Spinning a magnet inside a coil

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Winchester College.
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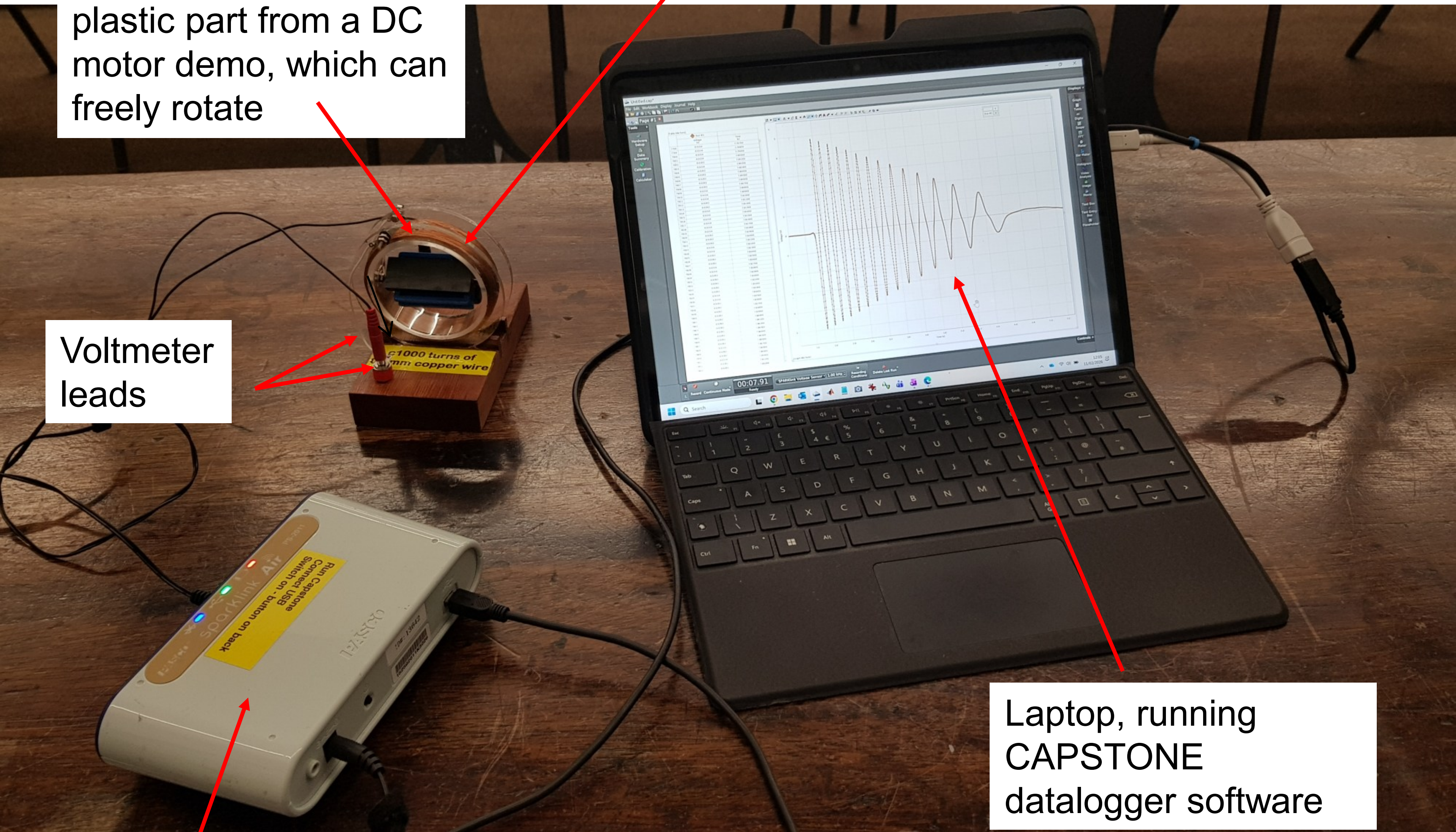
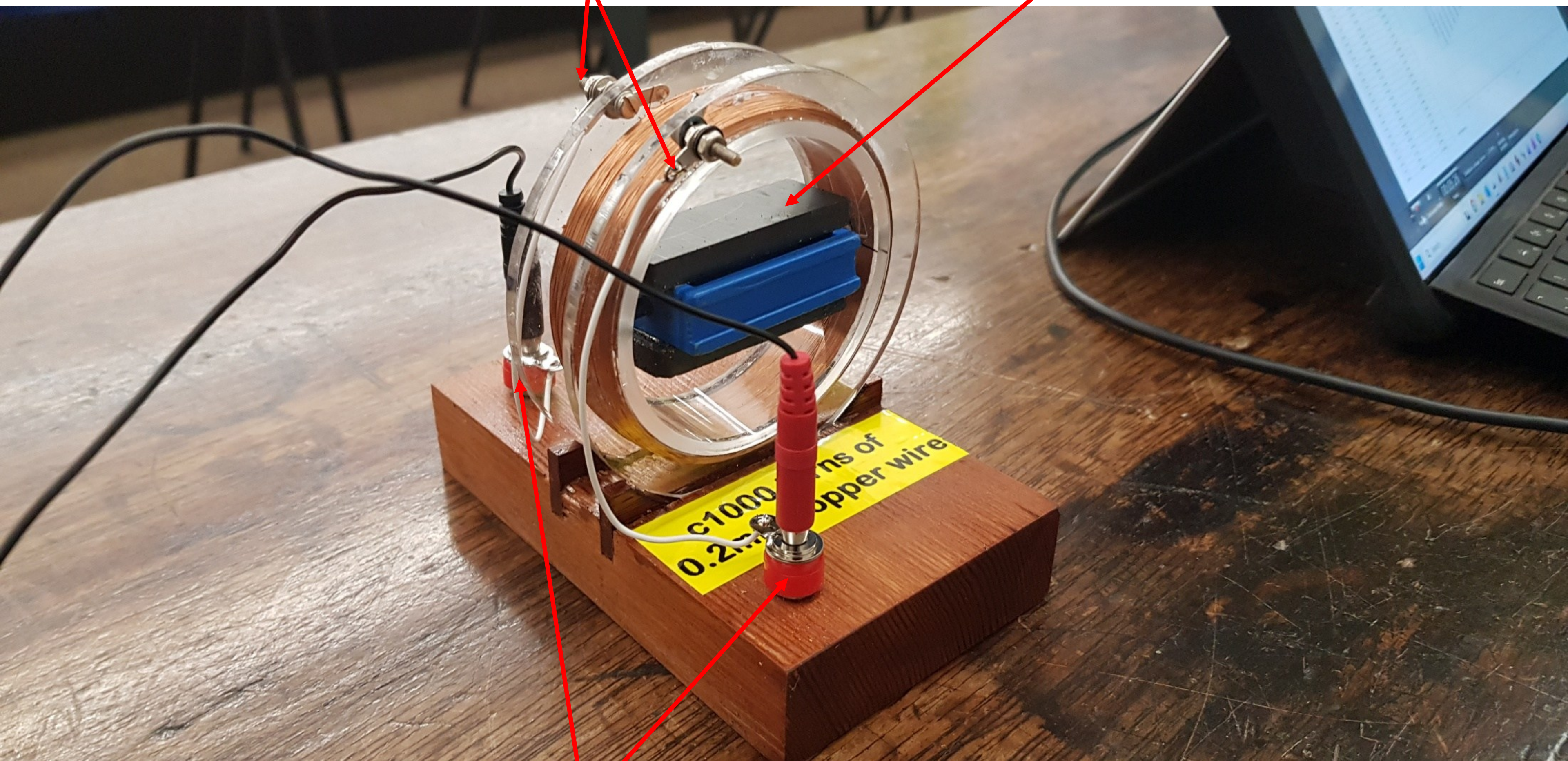

