Remember to slice end of 5th run because too much shit and Ari hit table

Keep in mind that u have to take into account that it "starts" recording all at different positions, so → it is not a "phase difference" just starts at different places → simply slice away.

3 main sweeps:

- increments of 0.50 sweep, very broad
- increments of 0.10 sweep
- increments of 0.01 sweep.

1. Major Next steps: make calibration for transducer to position values.

$$V(t) = c_1 \cdot \theta(t) + c_2$$

set different increments, find offset and build relationship for $\theta(t) \to$ with uncertainty some how

Throw entire arrays in there.

2. Beta constant determination through undriven runs

peaks follow trough:

$$A = A_0 \cdot e^{-\beta t} + \text{offset} \qquad A = -A_0 e^{-\beta t} + \text{offset}$$

extract β and report uncertainty through weighted mean and uncertainty.

3. Determine torque to I ratio like in equation 1.11. Assume errors, propagate, and plug in different A.

You can only find A once you did step 1.

4. Next determine nat freq of oscillator using ODE knowledge.

* Ask Cooke about my version of curve fit + Final project stuff

* Ask photoelec effect grading.

5. Amplitude measuring done through voltage conversion

→ Amplitude (phase diff)

phase diff (some operation between drive and response)

can calc steady state through β

6. At close resonance:

Amplitude (phase diff)

phase diff (Hz from natural freq)

7. Big end goals:

Fourier B.S.

For every drive freq, extract:

- Amplitude → function, using conversion and box
- phase diff → ez, X value. peak to peak
  trough to trough analysis

AND compare/use Eq 1.11

lab and

Manual Eq. 1.12

Basically through every run, make array of quantities (through peak finder or difference) and build $\theta(t)$ function. Can do chi2 for every run, but is that goal?

For fourier, how do I find $\Psi(\omega)$ derivative analysis?

