JINTIAN WANG 22nd Jan 2026. GP04

4.1 No weight on spring.

$\theta = -0.489(1)$ rad.

Adding 20g brass on left hand side spring

$\theta = 1.769(1)$ rad.

$\Delta\theta = 2.258(2)$ rad.

Zero error for Venier: 5.04(1) mm.

Diameter ~~for~~ reading: 57.55(1) mm.

Diameter measured: 52.51(2) mm.

Radius calculated: 26.26(2) mm.

$K = \frac{\tau}{\theta} = \frac{rF}{\theta} = \frac{rmg}{\theta} = 2.282(6) \times 10^{-3}$ N.m.rad^{-1}.

(Assume 0.1% error for m).

50g: $\theta = 5.066(1)$ rad

$K = \frac{mgr}{\theta} = 2.543(5) \times 10^{-3}$ N.m.rad^{-1}

$K_{(final)} = 2.413(6) \times 10^{-3}$ N.m.rad^{-1}.

-0.465
1.736

4.2 Diameter: 100.35 − 5.04 = 95.31(2) mm

$R = 47.66(2)$ mm

$m = 121.44(1)$ g

$I = \frac{1}{2}MR^2 = 1.379(1) \times 10^{-4}$ kg.m^2

$\omega_0 = \sqrt{\frac{K}{I}} = 4.18(1)$ rad s^{-1} $\quad T = 1.503(3)$ s.

4.3 Peak 1: $t = 12.20(4)$ s $\quad \omega = 6.355(1)$ rad s^{-1}

2: $t = 13.64(4)$ s $\quad \omega = 4.856(1)$ rad s^{-1}

3: 15.08 $\quad$ 3.508

4: 16.52 $\quad$ 2.238

5: 17.88 $\quad$ 1.224

~~6~~.

$T = 1.42(2)$ s

Predicted value and measured value are close to each other, we get ~~clos~~ pretty accurate period. Maybe errors in K.

4.4. 3mm. 1st: $Ae^{-Bt}\sin(wt+\varphi)+C$. $B=\frac{\nu}{2}$.

~~$A=182\pm4.6$~~

$B=0.468\pm0.0029$

$W=4.30\pm0.0030$

~~$\varphi=-13.5\pm0.026$~~ .

$Q=\frac{W}{\nu}=\frac{W/2}{\frac{\nu}{2}}=\frac{W}{2B}=4.59(3)$

2nd:

$B=0.452\pm0.0031$

$W=4.28\pm0.0032$

$Q=4.73(1)$

3rd:

$B=0.461\pm0.0038$

$W=4.29\pm0.0035$

$Q=4.65(4)$

$\overline{Q_3}=4.66(6)$

4mm:

1st: $B=0.419\pm0.0040$, $W=4.29\pm0.0037$, $Q=5.12(5)$

2nd: $B=0.418\pm0.0030$, $W=4.31\pm0.0036$, $Q=5.16(4)$

3rd: $B=0.430\pm0.0036$, $W=4.28\pm0.0039$, $Q=4.98(5)$

$\overline{Q_4}=5.09(7)$

6mm:

1st: $B=0.244\pm0.0025$, $W=4.28\pm0.0026$, $Q=8.77(9)$

2nd: $B=0.230\pm0.0025$, $W=4.28\pm0.0024$, $Q=9.3(1)$

3rd: $B=0.251\pm0.0027$, $W=4.28\pm0.0025$, $Q=8.53(9)$

$\overline{Q_6}=8.9(3)$

4.5. The data is an exponential function, since the error bar is small for ~~ex~~ decay constant which means it is meaningful when fitted by exponential functions.

For each spacing, Qs are distributed around a certain value, which means they are consistent with each other and has random errors.

For each spacing, combine and take average of Q then get the best value.

$W_0 = 4.18$
$W_r = 4.28$
The difference is significant because Q exists. For $W_r = W_0\sqrt{1-\frac{1}{4Q^2}}$ thus by considering a Q value W_r ~~not~~ becomes larger.