Two magnadur magnets glued to a plastic part from a DC motor demo, which can freely rotate
A thousand turns of 0.2mm copper wire
Voltmeter leads
c1000 turns of
mm copper wire
sparklink Air
Run Capstone
Connect USB
Switch on - button on back
PASCO
Laptop, running CAPSTONE datalogger software
PASCO USB datalogger

Two magnadur magnets (opposing outward poles) glued to a plastic part from a DC motor demo, which can freely rotate inside a coil of 1000 turns of 0.2mm copper wire.

Wire ends soldered to these terminals



Standard school laboratory voltmeter connectors

Datalogger (voltage, time) set at 1000Hz. Data imported to Excel.

Magnet spinning in a coil

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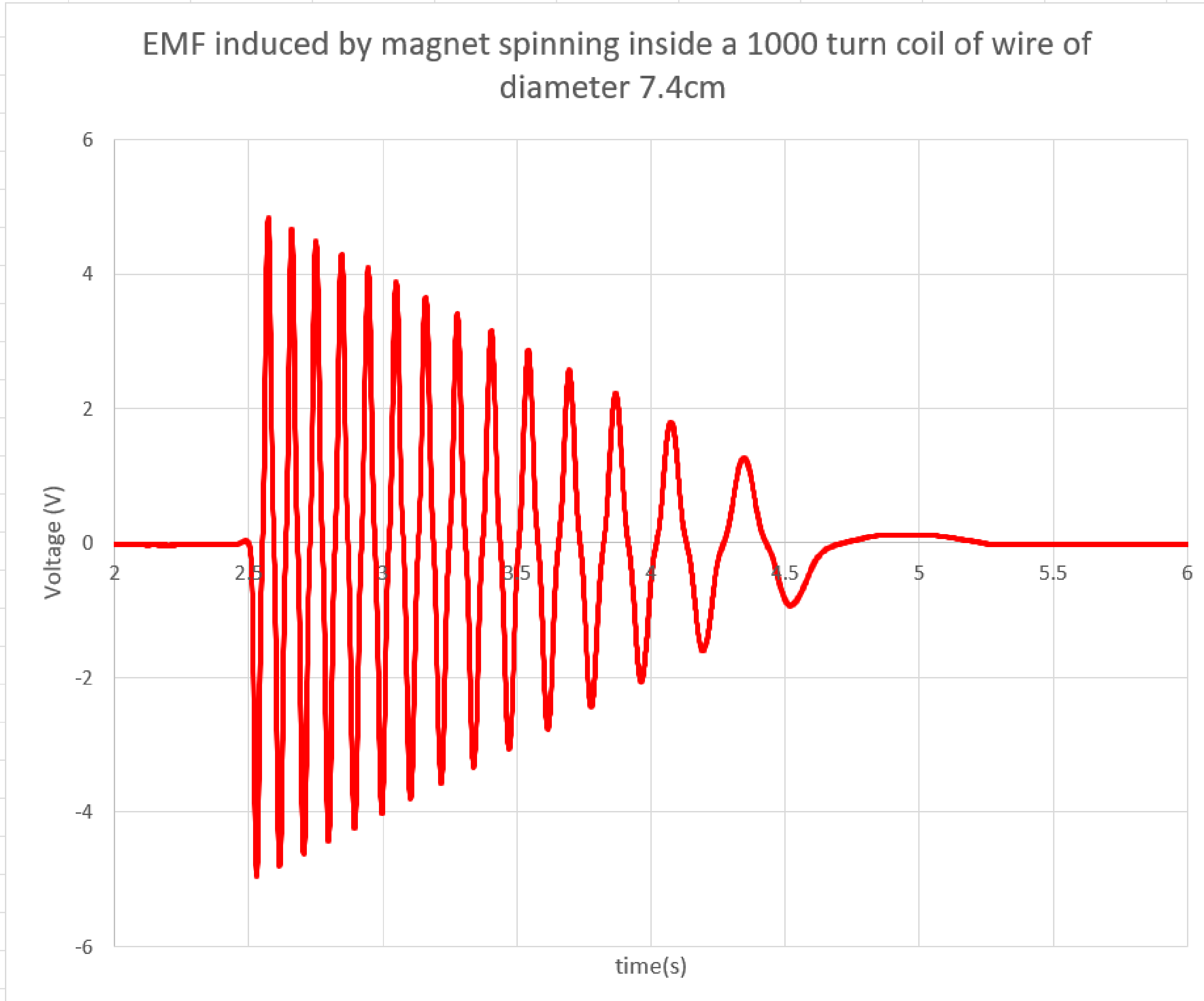
Voltage (V)	Time (s)
-0.0214	0
-0.0214	0.001
-0.0262	0.002
-0.0214	0.003
-0.0262	0.004
-0.0262	0.005
-0.0262	0.006
-0.0262	0.007
-0.0262	0.008
-0.0262	0.009
-0.0262	0.01
-0.0262	0.011
-0.0262	0.012
-0.0262	0.013
-0.0262	0.014
-0.0214	0.015
-0.0262	0.016
-0.0262	0.017
-0.0214	0.018
-0.0262	0.019
-0.0262	0.02
-0.0262	0.021
-0.0262	0.022
-0.0214	0.023
-0.0262	0.024
-0.0214	0.025
-0.0262	0.026



