Model fit 2

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For the curriculum of

Experimental Physics

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§1. Introduction

We will be considering the data set provided by the lab[1] to conduct a model fit experiment, you may refer to the appendix A to refer to the data set. Our goal is to find a fair model fit to the data set by referring it to a model and testing the relation between the found model and the data by using analysis techniques in our Error & Analysis textbook.[2]

§2. Theory

From the data set, we will consider the column as x and y. Where x refers to the first column and y will be referred to the second column (refer to the appendix). We've chose these names for these columns since we will be considering the dependence of y in relation to x. The reason we decided on this is if we were to plot the data set of x vs y we get the following plot.

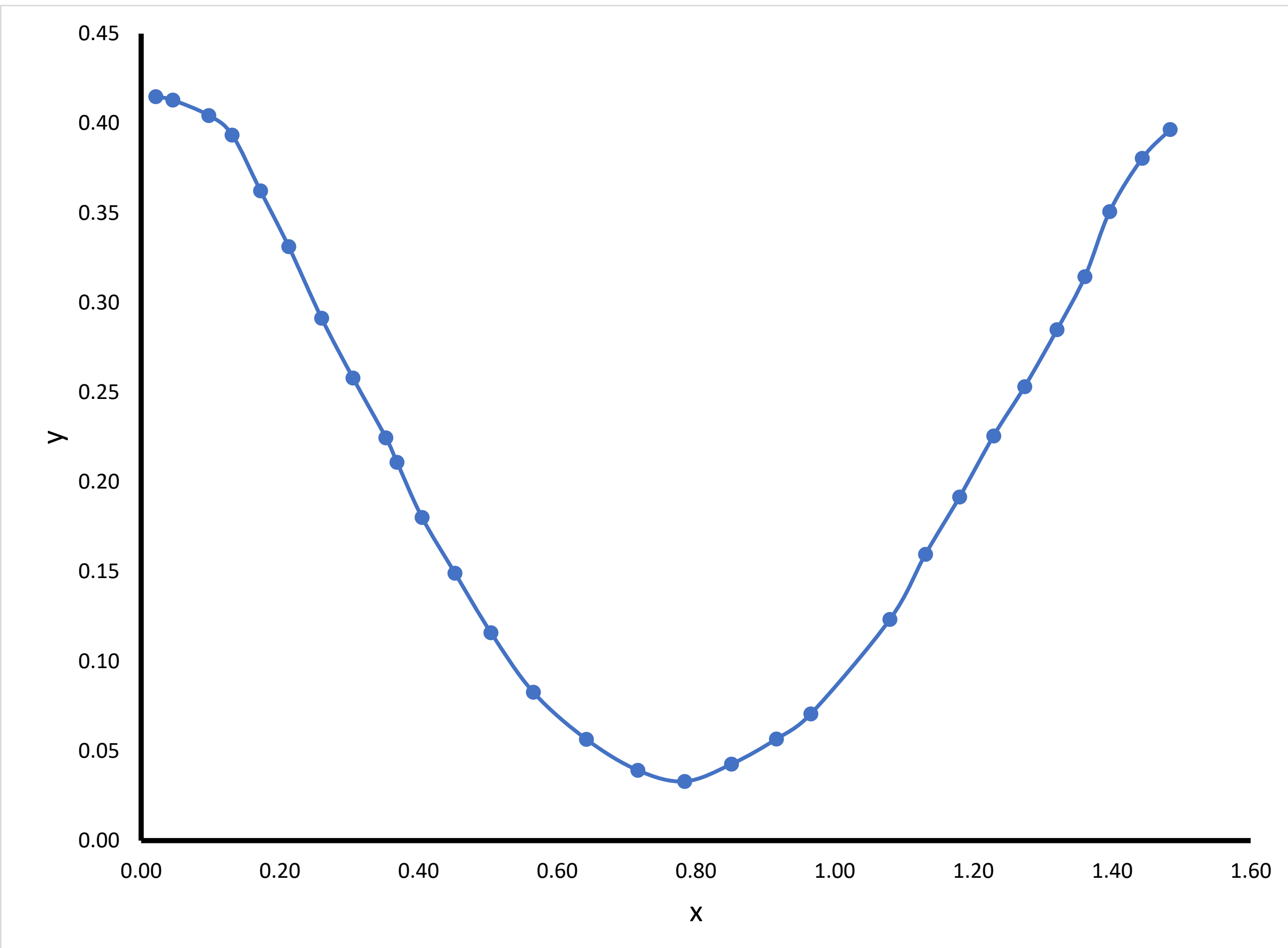

Figure 1. Dependence of y in relation to x

Whereas if we were to look at it as the dependence of x in relation to y.