(But it increases, differs in changing).
Although not pretty much.

5.1 By increasing the width, less damping. Thus the peak is becoming higher when less damped, and width of peak is smaller, frequency of maximum.

~~Not~~ Resonant frequency is not exactly the same as that theoretical frequency. ~~High~~ Peak frequency = 0.72Hz.
Natural frequency: 0.67Hz.
Difference = 7.5%

At high frequency, damping affects ~~more~~ less and cause amplitude higher than in lower frequency. Low frequency makes damping to affect more since they has

$$\gamma = \frac{W_0}{G}$$

5.2. χ_c : W_0

χ : W

W : γ

$\leftarrow$

3mm:

$k = 1.52049 \pm 0.02591$

$\chi_c = 4.89472 \pm 0.00716$

$\gamma = 1.56146 \pm 0.02378$

$Q = \frac{\chi_c}{\gamma} = 3.13$ (5)

4mm:

$k = 1.4927 \pm 0.02256$

$\chi_c = 4.75545 \pm 0.00511$

$\gamma = 1.06039 \pm 0.01663$

$A = 0.02558 \pm 0.00115$

$Q = \frac{\chi_c}{\gamma} = 4.49$ (4)

6mm:

$k = 1.52470 \pm 0.02781$

$\chi_c = 4.60352 \pm 0.00475$

$\gamma = 0.64281 \pm 0.01351$

$Q = \frac{\chi_c}{\gamma} = 7.2$ (1)

※ While increasing the gap, Q ~~decreases~~ increases which makes sense that energy dissapated over time is less. However while comparing with previous Q, it goes smaller (which means more damping). It may because that we collect data among all sets of frequencies (from $w=2$ to 9) but we only collect for sinye freqaency ($w=0$) in previous questions. This cause damping ~~effect~~ cause more effect in question 5 and, Q decreases. Thus they ~~disagree~~ disagree within error!

5.3 $w \to 0$: In phase. $\Delta\phi = 0$

$w \to w_0$: $\Delta\phi = \frac{\pi}{2}$. 90° out of phase

$w \to \infty$: Antiphase. $\Delta\phi = \pi$. (180°)

In theory we have: $\tan\Delta\phi = \frac{w\gamma}{w_0^2 - w^2}$.