Determine peak (time,voltage)

Estimate period from difference between peak times, and hence frequency

Magnet spinning in a coil
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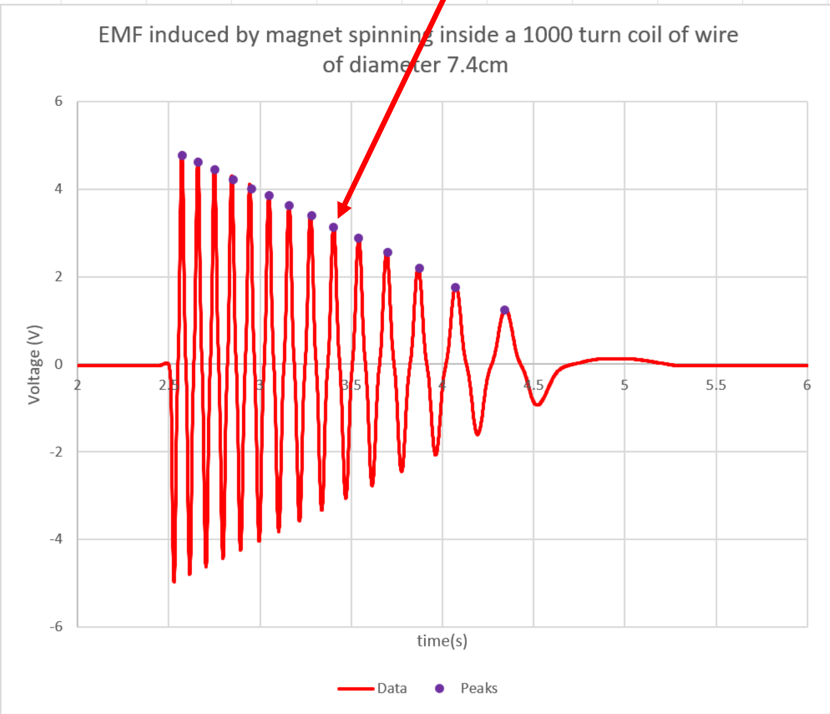
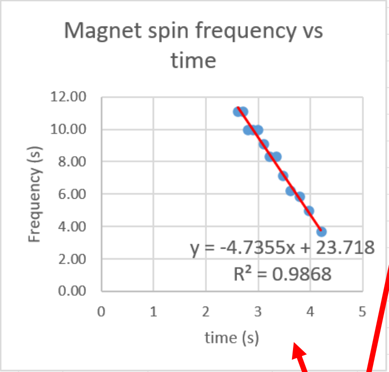
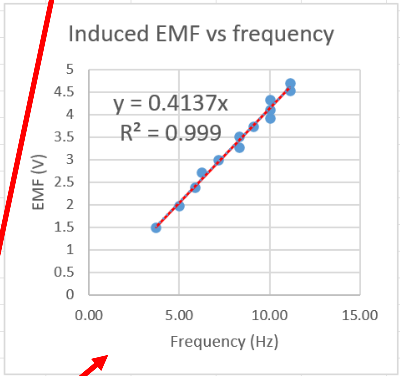
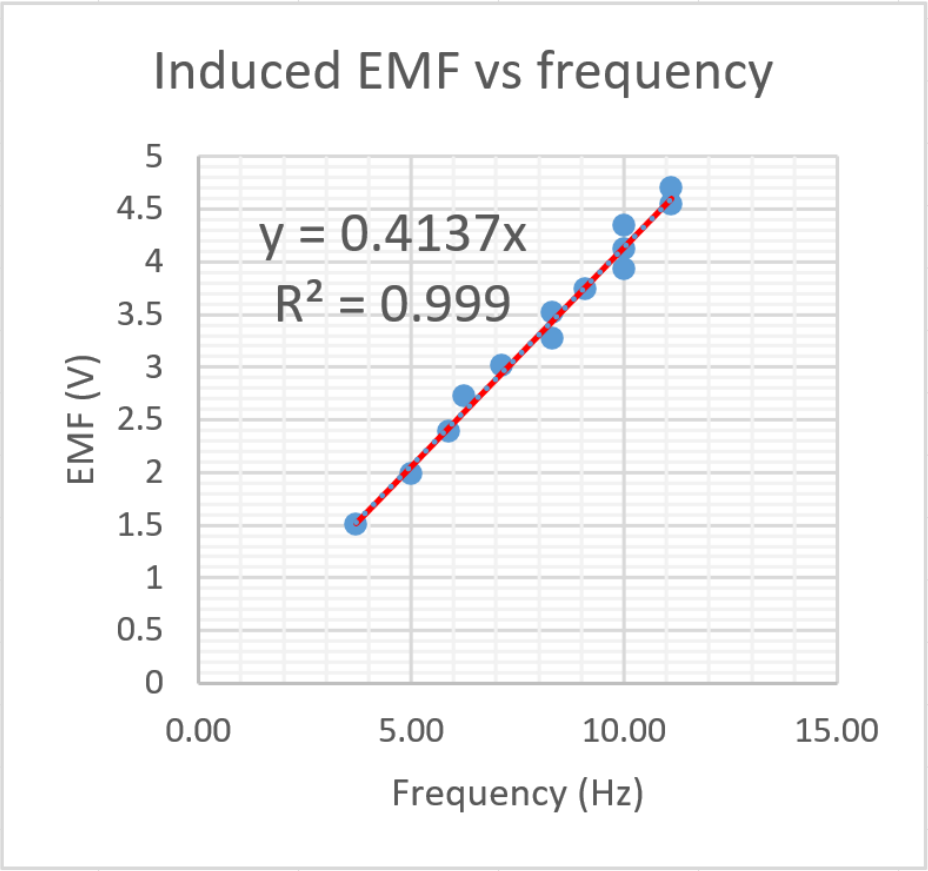


