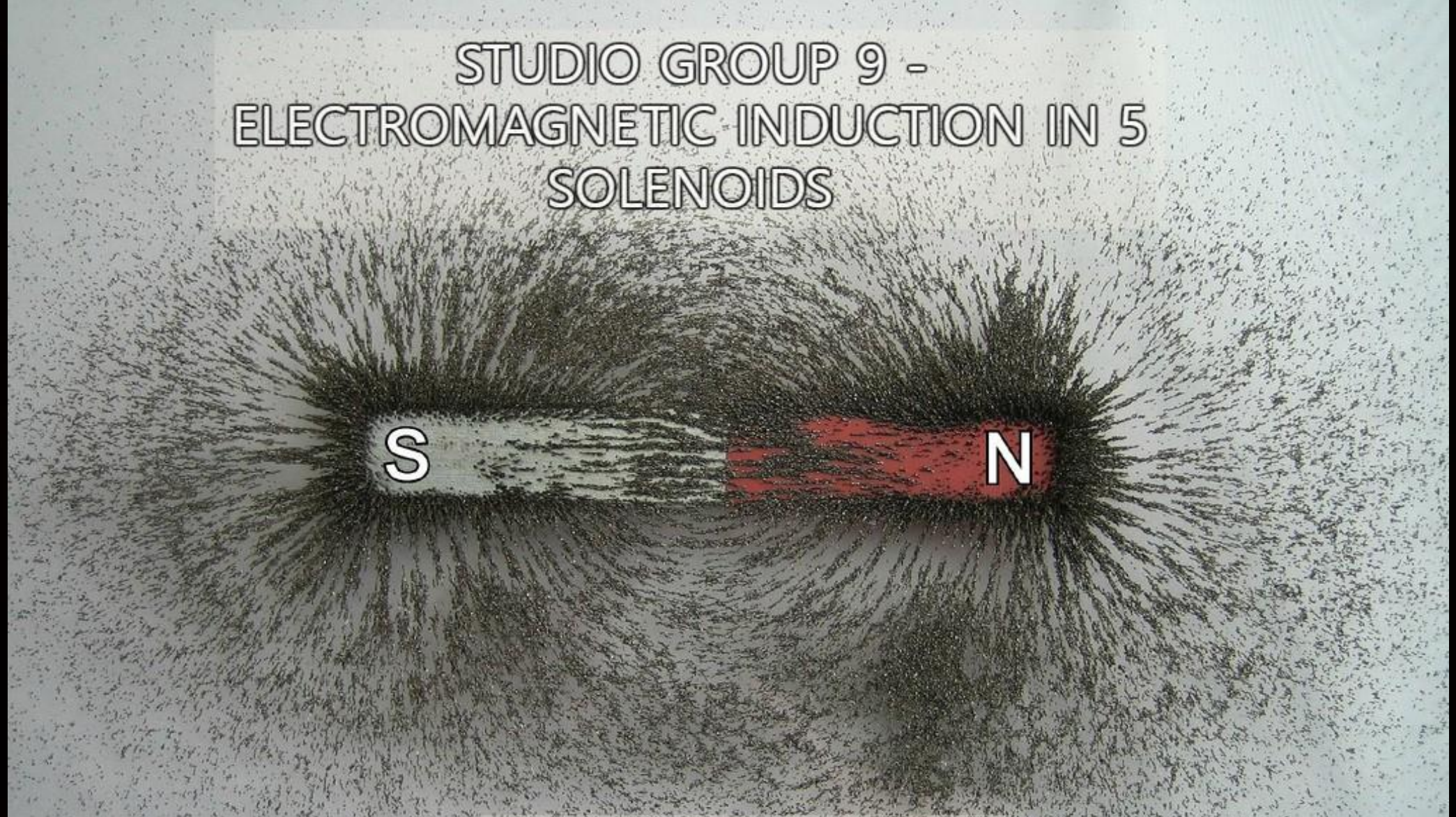
STUDIO GROUP 9 - ELECTROMAGNETIC INDUCTION