

Physics 2130: Lab 2A

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```
import matplotlib.pyplot as pyplot
import numpy as np
from scipy.optimize import curve_fit
def plot_fitted_and_raw(data_path: str,
                        mintime: float,
                        maxtime: float,
                        guessed_values: tuple[float, float, float, float, float],
                        fig: int,
                        label: str = "",
                        display_hand_fit: bool = False):
    data = np.loadtxt(data_path, delimiter=",", skiprows=1)
    data = data[
        (data[:, 0] > mintime) &
        (data[:, 0] < maxtime)
    ]
    t_vals = data[:, 0]
    positions = data[:, 1]

    pyplot.figure(fig)

    pyplot.scatter(t_vals, positions, color = "green", label=label)

    x_0 = guessed_values[0]
    A = guessed_values[1]
    B = guessed_values[2]
    w_1 = guessed_values[3]
    d = guessed_values[4]

    def plot_fit(t, x, amp, beta, omega, delta):
        pos_vals = []
        for t_val in t:
            pos_vals.append(x + amp*(np.e**(-beta*t_val))*np.cos(omega*t_val-delta))
        return pos_vals

    if (display_hand_fit):
        p = plot_fit(t_vals, x_0, A, B, w_1, d)
        pyplot.plot(t_vals, p, label=f"{label}-hand-fit", color="red")
    popt, covm = curve_fit(plot_fit, t_vals, positions)
    pyplot.plot(t_vals, plot_fit(t_vals, *popt), label=f"{label}-machine-fit", color="red")
    pyplot.legend()
    pyplot.xlabel("time (s)")
    pyplot.ylabel("position (m)")
    return popt, covm

x_0 = 0.71
A = 0.177
```

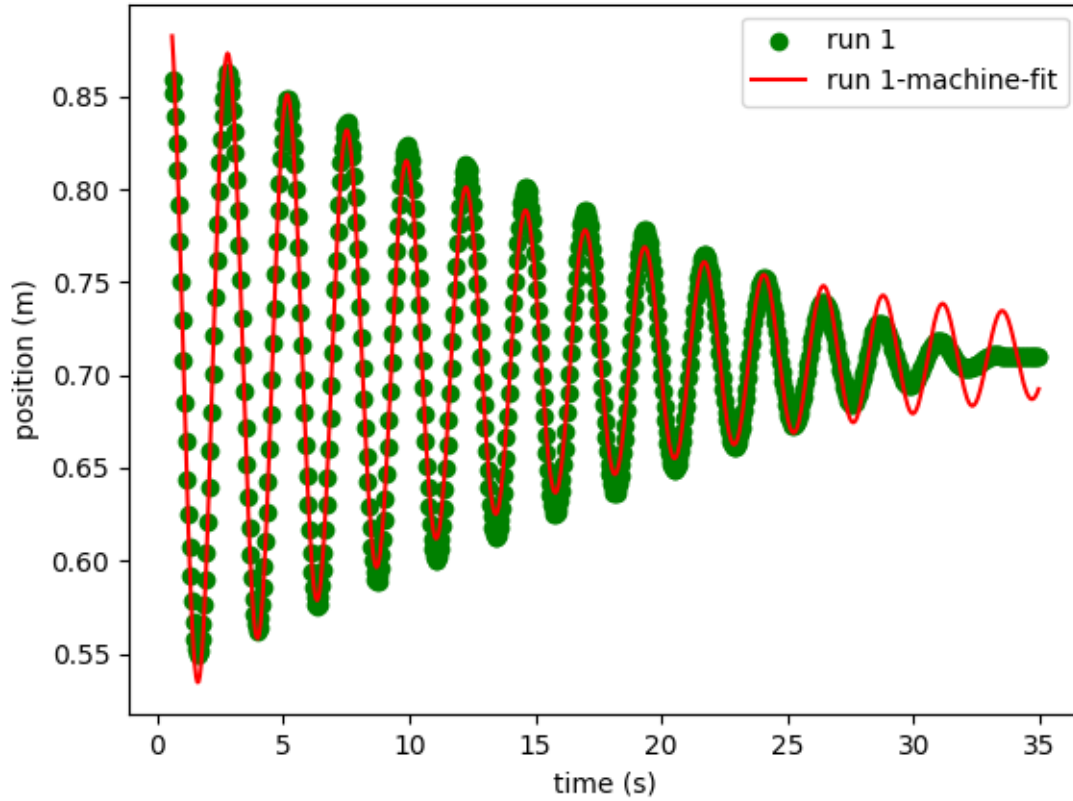
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B = 0.05
w_1 = 2.7
d = 1.3
guessed_fits = (x_0, A, B, w_1, d)
popt1, covm1 = plot_fitted_and_raw("./data/run1.csv", 0.55, 35, guessed_fits, 0, "run 1")
print(popt1)
for el in np.diag(covm1):
    print(np.sqrt(el))

x_0 = 0.6606
A = 0.2
B = 0.05
w_1 = 2.6
d = 1.3
guessed_fits = (x_0, A, B, w_1, d)
popt2, covm2 = plot_fitted_and_raw("./data/run2.csv", 0.35, 14, guessed_fits, 1, "run 2")
print(popt2)
for el in np.diag(covm2):
    print(np.sqrt(el))

pyplot.show()

