Python Data Analysis
The effective cross sectional area of a parachute

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Abstract
In this project, I want to calculate the effective cross sectional area of a parachute. Python is used for all the data analysis.

Introduction
The air resistance of a parachute depends on many factors. It depends on the speed of a parachute, the air density, the shape of the parachute and the cross sectional area. Once we know all the other factors, we can calculate the effective cross sectional area of the parachute. In this experiment, we calculated the effective area of a parachute using Python as a tool.

Theory
The air resistance on the parachute in air should be, from the drag force equation, $F_D = \frac{1}{2}\rho v^2 C_D A$. where F_D is the air resistance, ρ is the density of air, v is the speed of the parachute, C_D is the drag coefficient and A is a cross-sectional area. The drag force equation can also be written as $k\sqrt{F_D} = v$, where $k = \sqrt{\frac{2}{\rho C_D A}}$. k is determined by experiments; ρ and C_D are given by wikipedia. Therefore, we have $A_{eff} = \frac{2}{\rho C_D k^2}$.

Method
1) Make a parachute, using plastic bags.
2) Measure the speed and corresponding air resistance.
3) Obtain the constant k from experimental data using Numpy.
4) Calculate the A using k, ρ and C_D.
5) Measure the area A directly and see if they agree.

Data Analysis

#	Weight attached (g)	Time period 1 (sec)	Time period 2 (sec)	Mean time period (sec)	Terminal speed (m/sec)	note
0	50	1.71	1.64	1.675	2.179	

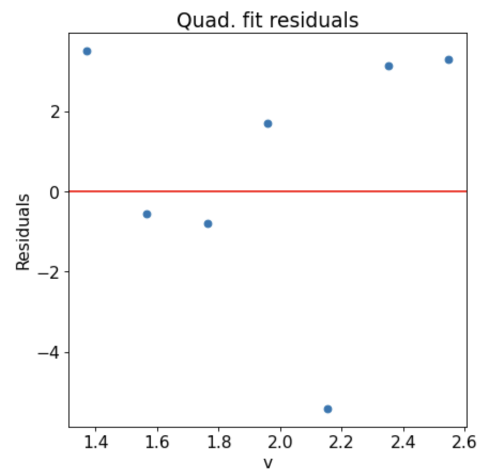
1	50	1.55	1.49	1.52	2.401	
2	50	1.62	1.56	1.59	2.295	
3	70	3.36	2.28	2.82	1.29432624	
4	70	1.83	1.75	1.79	2.03910615	
5	70	0.97	1.85	1.41	2.58865248	
6	90	1.92	1.81	1.865	1.95710456	
7	90	1.47	1.38	1.425	2.56140351	
8	90	1.81	1.70	1.755	2.07977208	
9	110	1.04	0.97	1.005	3.6318408	
10	110	1.17	1.09	1.13	3.2300885	
11	110	1.79	1.63	1.71	2.13450292	
12	110	1.20	1.13	1.165	3.13304721	
13	130	1.61	1.52	1.565	2.33226837	
14	130	1.52	1.45	1.485	2.45791246	
15	130	1.58	1.49	1.535	2.37785016	
16	150	1.36	1.27	1.315	2.7756654	
17	150	1.28	1.22	1.25	2.92	
18	150	1.27	1.22	1.245	2.93172691	
19	170	1.18	1.13	1.155	3.16017316	
20	170	1.15	1.09	1.12	3.25892857	
21	170	1.02	0.97	0.995	3.66834171	

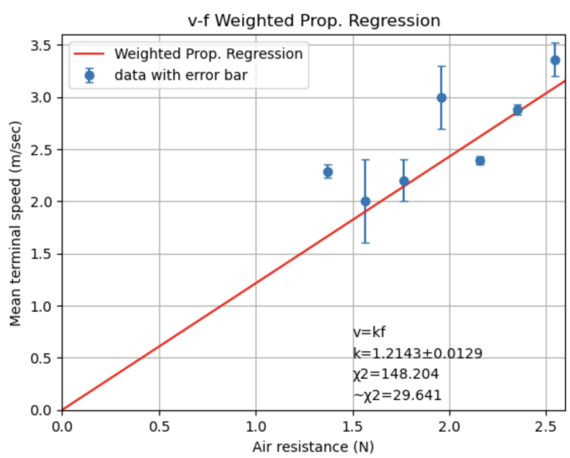
From this, we have:

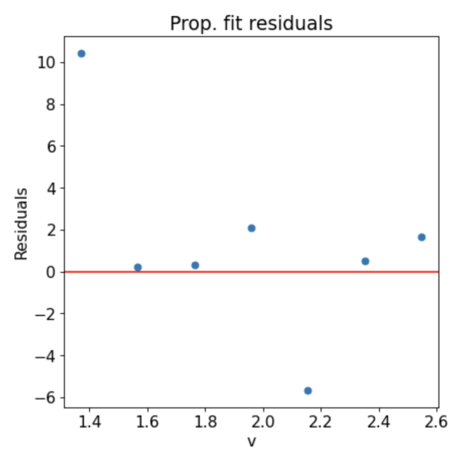
Weight attached (g)	Total weight (N)	Mean terminal speed (m/sec)	Standard error (m/sec)
50	1.371	2.29	0.06
70	1.567	2.0	0.4
90	1.763	2.2	0.2

110	1.959	3.0	0.3
130	2.155	2.39	0.04
150	2.351	2.88	0.05
170	2.547	3.36	0.16

Do the curve fit using scipy.optimize
Plot two curves using matplotlib.pyplot







We can see that the quadratic fit is better than the proportional fit, indicating that our theory is reliable.
Calculate the effective area A

$A_{effective} = 0.38 \pm 0.03\, m^2$

Measure the area directly

	The long axis a	The short axis b
1	78.5	58.5

2	68.0	61.3
3	73.5	66.0
4	67.0	55.4
5	79.5	66.0

Using $A = \frac{\pi ab}{4}$

$A_{direct\ measurement} = 0.35 \pm 0.02\ m^2$

Summary

Python was used extensively in this project. Numpy, scipy.optimize and matplotlib.pyplot are very useful tools.