Take $w = 0$: $\tan\phi = 0$. $\Rightarrow \phi = 0$ Inphase

$w = w_0$: $\tan\phi \to \infty$ $\Rightarrow \phi = \frac{\pi}{2}$ 90°

$w \to \infty$: $\tan\phi = 0$ $\Rightarrow \phi = \pi$ Antiphase

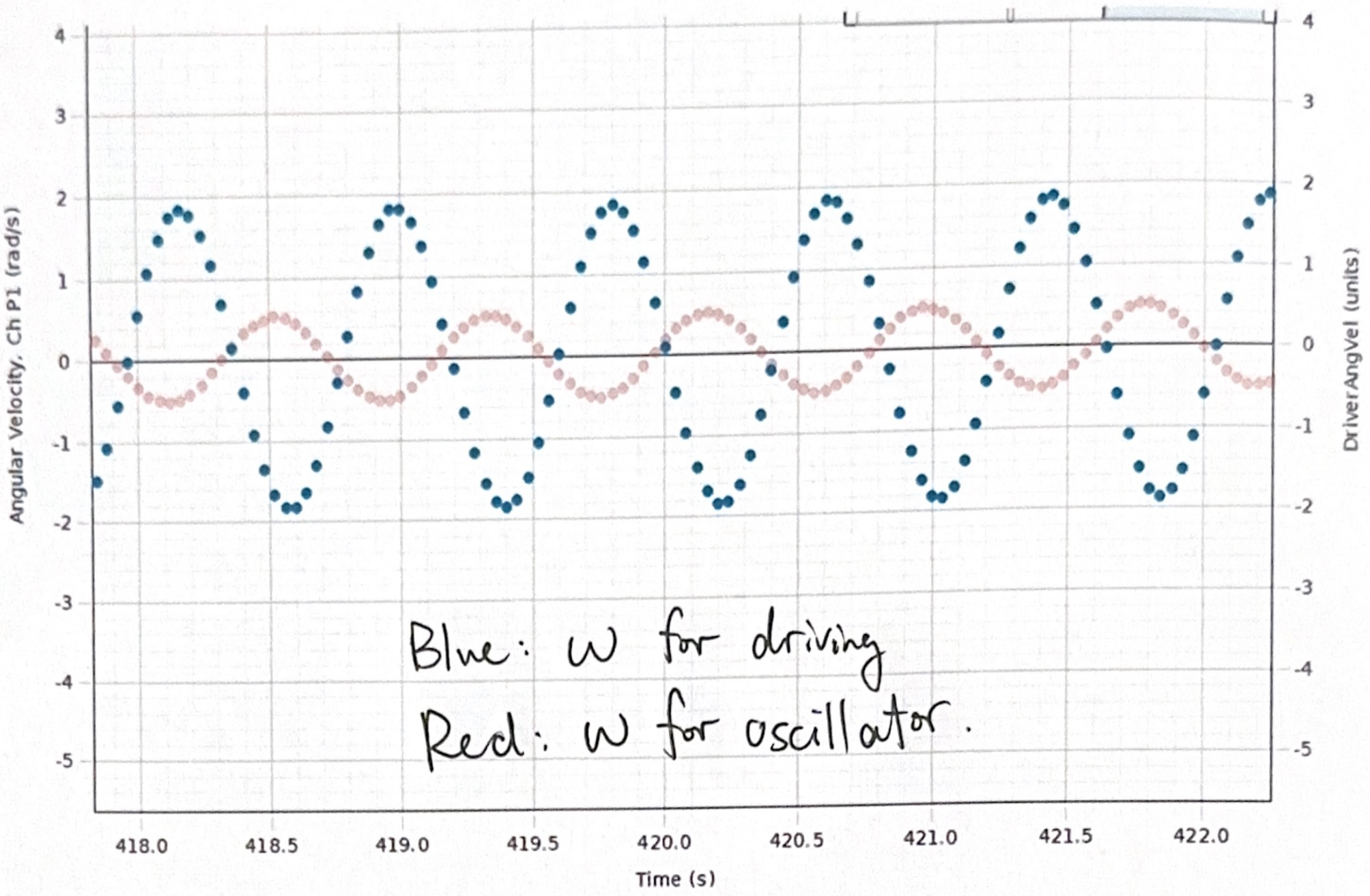
Thus the phase difference agree with the one in theory.

Summary:

The experiment goes through several classical solutions within the oscillations, damping, forced driven etc. It focus on Q factors, γ and driven w. We collect data from PASCO and compute fit curves and plot beautiful graphs, and get deeper understanding among pendulums and oscillations. Theories instruct the methods to calculate natural frequencies, spring constants, quality factors and so on. Quantitive results show that as ~~fre~~ driving frequency increase, peak frequency decreases. Less damping, higher Q. And amplitude of damped oscillation goes down exponentially. Python analysis gives out Q under driven is smaller than that out of driver, which is interesting. The phase difference also fits the theory very good.

