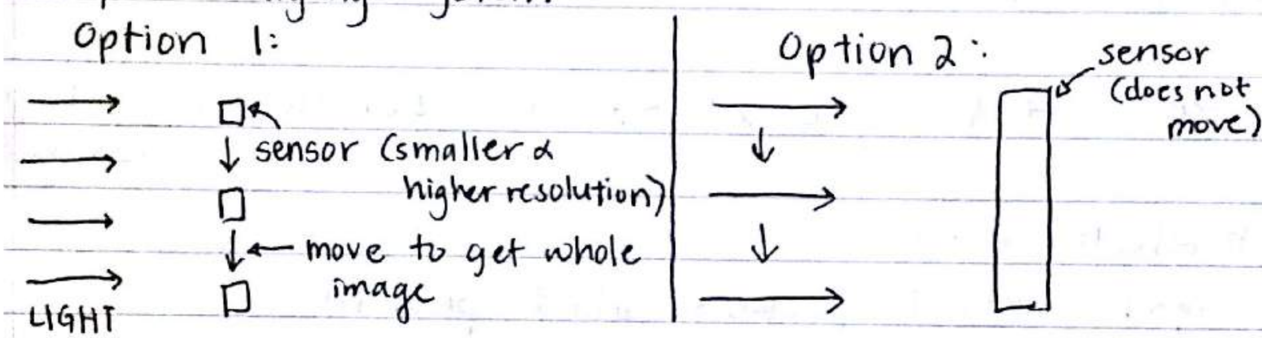
Introduction to Imaging

- cameras, medical imaging
  - enabled + dramatically enhanced by math / hardware design techniques we will learn.

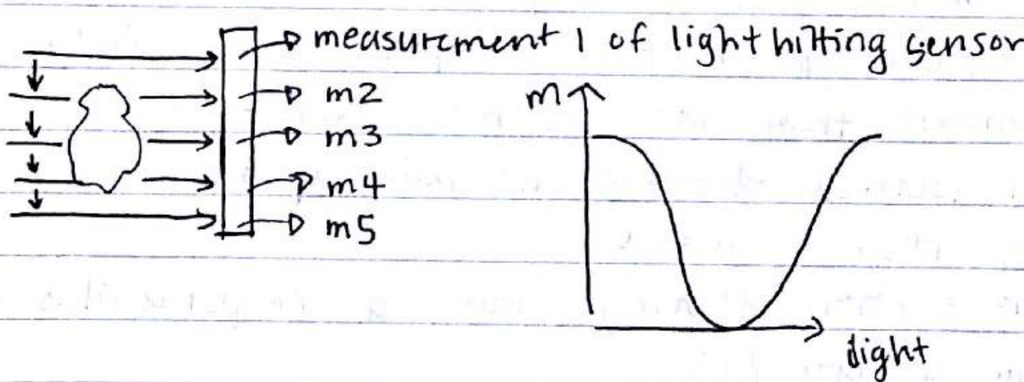
Energy src.))) Subject (((Energy detection

Imaging system

Simplest Imaging System:



e.g.:



this is a 1-D representation. But, you can rotate the light source for more D's.

Cellphone Camera:

- no moving components (sans mechanical focus)
- array of sensors

Ultrasound Imaging:

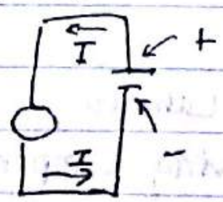
- sound waves (variation in pressure)
  - changes due to material properties
- depth of dimension is recovered by keeping truck of how long it took echo to come back
- x-y dimensions are by recovered by electronically focusing/steering waves

Imaging Lab #1:

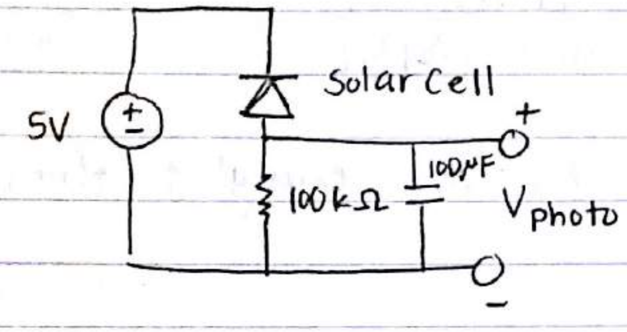
Sensor → Analog Circuit → Analog 2 Digital → Post Processing

Photodetector Basics:

- Light comes in packets called photons:
  - more photons → brighter
- Electronic photodetectors captures these photons and converts them into electrons (charge: Q)
- All electrical elements can build up charge → voltage (V)
- Capacitance: $Q = CV$
- # electrons flowing through device per unit is defined as current (I).
- Key pts:
  - current flows from high V to low.
  - closed loops for circuits.



Circuit:



Bouguer-Lambert-Beer Law: $\boxed{I = I_0 e^{-ax}}$

$I_0 \longrightarrow \boxed{\overset{\leftarrow a \rightarrow}{x}} \longrightarrow I$

light — homogenous material with attenuation factor x. — detector

a: path length thru material

I_0 : initial intensity I: output intensity

$I_0 \rightarrow \boxed{x_1 \mid x_2} \rightarrow I_2$ ($\leftarrow a \rightarrow \leftarrow a \rightarrow$)

$$I_1 = I_0 e^{-ax_1}$$

$$I_2 = (I_0 e^{-ax_1}) e^{-ax_2}$$

$$\boxed{I_2 = I_0 e^{-a(x_1+x_2)}}$$

$I_0 \rightarrow \boxed{x_1 \mid x_2} \rightarrow I_2$ ($\leftarrow a_1 \rightarrow \leftarrow a_2 \rightarrow$)

$$I_2 = I_0 e^{-a_1x_1 - a_2x_2}$$

$I_0 \rightarrow \boxed{x_1}\boxed{x_2} \dots \boxed{x_n} \rightarrow I_N$ (a_1, a_2, …, a_n)

$$I_N = I_0 e^{-\sum_{n=1}^{N} a_n x_n}$$

$$\frac{I_N}{I_0} = e^{-\sum_{n=1}^{N} a_n x_n} = T_N \text{ (transmittance)}$$

$$\boxed{-\ln\left(\frac{I_N}{I_0}\right) = \sum_{n=1}^{N} a_n x_n} = \text{“}b\text{”}$$

a linear combination of a and x
(coefficients)

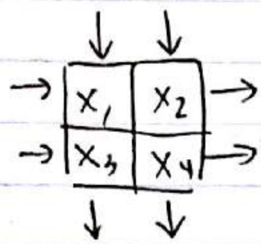
$I_0 \rightarrow \boxed{x_1}\boxed{x_2} \rightarrow I_2 \quad \overset{1}{\cancel{\alpha}}(x_1 + x_2) = b_1$

$\quad a=1 \quad a=1$

$x_1 + x_2 = b_1$

can't distinguish: $\boxed{x_1}\boxed{x_2}$ and $\boxed{x_2}\boxed{x_1}$

Measurement 2: $\cancel{I}$ $\overset{I_0}{\downarrow}\boxed{x_2}\boxed{x_1}\underset{I_1}{\downarrow}$ $\quad x_2 = b_2$. enough to solve!



$$
\begin{aligned}
x_1 + x_2 &= b_1 \\
x_3 + x_4 &= b_2 \\
x_1 + x_3 &= b_3 \\
x_2 + x_4 &= b_4
\end{aligned}
$$

doesn't work.

$\leftarrow$ we know this

$(x_1 + x_2 + x_3 + x_4 - x_1 - x_3)$