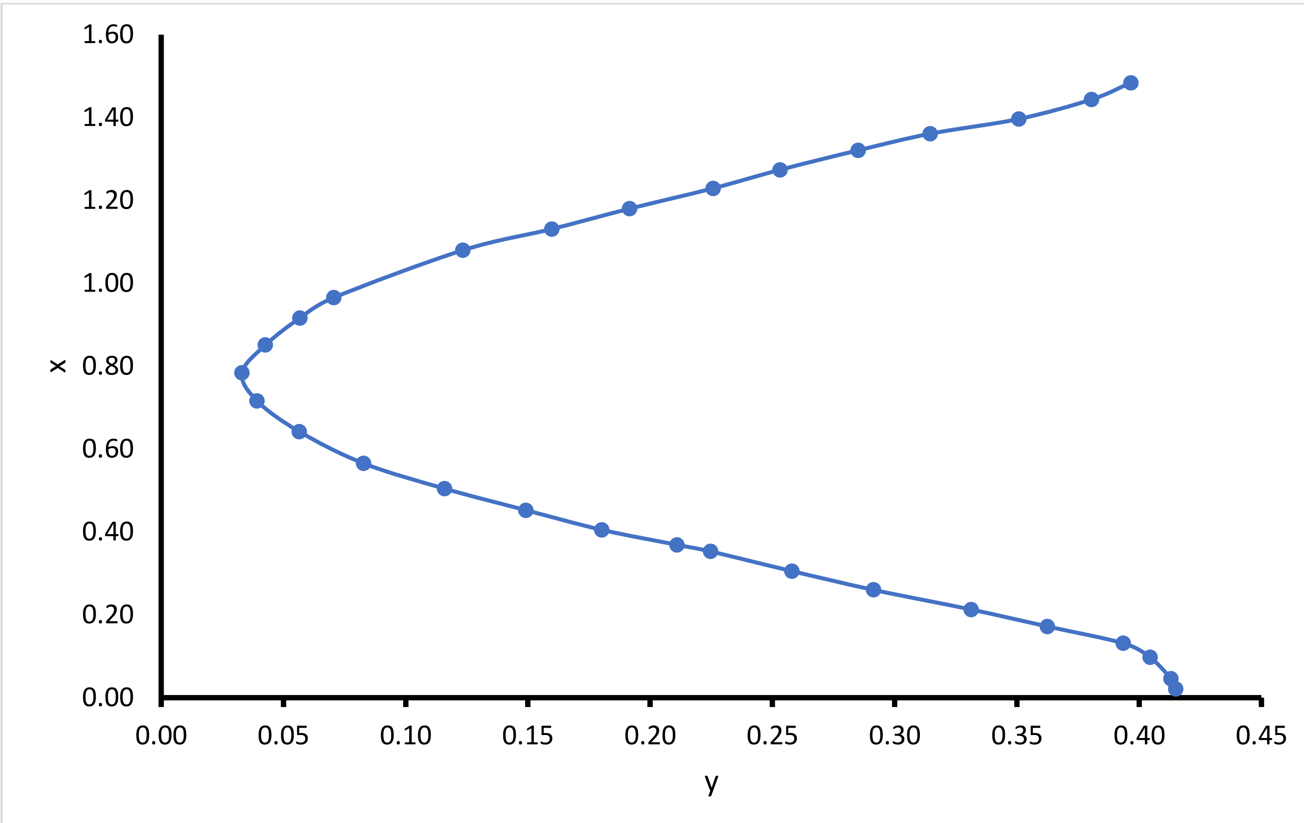

Figure 2. Dependence of x in relation to y

We prefer looking at figure 1 instead of figure 2 for our statistical analysis because we can relate figure 1 to a continuous function of y in terms of x whereas in figure 2, we may find two values that are at the same y but have different x. This would be another interesting way of analyzing the data by looking at the upper part of x and the lower part x to relate them to probably what may look like a root function. However, for this model experiment we will be focusing on figure 1 to find a model to fit our data.

We first start by looking at what type of function that may be. Our first hypothesis is perhaps this may look like a gaussian function that was flipped (meaning the constant before the exponential is negative).

A gaussian function has the following form,

$$f(x) = Ae^{\frac{-(x-b)^2}{2c^2}}$$

Where A, b and c are parameters we would need to find. We've added another parameter O for the shift of our gaussian function. This is because our data set's lower peak is not at 0 so it will be shifter by a parameter O that we will find as well.