IN 5 SOLENOIDS



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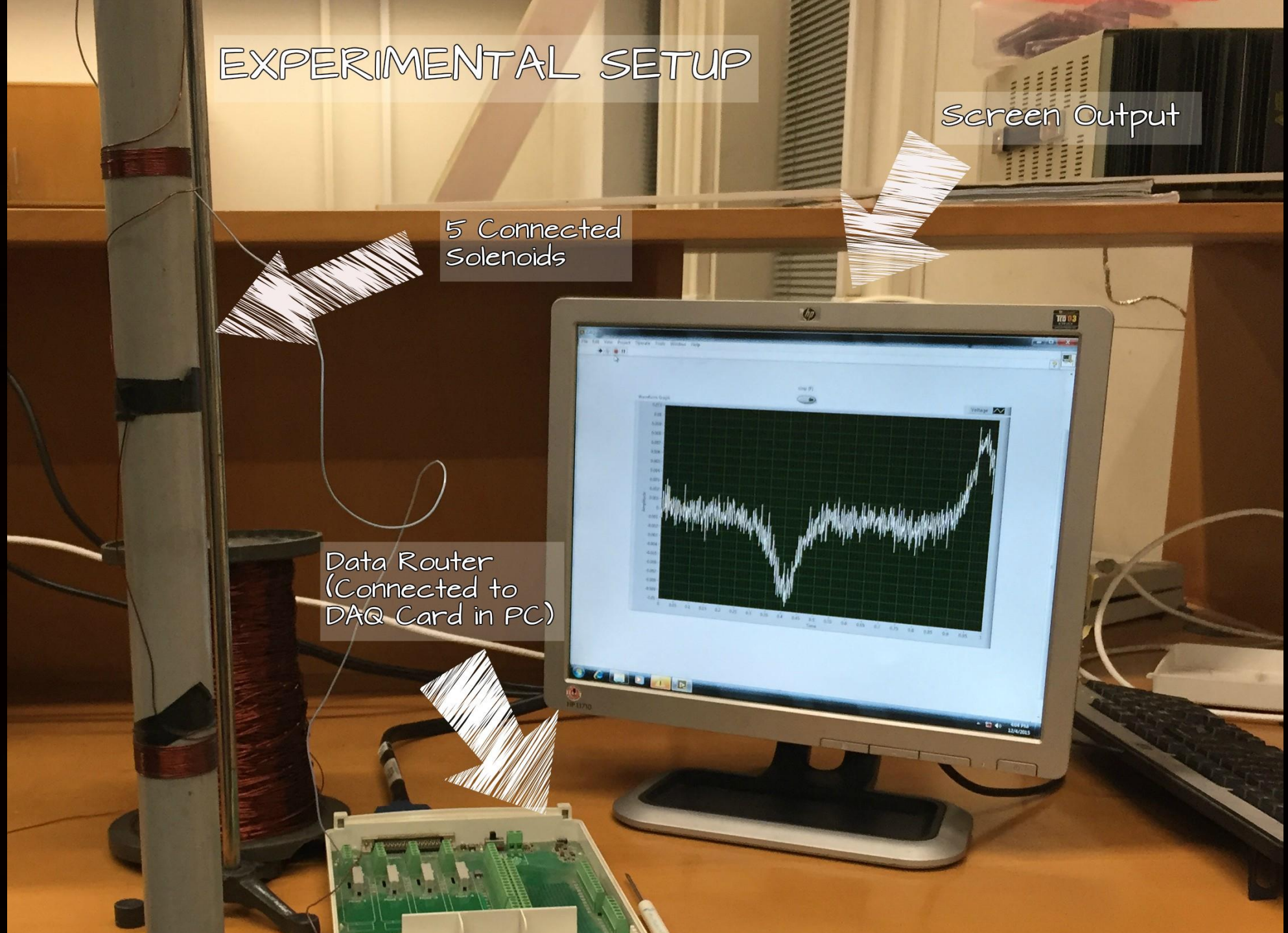
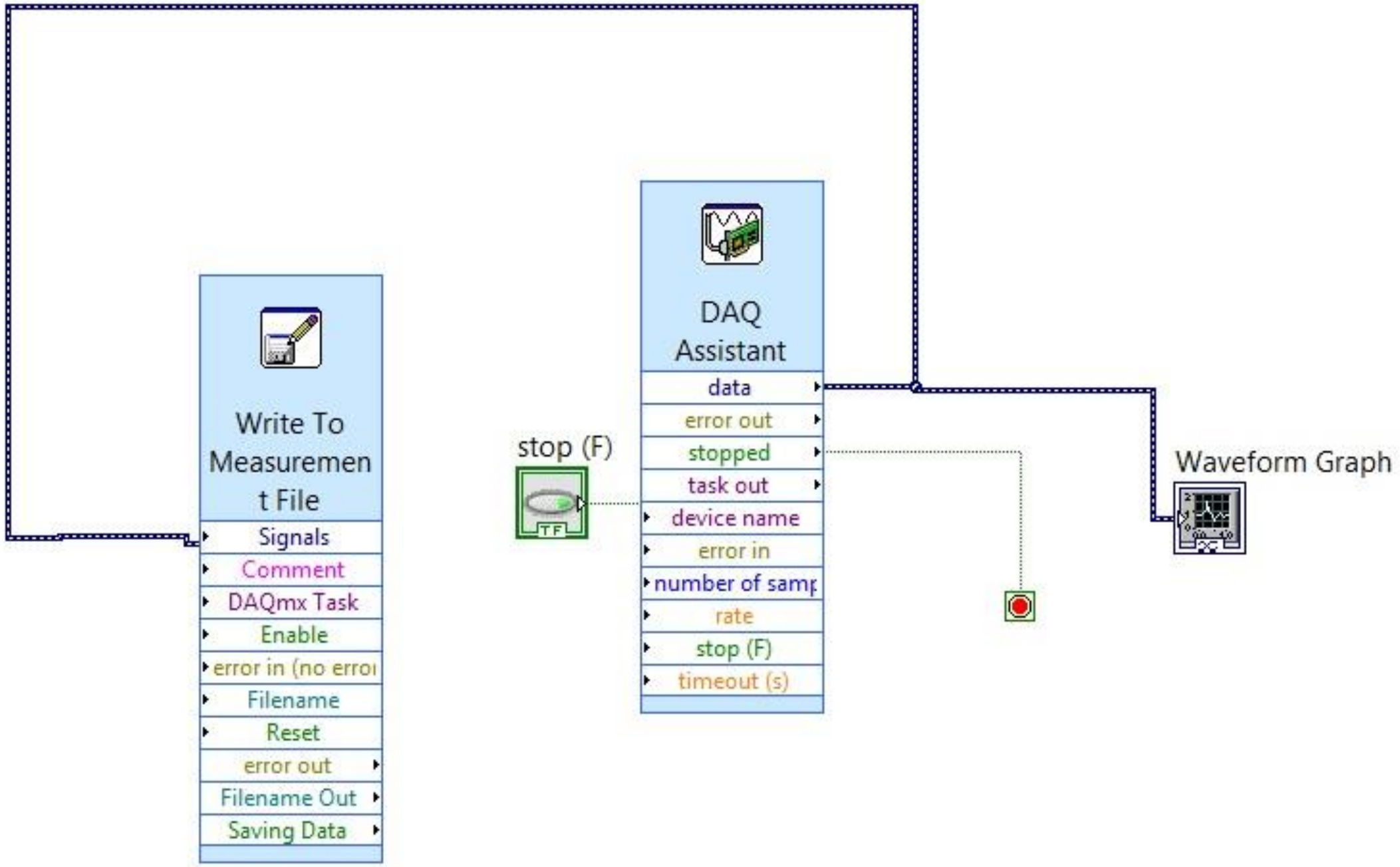

