Short-Run and Long-Run Behavior

This activity will examine the behavior of tossing a coin and the proportion of heads using small numbers of tosses and large numbers of tosses. We will use the *RandInt*, *CountIf*, and *Fill Down* functions to explore this behavior.

1. Open a New document, ctrl N and select *Add Lists & Spreadsheet*.

2. Define a variable based on the number of tosses of the coin.

   - Name column A: **tosses**.
   - Arrow down to the first cell and type **1** in the first cell and **2** in the second cell.
   - While the 2nd cell is still highlighted, press and hold shift and then press the up arrow. This will highlight the first two cells.
   - With the first two cells highlighted, press ctrl menu and select *Fill Down*.
   - Press the down arrow until the fill reaches the 50th cell. The numbers 1 – 50 should now be in **tosses**.

3. Calculate the proportion of heads for each number of coin tosses. The *RandInt* function can be used to generate random numbers. Letting the integers be only 0 or 1 will simulate tossing a coin. For this activity, 0 will represent a head and 1 will represent a tail.

   - Name column B: **propheads**.

   - Arrow down to the first cell, press = and type the following:

     countif(randint(0,1,*a1*),?=0)/(*a1*)

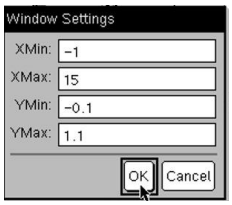
   *Note: "**a1**" references the cell just like Excel. When **Fill Down** is used later the cell reference will change just as it does in Excel. "?" is a dummy variable for the **CountIf** function. **?=0** tells the CountIf function to count the number of 0s generated from the RandInt function.*

   - Press enter and the proportion of heads will be displayed.

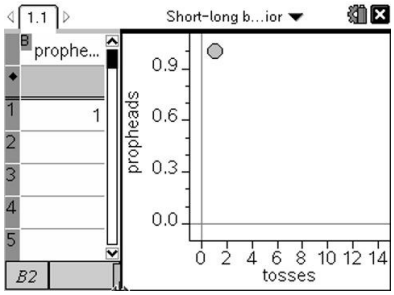
What was your result? Explain what this means in context of the problem.

4. Graph the proportions as they are calculated for the # of tosses.

- In the *Lists & Spreadsheet* page, press (doc▾), *Page Layout, Select Layout, Layout 2*.
- Press (ctrl) (tab) to move to the new window within the split screen. Press (menu) and select *Add Data & Statistics*.
- Press (tab) and select **tosses** for the horizontal axis. Press (tab) again and select **propheads** for the vertical axis.
- Arrow to a blank space in the graph and press (ctrl) (menu). Select *Zoom, Window Settings*. Set your window with the following settings.



- Increase the size of the *Data & Statistics* window to look like the screen pictured here. Press (doc▾), *Page Layout, Custom Split*. A directional icon will appear and you now resize the windows. Press the left arrow to increase the size of the *Data & Statistics* window.



- In the *Data & Statistics* window, arrow to the empty space and press (ctrl) (menu). Select *Connect Data Points*.
- Press (ctrl) (tab) to return to the *Lists & Spreadsheet*. Navigate to the first cell for **propheads**.
- Press (ctrl) (menu) and select *Fill Down*.
- Press the down arrow to the next cell and then press (enter).

Describe what happened in the <u>prophead</u> list and on the graph. What was your proportion of heads for two coin tosses?

- Press (ctrl) (menu) and select *Fill Down*.
- Press the down arrow to the next cell and then press (enter). There should now be three proportions in **prophead** and three points displayed on the graph.

What is your proportion of heads for three coin tosses?

Compare your graph with other students in the class and list the similarities and differences.

5. Explore what happens to the proportions as you increase the number of tosses.

- With the third cell highlighted, press (ctrl) (menu) and select *Fill Down*.
- Press the down arrow to highlight the cells to 10 tosses and press (enter).

What is your proportion of heads for ten coin tosses?

Briefly describe what is happening to your graph.

- Arrow to the tenth cell in **propheads** and fill down to 30 tosses.

- You will need to change the window on your graph to see the behavior beyond 15 tosses. (ctrl) (tab) to the *Data & Statistics window* and arrow to a blank space in the graph. Press (ctrl) (menu) and select *Zoom, Window Settings*. Change *XMax* to **50**.

What is your proportion of heads for thirty coin tosses?