Thus, the model we will investigate is,

$$y(x) = Ae^{\frac{-(x-b)^2}{2c^2}} + O$$

§3. Results & Analysis

For our analysis we will be using Microsoft Excel's Solver to do our non-linear regression and find the minimal values of what our parameters A, b, c and O. Where the results found for these parameters are in the following table. Refer to appendix b for Solver's analysis.[3]

A	0.543256
b	0.789154
c	2.15832
O	0.573302

Table 1. Microsoft Excel's Solver results for our parameters of our model

We can use these parameters to plot our model and relate it to our data set in the following figure.

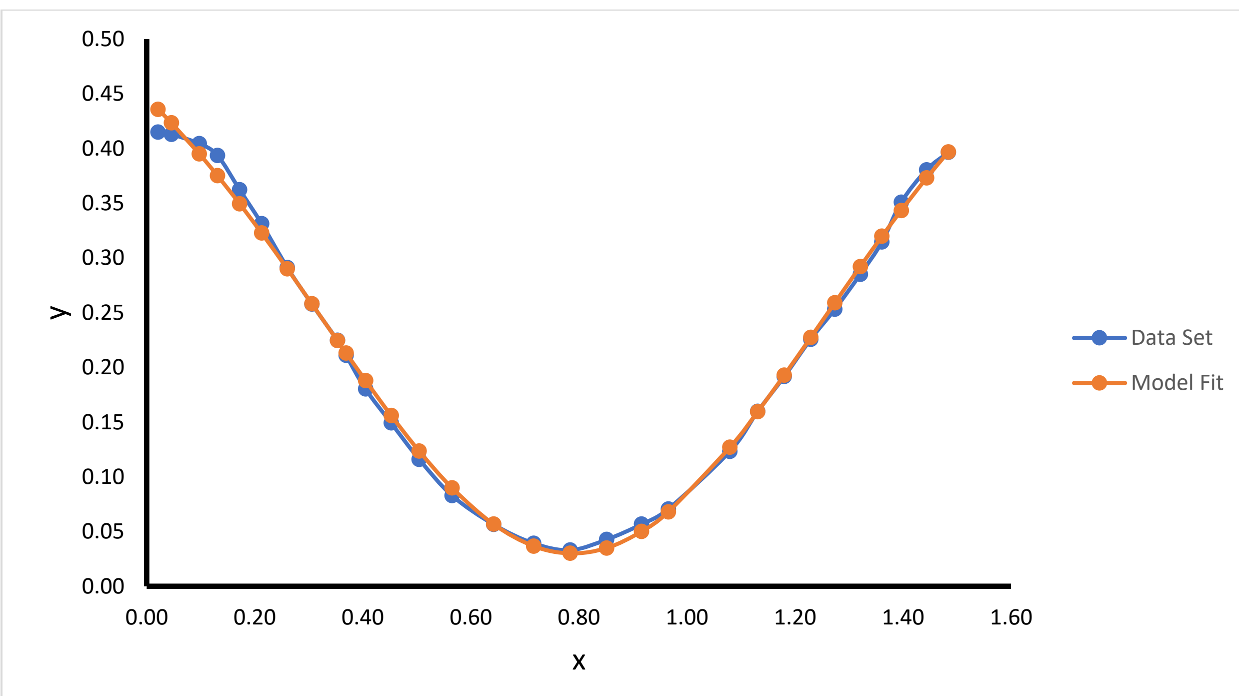

Figure 3.

We can say qualitatively from figure 3 that our model seems to fit our data set. However, in order to have a quantitative way of proving this we can find the expected chi squared values and use chi-square in order to find whether our model fits our data.

Chi-Square Test

N	DF	Chi-Sq	P-Value
6.81226	29	0.0087201	1.000

After doing chi squared in Minitab, we get a Chi-Squared of 0.0087201, we will further discuss these finding in the discussion section. Refer to appendix C for Minitab Chi-Squared results.

§4. Discussion

From our values of Chi-Squared we got a value of 0.0087201 which is a value that is less then 1. From our source a chi-squared of less then 1 would mean that would indicate that the model is over fitting the data meaning it is also fitting the noise we would presumably have. The reason why we ignore this is since this is a photo image of a rope and translated to data points. Ignoring the error, we may have for this we can say with 95% confidence interval from our chi-squared in Minitab that our model fits our data.[4]

§5. Conclusion

In conclusion, it would be interesting to consider figure 2 as our model fit by looking at two bounds of x with a dependence of relation to y but due to time constraints this was not considered. Overall, we were able to find a nice model that describes our data.