EXPERIMENTAL SETUP
Screen Output
5 Connected Solenoids
Data Router (Connected to DAQ Card in PC)

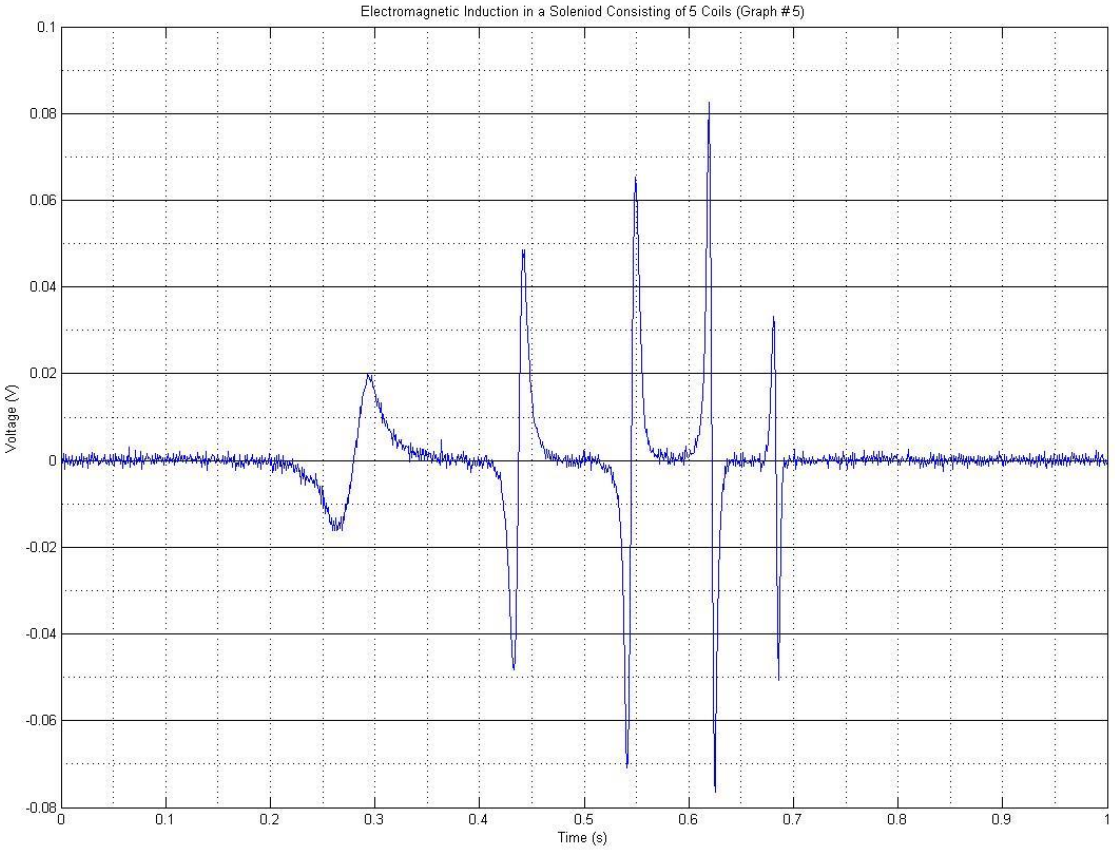

Write To Measurement File
Signals
Comment
DAQmx Task
Enable
error in (no error
Filename
Reset
error out
Filename Out
Saving Data
DAQ Assistant
data
error out
stopped
task out
device name
error in
number of samp
rate
stop (F)
timeout (s)
stop (F)
TF
Waveform Graph

Velocity Measurement Using Naïve VS Accurate Methods

- Naïve Method

v = Δz/Δt, where Δz = a.

Approx. Value Peak 2 for
V = 2.438 m/s.



Theoretical Derivation

$$B_d = \frac{\mu_\circ}{4\pi R^3}\left[\frac{(3m.R)R}{R^2} - m\right]$$

$$R = \rho\cos\varphi i + \rho\sin\varphi j + zk$$

$$B_d = \frac{\mu_o m}{4\pi(\rho^2 + z^2)^{5/2}}\left[3z\rho\cos\varphi i + 3z\rho\sin\varphi j + (2z^2 - \rho^2)k\right]$$

$$B_d = \frac{\mu_o m}{4\pi(\rho^2 + z^2)^{5/2}} [3z\rho\cos\varphi i + 3z\rho\sin\varphi j + (2z^2 - \rho^2)k]$$

$$\Phi_d = \int_0^{2\pi} d\varphi \int_0^{a} d\rho \frac{\mu_o m(2z^2\rho - \rho^3)}{4\pi(\rho^2 + z^2)^{5/2}}$$

$$\Phi_d = \frac{\mu_o m\, a^2}{2(a^2 + z^2)^{3/2}}$$

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$$\text{emf} = \frac{-d\Phi_d}{dt} = \frac{-d\Phi_d}{dz}\frac{dz}{dt} = \frac{d\Phi_d}{dz}v$$

$$\text{emf} = -\frac{3}{2}\mu_o m a^2 v \frac{z}{(a^2 + z^2)^{5/2}}$$

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$$\frac{d\,\text{emf}}{dz} = 0 \rightarrow z = \pm a/2$$

$$v = \frac{z(\varepsilon +) - z(\varepsilon -)}{t(\varepsilon +) - t(\varepsilon -)} = \frac{a/2 - (-a/2)}{dt} = \frac{a}{dt}$$