$$\theta(t) = c_1 V(t) + \boxed{c_2}$$

0.05 rad

$$\theta(t) = \boxed{c} V(t)$$

↓

0.1

$$\theta(t) = \boxed{c} V(t)$$

↓

0.2

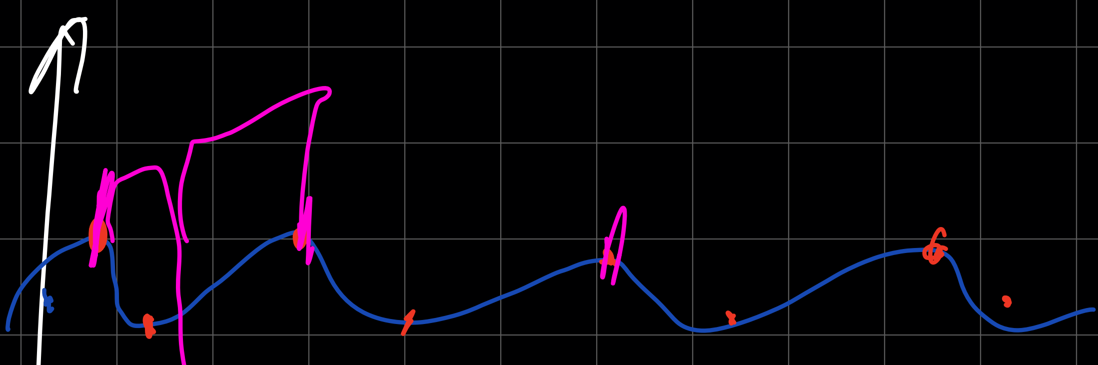
↓

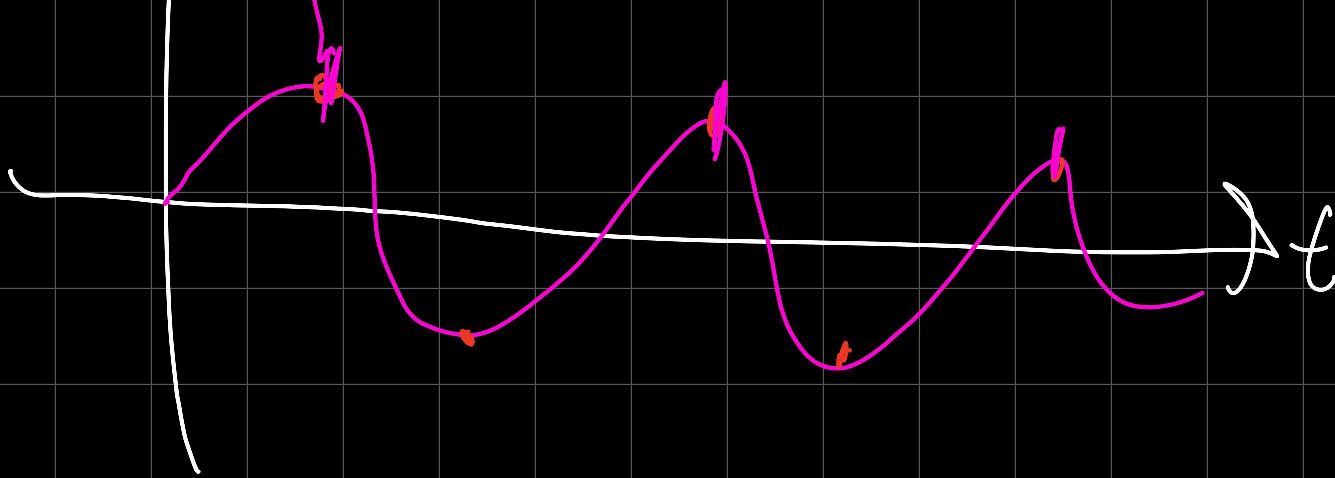
0.4

↓

0.6

✓

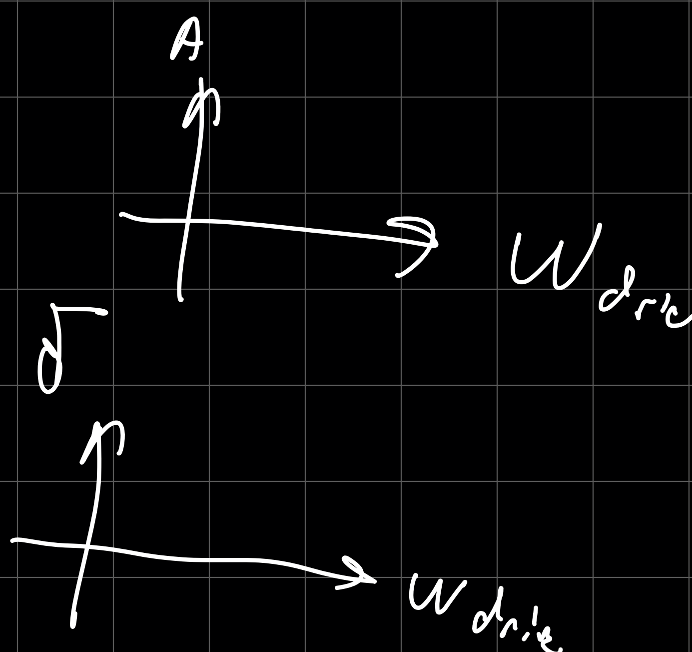




FFT: A vs

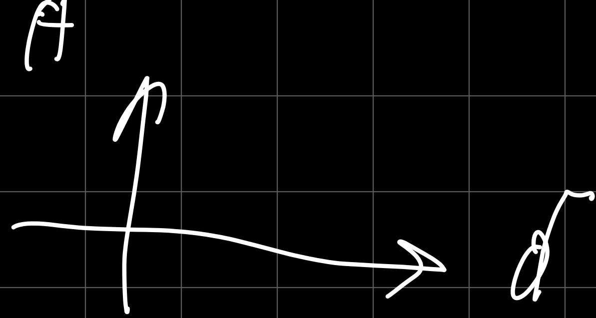
Calibration torque

Po graphs of



Torque

conversion:



$$V_{out} = V_3 \cos(\omega t) \rightarrow 700\ Hz$$

$$\propto$$

$$T_{ext} = \tau_0 \cos(\omega t)$$

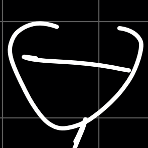
0 offset

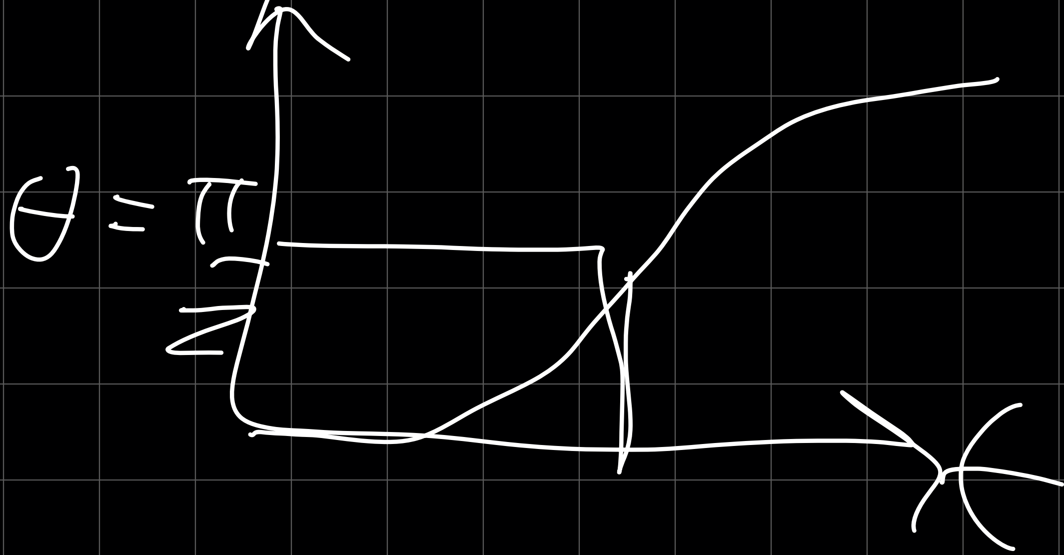
$$T_{ext}(t) = c\, V(t) + \cancel{V_{offset}}$$

Record different P2P

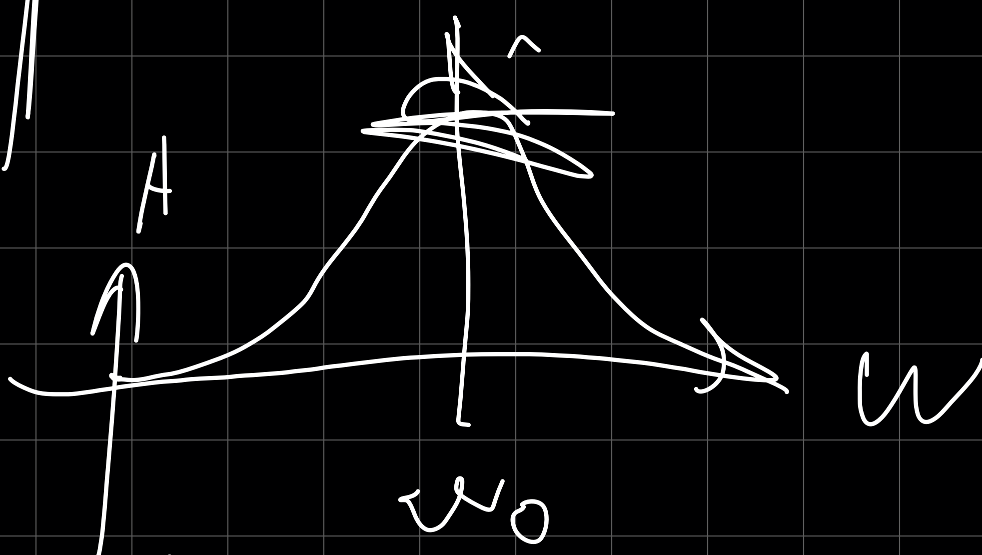
record different freq.

