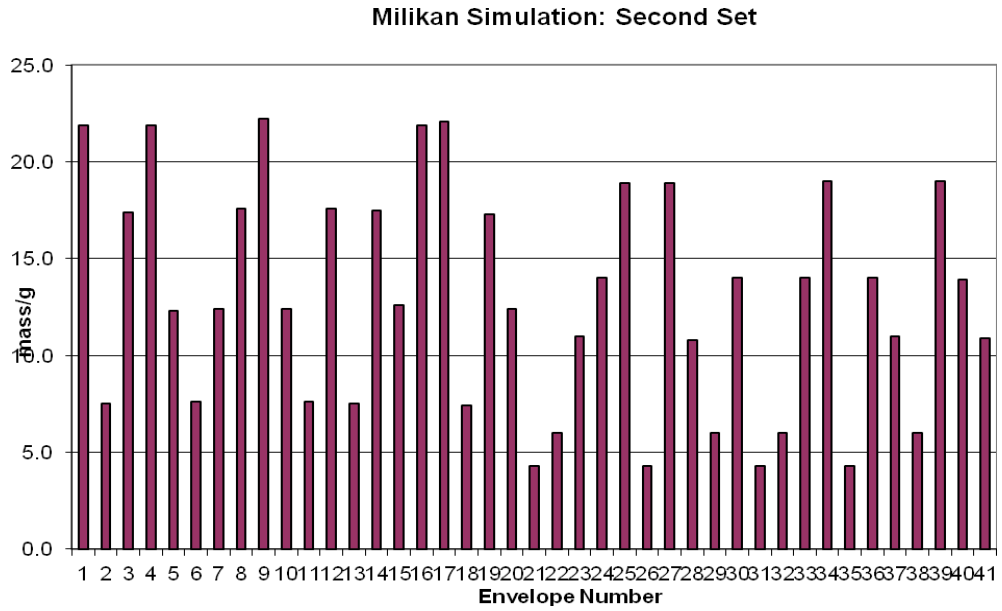
Env #	m/g	# cards	New Env #	m/g	Difference	Units
1	21.9	12	1	4.3		1
2	7.5	3	2	4.3	0.0	1
3	17.4	9	3	4.3	0.0	1
4	21.9	12	4	4.3	0.0	1
5	12.3	6	5	6.0	1.7	2
6	7.6	3	6	6.0	0.0	2
7	12.4	6	7	6.0	0.0	2
8	17.6	9	8	6.0	0.0	2
9	22.2	12	9	7.4	1.4	3
10	12.4	6	10	7.5	0.1	3
11	7.6	3	11	7.5	0.0	3
12	17.6	9	12	7.6	0.1	3
13	7.5	3	13	7.6	0.0	3
14	17.5	9	14	10.8	3.2	5
15	12.6	6	15	10.9	0.1	5
16	21.9	12	16	11.0	0.1	5
17	22.1	12	17	11.0	0.0	5
18	7.4	3	18	12.3	1.3	6
19	17.3	9	19	12.4	0.1	6
20	12.4	6	20	12.4	0.0	6
21	4.3	1	21	12.4	0.0	6
22	6.0	2	22	12.6	0.2	6
23	11.0	5	23	13.9	1.3	7
24	14.0	7	24	14.0	0.1	7
25	18.9	10	25	14.0	0.0	7
26	4.3	1	26	14.0	0.0	7
27	18.9	10	27	14.0	0.0	7
28	10.8	5	28	17.3	3.3	9
29	6.0	2	29	17.4	0.1	9
30	14.0	7	30	17.5	0.1	9
31	4.3	1	31	17.6	0.1	9
32	6.0	2	32	17.6	0.0	9
33	14.0	7	33	18.9	1.3	10
34	19.0	10	34	18.9	0.0	10
35	4.3	1	35	19.0	0.1	10
36	14.0	7	36	19.0	0.0	10
37	11.0	5	37	21.9	2.9	12
38	6.0	2	38	21.9	0.0	12
39	19.0	10	39	22.0	0.1	12
40	13.9	7	40	22.1	0.1	12
41	10.9	5	41	22.2	0.1	12

Narrative for Millikan Simulation 2:
Envelopes with 1, 2, 3, 5, 6, 7, 9 10, and 12 Index Cards

This narrative is to explain the data and calculations in the Excel file for this experiment.