	t peak (s)	Peak V (volts)	Period /s	f /Hz	t (s)	V (volts)
1	2.57	4.77				
2	2.66	4.63	0.09	11.11	2.615	4.7
3	2.75	4.46	0.09	11.11	2.705	4.545
4	2.85	4.23	0.10	10.00	2.8	4.345
5	2.95	4.01	0.10	10.00	2.9	4.12
6	3.05	3.86	0.10	10.00	3	3.935
7	3.16	3.63	0.11	9.09	3.105	3.745
8	3.28	3.41	0.12	8.33	3.22	3.52
9	3.4	3.14	0.12	8.33	3.34	3.275
10	3.54	2.88	0.14	7.14	3.47	3.01
11	3.7	2.57	0.16	6.25	3.62	2.725
12	3.87	2.21	0.17	5.88	3.785	2.39
13	4.07	1.77	0.20	5.00	3.97	1.99
14	4.34	1.25	0.27	3.70	4.205	1.51

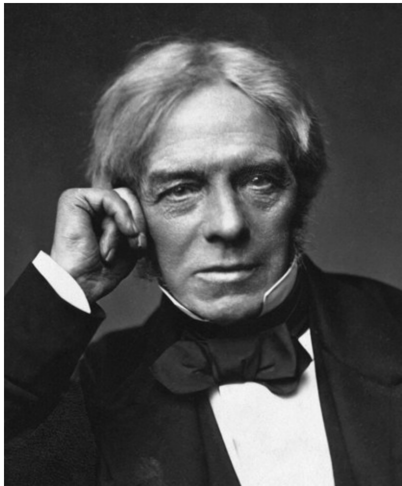




Assign t and V to be the mean average of the data used to estimate frequency

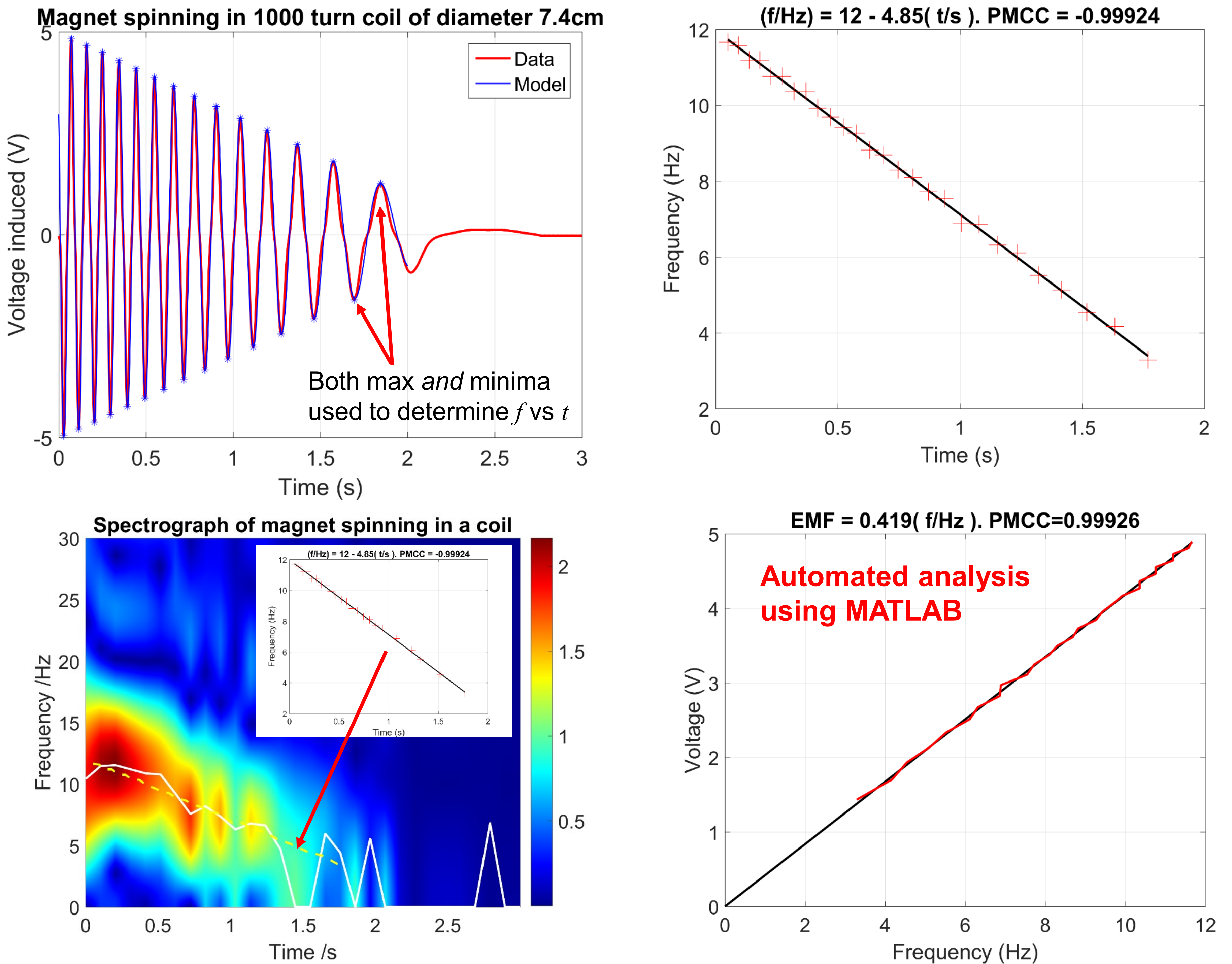


Michael Faraday (1791-1867)