4

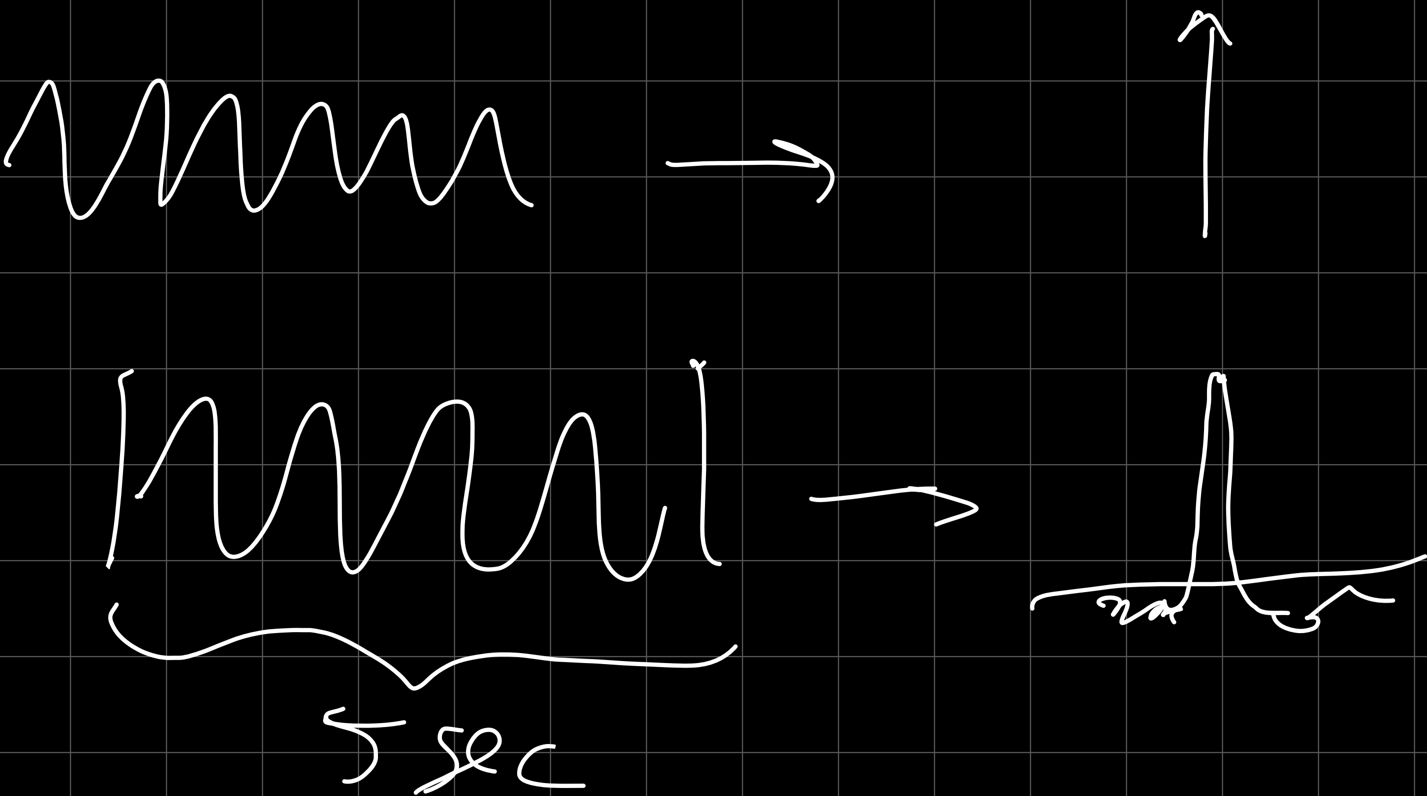


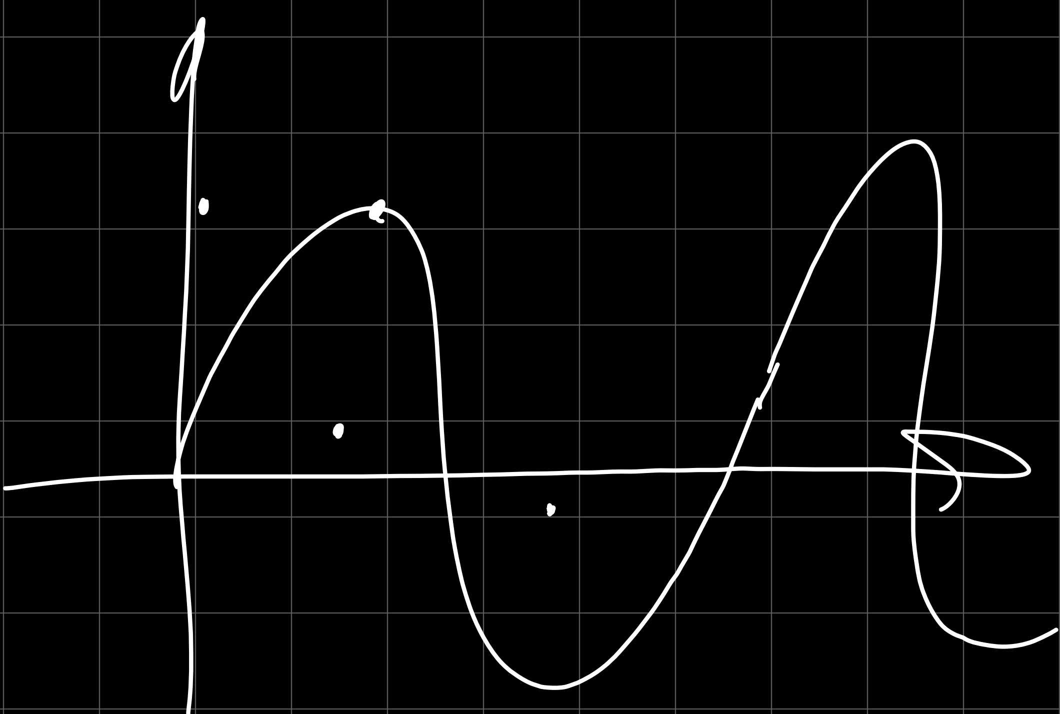

θ = π


A
t


A
ω
ω0


ω


5 sec



Notes from Data Analysis:

1. Find β to justify heavy underdamping

(2 references classical mechanics)

1

$$\omega_d = \sqrt{\omega_0^2 - \beta^2}$$

2

$$A(t) = A_1 e^{-\beta t}$$

peak amplitude

original

n oscillating

solve for ω_0 = I guess

β

Do max and min, peak to peak, trough to trough

$$\omega = \frac{f}{2\pi}$$

$$T \cdot f = 2\pi \qquad T = \frac{2\pi}{f}$$

Calibrate for offset:

$$V(t) = c_1\,\theta(t) + c_2$$

$$c_1 = \frac{V(t) - c_2}{\theta(t)}$$

if offset 0, then in β calculation ratios divide automatically

if not, ratios

Steps: Sunday morning

After max min finding

- remove offset

fuck offset uncertainty (insignificant)

- find β

amplitude envelope:

- find calibration

$$A_{maxs} = A_0 e^{\beta t}$$

$$\frac{A_{maxs}}{A_0} = e^{\beta t}$$

$$\frac{[0:-1]}{[1:]}$$

$$\ln \frac{A_{maxs}}{A_0} = \beta t$$

$$\frac{1}{\Delta t} \ln\left(\frac{A_{maxs}}{A_0}\right) = \beta$$

$$= \beta$$

Beta should

be negative

$$w_0 = \sqrt{}$$

$$\left(w_d^2 + \beta^2\right)^{\frac{1}{2}}$$

$$w_0 = \sqrt{(\text{unc } w_d)^2 \cdot (\quad)^2 + (\text{unc } \beta)^2 \cdot} \quad \frac{\beta^2}{w_d^2 + \beta^2} \quad \frac{\beta}{\sqrt{w_d^2 + \beta^2}} \cdot$$

$$w_0 =$$

Now: calibrate the thingy.

appropriate units

Offset removed: $V(t) = a_1 \, \theta(t)$

$$T = \frac{1}{f} \qquad w = \frac{2\pi}{T} \qquad \frac{V(t)}{\theta(t)} = a_1 \qquad f = \frac{w}{2\pi}$$

$$T \cdot w = 2\pi$$

$$w = \frac{2\pi}{T} \qquad \frac{V_{\text{peaks}}}{\theta_{\text{displaced}}} = a$$

you will

$$[f] = s^{-1} = Hz$$

Fix calibration by removing garbage

noise at beginning and end.

