About the Lesson

In this activity, students examine equations in the family of linear functions which are of the form $y = m\,x$, each of which correspond to a different family of sharks. They relate the slope to the ratio of the shark's fork length to its total length. When comparing two sharks of the same length, students conclude that slopes of the lines of the three families decrease with increasing length of the upper caudal lobe.

As a result, students will:

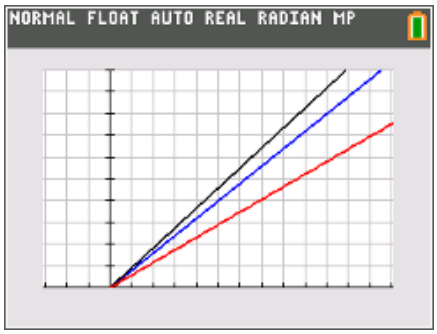
- Find the slope of a line given two points.
- Interpret the real world meaning of the slope of a linear function in the context of a problem.
- Write an equation in the form $y = m\,x$ to represent a linear relationship between two quantities.
- Relate the value of the slope to the steepness of the graph of the line.

Vocabulary

- family of functions
- slope

Teacher Preparation and Notes

- Students should have experience in calculating slope from two points.
- Students should be able to enter an equation in the Y- editor and set a viewing window to produce its graph.



Tech Tips:

- This activity includes screen captures taken from the TI-84 Plus C Silver Edition. It is also appropriate for use with the TI-84 Plus family with the latest TI-84 Plus operating system (2.55MP) featuring MathPrint™ functionality. Slight variations to these directions given within may be required if using other calculator models.
- Access free tutorials at http://education.ti.com/calculators/pd/US/Online-Learning/Tutorials
- Any required calculator files can be distributed to students via handheld-to-handheld transfer.

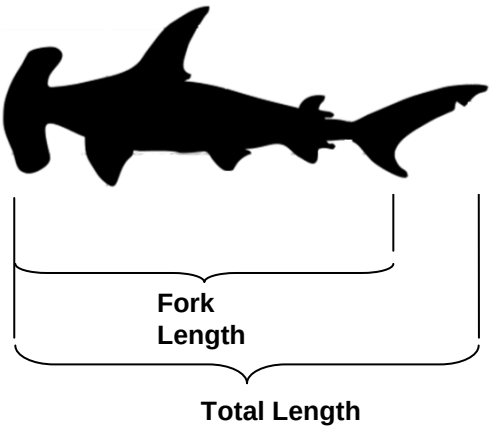
Compatible Devices:

- TI-84 Plus Family

Associated Materials:

- SharkFrenzy _Student.pdf
- SharkFrenzy_Student.doc

One way scientists can classify a shark is by is by measuring its "fork length". In this activity students will explore why.



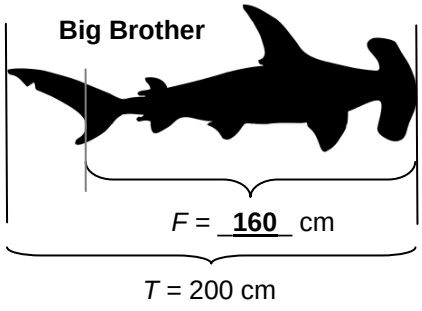
1. Explain why you think that name "fork length" is given to that particular length.

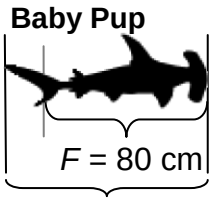
Answer: The name fork length is appropriate since it measures how far the head of the shark is from the fork of its tail fin.

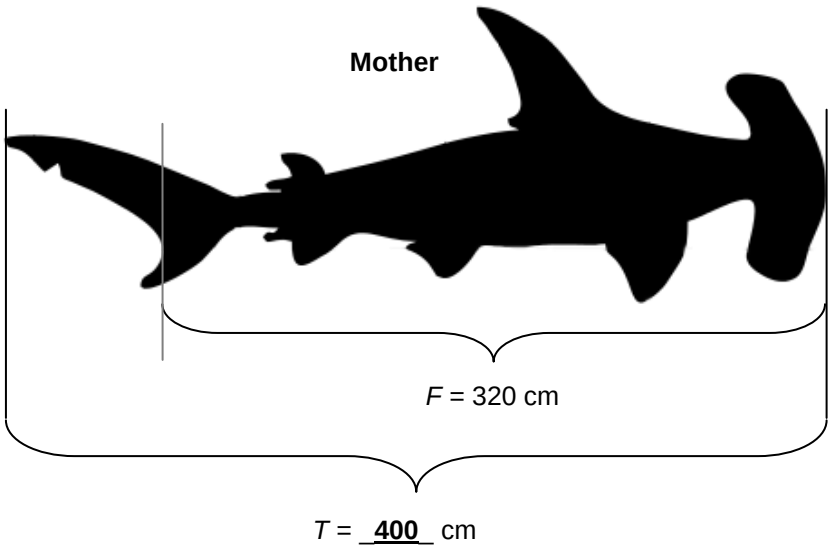
2. Suppose you have caught, measured, and tagged a family of hammerhead sharks. (Do not attempt without adult supervision.) If the sizes of all the members of this family were the same shape but different sizes, determine the missing lengths. Then complete the table. Discuss any patterns you see.

