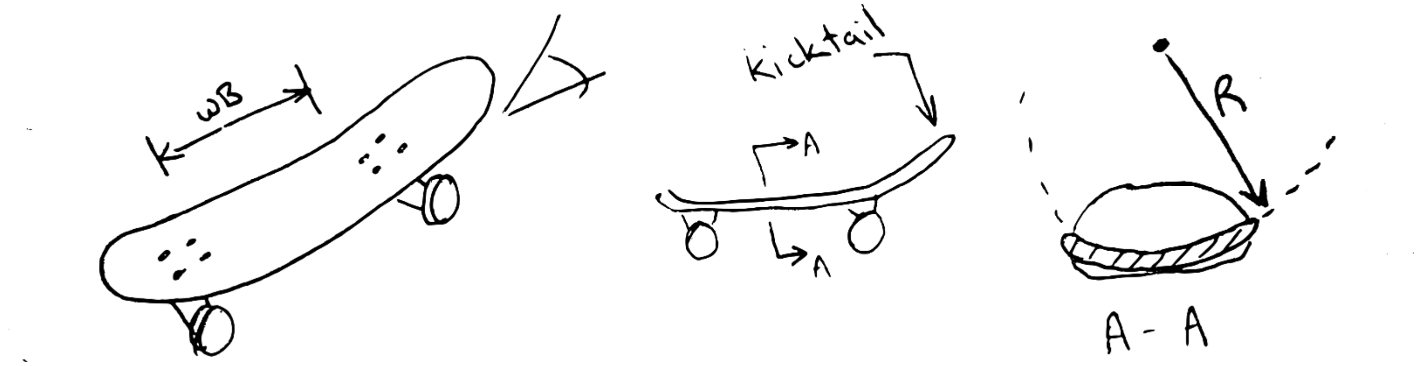
Skateboard Design & Applied Math with Fingerboards



Overview:

Students will experiment with different fingerboard shapes to understand how the shape affects their performance. After trying all shapes and discussing, students will be able to design and print their own fingerboards based on the data they collected!

Grade Levels: Elementary school through high school

Standards*:

NGSS:

K-2-ETS1-2 Engineering Design: *Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.*

K-2-ETS1-3 Engineering Design: *Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.*

MS-ETS1-3: *Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*

HS-ETS1-2 Engineering Design: *Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.*

CCSS:

CCSS.Math.Content.8.G.B.7: *Apply the Pythagorean Theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.*

CCSS.Math.Content.HSG.SRT.C.8: Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*

**It is assumed that teachers will tweak the lesson plan as needed to better suit their students.*

Learning objectives:

1) Students will observe and understand how a skateboard's shape affects its performance.
2) Students will learn how to develop appropriate conclusions from data.
3) Students will apply their new knowledge to design and test their own skateboard designs.
4) Students will apply math in the design process.

Lesson outcome:

1) Each student will collect data on fingerboard performance.
2) Students will come to conclusions based on the data collected.
3) Students will gain exposure to the 3D design and printing process.
4) Students will get their own fingerboards to take home.

Materials:

- Fingerboard trucks (2 per student)*
- Fingerboard wheels (4 per student)*
- Miniature screws (8 per student)*
- Miniature nuts (4 per student)*
- 3D printer
- 3D printer filament such as PLA
- Laptops/computers with internet access (1 per student)
- Calipers or rulers (1 per student)
- Paper and pencils for sketching
- Mini Philips head screwdriver
- Mini socket wrench (2.5 mm)*

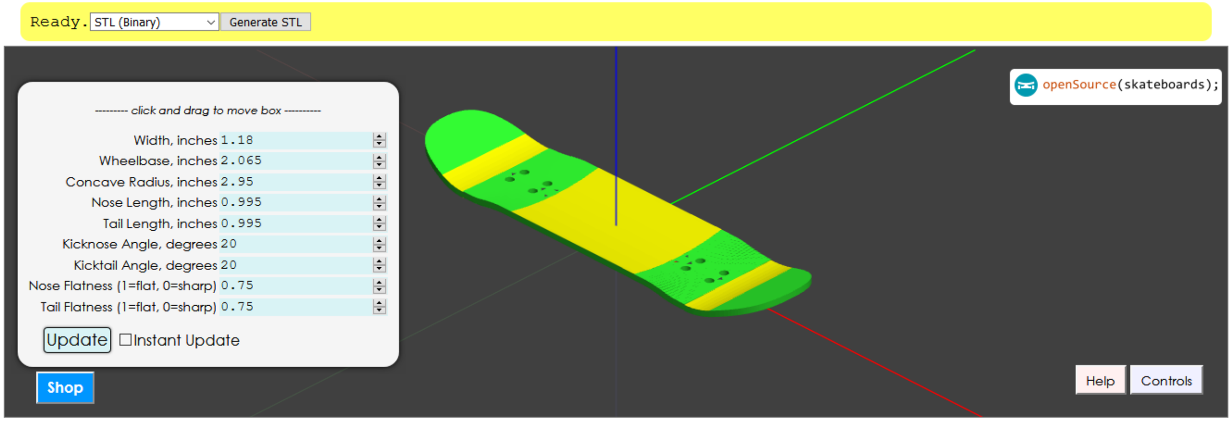
Fingerboard kits (trucks, wheels, hardware, and tool) may be ordered individually or in bulk from www.opensourceboards.com/shop.html.

Instructions:

Before class:

1) Instructor prints at least 5 different shape fingerboards.*

   Boards may be designed and printed via: www.opensourceboards.com/CAD/fingerboard-simple.html.