Always plot before processing

Then Calibrate torque ↗ through picture by cooke and with proper data

Then Transform all collected voltage signals into amplitudes

Extract: Avg amplitude for that driv
Force

↙ freq. →

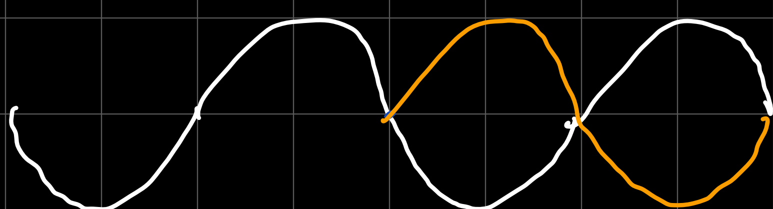
y x

build these three point by point

phase difference for that drive freq.

↙

y



x

Amp vs. phase difference

$\downarrow$ $\quad\quad\quad\quad\quad$ $\downarrow$

y $\quad\quad\quad\quad\quad$ x

Then FFT $\rightarrow$ Goddamn it

Calibration of torque: $\tau_{ext}(t) = \tau_0 \cos(\omega t)$

$$V(t) = m(\tau_{ext}) + b$$

$b = 0$

$$V(t) = a\,\theta(t) \leftarrow V(t) - b = m\,\tau_{ext}$$

$$= \quad V_{pp}\cos(\omega t) = m\,\tau_0 \cos(\omega t)$$

external $\quad$? $\quad$ $= \tau_0$

$$\boxed{V(t)} = m\,\boxed{\tau_0 \cos(\omega t)}$$

$$\frac{V_{pp}}{2}\ \cancel{\cos(\omega t)} = m\,\tau_0\ \cancel{\cos(\omega t)}$$