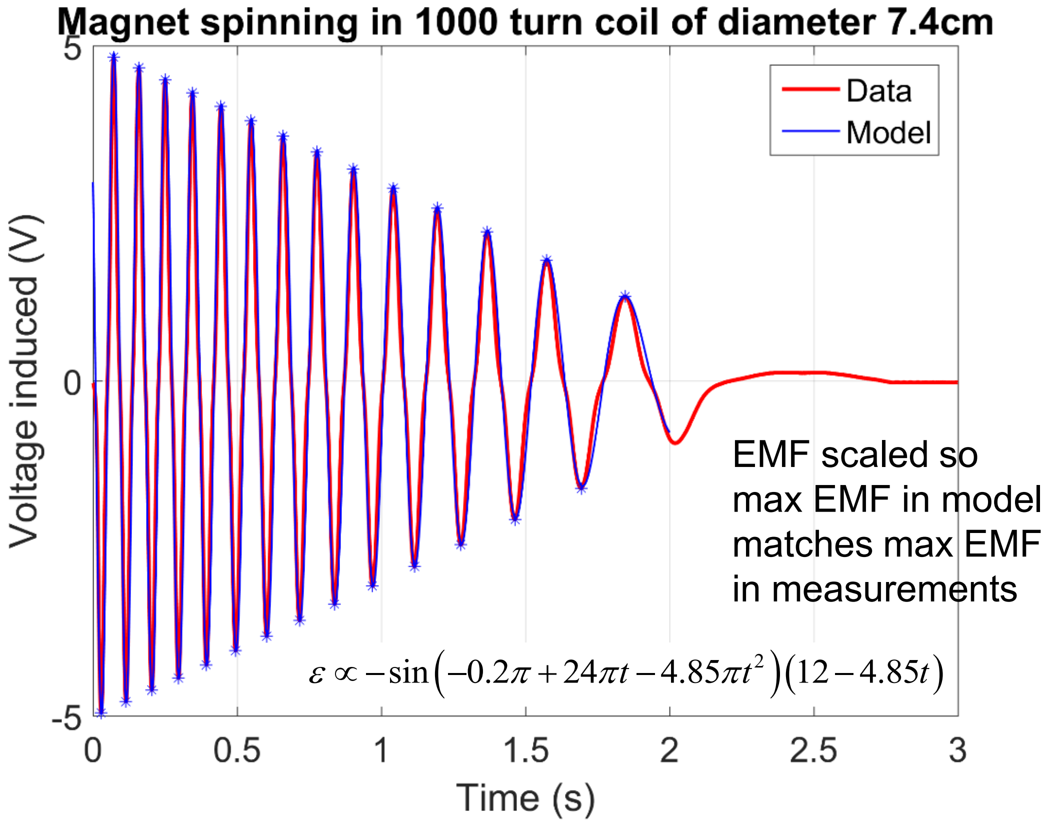


Faraday's Law: ***"The rate of change of magnetic Flux linked is proportional to the EMF induced"***

Since the system change is only the rotational speed of the magnet, one might expect EMF to be directly proportional to the rotational frequency. The graph above agrees with this hypothesis to a very high degree of correlation!



Magnet spinning in 1000 turn coil of diameter 7.4cm
Data
Model
Voltage induced (V)
Time (s)
Both max *and* minima used to determine *f* vs *t*
(f/Hz) = 12 - 4.85(t/s). PMCC = -0.99924
Frequency (Hz)
Time (s)
Spectrograph of magnet spinning in a coil
Frequency /Hz
Time /s
(f/Hz) = 12 - 4.85(t/s). PMCC = -0.99924
EMF = 0.419(f/Hz). PMCC=0.99926
Automated analysis using MATLAB
Voltage (V)
Frequency (Hz)



$$\varepsilon = -\frac{d\Phi}{dt}$$ Faraday's law

$$\Phi = NBA$$ Flux linked

$$B \approx -B_0 \cos\theta$$ Magnet flux density

$$\theta = \theta_0 + 2\pi\int_0^t f dt$$ Angle rotated

$$\theta = -0.2\pi + 2\pi\int_0^t \left(12 - 4.85t\right) dt$$

$$\theta = -0.2\pi + 24\pi t - 4.85\pi t^2$$

Guessed from model fit to data

$$\varepsilon = -NA\frac{dB}{dt}$$

$$\varepsilon = -NAB_0 \sin\theta \times \frac{d\theta}{dt}$$

$$\varepsilon = -2\pi NAB_0 \sin\left(-0.2\pi + 24\pi t - 4.85\pi t^2\right)\left(12 - 4.85t\right)$$

$$\varepsilon \propto -\sin\left(-0.2\pi + 24\pi t - 4.85\pi t^2\right)\left(12 - 4.85t\right)$$