**If possible, print enough of each shape so that all students can be using a fingerboard during the data collection process (otherwise, students may take turns).*

2) Instructor creates stations for each shape board. (For example, one station might have boards with very steep kicktails; another station might have boards with a very small concave radius.) The station can be as simple as a flat surface, or it can incorporate various ramps and obstacles made of books, cardboard, etc. Each station will have several measuring devices (rulers, calipers, etc.).

Day 1:

1) **Overview:** Instructor explains project to class. Instructor reviews terminology of skateboards (use one of the pre-made fingerboards as an example):

   Skateboard components:

   - Deck
   - Trucks
   - Wheels
   - Bearings
   - Bolts
   - Nuts

   Skateboard geometry:

   - Width
   - Length
   - Wheelbase
   - Concave
   - Nose & Tail Length
   - Kicknose & Kicktail Angle

   Geometry reference diagram: http://bit.ly/2glNwCg

2) Instructor breaks class into groups.

3) **Data collection:** Each group spends 10 minutes at each station.

First 5 minutes: students independently play with the boards, and take notes on what they notice.

Next 5 minutes: students will share their thoughts with the group for each shape. Each writes their observations for the performance of the fingerboard.

Students will measure and record:

- Width
- Length
- Kick angle
- Concave
- Nose and tail length
- Wheelbase

Students will write down observations for each shape, trying not to make conclusions until they've been to every station. Sample observations might be:

Station 1:

- *Average height I could "pop" skateboard to: 3 inches*
- *Easy to land on*
- *Felt flexible*

Station 2:

- *Average height I could "pop" skateboard to: 1 inch*
- *Even easier to land on than station 1*
- *Felt heavier*
- *Awkward for fingers*
- *Felt stiffer*

…

Instructor will define any specific tests he/she would like the students to perform.

Day 2:

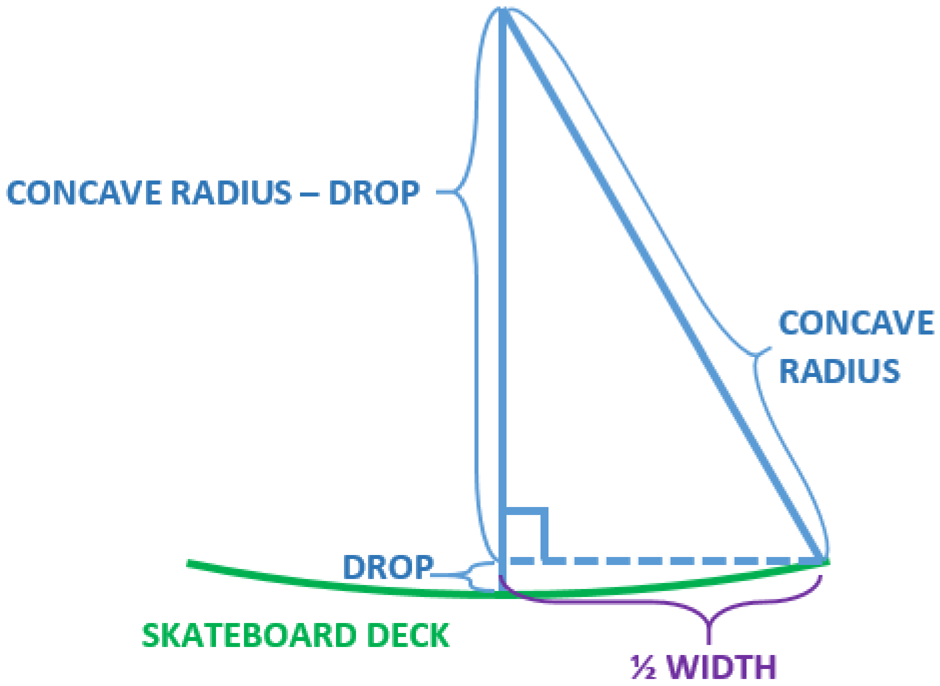
1) **Discussion:** Instructor facilitates class discussion around shapes and observations, and establishes general trends based on consensus of class.

   For example, a steeper kick angle makes the board pop up higher; a board with more concave is stiffer; a smaller board is lighter and easier to maneuver; the smaller the surface area of the board in contact with the "ground" when popped, the less high it pops, etc.

2) **Design:** Students independently design their own boards by defining their own values for the parameters they measured, based on their goals for fingerboard performance. Students write these values down and create sketches labeling their boards' dimensions.

3) **CAD:** Students convert their designs to digital models using the Fingerboard Designer at www.opensourceboards.com/CAD/fingerboard-simple.html.

Since the modeling tool uses concave *radius* and not concave *drop*, the instructor may use this as an opportunity to apply the Pythagorean Theorem:



If students want a specific **concave drop**, they'll need to calculate the corresponding radius.

$$a^2 + b^2 = c^2$$

$$(concave\ radius - concave\ drop)^2 + \left(\frac{1}{2}width\right)^2 = (concave\ radius)^2$$

If students are not yet at that level of math, they can use the online concave value converter: https://www.opensourceboards.com/tools/concave_converter.html

4) Students download their final design as STL files, which are collected by the instructor.

Between Day 2 and 3:

Instructor prints each student's fingerboard.

The instructor may choose to run other lessons between Days 2 and 3 while the fingerboards print. Multiple fingerboards may be printed at once. Depending on their shapes, some fingerboards may require supports when printing.

Day 3:

1) Students assemble their fingerboards. They test them and write down observations (both expected and unexpected). They may also paint or use Sharpies to customize the appearance of their boards.

   If the bolts do not fit through the holes, use a drill with a 1/16" bit to widen the holes.

2) Students share their findings as a class.

   Reflections:

   What surprised you most?

   If you could design your board again, what (if anything) would you change?

   How could we have done this experiment without 3D printers?

   What was the most challenging part? How did you get through it?

   What was your favorite part of the process?