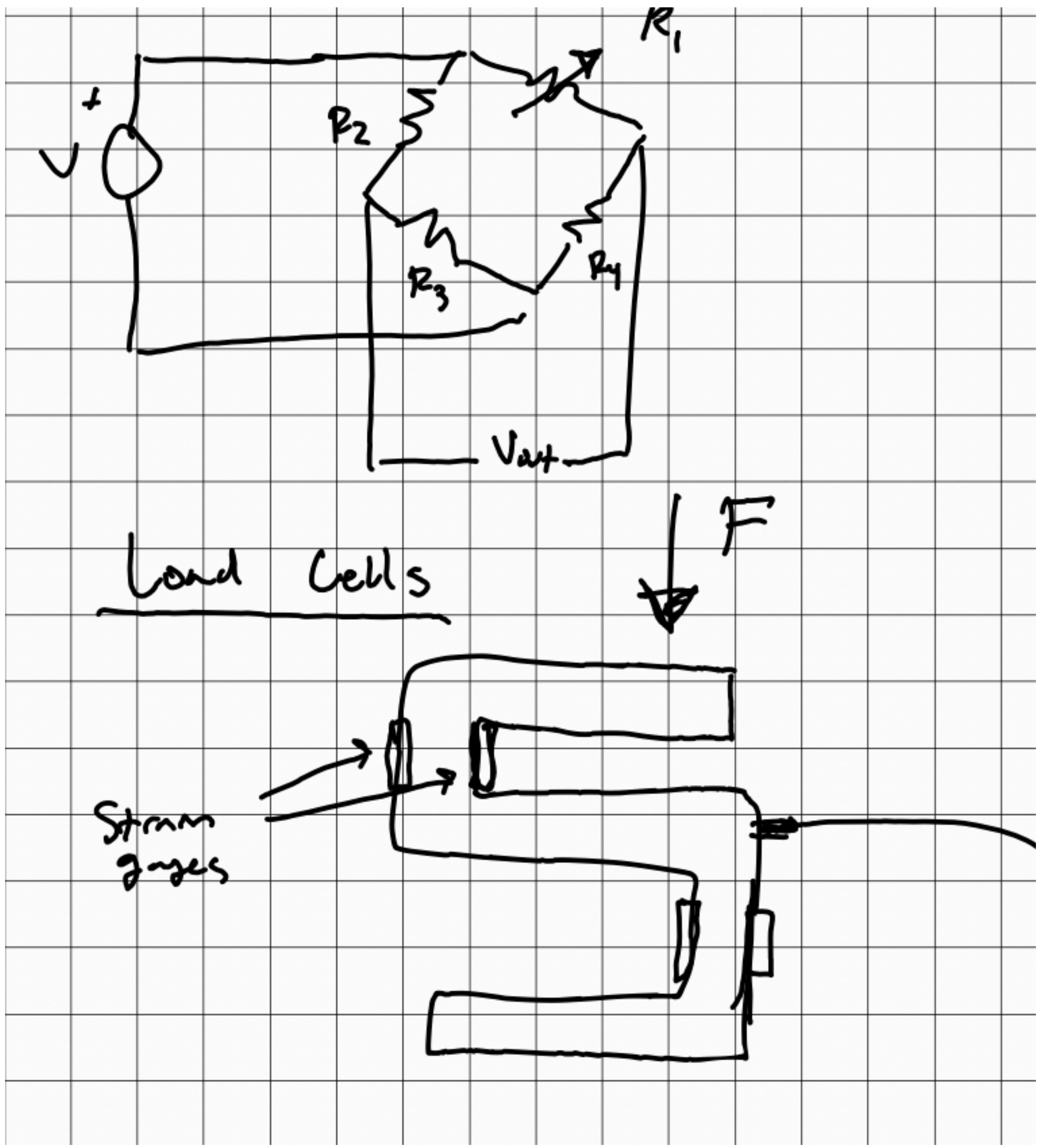


Wheatstone Bridge



$$V_{out} = V_{ex}\left(\frac{R_1}{R_1+R_4} - \frac{R_2}{R_2+R_3}\right)$$

Sensor Survey



Sensor Survey

Temperature

- thermistor
- thermometer
