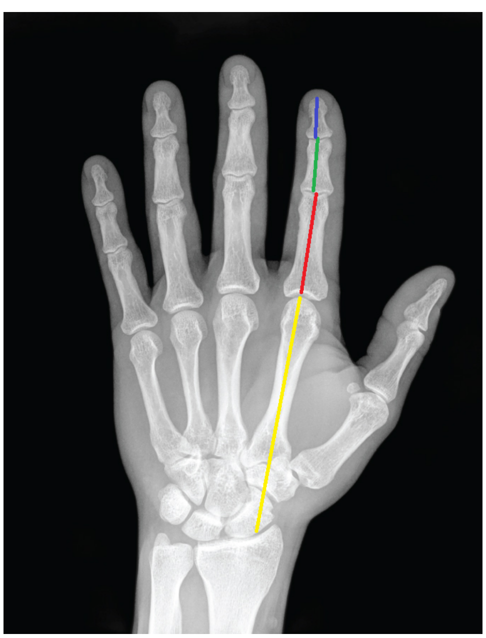
Modeling the Grasping Hand

Your goal is to create a primary finger on a hand that can “grasp”. Human index fingers have a fantastic ability to grasp a wide variety of objects. Understanding this feature allows a pitcher to change the speed of her or his delivery. By changing the arrangement of fingers that make contact with the ball, the pitcher can change the speed that the ball will leave the hand without changing his or her arm speed.

Knuckleball orientation via [Shutterstock]

Changeup orientation via [Shutterstock]

Let’s see how the Fibonacci Sequence is related to the amount of contact between the index finger and something it is grasping.



X-ray of Hand by OpenStax via [Wikimedia Commons]

Notice the bones of the hand in the X-ray above. Focus on the index finger. See how there are 3 phalanges that make up the finger (blue, green, and red)? The palm of the hand has a long bone in it (metacarpal) and several small bones at the base (carpals), labeled with yellow. You are going to design a finger with a similar arrangement.

Resource by Jeff Grant

Overview

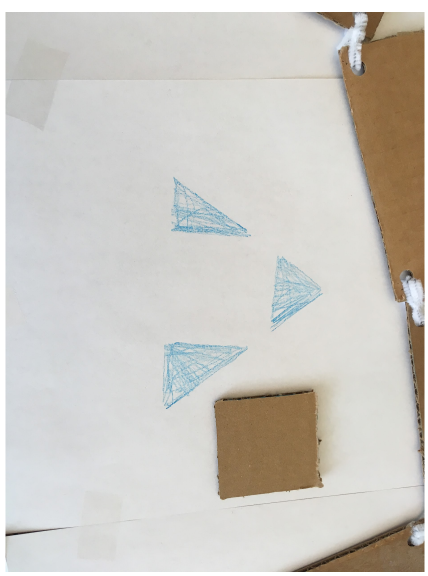
At your station you will be given a variety of cardboard pieces so that you can create a model finger. Your goal is to create a model finger that when curled around different objects, makes close contact with those objects, forming a good “grip” on the object. You will use cardboard segments of different lengths to represent “phalanges.” By varying the number and lengths of the phalanges in your “finger” you can try to make a finger that is good at gripping. The “best” finger design will grasp a variety of objects with the maximum amount of surface area contact.

Rules:

- Your finger must be between 5cm and 50cm in length
- Your finger must include a minimum of 4 phalanges, and up to 8.
- Each phalanx should be connected by a 6 ½ cm piece of pipe cleaner.
- Phalanges can arranged be in any order.

Procedure:

1. Make a sample model finger with four “phalanges” that are all the same size following the rules above.
2. Choose an object (W, S, Y or Z) that your model finger will have to “grasp” and tape it down on a table top or have a lab partner hold it in place.
3. Now try to curl your model finger model around the object.
4. Observe how well it makes surface contact (edges of the phalanges with the edges of the object).
    - You need to make a judgement call about how you think the model would be able to “grasp” the object. To “grasp’ in this context does not mean that the model will be able to lift. To “grasp” just mean to touch the object. You should be looking to create the most surface area contact with the objects.



In the images to the left you can see how the model finger is coming into contact with the square object. Notice the lengths of each section of finger that is in contact with the square - most of the finger length is not actually touching the square! If you are having trouble visualizing the lack of contact between the square and the finger, try coloring the area between the model finger and the object. This will help you rank the amount of contact between the finger and the square.

5. Now it is your turn to let those creative juices flow. Take apart that finger and try to put together a better finger by rearranging the order of pieces and the number of pieces. Remember to follow the rules above.
6. Test and retest your arrangement until you feel like the finger you have created makes the most contact with all four objects it needs to wrap around.