prop constant

$\boxed{\frac{V_{pp}}{2}} = \boxed{m}\,\boxed{\tau_0}$

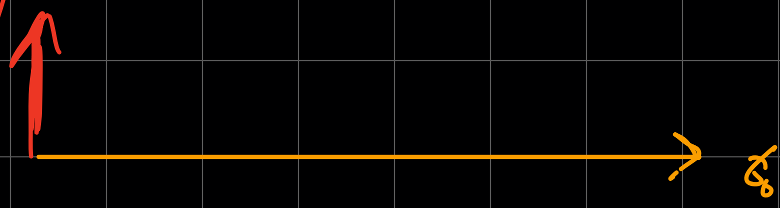
$\boxed{V(t) = a\,\theta(t)}$

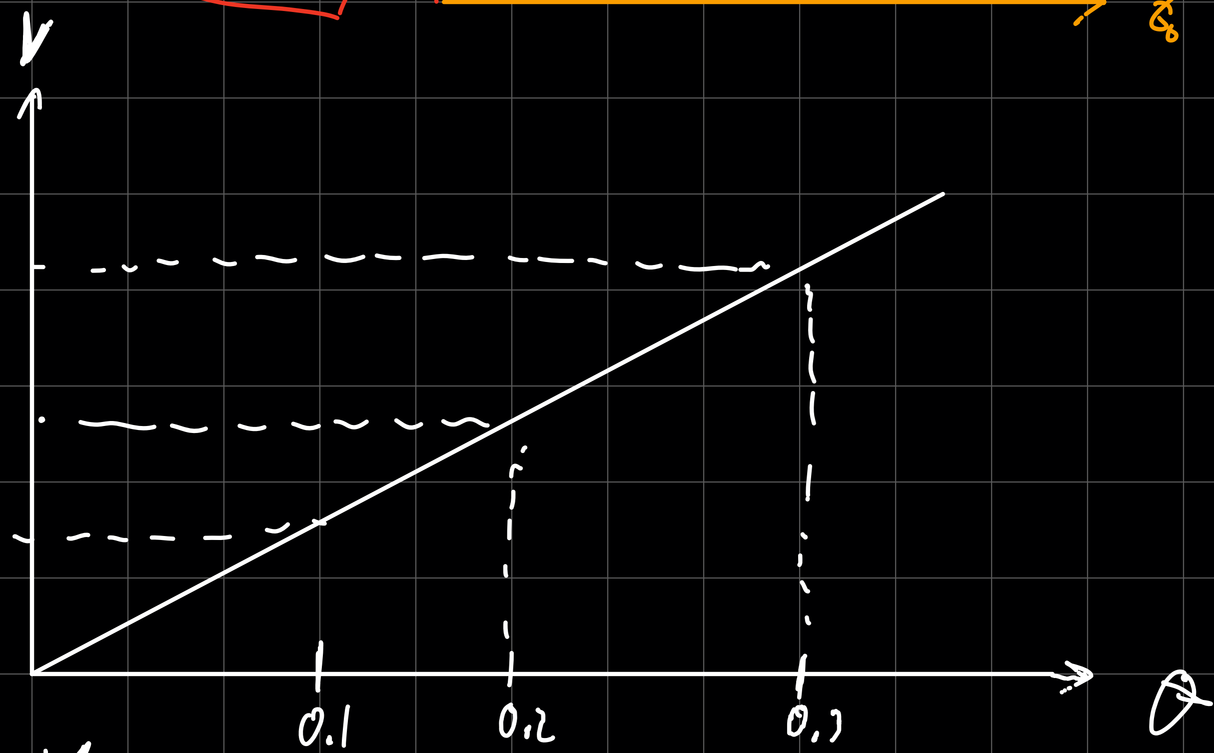
different voltages

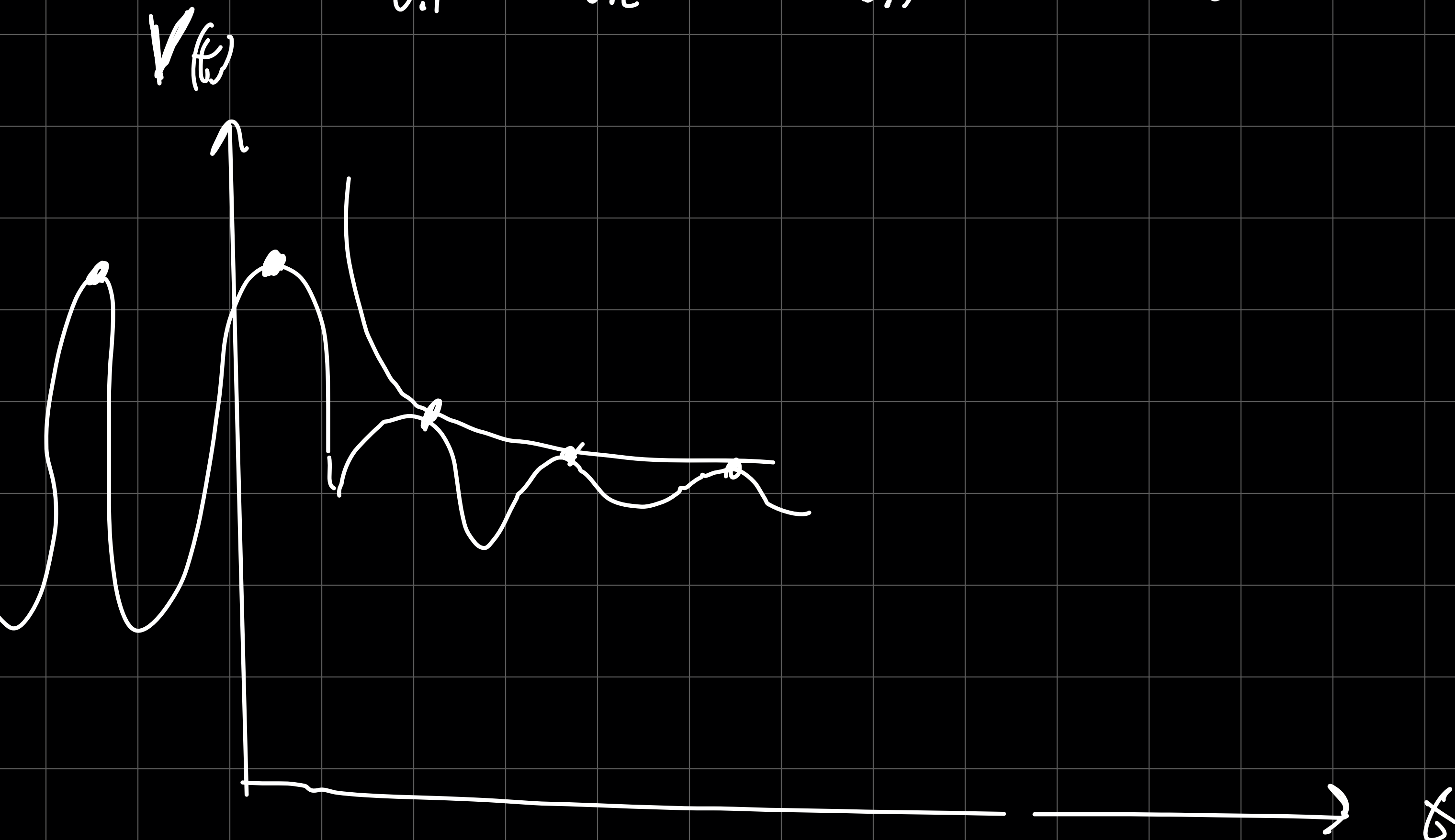
2.5 V

1.5 V

$V_{pp} \propto \tau_0$





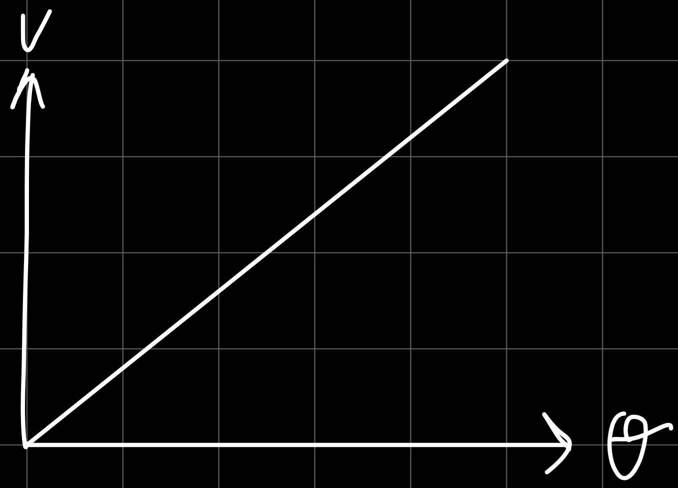


can't calibrate

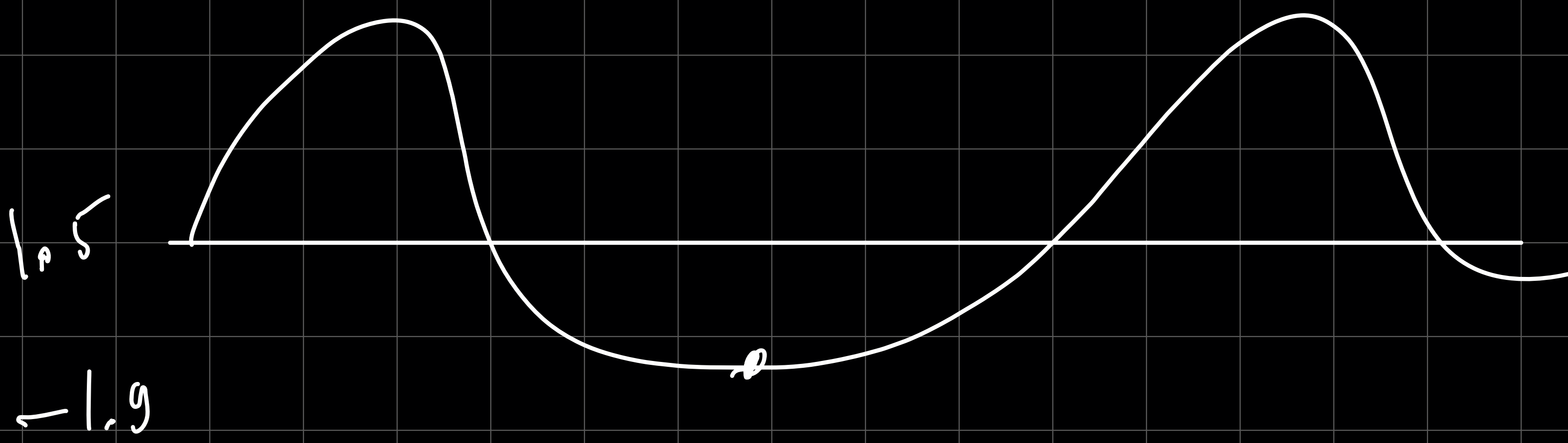