- thermocouple

- resistance temperature device

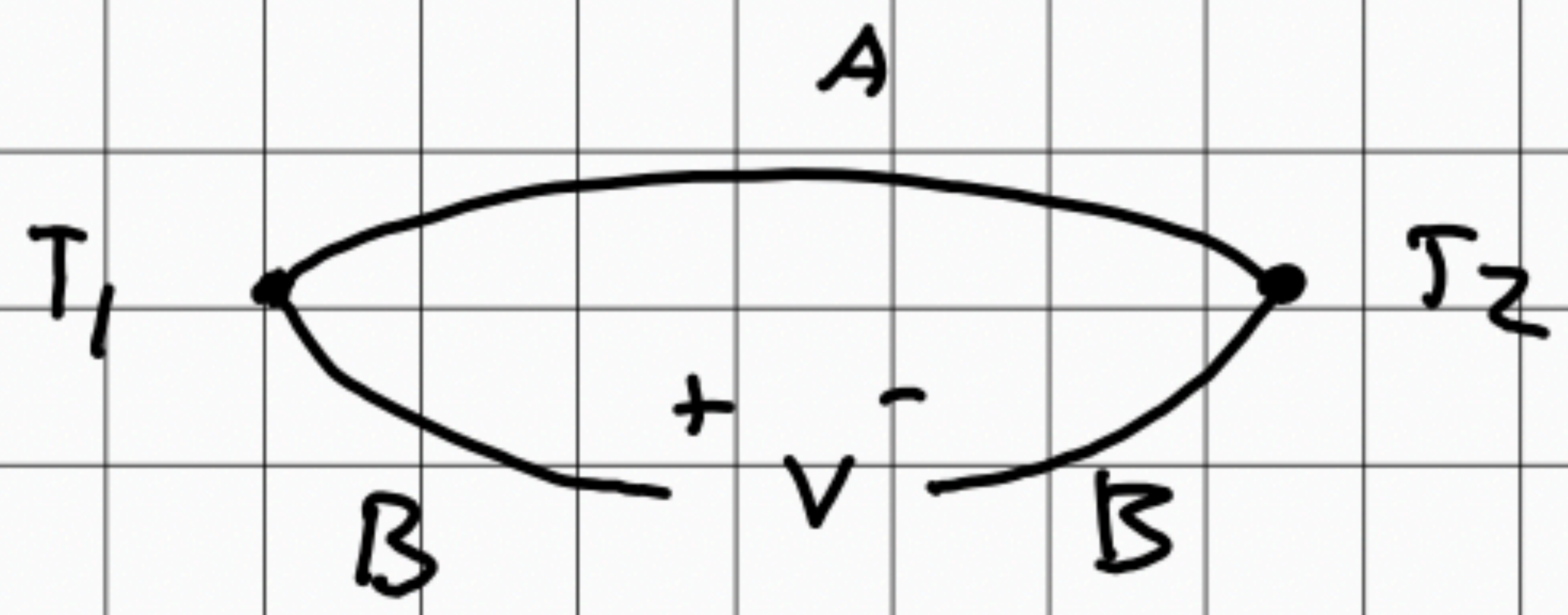
$$R = R_0 [1 + \alpha (T - T_0)]$$

Voltage divider

- thermistor

$$R = R_0 e^{(\beta [\frac{1}{T} - \frac{1}{T_0}])}$$