Image Credit: Jeff Grant

   - Do not let the model finger overlap the object. See the picture above for an example of an overlap you want to avoid.

Tips for success

- Think about the Fibonacci Sequence as you put together your model finger.
- Look at all the pieces at your station before you start.
- Draw a line on a sheet of paper that is 50cm long. This way, as you are putting together your "finger", you can measure against the line so that your finger will not exceed the maximum length.
- Try different arrangements.
- Be sure to secure your object before you begin so that your model finger can easily curl around it. Otherwise, the object may move and not provide the correct interpretation of the interaction between finger and object.

Once you and your group have decided that you have created the best finger for grasping all objects, draw out a picture of your “finger” and make sure to give proper measurements above the drawing. Here is an example finger diagram with measurements in cm.

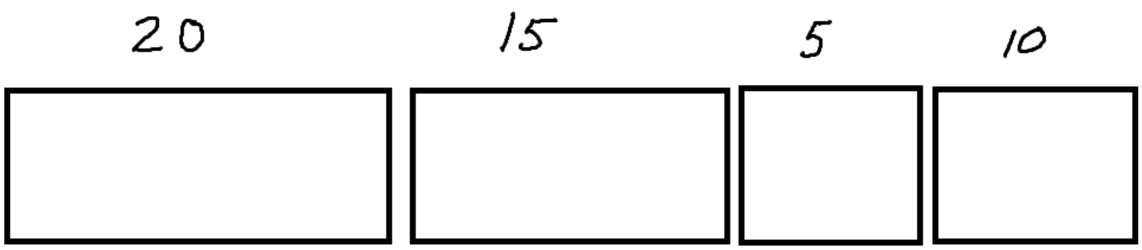


Image Credit Jeff Grant

<u>Demonstrate why your finger model is the “best” finger arrangement</u>
Why is your final finger model better than the previous finger models you made? Give a qualitative answer (descriptive answer, e.g. really well, not well, bad) based on how much the model touches the surface of the object as it curls around it.

Description of your final finger model interaction with object W.

Description of final finger model interaction with object X.

Description of final finger model interaction with object Y.

Description of final finger model interaction with object Z.

Measure the 5-8 different cardboard pieces of your finished finger/hand. (Only measure the lengths of each piece, starting with the piece labeled with a 1. Think of your model in the following way: Your first cardboard piece is the palm (1), the second piece would be proximal phalanx (2), and so on.

Fill in the Data Table (below) with the appropriate measurement for each part of your model.

Image Credit Jeff Grant

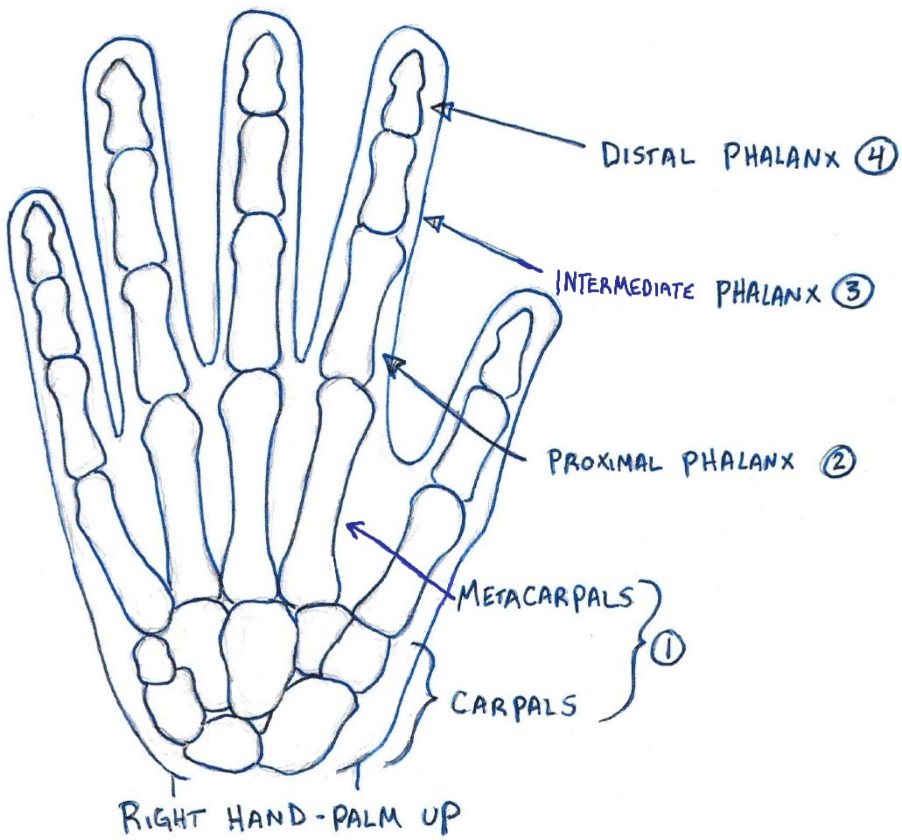


Image Credit: Jeff Grant

Model	Measurement in cm
Piece 1 (representing the carpal/metacarpal)	
Piece 2 (proximal phalanx)	
Piece 3 (intermediate phalanx)	