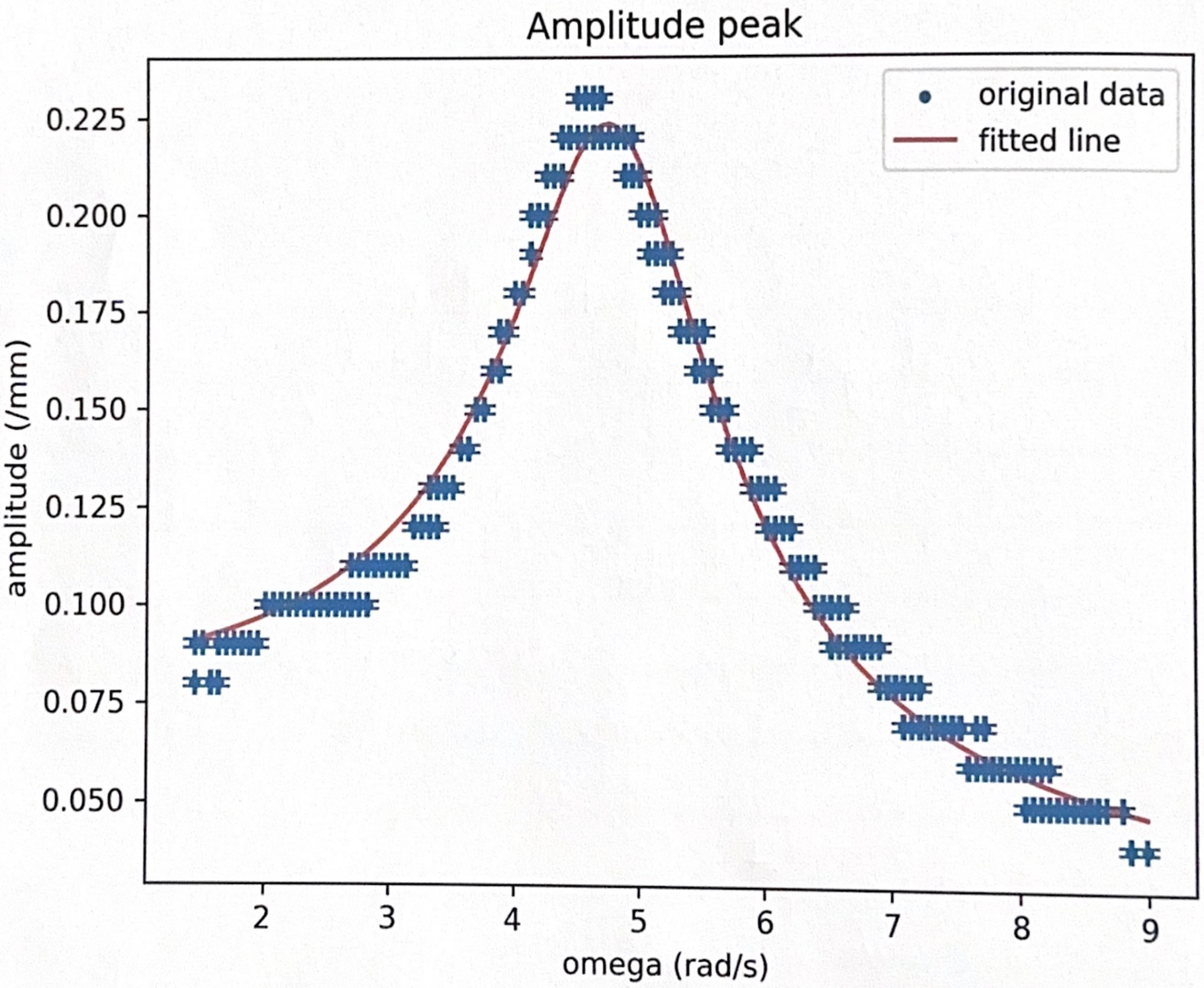
22.01.26 4.0 DB

Antiphase for $w_c \to \infty$