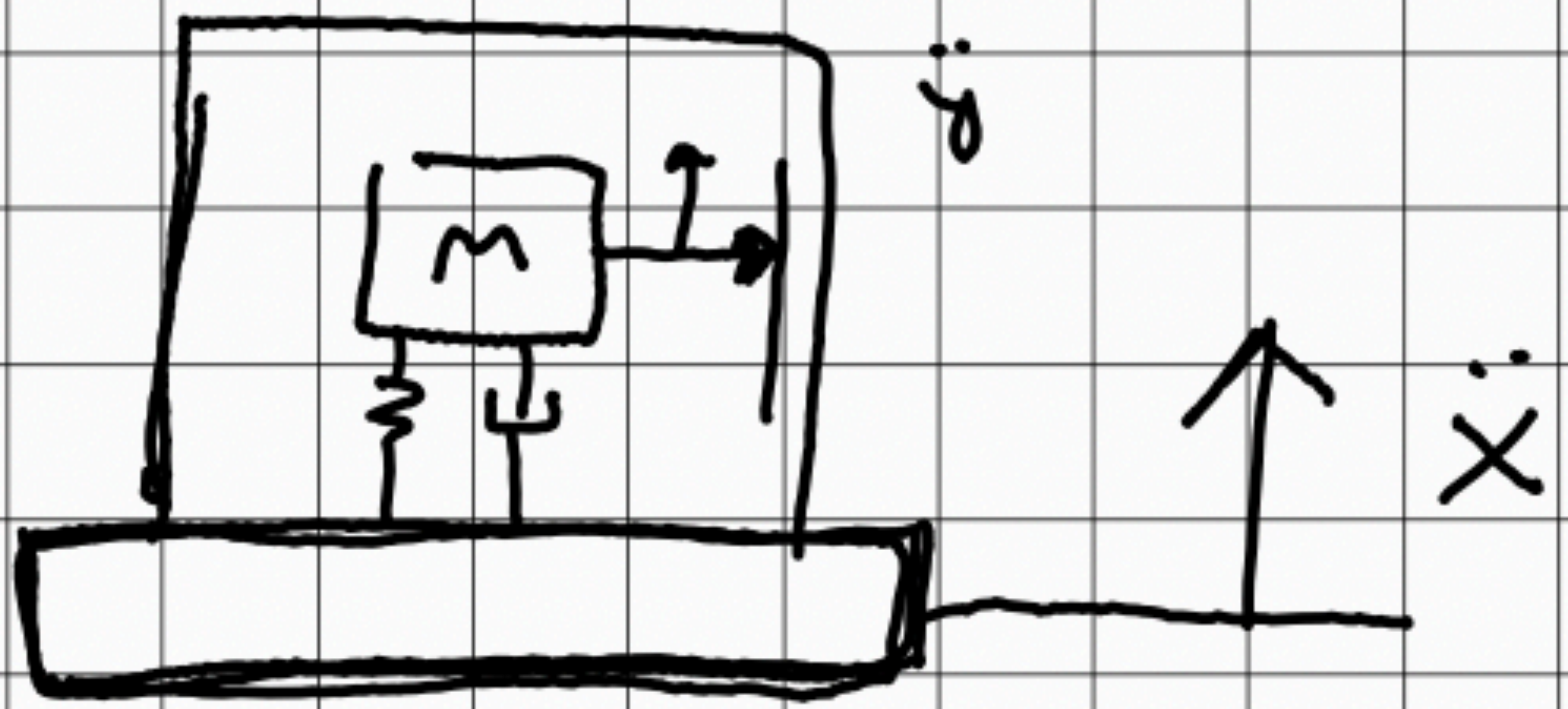
- Thermocouple



$$V = \alpha (T_1 - T_2)$$

Sensor Survey

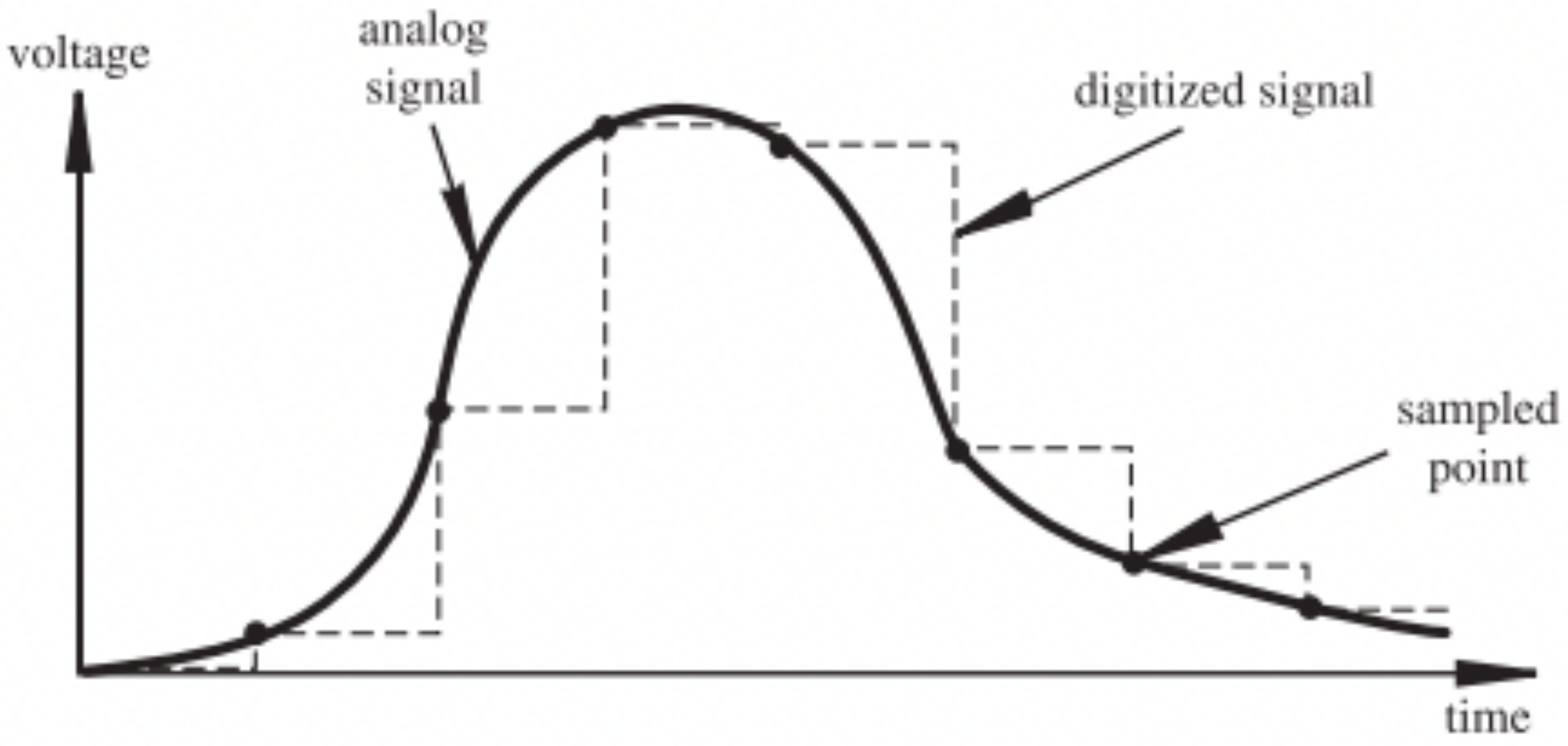
- Vibration & Acceleration



MEMs : microelectromechanical devices

Sampling Theory (Ch.8.1)

