Excel Analysis of Brownian Motion Data

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The analysis presented here is for 10 steel balls with data collected for 15 minutes, set by the timer on the orbital shaker. The tactile sensor was quickly tapped with the forefinger every time the disk reached the edge of the circle, and the disk was then quickly moved back to the center of the circle. The data collection rate for Voyager was set to 10 points/sec, ***and should not be set any higher or any lower***. We don't want a detailed measure of pressure—only that the sensor was quickly pressed by the forefinger.

Step 1: Open the csv file created by the PocketLab app. A small portion of the file is shown in Figure 1.

	A	B	C	D
1	Date	t (s)	Thermistor Temperature (Â°C)	Tactile Pressure (AU)
2	10:27.9	0	-57.101089	0.213168
3	10:28.0	0.1	-57.101089	0.213168
4	10:28.1	0.2	-57.101089	0.213168
5	10:28.2	0.3	-57.101089	0.213168
6	10:28.3	0.4	-57.101089	0.213168
7	10:28.4	0.5	-57.101089	0.213168
8	10:28.5	0.6	-57.101089	0.213168
9	10:28.6	0.7	-57.101089	0.213168
10	10:28.7	0.8	-57.101089	0.213168
11	10:28.8	0.9	-57.101089	0.213168
12	10:28.9	1	-57.101089	0.213168
13	10:29.0	1.1	-57.101089	0.213168
14	10:29.1	1.2	-57.101089	0.213168

Figure 1

Step 2: Remove the Date and Thermistor data columns, as they are not needed. See Figure 2.

	A	B
1	t (s)	Tactile Pressure (AU)
2	0	0.213168
3	0.1	0.213168
4	0.2	0.213168
5	0.3	0.213168
6	0.4	0.213168
7	0.5	0.213168
8	0.6	0.213168
9	0.7	0.213168
10	0.8	0.213168
11	0.9	0.213168
12	1	0.213168
13	1.1	0.213168
14	1.2	0.213168

Figure 2

Step 3: As seen in Figure 2, there are a lot of tactile pressures of 0.213168 AU. These are the "zeros" for pressure—when no forefinger is applied to the tactile

sensor. (This number may be slightly different from one sensor to another.) Sort the data set by tactile pressure from highest to lowest and delete all rows for which the tactile pressure is less than 1 AU. This will remove all of the "zeros" plus a small number of other pressures that are nearly zero. The result is shown in Figure 3.

	A	B
1	t (s)	Tactile Pressure (AU)
2	359	20.500231
3	416.4	14.314744
4	277.3	14.086374
5	565.1	13.649487
6	290.5	12.847532
7	381.7	12.847532
8	345.7	12.478632
9	47.5	12.128897
10	315	12.128897
11	460.4	11.960754
12	408	11.481238
13	440.7	11.481238
14	370.6	11.329196

Figure 3

Step 4: Sort the remaining data set by t(s). The result appears in Figure 4. Times shown have tactile pressures in which the forefinger was in contact with the sensor.

	A	B
1	t (s)	Tactile Pressure (AU)
2	2.7	3.329456
3	12.8	10.894535
4	12.9	1.308948
5	34.8	8.194369
6	34.9	3.542336
7	47.5	12.128897
8	47.6	1.453087
9	59	9.533201
10	59.1	5.171502
11	85.5	6.781975
12	85.6	7.500042
13	93.6	10.36057
14	101.7	8.724017

Figure 4

Step 5: We now need to add a column that computes the t(s) differences in adjacent rows. These differences should represent the time for the disk to move from the center of the circle to the edge. See Figure 5 for the result. Note that the formula in cell D3 is *=A3-A2* and that this formula was copied in the reminder of the cells in column B.

	A	B	C	D
1	t (s)	Tactile Pressure (AU)		Time (s)
2	2.7	3.329456		
3	12.8	10.894535		10.1
4	12.9	1.308948		0.1
5	34.8	8.194369		21.9
6	34.9	3.542336		0.1
7	47.5	12.128897		12.6
8	47.6	1.453087		0.1
9	59	9.533201		11.4
10	59.1	5.171502		0.1
11	85.5	6.781975		26.4
12	85.6	7.500042		0.1
13	93.6	10.36057		8
14	101.7	8.724017		8.1

Figure 5

Step 6: Something does not seem right with the data of Figure 5. There are a lot of Time differences of 0.1 seconds! These result when we press the sensor for more than 0.1 seconds, and they do not represent time for the disk to move from the center to the edge of the circle. We need to eliminate these 0.1 second differences.

Select and highlight the entire Time (s) column. We want to paste this to a new worksheet in our Excel workbook. When pasting be sure to select **Paste Special Values**. We don't want the formulas copied, just the values. The result is shown in Figure 6.

	A
1	Time (s)
2	
3	10.1
4	0.1
5	21.9
6	0.1
7	12.6
8	0.1
9	11.4
10	0.1
11	26.4
12	0.1
13	8
14	8.1

Figure 6

Step 7: To easily get rid of the 0.1 s Time values, sort the data from highest to lowest. This will send all of the 0.1 values to the bottom of the column. You can then delete all of the rows with 0.1 Time values. The result is shown in Figure 7. The items remaining are the times for the disk to move from the center of the circle to the edge of the circle! They are ready for a histogram!

	A
1	Time (s)
2	49.7
3	35.4
4	33.2
5	32.8
6	27.4
7	26.8
8	26.4
9	25.8
10	25
11	22.8
12	21.9
13	21.4
14	19.7

Figure 7

Step 8: Prepare the histogram. Highlight the entire column A. Select *Insert*. From the *Charts ribbon* select *Insert Statistics Chart/Histogram*. Choose the *Histogram chart type* in the left of the drop down. A histogram will appear. To change the bins to a width of 5 seconds, right click on the horizontal axis labels at the bottom of the chart and select *Format axis…* from the popup menu. Note that the horizontal axis labels are of the form (v1, v2]. These intervals are open on the left and closed on the right. Finally change the bin width to 5. The resultant histogram is shown in Figure 8. You can "fancy up" this chart to your heart's content.

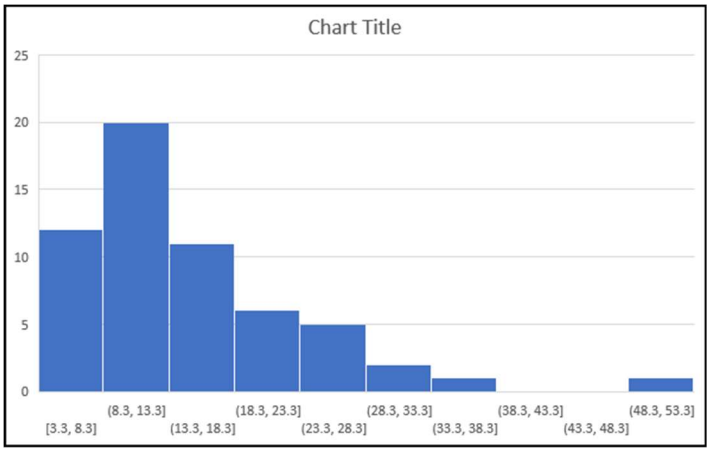

Figure 8