Piece 4 (distal phalanx or another intermediate phalanx)	
Piece 5 (distal or another intermediate phalanx) *Only fill in if you have more than 4 pieces in your model*	
Piece 6 (distal or another intermediate phalanx) *Only fill in if you have more than 5 pieces in your model*	
Piece 7 (distal or another intermediate phalanx) *Only fill in if you have more than 6 pieces in your model*	
Piece 8 (distal phalanx) *Only fill in if you have 8 pieces in your model*	

Graph your results

Now you need to graph the length of each of the rectangles in your model's measurements. Graph the phalanx number (1 up to 8, on the x-axis), and the length of that phalanx (in cm, on the y axis). Complete a line graph for your best and final model that you created and do your best to connect the dots in a curve, like below.

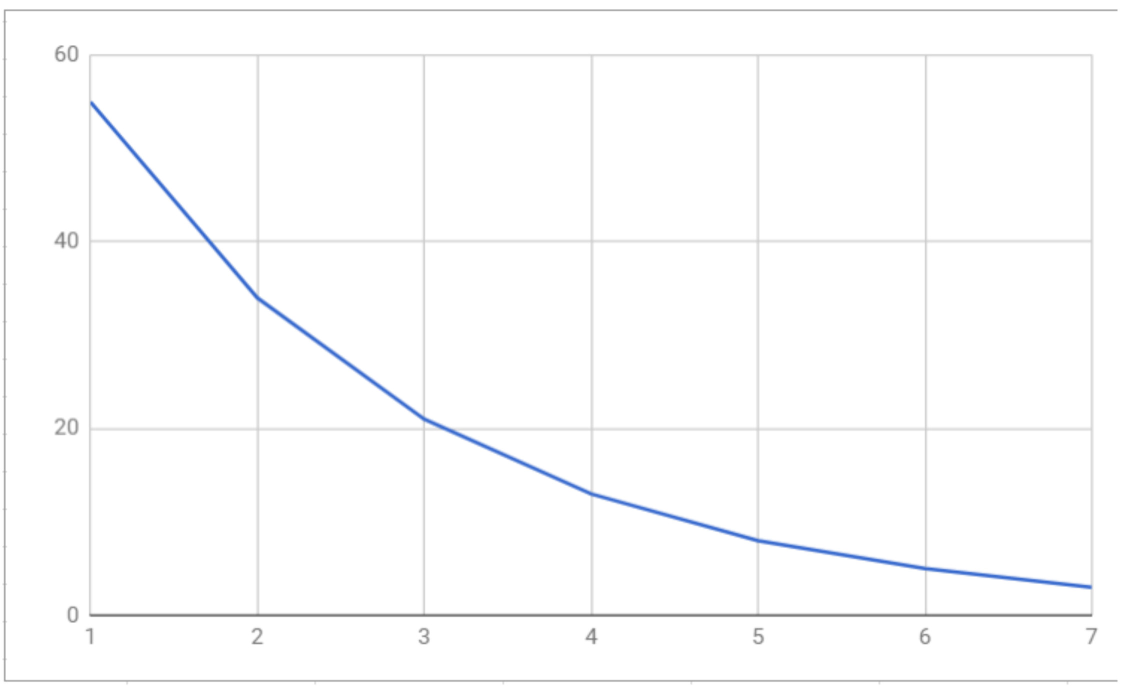


Image Credit: Jeff Grant via Google Sheets

The above curve is a Fibonacci sequence where the y-axis is the length of the pieces and the x-axis is the number of the piece.

Analysis:

1. Compare your graph with the one provided above. Does it match up in a similar pattern?

2. Give a justification for why or why not the model fit this curve pattern.

3. Talk with another lab group. How closely does their finger match yours? How does their graph compare? Write your notes from this share session below.

4. The curve on the graph above represents the Fibonacci sequence. How does Fibonacci sequence relate to the ability to grasp? Use what you learned from this activity to justify your answer.

5. Do you think that measuring the finger of an animal and comparing it to the Fibonacci sequence can help us to predict that animal's ability to grasp? Justify your answer.