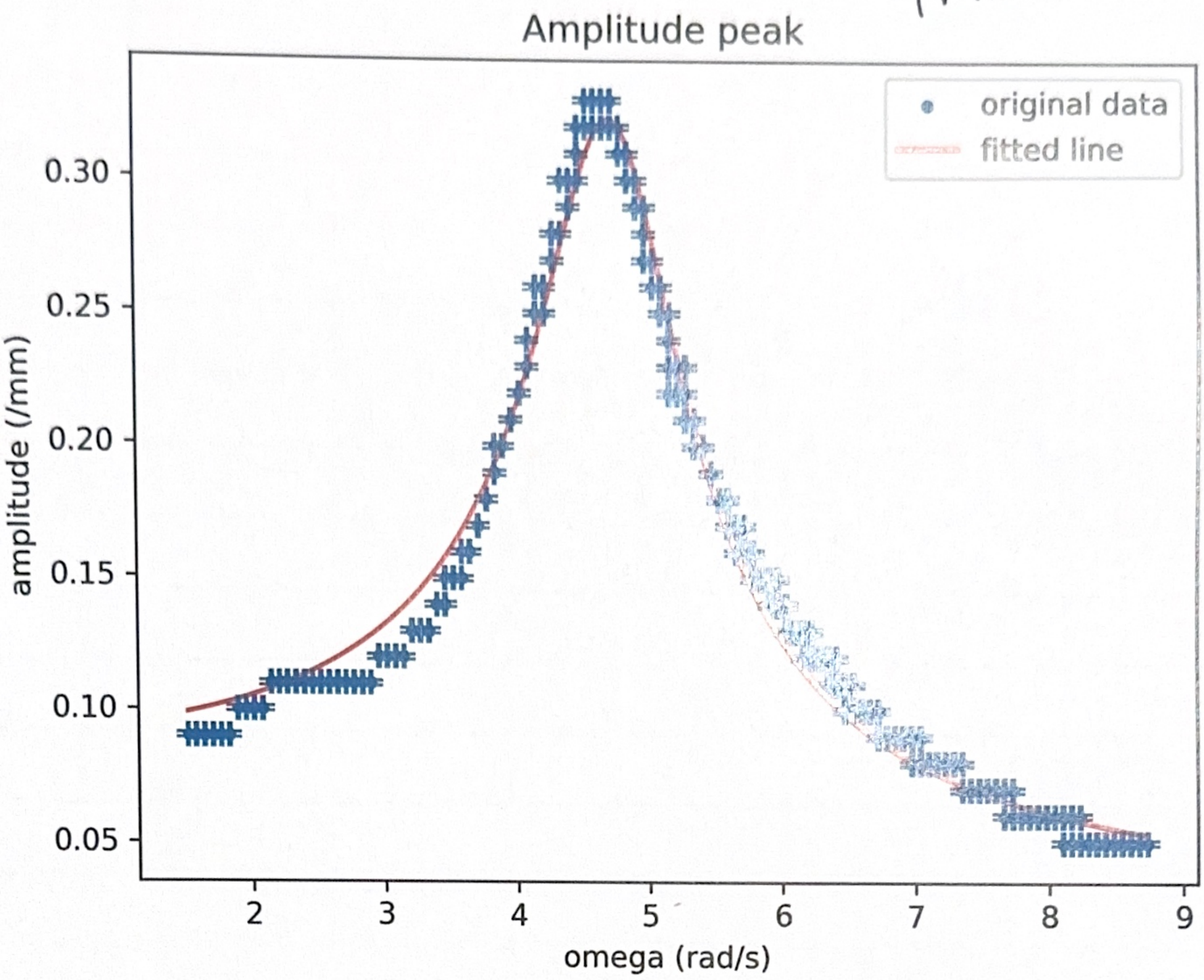
Blue: w for driving

Red: w for oscillator.