Values of velocities calculated for each coil using the naïve method

Peak#	Max peak time/s	Min peak time/s	Max peak voltage/V	Min peak voltage/V	Velocity/ms^-1 (a/Δt)
1	0.295	0.264	0.0191	-0.0161	0.708
2	0.442	0.433	0.0469	-0.0483	2.740
3	0.549	0.541	0.0655	-0.0708	2.438
4	0.619	0.625	0.0825	-0.0765	3.650
5	0.681	0.686	0.0331	-0.0507	4.390

- Accurate Method

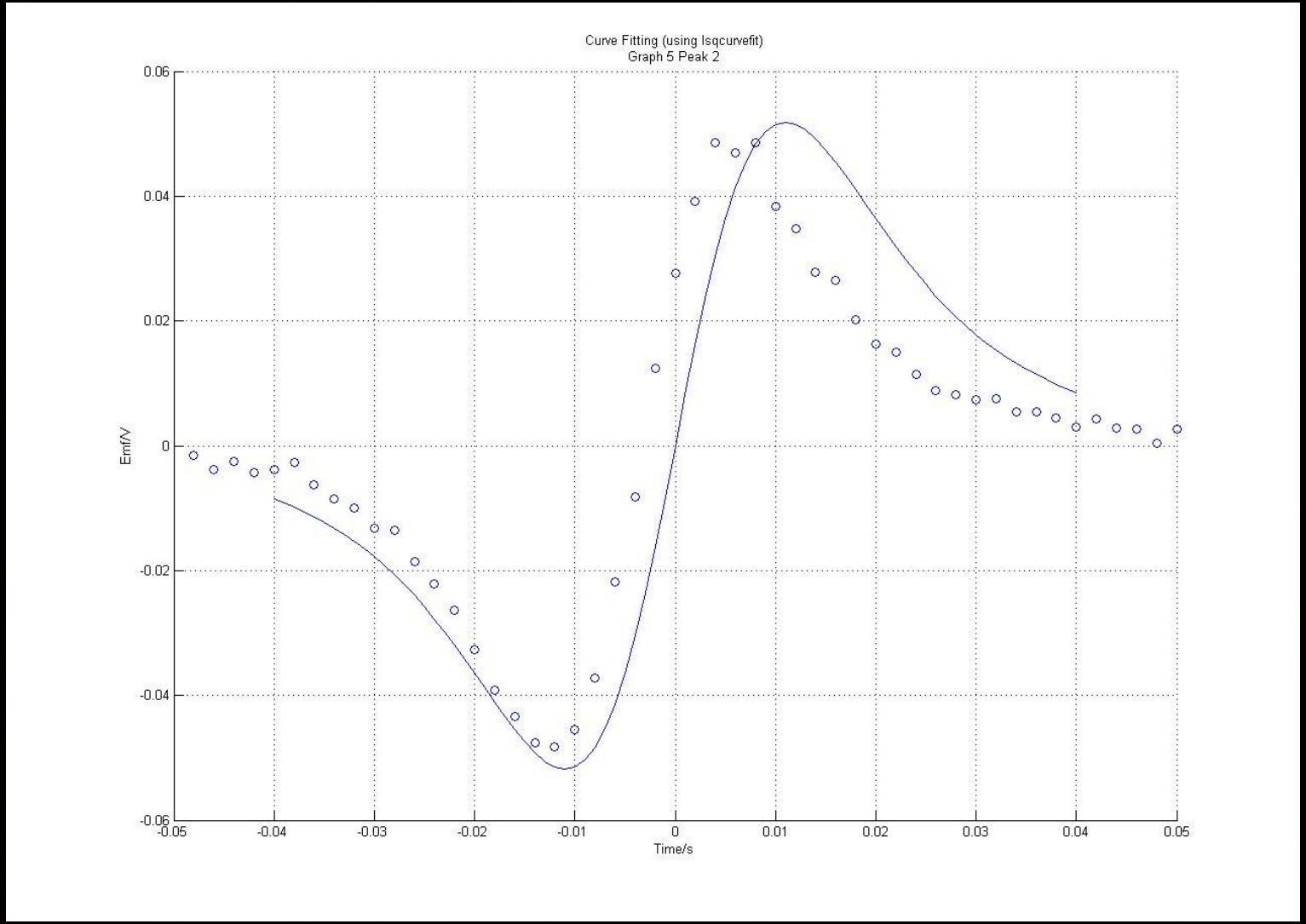
$$\mathrm{emf}(\Delta t) = \frac{(-3/2)\mu_\circ a^2\,\alpha(v^2\Delta t)}{(a^2 + v^2\Delta t^2)^{5/2}}$$

Using LSQ Curve Fit, accurate value of V was measured.