Answer: Check that students are careful not to reverse the ordered pairs in the table. Students may notice a doubling pattern. They may also notice that the fork length is 4/5 or 80% of the total length, but if not, this will come up later. In reality, family members of sharks (like human family members) are not perfectly proportional; however, the younger hammerhead sharks look more like their older family members than is true for most other shark species (and humans). For example, a human infant's head is much larger in proportion to its body than an adult's.

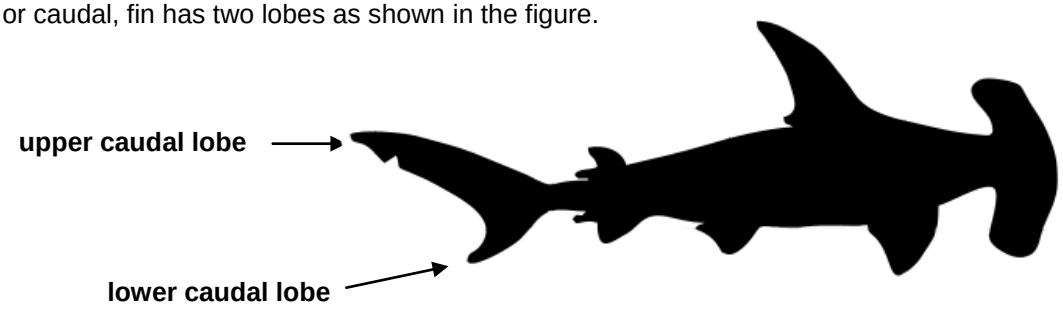
Hammerhead Shark	Total Length, *T* (cm)	Fork Length, *F* (cm)
Baby Pup	100	80
Big Brother	200	160
Mother	400	320







3. The tail, or caudal, fin has two lobes as shown in the figure.



Do you agree or disagree with each of these statements?

A. *The longer the lower caudal length, the longer the total length of the shark is.*

Circle one: AGREE DISAGREE

B. *The longer the upper caudal length, the longer the total length of the shark is.*

Circle one: AGREE DISAGREE

Explain your reasoning.

Answer: B is true. The total length includes the length of the upper caudal lobe plus the rest of the length of the shark. The lower caudal lobe has nothing to do with the total length. This relationship will be of use in the last question in the activity.

4. A baby hammerhead shark, called a pup, and its mother are tagged.

Measurements are shown in the table.

Shark	Total Hammerhead Length, *T* (cm)	Hammerhead Fork Length, *F* (cm)
Baby	90	72
Mother	400	320

A. If these points (*T*, *F*) were plotted, what is the slope of the line which passes through them?

Answer: The slope is $\frac{320 - 72}{400 - 90} = \frac{4}{5} = 0.80$.

B. What is the equation of the line which passes through these points?

Answer: $F - 72 = 0.80(T - 90)$; $F - 72 = 0.80T - 72$; $F = 0.80T$.

5. A baby thresher shark pup and its bull father are tagged. Measurements are shown in the table.

Shark	Total Thresher Length, *T* (cm)	Thresher Fork Length, *F* (cm)
Baby	300	174
Father	450	261

A. If these points (*T*, *F*) were plotted, what is the slope of the line which passes through them?

Answer: The slope is $\frac{261-174}{450-300} = \frac{87}{150} = \frac{29}{50} = 0.58$.

B. What is the equation of the line which passes through these points?

Answer:

$F - 174 = \frac{261-174}{450-300}(T - 300) \Rightarrow F = \frac{29}{50}T$ or

$F = 0.58T$

6. Two great white sharks re tagged. Measurements are shown in the table.

Shark	Total Great White Length, *T* (cm)	Great White Fork Length, *F* (cm)
Little Brother	500	460
Big Brother	600	552

A. If these points (*T*, *F*) were plotted, what is the slope of the line which passes through them?

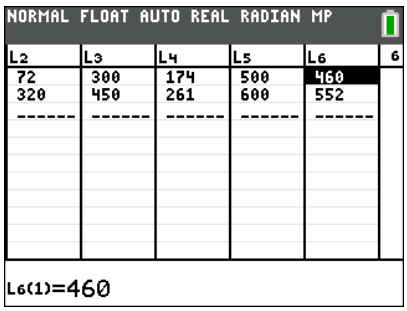
Answer: The slope is $\frac{552-460}{600-500} = \frac{92}{100} = \frac{23}{25} = 0.92$