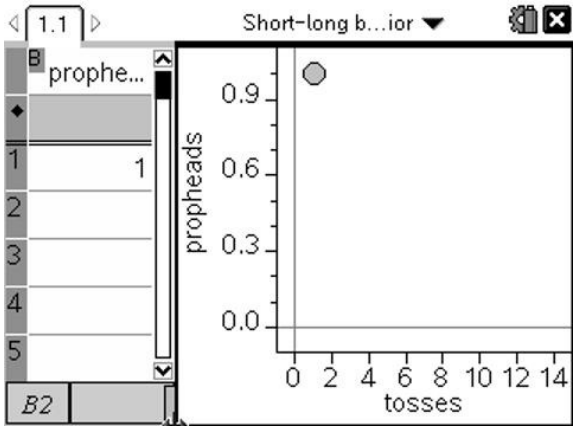
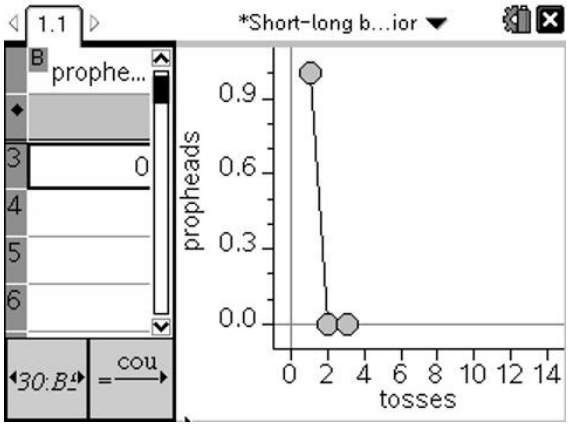
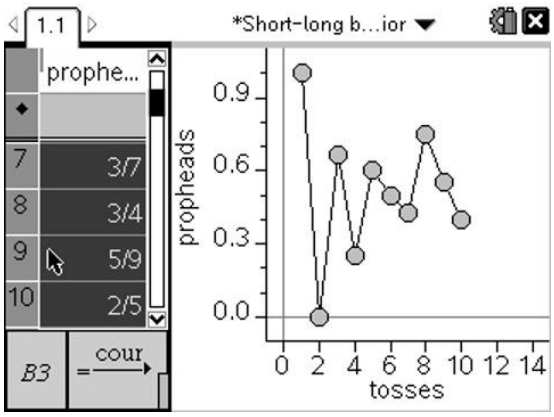
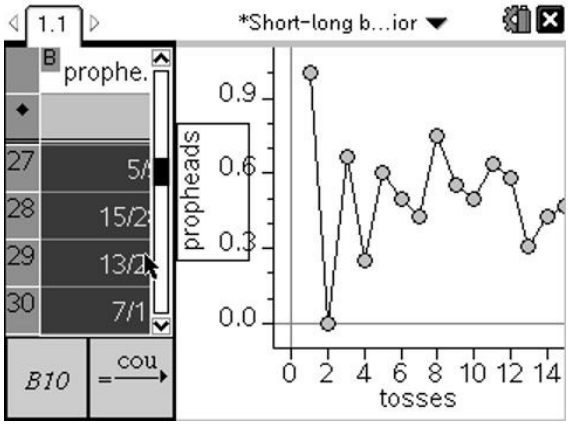
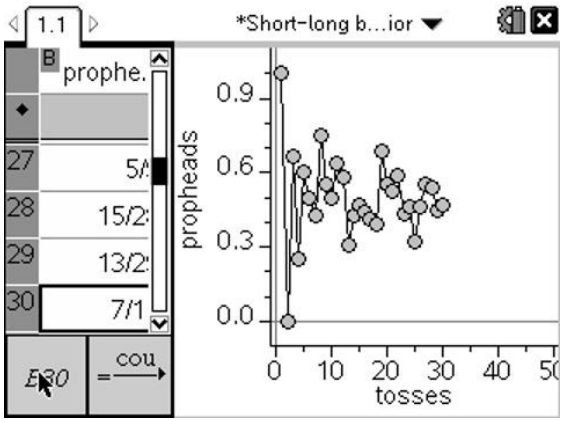
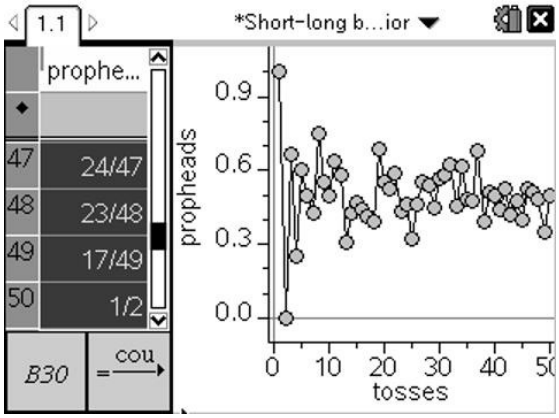
Describe your graph.

- Arrow to the thirtieth cell in **propheads** and fill down to 50.

What is your proportion of heads for fifty coin tosses?

Describe the behavior of the proportion of heads from one toss of the coin to fifty tosses of the coin.

How does this activity support the law of large numbers? Be specific.

Teacher Page

Here are sample screens from this activity that the students should be producing.