```



The model fits the curve relatively well until $t \rightarrow t_f$ where the error has built up the most and the fit begins to fail. I guessed x_0 using the value of the data when $t = t_f$, A by distance from the peak to x_0 , β was a complete guess and ω_1 and δ were slightly educated guess based on the shape of the graph.

$$x_0 = 0.71$$

$$A = 0.177$$

$$\beta = 0.05$$

$$\omega_1 = 2.7$$

$$\delta = 1.3$$

and the machine adopted my guesses to

$$x_0 = 0.7099221$$

$$A = -0.19411723$$

$$\beta = 0.06157102$$

$$\omega_1 = -2.6606827$$

$$\delta = -4.34149397$$

Which are generally close to mine but the machine seems to have decided that offsetting the curve by a lot fits the data better. The uncertainty associated with each of these values is

$$x_{0u} = 0.000336763169790041$$

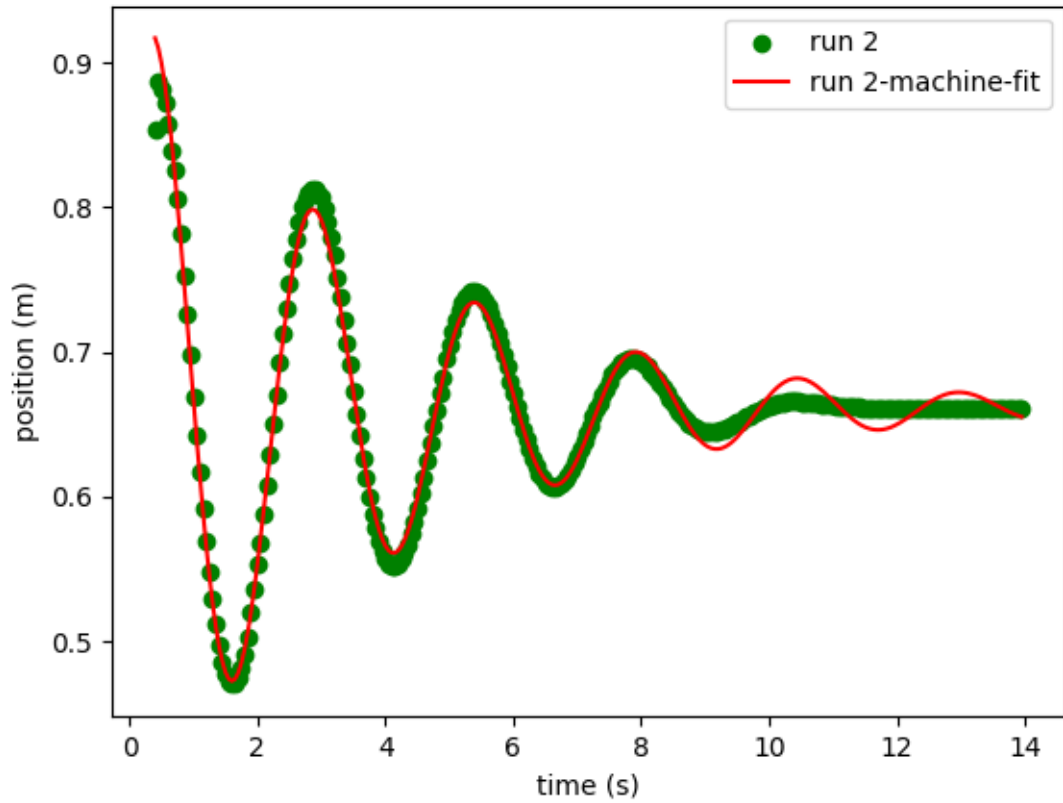
$$A_u = 0.0016034606530748328$$

$$\beta_u = 0.0007619444344572854$$

$$\omega_{1u} = 0.000754079820004922$$

$$\delta_u = 0.008039447229207356$$

This run is the one which shows the greatest disagreement with the observed data. As I stated earlier the error piles up and is most noticeable towards the end, this leads me to believe that the error originates from the fact that our model does not incorporate friction as its effects would pile up and result in a greater velocity (change in position) than actually observed, which is what we see.



The model generally fits this curve much better, likely because this run is dampened more severely so friction is beaten out by the dampening force. My guessing process was generally similar except I started from the parameters I guessed in run 1.

$$x_0 = 0.6606$$

$$A = 0.2$$

$$\beta = 0.05$$

$$\omega_1 = 2.6$$

$$\delta = 1.3$$

and the machine adopted my guesses to

$$x_0 = 0.66118243$$

$$A = 0.28286486$$

$$\beta = 0.25038451$$

$$\omega_1 = 2.48782223$$

$$\delta = 0.9432566$$

Which again are generally close to mine save, again, for the offset of phase and a pretty drastic change to beta that greatly improves the fit.

$$x_{0u} = 0.0005322378475141308$$

$$A_u = 0.0033493873170781464$$

$$\beta_u = 0.00386618733340337$$

$$\omega_{1u} = 0.003997938882975206$$

$$\delta_u = 0.012503337208939681$$