§6. Reference

[1] Dan Trojand, Gamma absorption, Experimental Physics I –Syllabus & Laboratory

[2] John R. Taylor, An Introduction to Error Analysis, The study of uncertainties in physical measurements, 2nd edition, University Science Books, 1997

[3] Daniel C. Harris, Nonlinear Least-Squares Curve Fitting with Microsoft Excel Solver, Chemistry & Materials Branch, Research & Technology Division, Naval Air Warfare Center, China Lake, CA, USA

[4] Philip R. Bevington, D. Keith Robinson, Data reduction and error analysis for the physical sciences, 3rd edition, Mc Graw-Hill Higher Education, 2003, Chapter 6

Appendix A

x	y
0.02	0.41
0.05	0.41
0.10	0.40
0.13	0.39
0.17	0.36
0.21	0.33
0.26	0.29
0.31	0.26
0.35	0.22
0.37	0.21
0.41	0.18
0.45	0.15
0.50	0.12
0.57	0.08
0.64	0.06
0.72	0.04
0.78	0.03
0.85	0.04
0.92	0.06
0.97	0.07
1.08	0.12
1.13	0.16
1.18	0.19
1.23	0.23
1.27	0.25
1.32	0.28
1.36	0.31
1.40	0.35
1.44	0.38
1.48	0.40

Table A. Data set provided by the lab

Appendix B

x	y	y(calc)	(y-y(calc))^2	A	0.543256
0.02	0.41	0.435846	0.0004355626611911	b	0.789154
0.05	0.41	0.42334	0.0001079590598868	c	2.15832
0.10	0.40	0.395019	0.0000884402363352	O	0.573302
0.13	0.39	0.375034	0.0003405930100898		
0.17	0.36	0.349548	0.0001650397013735		
0.21	0.33	0.322729	0.0000734682456337		
0.26	0.29	0.290105	0.0000013758769377		
0.31	0.26	0.258225	0.0000000614352405		
0.35	0.22	0.224488	0.0000000429702178		
0.37	0.21	0.21319	0.0000047981202063		
0.41	0.18	0.188001	0.0000605486815672		
0.45	0.15	0.156049	0.0000471160643559		
0.50	0.12	0.12346	0.0000564858305234		
0.57	0.08	0.089793	0.0000491476253431		
0.64	0.06	0.056721	0.0000000482074058		
0.72	0.04	0.036697	0.0000062061596682		
0.78	0.03	0.030081	0.0000088035858292		
0.85	0.04	0.034898	0.0000598672394026		
0.92	0.06	0.050107	0.0000434214725303		
0.97	0.07	0.068031	0.0000066934876062		
1.08	0.12	0.12701	0.0000136570393406		
1.13	0.16	0.159526	0.0000000389668708		
1.18	0.19	0.192827	0.0000014591013891		
1.23	0.23	0.227348	0.0000025186370680		
1.27	0.25	0.259109	0.0000358387552472		
1.32	0.28	0.292136	0.0000509459244029		
1.36	0.31	0.31973	0.0000266581752604		
1.40	0.35	0.343374	0.0000556736301203		
1.44	0.38	0.372998	0.0000557344438889		
1.48	0.40	0.396828	0.0000000761756640		
		SUM	0.0017982805205966		

Table B. Microsoft Excel's Solver results.

Appendix C

Observed and Expected Counts

Category	Observed	Historical Counts	Test Proportion	Expected	Contribution to Chi-Square
1	0.414976	0.435846	0.0639798	0.435847	0.0009994
2	0.412950	0.423340	0.0621439	0.423341	0.0002550
3	0.404423	0.395019	0.0579865	0.395019	0.0002239
4	0.393489	0.375034	0.0550529	0.375035	0.0009081
5	0.362395	0.349548	0.0513116	0.349548	0.0004721
6	0.331300	0.322729	0.0473747	0.322729	0.0002276
7	0.291278	0.290105	0.0425858	0.290106	0.0000047
8	0.257977	0.258225	0.0379059	0.258225	0.0000002
9	0.224695	0.224488	0.0329536	0.224488	0.0000002
10	0.211000	0.213190	0.0312952	0.213191	0.0000225
11	0.180220	0.188001	0.0275975	0.188002	0.0003221
12	0.149185	0.156049	0.0229072	0.156050	0.0003020
13	0.115944	0.123460	0.0181232	0.123460	0.0004575
14	0.082783	0.089793	0.0131811	0.089793	0.0005474
15	0.056502	0.056721	0.0083264	0.056721	0.0000009
16	0.039188	0.036697	0.0053869	0.036697	0.0001691
17	0.033048	0.030081	0.0044157	0.030081	0.0002927
18	0.042636	0.034898	0.0051229	0.034898	0.0017154
19	0.056697	0.050107	0.0073555	0.050108	0.0008665
20	0.070618	0.068031	0.0099865	0.068031	0.0000984
21	0.123315	0.127010	0.0186444	0.127011	0.0001075
22	0.159724	0.159526	0.0234176	0.159527	0.0000002
23	0.191619	0.192827	0.0283059	0.192827	0.0000076
24	0.225761	0.227348	0.0333734	0.227349	0.0000111
25	0.253123	0.259109	0.0380358	0.259110	0.0001383
26	0.284998	0.292136	0.0428839	0.292136	0.0001744
27	0.314567	0.319730	0.0469345	0.319730	0.0000834
28	0.350835	0.343374	0.0504054	0.343374	0.0001621
29	0.380464	0.372998	0.0547541	0.372999	0.0001494
30	0.396552	0.396828	0.0582521	0.396828	0.0000002