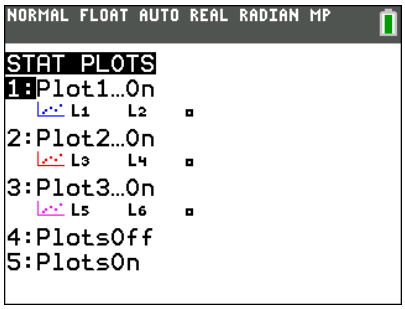
B. What is the equation of the line which passes through these points?

Answer: $F - 460 = 0.92(T - 500)$; $F - 460 = 0.92T - 460$; $F = 0.92T$.

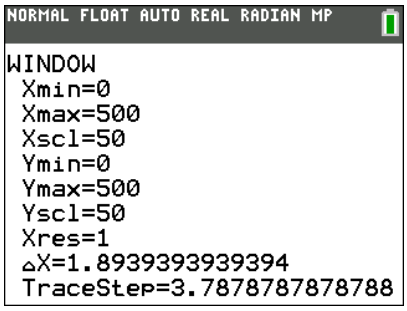
For question number 7, you could have students predict which letter corresponds with which shark before graphing the equations.

Another option is to plot the data points in the Stat Editor. Press [STAT] [ENTER]. Type the data in L_1 to L_6 as shown to the right. The above answers can then be confirmed by doing linear regressions. Press [STAT] and choose CALC, LinReg (ax+b). Then you will need to enter Xlist: L_1 and Ylist: L_2. Use [2nd] [1] for L_1 and [2nd] [2] for L_2. You can choose to Store RegEQ into Y_1. Use [ALPHA] [TRACE] for [F5] to get Y_1 or use [VARS], Y-VARS, FUNCTION, Y_1. Repeat this process to find the regression for the other pairs of lists. The data can be plotted by pressing [2nd] [Y=] for [STAT PLOT]. Select the scatter plot and appropriate list as shown to the right.



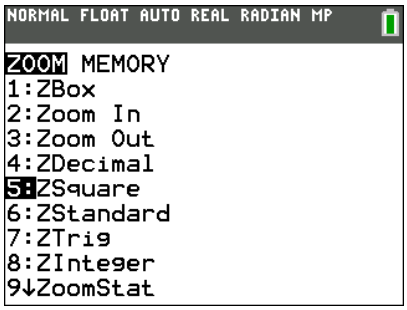


The window described below and shown to the right will give a tick mark every 50 cm. Grid lines can be shown on the TI-84C handheld and TI-84 SmartView software View when Graphing Calculator Model displayed is the TI-84 plus C. Turn on the GridLine by pressing [2nd] [ZOOM] to change the [FORMAT] settings.



TI-84 Plus users could use GridDot.

Students are instructed to use ZOOM 5:Square to produce a “square window” with a true geometric perspective.



Tech Tip: Students will graph these equations by pressing [Y=]. They will need to use *X*, using the [X,T,Θ,n] button, instead of *T* as they graph the three fork length equations in Y_1, Y_2, and Y_3. Be sure to change the [WINDOW] to Xmin = 0, Xmax = 500, Xscl = 50, Ymin = 0, Ymax = 500, and Yscl = 50.

7. Enter all three of your equations in your calculator to display this family of linear functions. Use the window $0 < x < 500$ and $0 < y < 500$ where Xscl and Yscl are each 50.

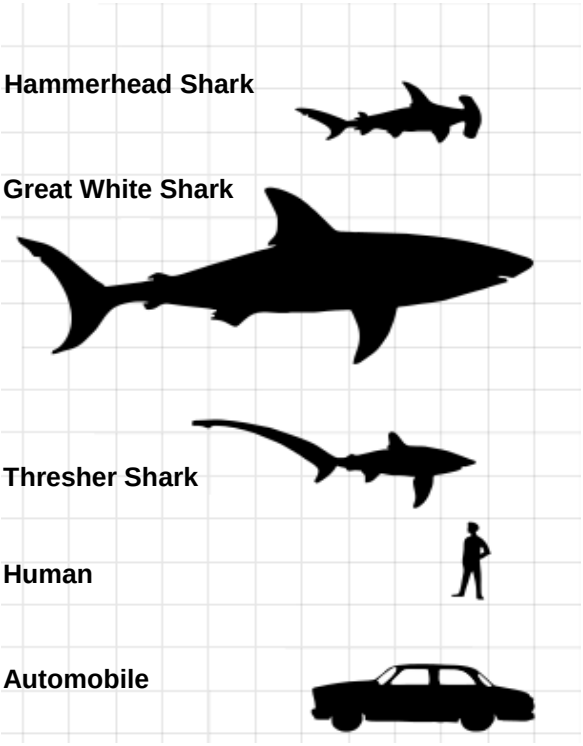
Then press ZOOM 5:Square to produce a "square window" with a true geometric perspective.