$\boxed{\tau \text{ and } V}$

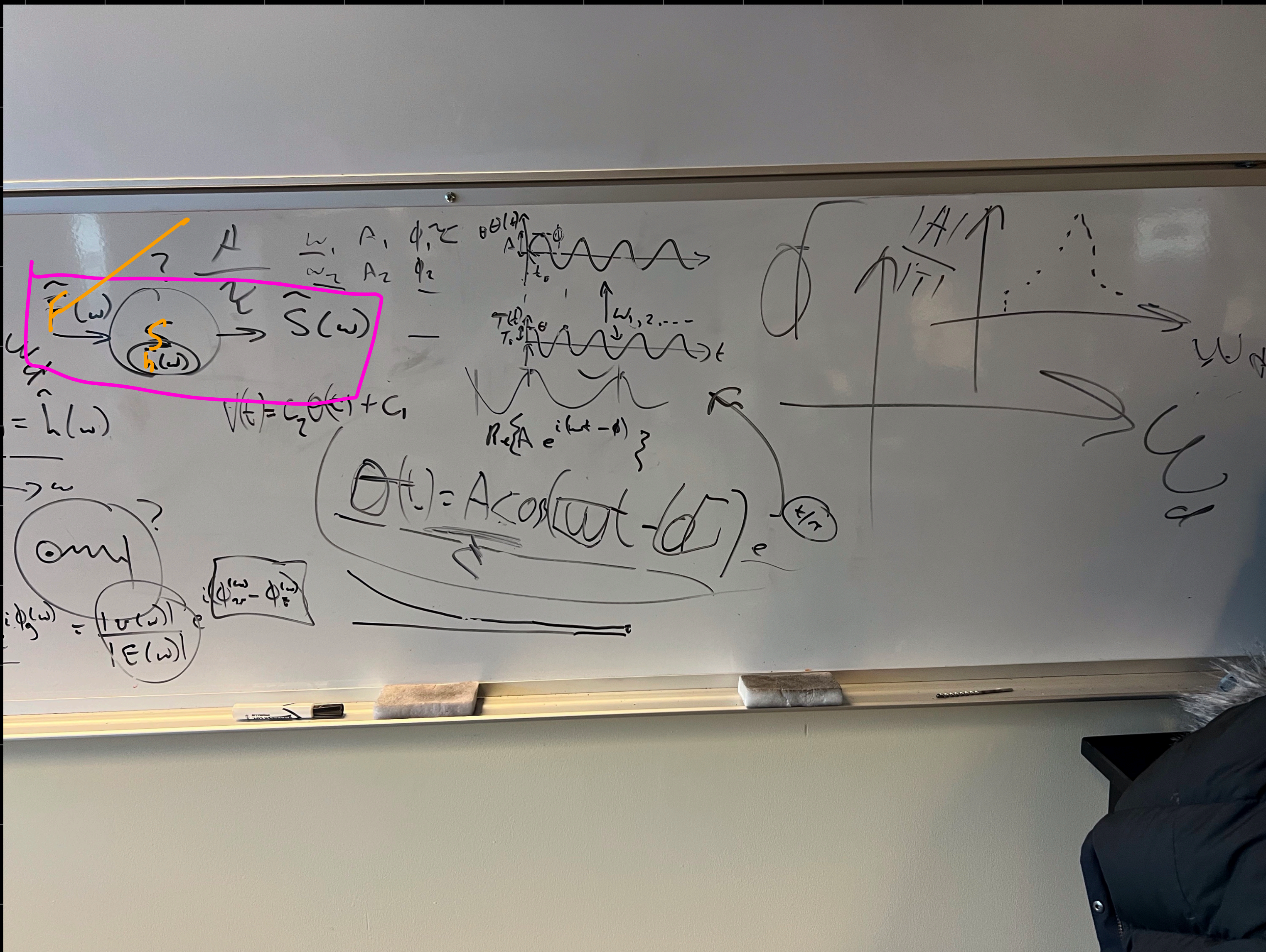
can't calibrate

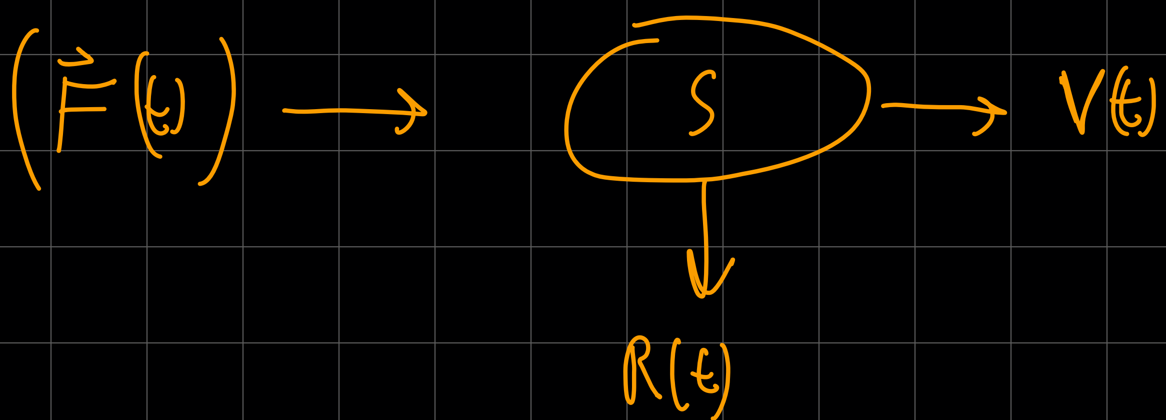
θ and V



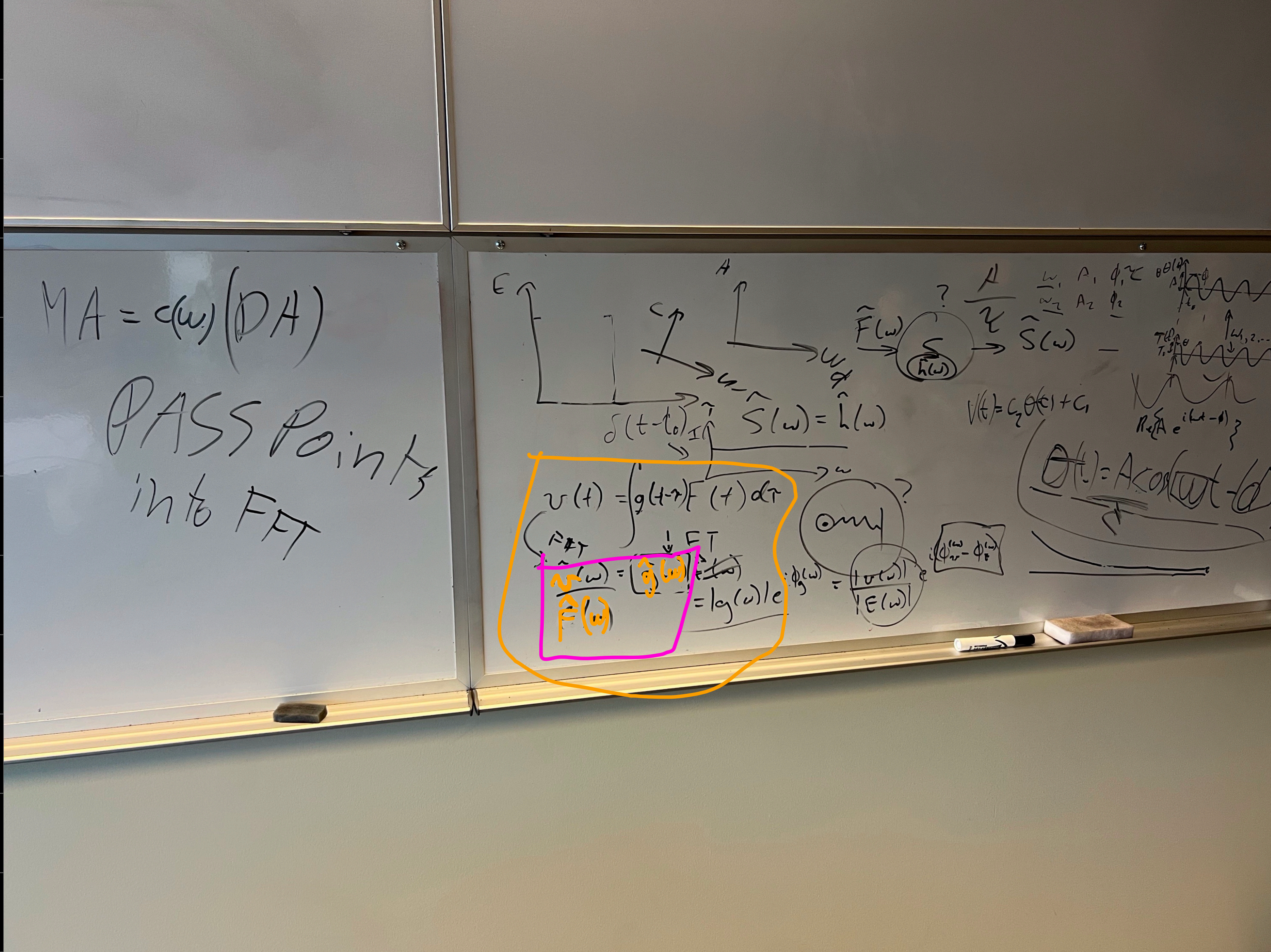
$$a = \frac{V}{\theta}$$

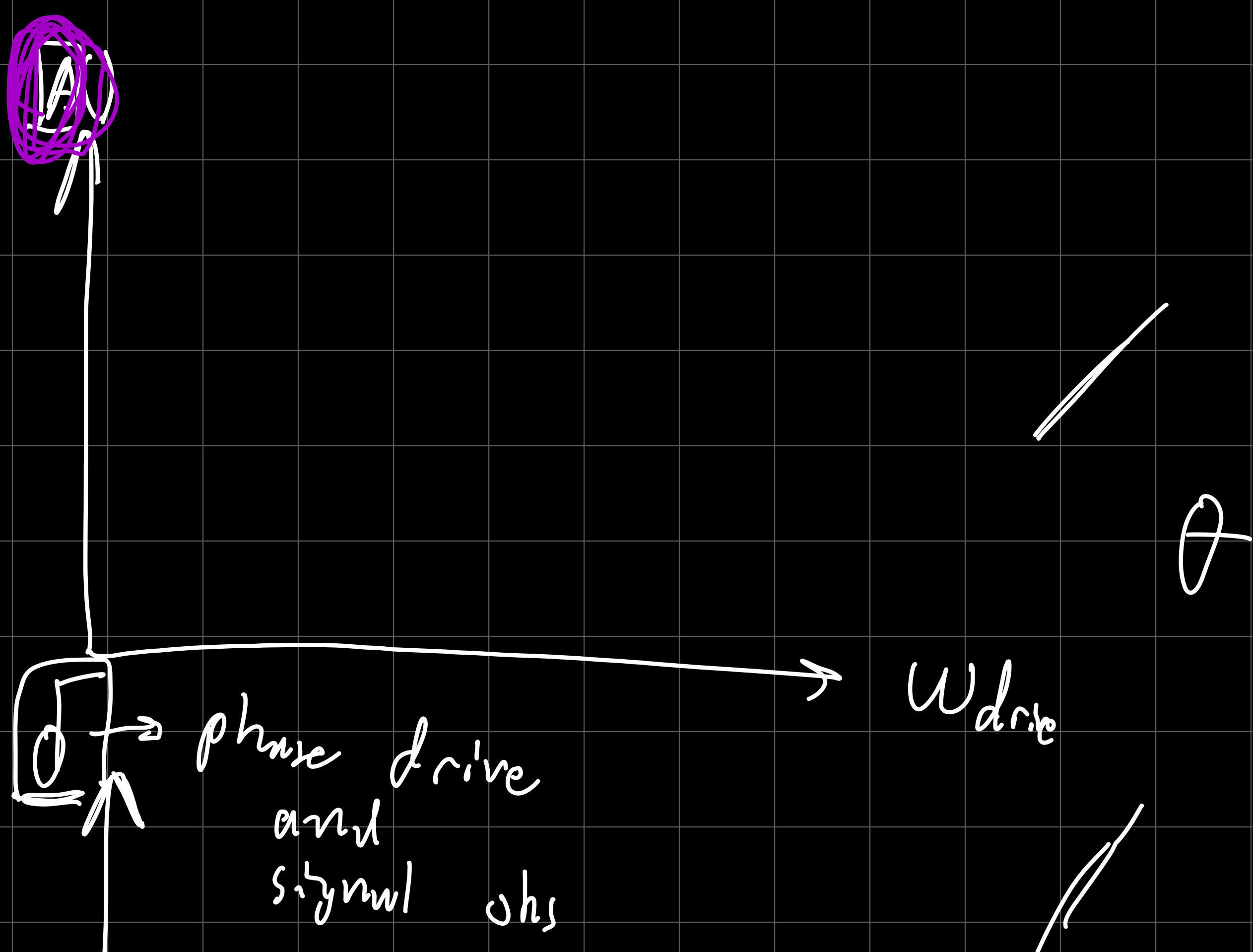


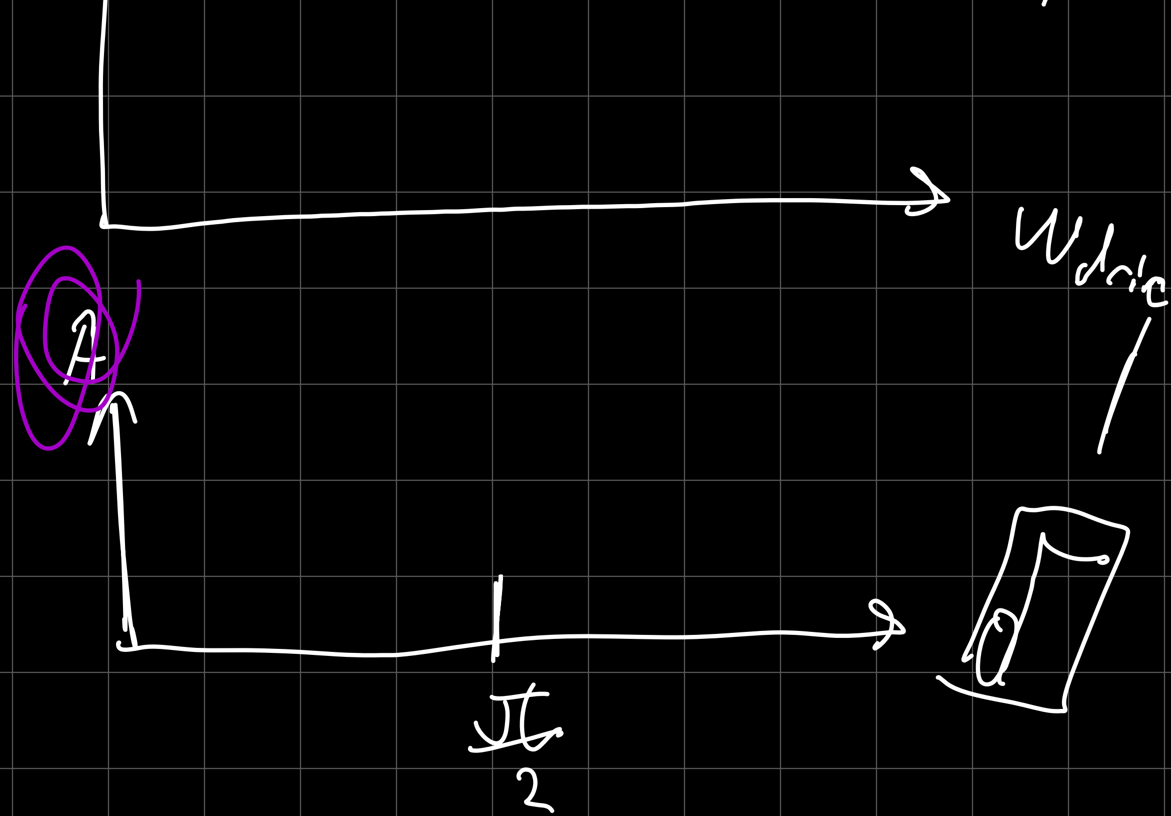


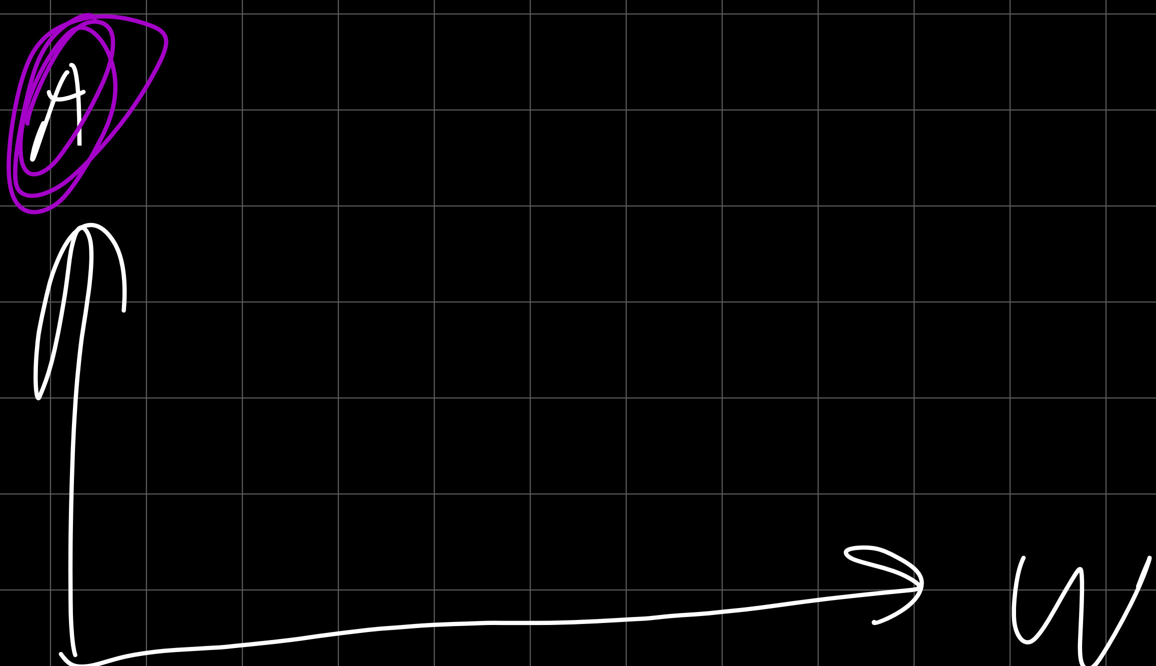


$$R(t) = \frac{V(t)}{F(t)}$$


MA = c(ω)(DA)
PASS Points into FFT
F(ω)
S(ω)
S(ω) = h(ω)
v(t) = ∫g(t-τ)F(τ)dτ
FFT
FT
V(t)=c2θ(t)+c1
θ(t)=Acos(ωt-φ


A
θ
ωdrive
φ
phase drive
and
signal obs


A
$\frac{\pi}{2}$
0


A
W


0
W

Email ~~TA~~ → Cali don't work for both

text Ari. → maybe not

Manually np. gen from txt,

Manually sketch one, other, together

Then extract the Amp using <u>only</u> peaks
Find mean and SEM. note down
driv freq. Rinse and repeat.

Now: after sketch

amplitude array per run, take mean
know what driving freq there was
make graph. That is easy

now find the phase difference: how
using ai algorithm

Amp vs. phase

next: make array and plot them!

3 graphs.

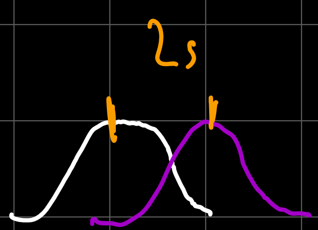
Then, my favorite part of life, fourier transform I love this

when two waves are

$T = 8s$

2s apart

$\frac{2s}{T} \cdot 2\pi$



$\cdot \omega$