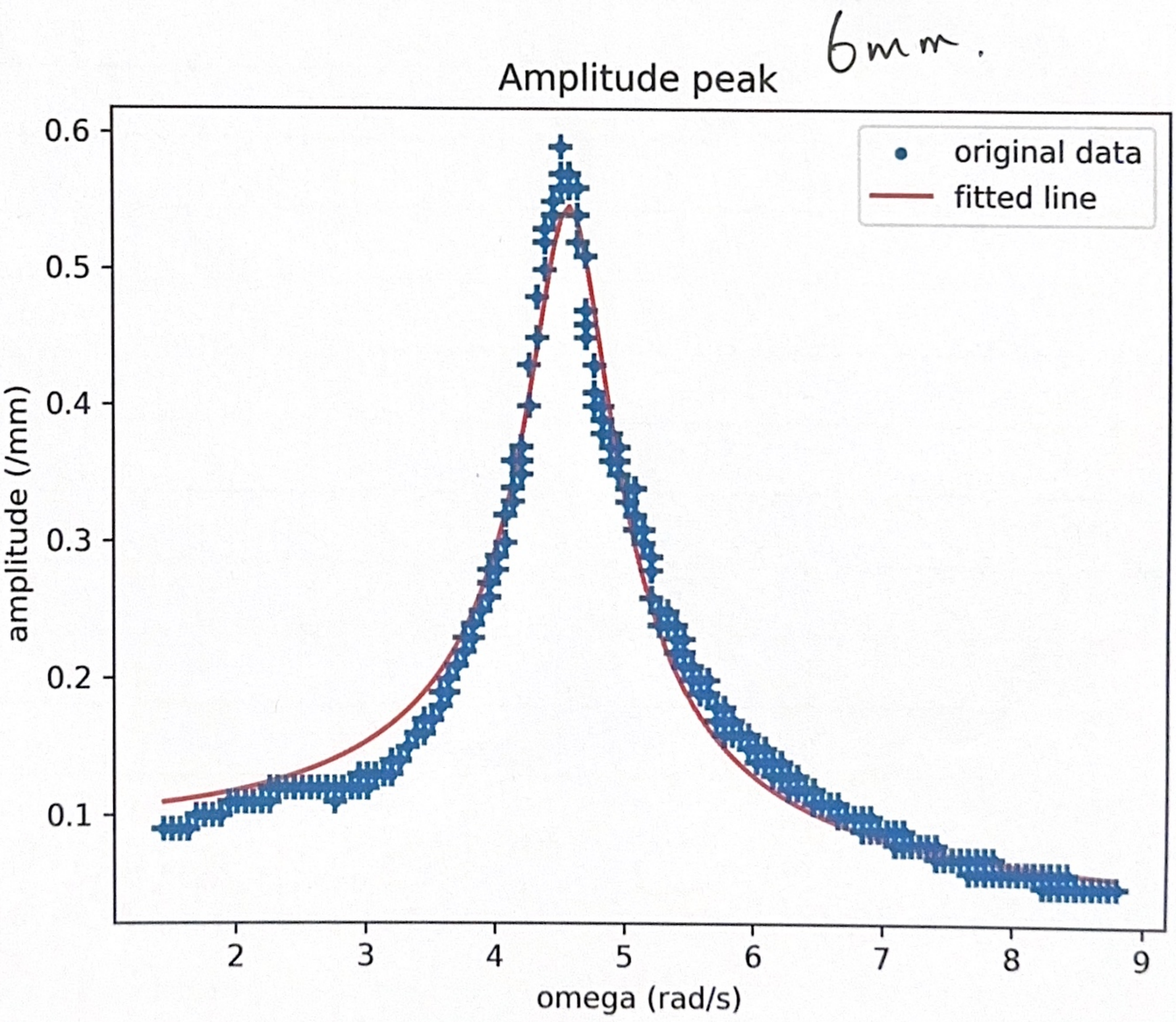


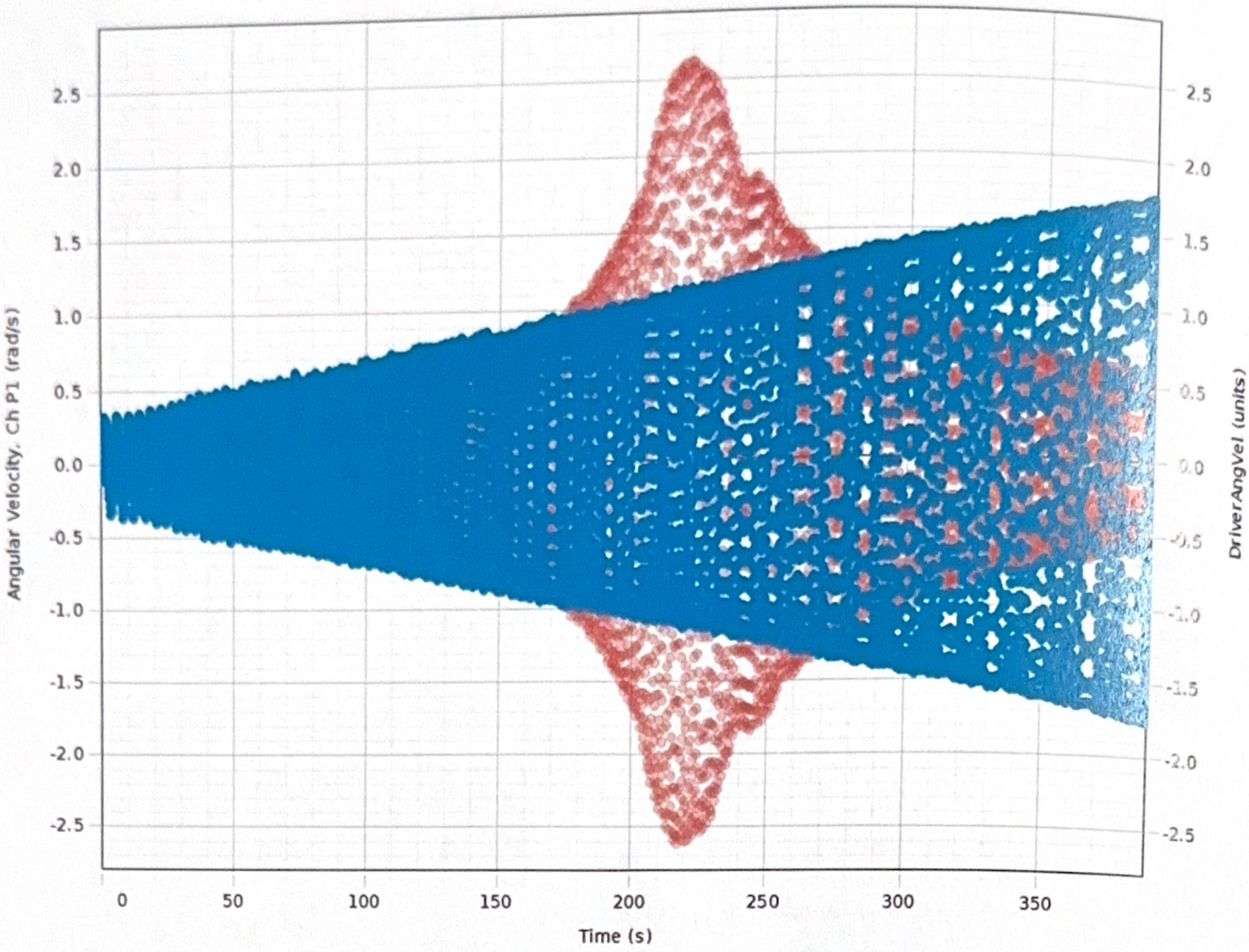
3mm

4mm


Amplitude peak
original data
fitted line
0.30
0.25
0.20
0.15
0.10
0.05
amplitude (/mm)
2
3
4
5
6
7
8
9
omega (rad/s)

6mm.


Amplitude peak
original data
fitted line
0.6
0.5
0.4
0.3
0.2
0.1
amplitude (/mm)
2
3
4
5
6
7
8
9
omega (rad/s)


Angular Velocity, Ch P1 (rad/s)
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0
50
100
150
200
250
300
350
Time (s)
DriverAngVel (units)