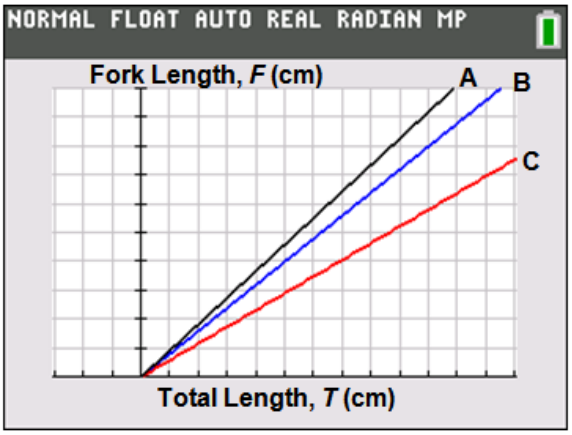
Below are silhouettes of three families of sharks showing how their lengths compare to the size of a human and the length of a car.

Which shark matches which graph? Circle one letter choice for each shark family and write the equation of the linear model.

Answer:

Hammerhead Shark	A	(B)	C	Equation: $F = 0.80T$
Great White Shark	(A)	B	C	Equation: $F = 0.92T$
Thresher Shark	A	B	(C)	Equation: $F = 0.58T$





Graphic from http://upload.wikimedia.org/wikipedia/commons/8/8d/Sharks_silhouettes.svg.

Teaching Tip: Ask students whether they think the relationship between fork length and total length is a directly or inversely proportional. (The relationship is direct.) Have them defend their answers using evidence from the graph.

8. Interpret the real world meaning of the slope and *y*-intercept of these lines.

The *y*-intercept indicates the fork length when the total length is zero. It makes that the fork length is also zero.

The slope is the ratio $\frac{Fork\,Length}{Total\,Length}$.

The fork length of the hammerhead is 80% of its total length.
The fork length of the great white shark is 92% of its total length.
The fork length of the thresher shark is 58% of its total length.

9. Suppose you have caught several sharks which have the same total length.
Circle which one of these statements about the rear fin is true. Explain.

*A. Slopes of the lines of the three families **decrease** with increasing length of the upper caudal lobe.*

***B.** Slopes of the lines of the three families **increase** with increasing length of the upper caudal lobe.*

Answer: B is true. The length of the upper caudal lobe can be computed for each shark in the activity by finding the difference in the total length and the fork length, $T - F$. If the upper caudal lobe is zero length, the fork length and total length would be the same and the slope would be 1. The slope of each line is the ratio $\frac{\Delta F}{\Delta T}$, so the smaller the slope, the longer the upper caudal lobe of the shark.

Extension Questions

1. When scientists tag a shark, they often record only its fork length. Why might they do this?

Answer: Knowing the percentage of the fork length to the total length for different shark families, if you have the fork length you can compute the total length. The fork length measures most of the shark.

2. The Florida Museum of Natural History Website has a gallery of different species of sharks.
In this gallery, the thresher shark is described as follows:
The thresher shark can be easily identified by the long upper lobe of the caudal fin. The lobe can be as long as the body and gives the tail a slender "whiplike" appearance.
https://www.flmnh.ufl.edu/fish/Gallery/Descript/ThresherShark/ThresherShark.html

Suppose for this activity you measured a family of threshers that all had this property. What would be the slope of the line for this family?

Answer: The slope of the line would be 1/2.

3. Do you think that the weight of the shark would be related to the fork length of the shark?

If so, do you think it is linearly related?

Answer: In general, the larger the fork length, the larger the weight of the shark, even though sharks with the same fork length may weigh differently due to the amount in their stomachs, their stage of maturity, the weight of their liver, and other factors.

The weight is roughly directly proportional to the **cube** of the fork length, i.e.. $W = kF^3$ for some value of k. Weight is not a linear function of fork length. Weight depends more upon the volume, which is cubic.

For more information, see "Length-Length and Length-Weight Relationships for 13 Shark Species from the Western North Atlantic" by Nancy E. Kohler, John G. Casey, and Patricia A. Turner, Northeast Fisheries Science Center, National Marine Fisheries Service, Narragansett, RI 02882, http://www.nefsc.noaa.gov/publications/tm/tm110/ .