How can we ensure our digitized signals are accurate?



Sampling Theory (Ch.8.1)

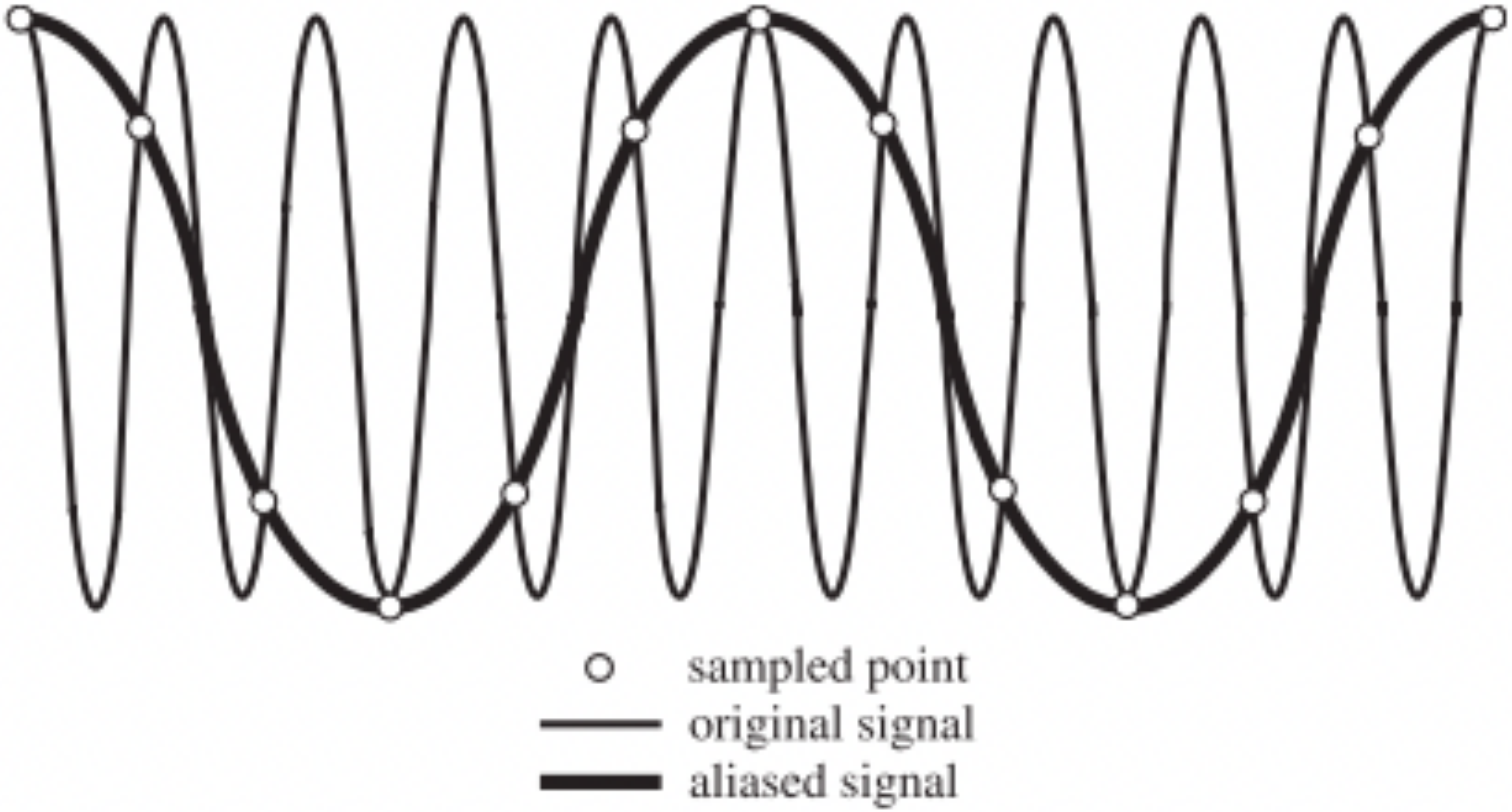
How fast or often the signal should be sampled to obtain an accurate representation.