Fitting Parameters:

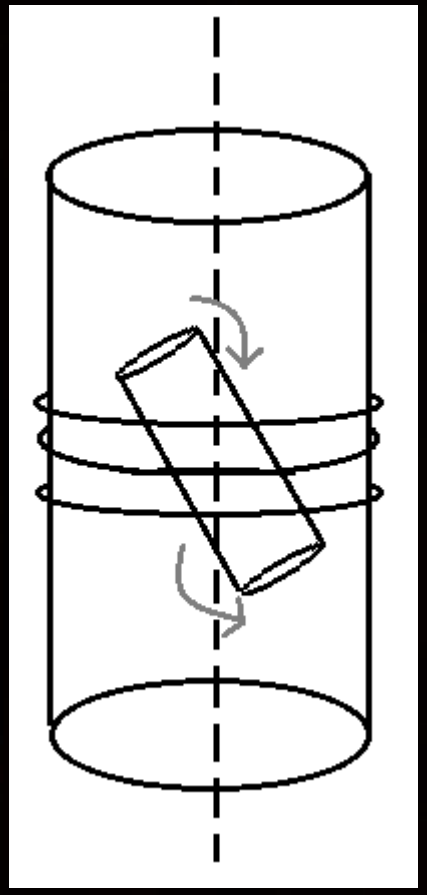
- V
- α

Best value for v = 2.054 m/s
Best value for α = 22.53

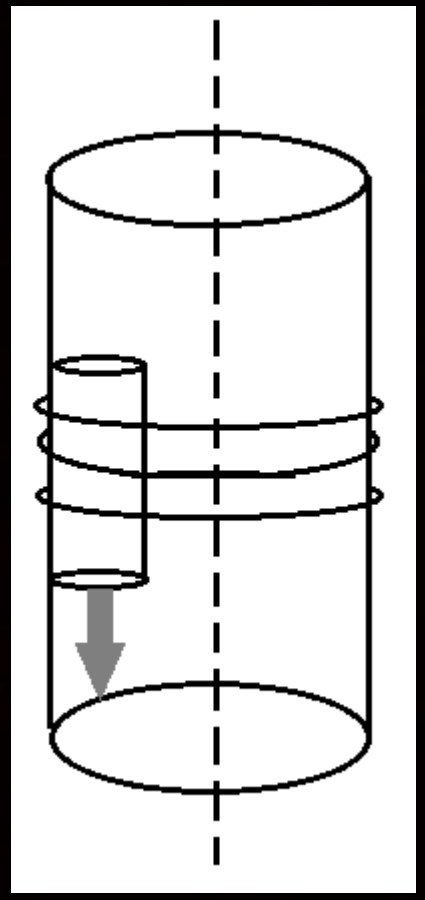


Deviations In Experiment

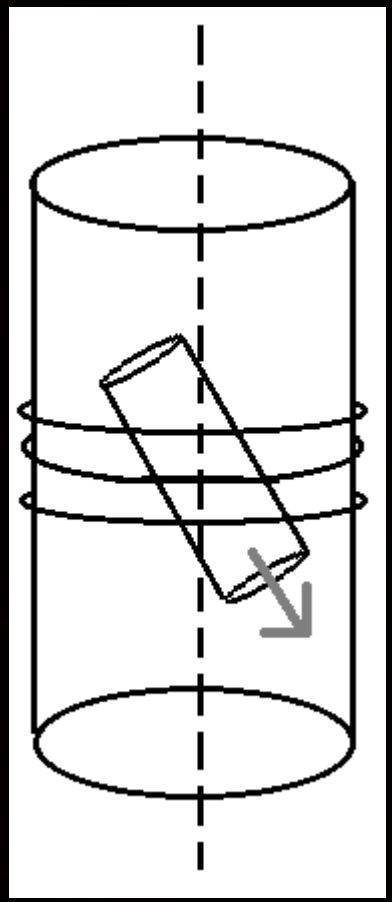
1. Spinning



2. Off-Axis



3. Collision With Walls



ANY QUESTIONS?

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