30 (100.00%) of the expected counts are less than 5.

Table C.1 Minitab chi-squared expectation values from observed and historical counts. Where the historical counts are from the model.

Chi-Square Test

N	DF	Chi-Sq	P-Value
6.81226	29	0.0087201	1.000

Table C.2 Results of Minitab's chi-squared

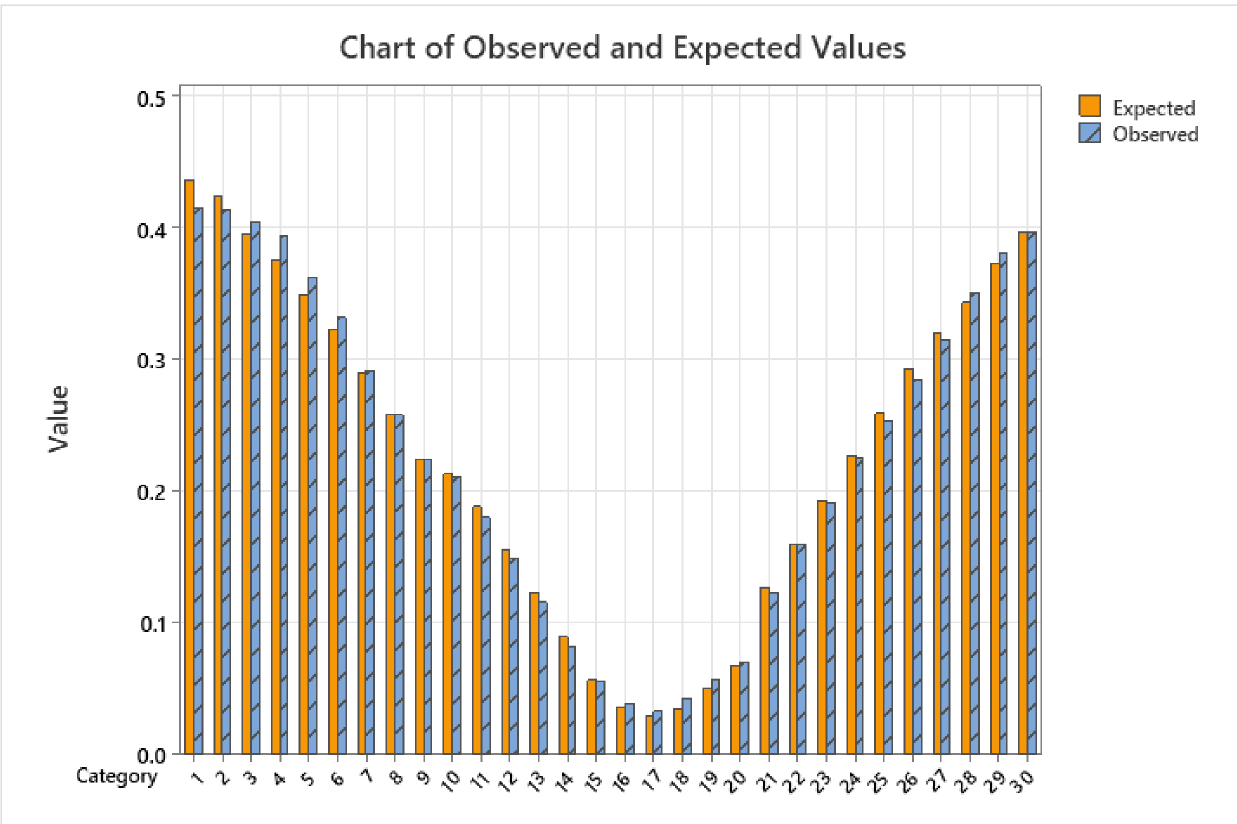

Figure C. Fit of observed and expected data from Minitab's Chi-squared