Shannon's sampling theorem: we need to sample a signal at a rate more than two times the maximum frequency component in the signal to retain all frequency components

$$f_s > 2f_{\max}$$

Why?

Sampling Theory (Ch.8.1)

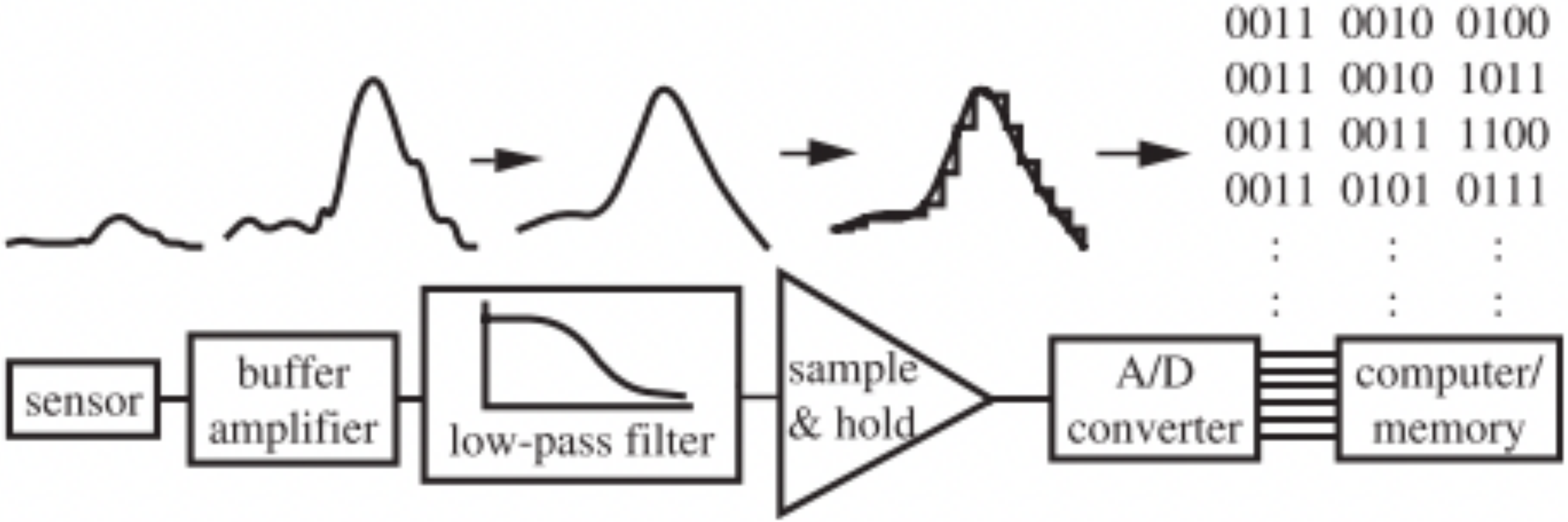


Analog to Digital Converter (Ch.8.3)

ADC Analog to digital Converter

→ most widely used
successive approximation

ADC overview



ADC successive approximation (most common)