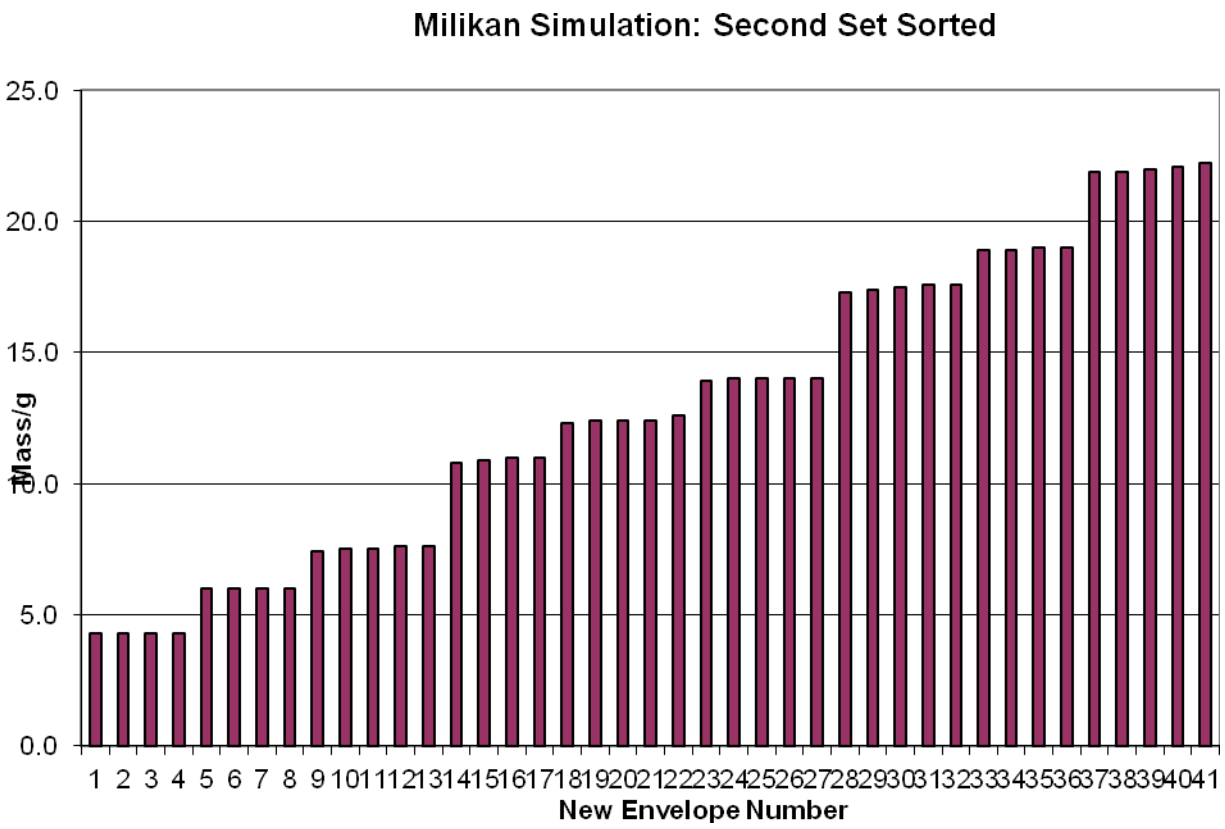
Columns A and B give the envelope number and the mass of each envelope with the cards. These columns are the basic data. Column C gives the number of cards in each envelope to assist you, the teacher, in interpreting the data.

Chart 1 is a bar graph of columns A and B. The bars appear, at first glance, to be random.



Column E is the same as column B except it has been reordered from low to high. Column D renumbers the envelopes to assist in plotting the data.

Chart 2 is a bar graph of columns D and E. Now the bars show some regularity. The first 4 have the same mass, the next 4 have the same mass as each other but different from the first 4. This trend continues but some groups have 5 bars.



If the first 4 bars are taken as the base unit then the next 4 show an increase in mass of about 1.7 g. After those 4 bars, the next 5 bars show an increase in mass of about 1.4 g again. These differences in mass between groups of bars are shown in column F. Notice that some differences are about 1.5 g while others are about 3.0 g. We can interpret these data as saying that the first group of envelopes each contain one card. If that is true, the second group contains 2 cards. Using this assumptions, column G gives the number of cards in each envelope. It could also be that the first group contains 2 cards per envelope, the second group 4 cards, etc.

We cannot say which of these interpretations is correct except we can calculate the mass of the "base unit". An envelope plus one unit of cards has a mass of 4.3 g. An envelope plus two units of cards has a mass of 6.0 g. A unit of cards has a mass of 1.7 g (6.0 g – 4.3 g). So an envelope has a mass of the total (envelope plus one unit) minus one unit or 4.3 g – 1.7 g or 2.6 g.

Remember that these values are only approximate since each envelope does not have exactly the same mass and each index card does not have exactly the same mass. I checked the mass of envelopes by determining the mass of 10 empty envelopes and recorded a mass of 27.250 g or 2.7 g per envelope.

This simulation was set up so that each set of envelopes contained 1 unit, 2 units, 3 units, 5 units, 6 units, 7 units, 9 units, 10 units, and 12 units where a unit was one card.

How does this relate to Millikan's data? The envelopes represent the oil drop on which the electrons reside. The index cards represent the electrons. The charge on the electron is that of the smallest "unit". In order for Millikan to be able to ensure that he had the smallest unit he had to take lots of measurements. He, also, had some idea what the answer was since Rutherford had determined an approximate value for the charge on an alpha particle which was assumed to have two unit charges.