Appendix: Galileo's "Lab Report"

Galileo reports the inclined plane experiment in his book "Two New Sciences." The book is written as a series of intellectual conversations among three characters (Simplicio, Sagredo and Salviati) concerning the work of "the author" (Galileo). In this excerpt, Simplicio, Sagredo and Salviati discuss the inclined plane experiment. (Note: One bracchio is about 0.6 meters. Bracchio is the Italian word for arm.)

> "**Simplicio:** Really I have taken more pleasure from this simple and clear reasoning of Sagredo's than from the (for me) more obscure demonstration of the Author, so that I am better able to see why the matter must proceed in this way, once the definition of uniformly accelerated motion has been postulated and accepted. But I am still doubtful whether this is the acceleration employed by nature in the motion of her falling heavy bodies. Hence, for my understanding and for that of other people like me, I think that it would be suitable at this place [for you] to adduce some experiment from those (of which you have said that there are many) that agree in various cases with the demonstrated conclusions.
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> **Salviati:** Like a true scientist, you make a very reasonable demand, for this is usual and necessary in those sciences which apply mathematical demonstrations to physical conclusions, as may be seen among writers on optics, astronomers, mechanics, musicians, and others who confirm their principles with sensory experience that are the foundations of all the resulting structure. I do not want to have it appear a waste of time on our part, [as] if we had reasoned at excessive length about this first and chief foundation upon which rests an immense framework of infinitely many conclusions--of which we have only a tiny part put down in this book by the Author, who will have gone far to open the entrance and portal that has until now been closed to speculative minds. Therefore as to the experiments: the Author has not failed to make them, and in order to be assured that the acceleration of heavy bodies falling naturally does follow the ratio expounded above, I have often made the test in the following manner, and in his company.
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> ≈8.0m, ≈67cm
>
> In a wooden beam or rafter about twelve braccia long, half a braccio wide, and three inches thick, a channel was rabbeted in along the narrowest dimension, a little over an inch wide and made very straight; so that this would be clean and smooth, there was glued within it a piece of vellum, as much smoothed and cleaned as possible. In this there was made to descend a very hard bronze ball, well rounded and polished, the beam having been tilted by elevating one end of it above the horizontal plane from one to two braccia, at will. As I said, the ball was allowed to descend along the said groove, and we noted (in the manner I shall presently tell you) the time that it consumed in running all the way, repeating the same process many times, in order to be quite sure as to the amount of time, in which we never found a difference of even the tenth part of a pulse-beat.
>
> $\sin^{-1} = \frac{1}{12}$ to $\frac{2}{12}$
>
> This operation being precisely established, we made the same ball descend only one-quarter the length of this channel, and the time of its descent being measured, this was found to be precisely one-half the other. Next making the experiment for other lengths, examining now the time for the whole length [in comparison] with the time of one-half, or with that of two-thirds, or of three-quarters, and finally with any other division, by experiments repeated a full hundred times, **the spaces were always found to be to one another as the squares of the times.** And this [held] for all inclinations of the plane: that is, of the channel in which the ball was made to descend, where we observed also that the times of descent for diverse inclinations maintained among themselves accurately that ratio that we shall find later assigned and demonstrated by our Author.
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> As to the measure of time, we had a large pail filled with water and fastened from above, which had a slender tube affixed to its bottom, through which a narrow thread of water ran; this was received in a little beaker during the entire time that the ball descended along the channel or parts of it. The little amounts of water collected in this way were weighed from time to time on a delicate balance, the differences and ratios of the weights giving us the differences and ratios of the times, and with such precision that, as I have said, these operations repeated time and time again never differed by any notable amount.
>
> **Simplicio:** It would have given me great satisfaction to have been present at these experiments. But being certain of your diligence in making them and your fidelity in relating them, I am content to assume them as most certain and true."

The excerpt is taken from Galileo, *Two new sciences*, tranl. Stillman Drake (Madison: University of Wisconsin Press, 1974), pp. 169-70.

Physics 11
Interpreting Graphs on Excel

1. For the following sets of data:

    a. Enter the data in the Microsoft Excel program. The first column will be the x-axis and the second column will be the y-axis
    b. Click and drag over the data (not the titles).
    c. Click on Insert.
    d. Click on the Scatter Plot and select the one without connecting lines.
    e. This should give the basic graph. Notice what shape the graph is. Decide if it looks linear, inverse, power, or root curves.
    f. Click on "Chart Tools" and "Layout" to add to the graph.
    g. Give the graph a title and label the axes with correct units.
    h. Remove the legend (under legend).
    i. Decide what type of relationship it is. Then "Add Trendline"
        i. Linear = linear
        ii. Power curves use "polynomial" with a power of 2.
        iii. Inverse and root curves use "Power Curve". Inverse curves will have a power of –1 and root curves will have a power of 0.5

    j. Under "More Trendline Options", choose "Display Equation on Graph". Adjust the equation of the graph to reflect reasonable significant digits.
    k. Choose "Forecast" back or forward if you wish your best fit line to extend past your data points.
    l. Use another sheet of the spreadsheet to do the next set of data.
    m. When you have completed all 7 graphs, save your file onto Mr. Larcombe's classroom computer or email to dlarcombe@suis.com.cn.

X	Y
1	80
2	40
3	27
4	20
5	16

X	Y
1	3
2	6
3	9
4	12
5	15

X	Y
0	0
1	2
2	8
3	18
4	32

Mass (kg)	Period (sec)
0.1	.220
.25	.350
.33	.400
.50	0.500
.75	.600
.90	.666

Mass (kg)	Acceleration (m/sec^2)
0.9	9.0
1.50	5.3
1.75	4.6
2.25	3.5
3.00	2.7
3.25	2.5

Time (sec)	Position (m)
0	0
1	4
2	14
3	31
4	56
5	88

X	Y
1	3.00
2	4.24
3	5.20
4	6.00
5	6.71
6	7.35